networktest

Juniper Networks EX Series/ Cisco Catalyst Interoperability Cookbook

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ILLUSTRATIONS

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Introduction

Objectives

This configuration guide aims to help networking professionals successfully interconnect Juniper Networks® and Cisco Ethernet switches using a variety of popular Layer 2 and Layer 3 protocols. By following the step-by-step procedures described in this document, it should be possible to verify interoperability and to pass traffic between the two vendors' switches.

Intended audience

This configuration guide is intended for any network architect, administrator or engineer who needs to interconnect Juniper and Cisco Ethernet switches.

This guide assumes familiarity with basic Ethernet and TCP/IP networking concepts, as well as at least limited experience with the Juniper and Cisco command-line interfaces (CLIs). No previous experience is assumed for the protocols discussed in this document.

For beginning readers unfamiliar with Juniper or Cisco CLI syntax, both companies' web sites offer free access to extensive software documentation. In addition, several excellent books on Juniper JUNOS Software and Cisco IOS configuration are available.

For Juniper JUNOS Software configuration, these titles include the forthcoming *JUNOS Enterprise Switching* by Harry Reynolds and Doug Marschk; *Day One: Exploring the JUNOS CLI* by Cathy Gadecki and Michael Scruggs, available in free PDF format or in book format; and the widely used *JUNOS Cookbook* by Aviva Garrett.

Popular titles on Cisco IOS configuration include *Cisco LAN Switching Fundamentals* by David Barnes and Basir Sakandar; *Cisco Routers for the Desperate* by Michael W. Lucas; and *Routing TCP/IP, Volume 1* by Jeff Doyle and Jennifer Carroll.

For basic TCP/IP networking concepts, the standard references are *Internetworking with TCP/IP, Volume 1* by Douglas E. Comer and *TCP/IP Illustrated, Volume 1* by W. Richard Stevens.

For IP multicast topics, *Interdomain Multicast Routing: Practical Juniper Networks and Cisco Systems Solutions* by Brian M. Edwards, Leonard A. Giuliano and Brian R. Wright offers both in-depth explanations of multicast routing protocols and numerous configuration examples using Juniper and Cisco routers.

Devices covered in this document

Using the commands given in this document, Network Test has verified interoperability between the Juniper EX4200 and Juniper EX8208 Ethernet switches and Cisco Catalyst 3560/3750 and Cisco Catalyst 6500 series Ethernet switches. The CDP interoperability

section also makes use of a Cisco Catalyst 4948 switch and the section for LLDP-MED makes use of a Cisco 2821 Integrated Services Router. Appendix B lists software versions tested.

Except where specifically noted, command syntax for the Juniper and Cisco switches does not change across product lines.

Conventions used in this document

The typographical syntax in this document follows that used in the Juniper *Complete Software Guide for JUNOS Software for EX Switches.*

The following table lists text and syntax conventions.

Convention	Description	Examples
Bold type	Represents text that you type	To enter configuration mode, type the **configure** command: `admin@host> **configure**`
Fixed-width text like this	Represents output that appears on the terminal screen	`admin@host> **show chassis alarms**` `No alarms currently active`
Italic text like this	• Introduces important new terms • Identifies book titles • Identifies RFC and Internet-draft titles • Identifies variables (options for which you substitute a value) in commands or configuration statements.	• A policy *term* is a named structure that defines match conditions and actions. • *JUNOS System Basics Configuration Guide* • RFC 4814, *Hash and Stuffing: Overlooked Factors in Network Device Benchmarking* • `admin@# **set system domain-name** *domain-name*`
< > angle brackets	Enclose optional keywords or variables.	`stub <default-metric *metric*>;`
| (pipe symbol)	Indicates a choice between the mutually exclusive keywords or variables on either side of the symbol. The set of choices is often enclosed in parentheses for clarity.	`broadcast | multicast (*string1* | *string2* | *string3*)`
# (pound sign)	Indicates a comment specified on the same line as the configuration statement to which it appears.	`rsvp { # Required for dynamic MPLS only`
[ ] (square braces)	Enclose a variable for which you can substitute one or more values.	`community name members [ *community-ids*]`

Indention and braces ({ })	Identify a level in the configuration hierarchy.	`[edit]`
		`routing-options {`
		`  static {`
		`  route default {`
		`  nexthop *address*;`
		`  retain;`
		`  }`
		`  }`
		`}`

; (semicolon)	Identifies a leaf statement at a configuration hierarchy level.	`nexthop *address*;`

Interoperability testing

For each interoperability test described here, this document uses a five-section format consisting of objective, technical background, Juniper configuration, Cisco configuration and test validation.

Cisco Discovery Protocol (CDP) Passthrough

Objective

To verify the ability of a Juniper switch to forward Cisco Discovery Protocol (CDP) traffic between two Cisco devices.

Background

The proprietary Cisco Discovery Protocol (CDP) allows sharing of information, such as IP address, model number and power requirements, among connected Cisco devices. Cisco devices use CDP messages to transmit information about their capabilities to other Cisco products in the network. Accordingly, an interoperability requirement for Juniper switches in the path between two Cisco devices is the ability to "pass through" CDP traffic without affecting CDP operation.

No extra configuration of Juniper or Cisco switches is required for CDP passthrough. Because Juniper EX Series switches forward CDP messages in regular Ethernet frames, a standard Ethernet switching configuration will work. Similarly, CDP is enabled by default on most Cisco devices, so no additional configuration is needed for Catalyst switches.

Topology

In this example, Cisco Catalyst 4948 and Cisco Catalyst 6509 switches will use CDP to exchange model numbers and interface information across a Juniper EX4200 switch. The interfaces used are as follows:

- Cisco Catalyst 4948: GigabitEthernet1/9 (Gi1/9)
- Juniper EX4200-24P: ge-0/0/0.0 (to 4948) and xe-0/1/0.0 (to 6509)
- Cisco Catalyst 6509: TenGigabitEthernet1/1 (Ten1/1)

All devices are configured as switches and all interfaces are in the default VLAN. No VLAN trunking is configured; if desired VLAN access and trunk ports can be configured, and CDP traffic will be forwarded just as in this example. Figure 1 below shows the topology for CDP passthrough.

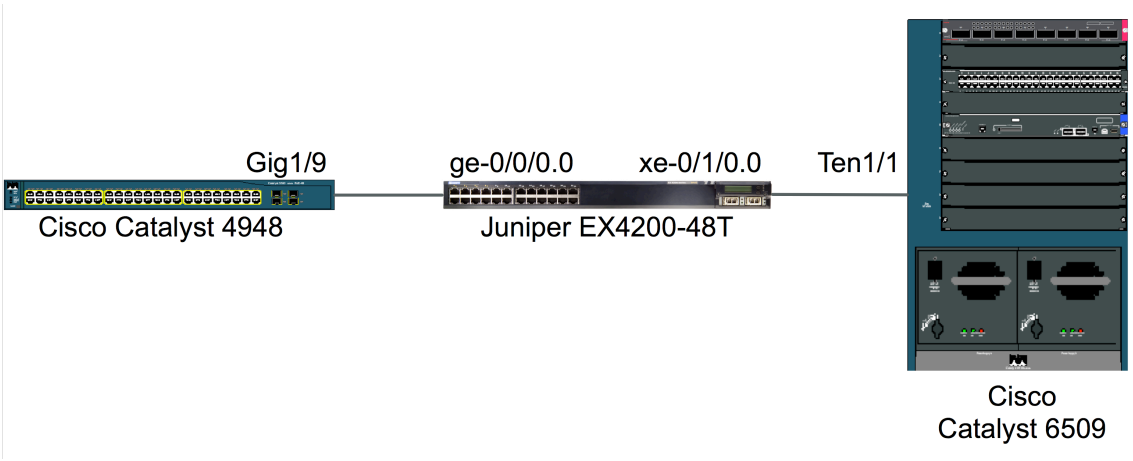

Figure 1: CDP Passthrough Topology

Juniper configuration

Ethernet switching is enabled on the two interfaces connected with the Cisco switches:

```
admin@EX4200> configure
admin@EX4200# set interfaces ge-0/0/0 unit 0 family ethernet-switching
admin@EX4200# set interfaces ge-0/0/0 description "4200To4948"
admin@EX4200# set interfaces xe-0/1/0 unit 0 family ethernet-switching
admin@EX4200# set interfaces xe-0/1/0 description "4200To6500"
```

The spanning tree protocol must be either disabled on all switches, or disabled on all switches. This command will enable rapid spanning tree on a Juniper EX Series switch:

```
admin@EX4200# set protocols rstp
```

To disable rapid spanning tree on a Juniper EX Series switch:

```
admin@EX4200# set protocols rstp disable
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

Cisco commands

Since CDP is enabled by default on Cisco devices, no additional configuration is needed. On the Catalyst 4948, interfaces will already be members of the default VLAN and rapid spanning tree (called PVST-Plus in Cisco documentation) will be enabled. All that remains is to add a description to the interface:

```
Cat4948# configure terminal
Cat4948(config)# interface GigabitEthernet1/9
Cat4948(config-if)# description 4948To4200
Cat4948(config-if)# end
```

Then issue similar commands on the Catalyst 6509:

```
Cat6509# configure terminal
Cat6509(config)# interface TenGigabitEthernet1/1
Cat6509(config-if)# description 6509To4200
Cat6509(config-if)# end
```

Validation

To verify that a Juniper EX Series switch will forward CDP messages between two Cisco devices, use the **show cdp neighbors** command on either Cisco device.

The Catalyst 4948 will recognize the Catalyst 6509 via CDP:

```
Cat4948# show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
Cat6509          Gig 1/9           153          R S I     WS-C6509- Ten 1/1
```

And the Catalyst 6509 similarly will recognize the Catalyst 4948:

```
Cat6509# show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
Cat4948          Ten 1/1           132          R S I     WS-C4948  Gig 1/9
```

Note that in both cases, the Cisco switches correctly identified the hostname ("Device ID"), model number ("Platform") and interface ("Port ID") of the remote Cisco device. All this information is learned via CDP, which is forwarded without any additional configuration needed on the Juniper EX Series switch.

Ethernet OAM/802.3ah

Objective

To verify that Juniper and Cisco switches can exchange link discovery and link monitoring information using IEEE 802.3ah messages.

Background

The IEEE 802.3ah specification describes how Ethernet devices can exchange link discovery and link monitoring information as part of Ethernet operations, administration and management (OAM, sometimes called "OA&M"). These capabilities are critical for service providers rolling out Ethernet in the First Mile (EFM) capabilities and wishing to monitor the status of Ethernet links to customer sites. OAM capabilities are also useful in enterprise deployments, especially for customers with large or far-flung network topologies. While many switch vendors have proprietary messages for notifying link partners of changes in link state and other parameters, the 802.3ah specification provides a standards-based method for passing such messages in multivendor networks.

Topology

In this example, Juniper EX4200-24T and Cisco Catalyst 6509 switches exchange link-up and link-down messages using Ethernet OAM capabilities. The two switches are connected via their first 10-Gbit/s Ethernet interfaces:

- Juniper EX4200-24P: xe-0/1/0.0
- Cisco Catalyst 6509: TenGigabitEthernet1/1 (Ten1/1)

Figure 2 below shows the OAM/802.3ah configuration:

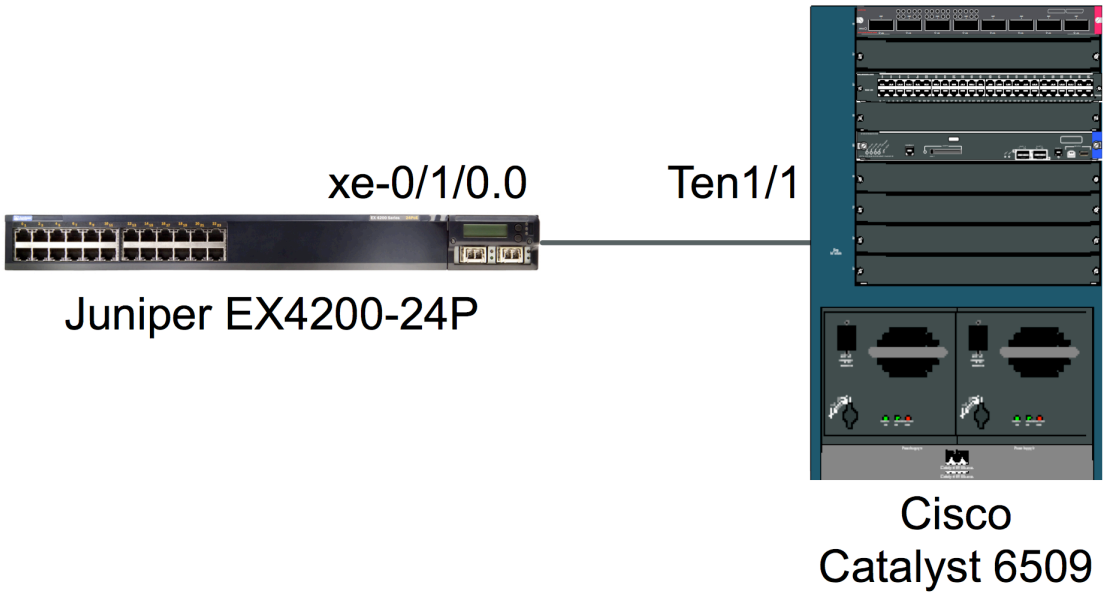

Figure 2: OAM/802.3ah Topology

At the time this procedure was verified (April 2009), the software versions used on Juniper EX8208 and Cisco Catalyst 3750-E switches did not support OAM/802.3ah.

Juniper commands

In this example, both the Juniper and Cisco switch interfaces were configured with IP addresses: 10.0.0.1 for Cisco and 10.0.0.2 for Juniper. In the case of the Juniper EX4200-24P, the IP interface was assigned to a VLAN, and the physical interface was then made a member of that VLAN. This involves three commands:

1. Create the VLAN:

```
admin@EX4200> configure
admin@EX4200# set vlans vlan10 vlan-id 10 l3-interface vlan.10
```

2. Assign an IP address to that VLAN:

```
admin@EX4200# set interfaces vlan unit 10 family inet address 10.0.0.2/24
```

3. Assign `interface xe-0/1/0.0` to be a member of the VLAN:

```
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching vlan
members 10
```

The final step is to enable Ethernet OAM on the interface. This example uses the **`link-discovery`** and **`remote-loopback`** parameters of the OAM **`link-fault-`**

management facility, but there are many other options; consult the Juniper JUNOS software documentation for further details.

```
admin@EX4200# set protocols oam ethernet link-fault-management interface
xe-0/1/0.0 link-discovery active remote-loopback
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

On the Catalyst 6509, the procedure is to set the **ethernet oam** command on the interface connected with the Juniper switch. In this example, an IP address is also configured, but that is not required for OAM/802.3ah to work.

```
Cat6509# configure terminal
Cat6509(config)# interface TenGigabitEthernet1/1
Cat6509(config-if)# ip address 10.0.0.1 255.255.255.0
Cat6509(config-if)# description 6509To4200
Cat6509(config-if)# ethernet oam
Cat6509(config-if)# end
```

Validation

On Juniper switches, the **show oam ethernet link-fault-management** command will return OAM/802.3ah link monitoring status:

```
admin@EX4200> show oam ethernet link-fault-management
Sample Output Interface: xe-0/1/0.0
Status: Running, Discovery state: Send Any
Peer address: 00:00:0C:4d:14:f7
Flags:Remote-Stable Remote-State-Valid Local-Stable 0x50
Remote entity information:
Remote MUX action: forwarding, Remote parser action: forwarding
Discovery mode: active, Unidirectional mode: unsupported
Remote loopback mode: supported, Link events: supported
Variable requests: unsupported
```

Changes to Ethernet link status will appear on the console and also in the parameters returned by the **show oam ethernet link-fault-management** command.

IP multicast switching

Objective

To verify the ability of a Juniper EX switch to correctly forward multicast traffic from a multicast routed network.

Background

Ethernet switches use Internet group management protocol (IGMP) snooping to determine where a switch should forward multicast traffic. With IGMP snooping enabled, a switch listens for IGMP reports from attached multicast subscribers. The switch then maps subscribed multicast group address(es) to the interface on which the subscriber is attached. When the switch receives traffic destined for one or more addresses, it will forward it only to those interfaces from which it has heard membership reports.

Topology

In this example, a streaming video server generates multicast traffic that is routed across a network running the Protocol Independent Multicast-Sparse Mode (PIM-SM) multicast routing protocol. One of the routers in this network is a Cisco Catalyst 6509, which in turn is attached to a Juniper EX4200 switch with multicast subscribers attached.

The streaming video server generates traffic to 10 multicast group addresses in the range of 225.0.1.0 through 225.0.1.9. Subscribers attached to the Juniper switch join all 10 multicast groups.

Figure 3 below illustrates the topology used to validate IP multicast switching functionality. On the Juniper switch, all interfaces are members of the default VLAN, and IGMP snooping is enabled. On the Cisco Catalyst 6509, PIM-SM routing is enabled.

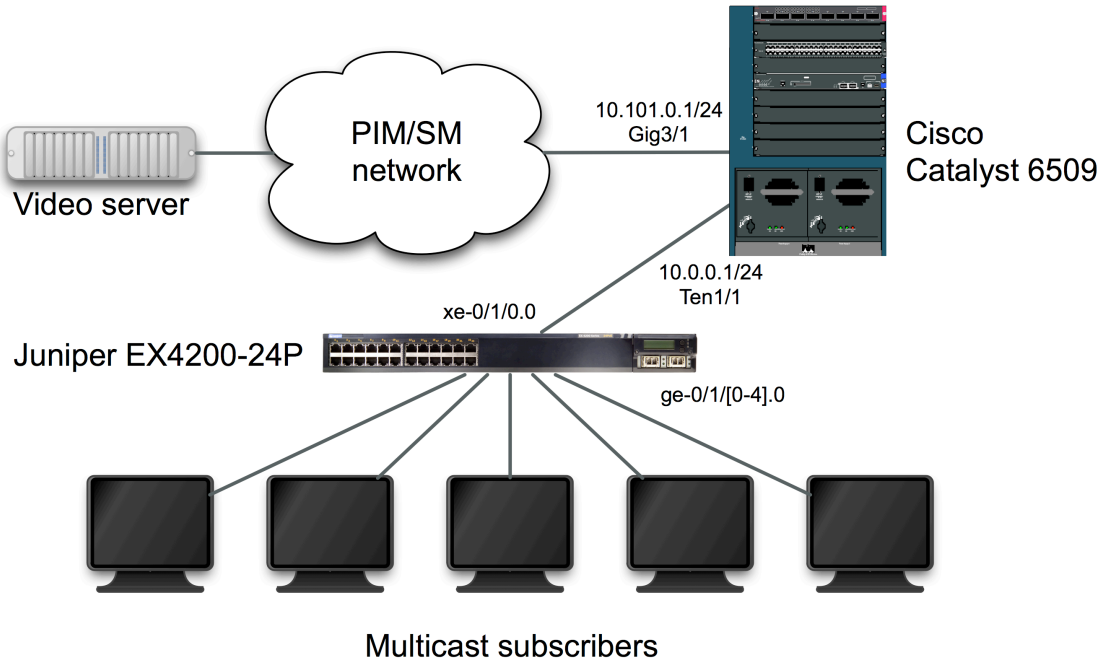

Figure 3: IP Multicast Switching Validation Topology

Juniper commands

In this simple example, all interfaces are members of the default VLAN and IGMP snooping is enabled on all VLANs:

```
admin@EX4200> configure
admin@EX4200# set protocols igmp-snooping vlan all
```

If desired, IGMP snooping can be enabled on a per-VLAN basis. For example, this command would enable IGMP snooping on a VLAN called "multicast-vlan":

```
admin@EX4200# set protocols igmp-snooping vlan multicast-vlan
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

Cisco commands

The following commands apply to a Cisco Catalyst 6509. Except where noted, the syntax is similar for Catalyst 3560/3750 switches.

1. Enable IP multicast routing:

```
Cat6500# configure terminal
Cat6500(config)# ip multicast-routing
```

On Cisco Catalyst 3560/3750 switches, the commands are slightly different:

```
Cat3750# configure terminal
Cat3750(config)# ip routing
Cat3750(config)# ip multicast-routing distributed
```

2. Configure interface TenGigabitEthernet1/1 (connected to the Juniper EX4200) with an IP address:

```
Cat6500(config)# interface TenGigabitEthernet1/1
Cat6500(config-if)# ip address 10.0.0.1 255.255.255.0
Cat6500(config-if)# exit
Cat6500(config)#
```

3. Configure interface GigabitEthernet3/1 with an IP address and support for PIM-SM:

```
Cat6500(config)# interface GigabitEthernet3/1
Cat6500(config-if)# ip address 10.101.0.1 255.255.255.0
Cat6500(config-if)# ip pim sparse-mode
Cat6500(config-if)# exit
```

5. Configure OSPF. This step is not strictly necessary for IP multicast forwarding; however, few if any routed networks carry exclusively multicast traffic.

```
Cat6500(config)# router ospf 1
Cat6500(config-router)# router-id 10.101.0.1
Cat6500(config-router)# log-adjacency-changes
Cat6500(config-router)# network 10.101.0.0 0.0.0.255 area 0
Cat6500(config-if)# exit
```

6. Configure a PIM rendezvous point (RP). In this case the RP will be interface GigabitEthernet3/1:

```
Cat6500(config)# ip pim rp-address 10.101.0.1
Cat6500(config-if)# end
```

Validation

On the Juniper EX4200 switch, results of the command **`show igmp-snooping membership`** will verify that the switch has correctly mapped multicast groups to the appropriate subscriber interfaces:

```
admin@EX4200> show igmp-snooping membership vlan default

VLAN: default

    225.0.1.0     *               246 secs
        Interfaces: ge-0/0/0.0
                    ge-0/0/1.0
                    ge-0/0/2.0
                    ge-0/0/3.0
                    ge-0/0/4.0

    225.0.1.1     *               249 secs
        Interfaces: ge-0/0/0.0
                    ge-0/0/1.0
                    ge-0/0/2.0
                    ge-0/0/3.0
                    ge-0/0/4.0
```

This output will continue through multicast group address 225.0.1.9.

The command **`show interface <name> extensive`** will verify correct forwarding of multicast traffic. The "Multicast packets" counter (under "MAC statistics") will increment on interfaces with multicast subscribers attached, and will not increment on other interfaces.

IP multicast routing

Objective

To verify the ability of a Juniper EX switch to learn multicast routing information from a Cisco device using the PIM-SM protocol.
To verify the ability of a Juniper EX switch to correctly forward multicast traffic based on routing information learned via PIM-SM.

Background

Protocol Independent Multicast-Sparse Mode (PIM-SM) is a popular choice for multicast routing. Devices running PIM-SM can learn topology information from other PIM-SM routers and make forwarding decisions based on that information.

Topology

This example is similar to that used in the "IP Multicast Switching" section, with one important change: Here, the Juniper EX4200 switch also acts as a PIM-SM router.

In this example, a streaming video server attached to one subnet on a Cisco Catalyst 6509 generates multicast traffic. The Cisco device uses PIM-SM to propagate routing information about that subnet to other subnets, including one in which a Juniper EX4200 switch, also running PIM-SM, is attached.

The Juniper EX4200 switch uses PIM-SM and OSPF to propagate routing information. Multicast subscribers attached to routed interfaces, each in a different IP subnet, receive traffic from the streaming video server. The subscriber interfaces also use IGMP to build a multicast forwarding table.

Figure 4 below illustrates the topology used to validate IP multicast routing functionality. PIM-SM and OSPF routing is enabled on both the Juniper and Cisco devices.

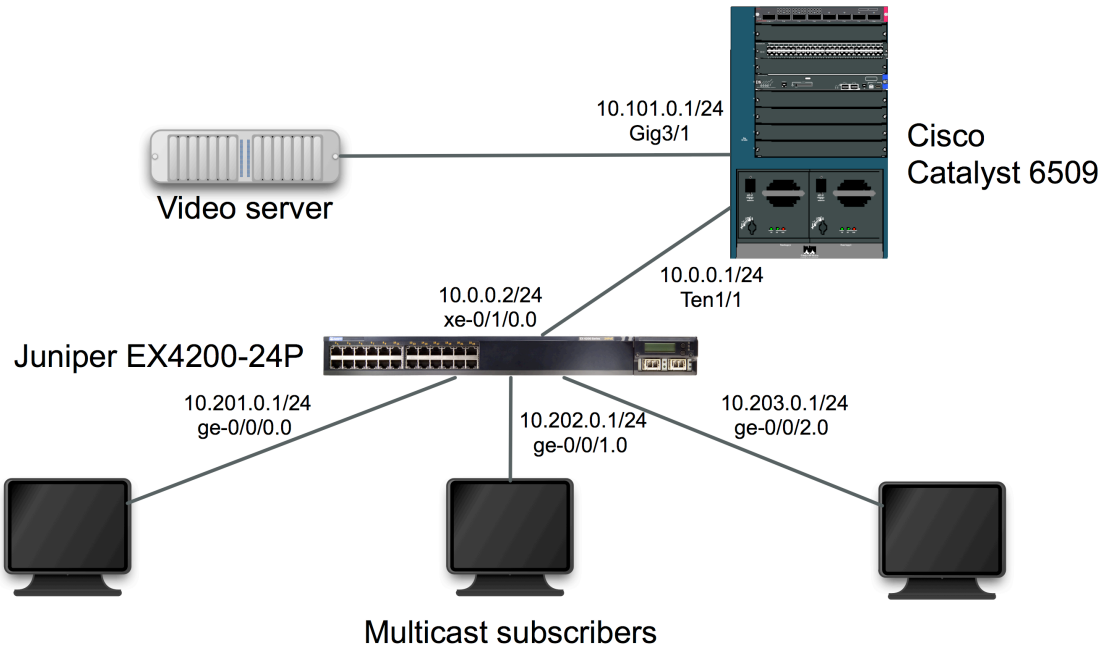

Figure 4: IP Multicast Routing Validation Topology

Juniper commands

1. Assign IP addresses to the interfaces:

```
admin@EX4200> configure
admin@EX4200# set interfaces ge-0/0/0.0 family inet address 10.201.0.1/24
admin@EX4200# set interfaces ge-0/0/1.0 family inet address 10.202.0.1/24
admin@EX4200# set interfaces ge-0/0/2.0 family inet address 10.203.0.1/24
admin@EX4200# set interfaces xe-0/1/0.0 family inet address 10.0.0.2/24
```

If the interfaces previously used the `ethernet-switching` keyword, it should be deleted first with the "**`delete interfaces <name> family ethernet-switching`**" command.

2. Enable IGMP version 3 on the subscriber interfaces:

```
admin@EX4200# set protocols igmp interface ge-0/0/0.0 version 3
admin@EX4200# set protocols igmp interface ge-0/0/1.0 version 3
admin@EX4200# set protocols igmp interface ge-0/0/2.0 version 3
```

3. Enable OSPF on the 10-Gbit/s Ethernet interface (connected to the Catalyst 6509) and the gigabit subscriber interfaces. This step is not strictly necessary for IP multicast forwarding; however, few if any routed networks carry exclusively multicast traffic.

```
admin@EX4200# set protocols ospf area 0.0.0.0 interface ge-0/0/0.0
admin@EX4200# set protocols ospf area 0.0.0.0 interface ge-0/0/1.0
admin@EX4200# set protocols ospf area 0.0.0.0 interface ge-0/0/2.0
admin@EX4200# set protocols ospf area 0.0.0.0 interface xe-0/1/0.0
```

4. Enable PIM-SM and set a rendezvous point (RP), in this example the 10-Gbit/s interface of the Catalyst 6509:

```
admin@EX4200# ip pim rp-address 10.0.0.1
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

The following commands apply to a Cisco Catalyst 6509. Except where noted, the syntax is similar for Catalyst 3560/3750 devices.

1. Enable IP multicast routing:

```
Cat6500# configure terminal
Cat6500(config)# ip multicast-routing
```

On Cisco Catalyst 3560/3750 switches, the commands are slightly different:

```
Cat3750# configure terminal
Cat3750(config)# ip routing
Cat3750(config)# ip multicast-routing distributed
```

2. Configure interface TenGigabitEthernet1/1 (connected to the Juniper EX4200) with an IP address:

```
Cat6500(config)# interface TenGigabitEthernet1/1
Cat6500(config-if)# ip address 10.0.0.1 255.255.255.0
Cat6500(config-if)# ip pim sparse-mode
Cat6500(config-if)# exit
Cat6500(config)#
```

3. Configure interface GigabitEthernet3/1 with an IP address and support for PIM-SM:

```
Cat6500(config)# interface GigabitEthernet3/1
Cat6500(config-if)# ip address 10.101.0.1 255.255.255.0
Cat6500(config-if)# ip pim sparse-mode
Cat6500(config-if)# exit
```

5. Configure OSPF. This step is not strictly necessary for IP multicast forwarding; however, few if any routed networks carry exclusively multicast traffic.

```
Cat6500(config)# router ospf 1
Cat6500(config-router)# router-id 10.0.0.1
```

```
Cat6500(config-router)# log-adjacency-changes
Cat6500(config-router)# network 10.0.0.0 0.0.0.255 area 0
Cat6500(config-router)# network 10.101.0.0 0.0.0.255 area 0
Cat6500(config-if)# exit
```

6. Configure a PIM rendezvous point (RP). In this case the RP will be interface TenGigabitEthernet1/1:

```
Cat6500(config)# ip pim rp-address 10.0.0.1
Cat6500(config-if)# end
```

Validation

Once subscribers attached to the Juniper EX4200 have joined multicast groups by sending IGMPv3 reports with join messages, any multicast traffic for those groups offered to interface GigabitEthernet3/1 on the Cisco Catalyst 6509 will be forwarded to all subscriber ports on the Juniper EX4200.

The JUNOS command **show pim neighbors brief** also will verify that the Juniper and Cisco devices see one another and can exchange topology updates.

Jumbo frame switching

Objective

To validate the ability of Juniper and Cisco switches to correctly forward bidirectional traffic consisting of jumbo frames.

Background

For many years the IEEE Ethernet specification has defined the maximum length of an Ethernet frame to be 1,518 bytes (or 1,522 bytes with an 802.1Q VLAN tag). The use of jumbo frames – those larger than 1,518 bytes – remains nonstandard.

In part because of the lack of a standard length for jumbo frames, there is confusion in the marketplace about the maximum frame length possible. Until recently, the Linux drivers for Ethernet interfaces in servers supported a maximum length of around 7,000 bytes. Ethernet interfaces of switches and routers typically support a larger protocol data unit (PDU) but there is some confusion as to whether that PDU should be a maximum of 9,000 bytes or 9,216 bytes. Adding to the confusion, implementations differ as to whether the 4-byte cyclic redundancy check (CRC) should or should not be included when stating the maximum frame length.

Juniper and Cisco switches both support 9,216-byte jumbo frames, including CRC. This section explains how to configure both vendors' switches to exchange jumbo frames.

Topology

In this example, a Juniper EX4200-24P switch exchanges jumbo frames with a Cisco Catalyst 6509. As commonly used in many organizations, VLAN trunk ports connect the switches and VLAN access ports at the edge accept untagged jumbo frames. However, the ability to switch jumbo frames does not depend on VLAN tagging. This example would also work with all interfaces passing untagged traffic.

Figure 5 below illustrates the configuration used to validate jumbo frame switching. As noted in the configuration sections below, all interfaces explicitly support switching of jumbo frames. On the Juniper EX4200-24P switch, a client attached to interface ge-0/0/0.0 uses an untagged VLAN ID of 2001. The 10-Gbit/s Ethernet interface xe-0/1/0.0 is a trunk port, conveying tagged traffic to the Cisco Catalyst 6509 switch. On the Cisco side, interface TenGigabitEthernet1/1 is also a trunk port. A server is attached to access port GigabitEthernet3/1.

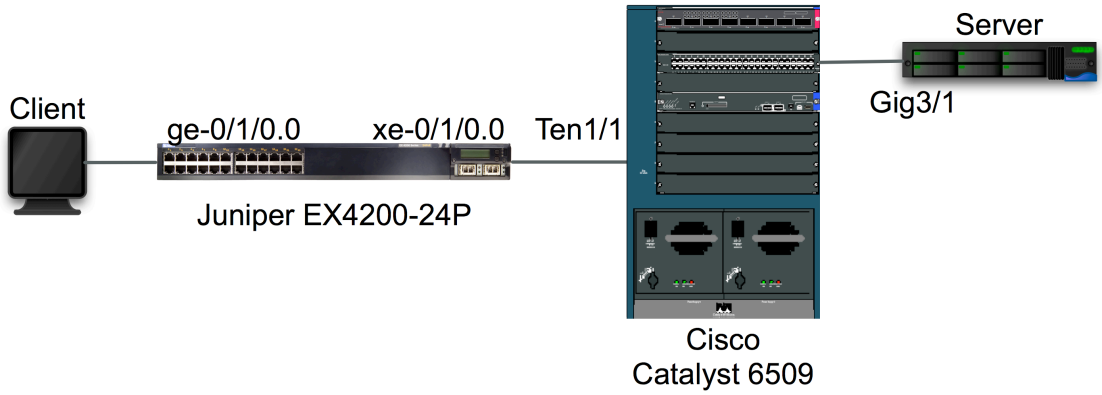

Figure 5: Jumbo Frame Switching Topology

Juniper commands

Jumbo frame support is enabled by adding the `mtu` keyword when configuring interfaces. Note that the `mtu` keyword applies to the physical interface and not the logical `unit` interface where VLAN membership is assigned.

Note that the JUNOS `mtu` keyword does not include the Ethernet CRC. Thus, to pass 9,216-byte Ethernet frames (including CRC), untagged (access) ports will take a command of **`mtu 9212`**, while trunk ports will take a command of **`mtu 9216`** (to accommodate the 4-byte VLAN tag).

In this example, MTU and VLAN settings are configured separately. First, MTU settings are applied to each interface. Again, note that interface xe-0/1/0 takes a larger MTU value to accommodate VLAN tagging:

```
admin@EX4200> configure
admin@EX4200# set interfaces ge-0/0/0 mtu 9212
admin@EX4200# set interfaces xe-0/1/0 mtu 9216
```

Next, a VLAN is created and interfaces are assigned to the VLAN. In this example, the gigabit Ethernet interface accepts untagged traffic from an edge device while the 10-Gbit/s Ethernet interface passes tagged traffic to the Cisco switch:

```
admin@EX4200# set vlans v2001 vlan-id 2001

admin@EX4200# set interfaces ge-0/0/0.0 family ethernet-switching vlan
members v2001
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching port-mode
trunk vlan members [ v2001 ]
```

The spanning tree protocol must be either disabled on all switches, or disabled on all switches. This command will enable rapid spanning tree on a Juniper EX Series switch:

```
admin@EX4200# set protocols rstp
```

To disable rapid spanning tree on a Juniper EX switch:

```
admin@EX4200# set protocols rstp disable
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

Cisco devices also use the `mtu` keyword in the interface configuration context to enable switching of jumbo frames. As with the Juniper configuration, VLANs are created separately. Unlike the Juniper example, MTU size and VLAN membership are both associated with the physical interface. Also, in Cisco IOS arguments to the `MTU` keyword do include the Ethernet CRC.

```
Cat6509# configure terminal
Cat6509# vlan 2001
Cat6509(config)# interface GigabitEthernet3/1
Cat6509(config-if)# mtu 9216
Cat6509(config-if)# no ip address
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 2001
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# interface TenGigabitEthernet1/1
Cat6509(config-if)# mtu 9216
Cat6509(config-if)# no ip address
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 2001
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# end
```

Validation

Generating jumbo frames between the client and server will validate the ability of the switches to exchange jumbo traffic. This can be verified by examining the network interface frame counters on the client and server. Alternatively, a test instrument can be configured to generate bidirectional jumbo frame traffic between the switches. Both switches should forward all jumbo frames with zero frame loss.

Jumbo frame routing

Objective

To validate the ability of Juniper and Cisco switches to correctly route bidirectional traffic consisting of jumbo frames.

Background

Some routing protocols such as open shortest path first (OSPF) require that both routers agree on the same maximum transmission unit (MTU) before exchanging routing information. For Ethernet interfaces, the requirement for matched MTUs applies equally to jumbo frames (those larger than 1,518 bytes) as to standard-length frames.

In part because of the lack of a standard length for jumbo frames, there is confusion in the marketplace about the maximum frame length possible. Until recently, the Linux drivers for Ethernet interfaces in servers supported a maximum length of around 7,000 bytes. Ethernet interfaces of switches and routers typically support a larger protocol data unit (PDU) but there is some confusion as to whether that PDU should be a maximum of 9,000 bytes or 9,216 bytes. Adding to the confusion, implementations differ as to whether the 4-byte cyclic redundancy check (CRC) should or should not be included when stating the maximum frame length.

Juniper and Cisco switches both support 9,216-byte jumbo frames, including CRC. This section explains how to configure both vendors' devices to set up an OSPF routing session using jumbo frames.

Topology

In this example, a Juniper EX4200-24P switch configured as an OSPF router exchanges jumbo frames with a Cisco Catalyst 6509 switch.

Figure 6 below illustrates the configuration used to validate jumbo frame routing. In this example, an OSPF routing session will be established between interface xe-0/1/0.0 on the Juniper switch and interface TenGigabitEthernet1/1 on the Cisco device. Both interfaces have IP addresses in the 10.0.0.0/24 subnet.

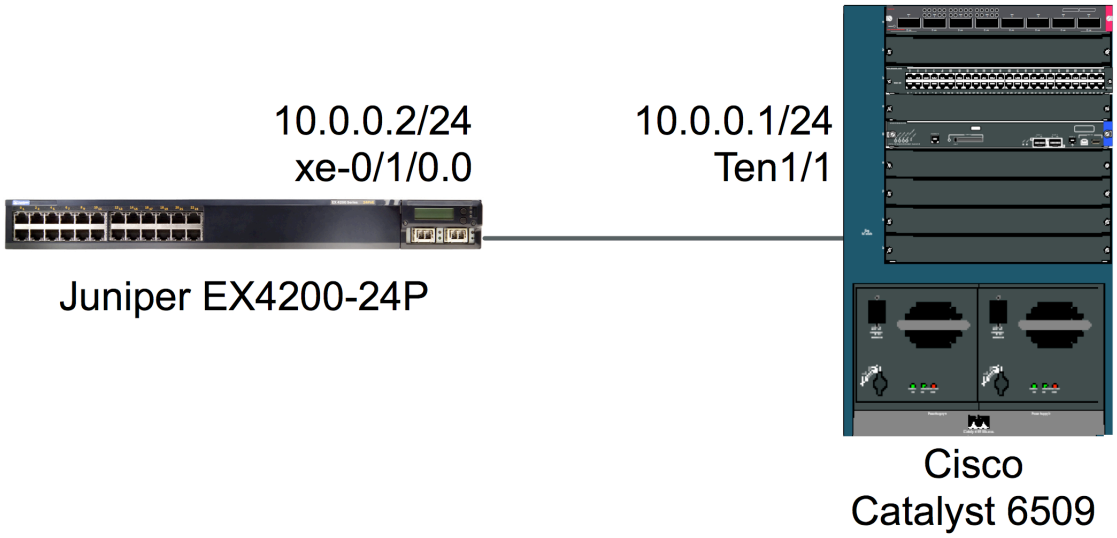

Figure 6: Jumbo Frame Routing Topology

Juniper commands

Jumbo frame support is enabled by adding the `mtu` keyword when configuring interfaces. Note that the `mtu` keyword applies to the physical interface and not the logical `unit` interface where an IPv4 address is assigned.

Note that the JUNOS `mtu` keyword does not include the Ethernet CRC. Thus, to pass 9,216-byte Ethernet frames (including CRC), the routing interface will take a command of **`mtu 9212`**.

First the MTU and IP address are assigned to interface xe-0/1/0:

```
admin@EX4200> configure
admin@EX4200# set interfaces xe-0/1/0 mtu 9212
admin@EX4200# set interfaces xe-0/1/0.0 family inet address 10.0.0.2/24
```

Then OSPF routing is configured. In this example, the interface is a member of OSPF area 0.

```
admin@EX4200# set protocols ospf area 0.0.0.0 interface xe-0/1/0.0
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

Cisco commands

Cisco devices also use the `mtu` keyword in the interface configuration context to enable switching of jumbo frames. Cisco IOS has separate commands for `mtu`, describing the maximum transmission unit for the *Ethernet* frame and for the `ip mtu`, describing the MTU for the *IP packet.*

```
Cat6509# configure terminal
Cat6509(config)# interface TenGigabitEthernet1/1
Cat6509(config-if)# mtu 9216
Cat6509(config-if)# ip address 10.0.0.1 255.255.255.0
Cat6509(config-if)# ip mtu 9198
Cat6509(config-if)# exit
Cat6509(config)# router ospf 1
Cat6509(config-router)# router-id 10.0.0.1
Cat6509(config-router)# log-adjacency-changes
Cat6509(config-router)# network 10.0.0.0 0.0.0.255 area 0
Cat6509(config-router)# end
```

This above example is for Catalyst 6500 series switches. On Catalyst 3750 switches, the global configuration `system mtu routing` command sets IP MTU size.

```
Cat3750# configure terminal
Cat3750(config)# system mtu routing 9198
Cat3750(config)# interface TenGigabitEthernet1/0/1
Cat3750(config-if)# no switchport
Cat3750(config-if)# ip address 10.0.0.1 255.255.255.0
Cat3750(config-if)# exit
Cat3750(config)# router ospf 1
Cat3750(config-router)# router-id 10.0.0.1
Cat3750(config-router)# log-adjacency-changes
Cat3750(config-router)# network 10.0.0.0 0.0.0.255 area 0
Cat3750(config-router)# end
```

The commands above have been verified with Catalyst 3750-E switches routing jumbo frames with Juniper EX4200 and EX8200 Series switches. On some versions of IOS, the Catalyst 3750 may instead use the global `system mtu jumbo <value>` command instead.

Validation

Unless both Juniper and Cisco interfaces agree on MTU size, OSPF routing adjacencies will remain in ExStart state, and will never transition to OSPF "full" state. To verify that an OSPF adjacency has entered OSPF "full" state on Juniper switches, use the **`show ospf neighbor`** command:

```
admin@EX4200> show ospf neigbhor
Address          Interface              State     ID               Pri  Dead
10.0.0.1         xe-0/1/0.0             Full      10.0.0.1           1    32
```

On the Cisco device, use the show ip ospf neighbor command:

```
Cat6500# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.0.0.2        128   FULL/BDR        00:00:35    10.0.0.2
TenGigabitEthernet1/1
```

The fact that both routers are in Full state indicates they have agreed to exchange IP packets up to 9,198 bytes long (9,216 bytes, including Ethernet header and CRC). OSPF routing establish will not work unless both sides agree on MTU size.

Link aggregation

Objective

To validate the ability of Juniper and Cisco switches to correctly forward traffic over a logical connection created using IEEE 802.3ad link aggregation.

To verify the ability of Juniper and Cisco switches to use the link aggregation control protocol (LACP) to dynamically remove a member from a link aggregation group (LAG).

To verify the ability of Juniper and Cisco switches to use the link aggregation control protocol (LACP) to dynamically insert a member into a link aggregation group (LAG).

Background

The IEEE 802.3ad link specification[1] defines a standards-based method for aggregating multiple physical Ethernet links into a single logical link. The logical link, known as a link aggregation group (LAG), is comprised of multiple *members* (individual pairs of physical interfaces on each switch). LAGs may be defined statically or dynamically, the latter using the link aggregation control protocol (LACP). With LACP enabled, 802.3ad-compliant switches can dynamically add or remove up to eight members to a LAG.

Link aggregation is useful both for increasing bandwidth beyond the limits of single physical interfaces and, especially when used with LACP, for adding redundancy to network connections.

Topology

In this example, a Juniper EX4200-24P switch uses a two-member LAG to exchange traffic with a Cisco Catalyst 6509 switch. The EX4200 switch also could be a chassis-based Juniper EX8200 series switch; both use the same link aggregation commands given here. LAG members also can reside on different physical switches in an EX 4200 Virtual Chassis configuration; see the JUNOS Software configuration guide for more details.

Interfaces xe-0/1/0 and xe-0/1/11 on the Juniper switch make up the members of the LAG. On the Cisco switch, the LAG members are interfaces TenGigabitEthernet1/1 and TenGigabitEthernet1/2. LACP is enabled on all LAG members.

Figure 7 below shows the topology used to validate link aggregation and LACP functionality.

[1] This specification recently was updated in IEEE 802.1AX-2008.

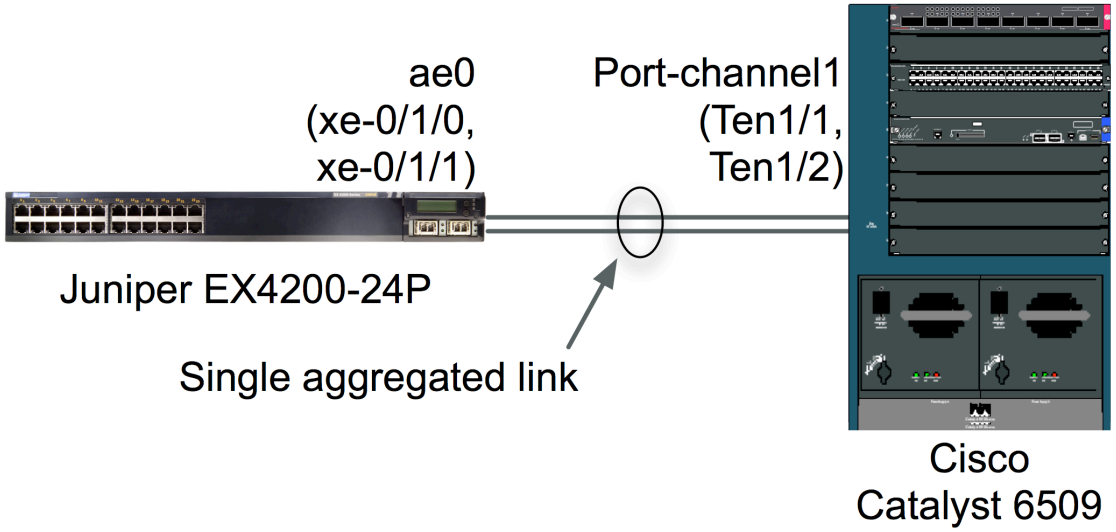

Figure 7: Link Aggregation Validation Topology

Juniper commands

Juniper JUNOS uses the **ae** interface notation to define each "aggregated Ethernet" instance. The procedure is as follows:

1. Configure the desired number of link aggregation instances (just 1, in this example):

```
admin@EX4200> configure
admin@EX4200# set chassis aggregated-devices ethernet device-count 1
```

2. Set the minimum number of members for the aggregated Ethernet interface (`ae0` in this example). At least one interface must be up for the LAG to be labeled "up".

```
admin@EX4200# set interface ae0 aggregated-ether-options minimum-links 2
```

3. Specify the members to be included within the aggregated Ethernet bundle:

```
admin@EX4200# set interfaces xe-0/1/0 ether-options 802.3ad ae0
admin@EX4200# set interfaces xe-0/1/1 ether-options 802.3ad ae0
```

4. Enable LACP on the aggregated Ethernet instance:

```
admin@EX4200# set interfaces ae0 aggregated-ether-options lacp active
admin@EX4200# set interfaces ae0.0 family ethernet-switching
```

5. (Optional) Assign the link aggregation interface to be an member of a VLAN. The following example assigns interface **`ae0.0`** to access-mode membership in VLAN **`v101`**:

```
admin@EX4200# set interfaces ae0.0 family ethernet-switching vlan members
v101
```

Link aggregation interfaces also can be configured in VLAN trunking mode to carry tagged traffic from multiple VLANs. The following example assigns interface **ae0.0** to trunk-mode membership to carry traffic from VLANs **v101** and **v102**:

```
admin@EX4200# set interfaces ae0.0 family ethernet-switching port-mode
trunk vlan members [v101 v102]
```

6. To disable or re-enable a member of the LAG, disable that member:

```
admin@EX4200# set interfaces xe-0/1/1 disable
```

Delete the `disable` command to re-enable the LAG member:

```
admin@EX4200# delete interfaces xe-0/1/1 disable
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Create the link aggregation group (called a `port-channel` in Cisco IOS terminology):

```
Cat6509# configure terminal
Cat6509(config)# interface Port-channel1
Cat6509(config-if)# no ip address
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

This example is for a Cisco Catalyst 6509. On Cisco Catalyst 3560/3750 switches, the syntax is slightly simpler:

```
Cat3750# configure terminal
Cat3750(config)# interface Port-channel1
Cat3750(config-if)# switchport mode access
```

2. Add interfaces to the link aggregation group. The command "`channel-group 1`" adds an interface to the link aggregation group defined in the previous step, while "`mode active`" enables LACP.

```
Cat6509(config)# interface TenGigabitEthernet1/1
Cat6509(config-if)# no ip address
```

```
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# channel-group 1 mode active
Cat6509(config)# interface TenGigabitEthernet1/2
Cat6509(config-if)# no ip address
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# channel-group 1 mode active
Cat6509(config-if)# end
```

This example is for a Cisco Catalyst 6509. On Cisco Catalyst 3560/3750 switches, the syntax is slightly simpler:

```
Cat3750(config)# interface TenGigabitEthernet1/0/1
Cat3750(config-if)# switchport mode access
Cat3750(config-if)# channel-group 1 mode active
Cat3750(config)# interface TenGigabitEthernet1/0/2
Cat3750(config-if)# switchport mode access
Cat3750(config-if)# channel-group 1 mode active
Cat3750(config-if)# end
```

Validation

The command **`show lacp interfaces <aggregated Ethernet interface>`** will show LAG state. The following command was run after disabling interface xe-0/1/1, and validates that LACP on both switches dynamically removed the second member of the LAG. Note that interface xe-0/1/1 is in "Detached" state:

```
admin@EX4200# run show lacp interfaces ae0
Aggregated interface: ae0
    LACP state:       Role   Exp   Def  Dist  Col  Syn  Aggr  Timeout  Activity
      xe-0/1/0       Actor    No    No   Yes  Yes  Yes   Yes     Fast    Active
      xe-0/1/0     Partner    No    No   Yes  Yes  Yes   Yes     Slow    Active
      xe-0/1/1       Actor    No   Yes    No   No   No   Yes     Fast    Active
      xe-0/1/1     Partner    No   Yes    No   No   No   Yes     Fast   Passive
    LACP protocol:        Receive State  Transmit State          Mux State
      xe-0/1/0                  Current   Slow periodic Collecting distributing
      xe-0/1/1            Port disabled     No periodic           Detached
```

The correct operation of a LAG with two or more members also can be verified by offering either switch traffic destined for the other switch at a rate higher than any single LAG member can carry. If the switch forwards all traffic across the LAG without loss, the LAG is operating properly.

Link-layer Discovery Protocol (LLDP)

Objective

To verify the ability of a Juniper EX switch and a Cisco Catalyst switch to exchange capabilities information using LLDP

Background

LLDP, based on the IEEE 802.1AB-2005 specification, is a standards-based method of exchanging device capabilities. Unlike Cisco Discovery Protocol (CDP), covered elsewhere in this document, LLDP is an open standard, and thus allows multiple vendors' devices to exchange capabilities data.

Topology

In this example, a Juniper EX4200-48T switch uses LLDP to learn the MAC address (chassis ID), port information, and system name of a Cisco Catalyst 3750-E.

Figure 8 below shows the LLDP validation topology. A Juniper EX4200-48T switch connects to a Cisco Catalyst 3750-E switch via 10-gigabit Ethernet interfaces. In this example, the ports connecting the two switches are configured as VLAN trunk ports, with traffic using VLAN ID 123 allowed. LLDP would also work with the two switch ports configured in access mode. Also note that this example assumes spanning tree protocol (STP) has been disabled on both switches, although LLDP would also work with STP enabled.

Figure 8: LLDP Validation Topology

Juniper commands

1. Define VLAN "v123":

```
admin@EX4200> configure
admin@EX4200# set vlans v123 vlan-id 123
```

2. Place interfaces xe-0/1/0.0 into trunk mode and allow tagged traffic with VLAN ID 123:

```
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching port-mode
trunk vlan members v123
```

3. (Optional) Enable LLDP. On Juniper EX switches, LLDP is enabled by default on all interfaces; if LLDP has not been disabled, skip this step. The following (optional) command enables LLDP on all interfaces but it also can be set on a per-interface basis:

```
admin@EX4200# set protocols lldp interface all
```

4. Disable rapid spanning tree protocol (RSTP). In this example RSTP is disabled on all interfaces but it also can be set on a per-interface basis:

```
admin@EX4200# delete protocols rstp
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Define VLAN 123:

```
Cat3750-E# configure terminal
Cat3750-E(config)# vlan 123
Cat3750-E(config-vlan)# exit
```

2. Define interface TenGigabitEthernet1/0/1 as a trunk port allowing tagged traffic from VLAN 123:

```
Cat3750-E(config)# interface TenGigabitEthernet1/0/1
Cat3750-E(config-if)# switchport trunk encapsulation dot1q
Cat3750-E(config-if)# switchport trunk allowed vlan 123
Cat3750-E(config-if)# switchport mode trunk
Cat3750-E(config-if)# exit
```

3. Enable LLDP:

```
Cat3750-E(config)# lldp run
```

4. Disable rapid spanning tree protocol (RSTP) for VLAN 123:

```
Cat3750-E(config)# no spanning-tree vlan 123
Cat3750-E(config)# end
```

Validation

On the Juniper switch, the command **show lldp neighbors** will verify that the Cisco switch is attached to interfaces xe-0/1/0.0:

```
admin@EX4200> show lldp neighbors

LocalInterface Chassis Id        Port info     System Name
xe-0/1/0.0     00:18:ba:c0:ff:ee  TenGigabitEthernet1/0/1 Cat3750-E
```

LLDP-Media Endpoint Discovery (LLDP-MED)

Objective

To verify the ability of a Juniper EX switch to exchange LLDP-MED messages with a Cisco IP Phone, enabling the phone to register with a Cisco PBX.

Background

LLDP-Media Endpoint Discovery (LLDP-MED) is an extension to LLDP used by many switches and IP phones to exchange capabilities and configuration information. Phones can learn VLAN ID assignments and other attributes using LLDP-MED. In a typical LLDP-MED exchange, a switch will send VLAN configuration information to a phone. Once the phone learns and sets the correct VLAN ID, thus putting it in the same broadcast domain as a PBX or proxy, it then can use DHCP discovery messages to find and register with the PBX or proxy.

Topology

In this example, a Juniper EX4200-24P switch connects two Cisco 7961 IP phones and Cisco CallManager Express (CME) software running on a Cisco 2821 Integrated Services Router (ISR). Since the Juniper EX4200 is purely an Ethernet switch in this configuration, the Cisco 2821 ISR is essentially just a host from the switch's perspective. Thus, although the switch forwards IP traffic between Cisco devices on the 10.10.40.0/24 subnet, it needs no knowledge of IP addressing for the Cisco router or IP phones.

Figure 9 below illustrates the LLDP-MED validation topology. The EX4200 switch connects phones on ports ge-0/0/0 and ge-0/0/1 to the Cisco 2821 ISR on port ge-0/0/22.

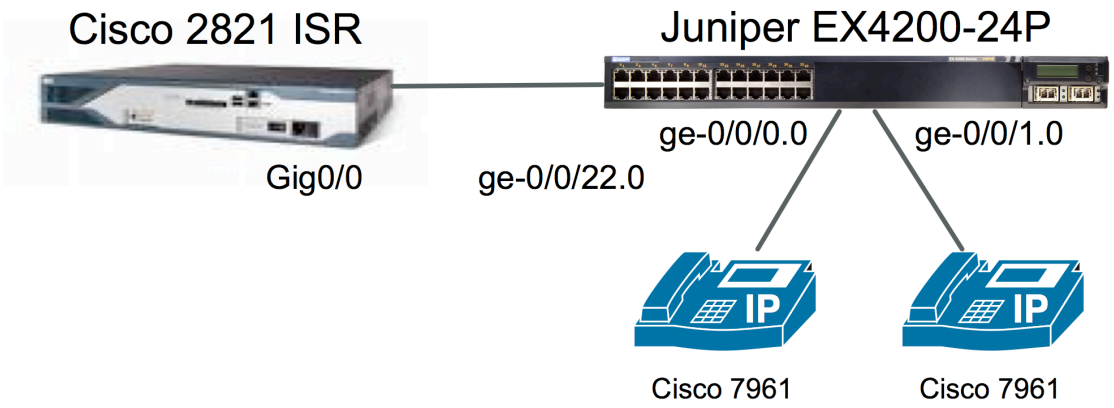

Figure 9: LLDP-MED Validation Topology

Juniper commands

1. Define separate "data-only" and "voice-only" VLANs:

```
admin@EX4200> configure
admin@EX4200# set vlans voice-only vlan-id 30
admin@EX4200# set vlans data-only vlan-id 40
```

2. Configure the interfaces to which IP phones are attached as access-mode members of the "data-only" VLAN:

```
admin@EX4200# set interfaces ge-0/0/0.0 family ethernet switching vlan
members data-only
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet switching vlan
members data-only
```

Configuration to accept tagged VoIP traffic is given in step 4 below.

3. Configure the interface connected to the Cisco 2821 ISR to be an access-mode member of the "data-only" VLAN:

```
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet switching vlan
members voip-only
```

4. Configure the Juniper EX4200 to accept tagged VoIP traffic from the phones:

```
admin@EX4200# set ethernet-switching-options voip interface ge-0/0/0.0 vlan
voice-only
admin@EX4200# set ethernet-switching-options voip interface ge-0/0/1.0 vlan
voice-only
```

In these commands, the `voip` keyword indicates that the switch will accept tagged VoIP traffic even though the switch interfaces are access members of a different VLAN.

5. Enable PoE. In this example PoE is enabled on all interfaces but it also can be set on a per-interface basis:

```
admin@EX4200# set poe interface all
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

Cisco commands

Note: This example omits `telephony-service, ephone` and `tftp-server` commands specific to the setup of CallManager Express and IP phones. Also omitted are `crypto pki trustpoint` and `crypto pki certificate` commands for sites using authentication and encryption. Consult Cisco 2821 ISR documentation for further details.

1. Configure an IP address of 10.10.40.1/24 on interface GigabitEthernet0/0:

```
2821# configure terminal
2821(config)# interface GigabitEthernet0/0
2821(config-if)# ip address 10.10.40.1 255.255.255.0
2821(config-if)# duplex auto
2821(config-if)# speed auto
2821(config-if)# exit
```

2. Configure a DHCP pool for attached PCs and phones to use:

```
2821(config)# ip dhcp pool pc
2821(dhcp-config)# network 10.10.40.0 255.255.255.0
2821(dhcp-config)# default-router 10.10.40.1
2821(dhcp-config)# exit
```

Validation

It will be possible for either phone to call the other if both phones have registered through the EX4200 switch with CME running on the Cisco router. The command **`show ephone registered`** on the Cisco router also will indicate phone status:

```
c2821-TME# show ephone registered

ephone-1 Mac:0017.4321.1234 TCP socket:[2] activeLine:0 REGISTERED in SCCP
ver 12
mediaActive:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0
IP:10.10.10.3 51246 7961   keepalive 0 max_line 6
button 1: dn 1  number 4001 CH1   IDLE         CH2   IDLE

ephone-2 Mac:0017.1234.4321 TCP socket:[1] activeLine:0 REGISTERED in SCCP
ver 12
mediaActive:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0
IP:10.10.10.2 52770 7961   keepalive 5 max_line 6
button 1: dn 2  number 4002 CH1   IDLE         CH2   IDLE
```

Real-Time Performance Monitoring (RPM)

Objective

To validate the ability of Juniper EX Series switches to perform real-time health checks on attached devices.

Background

Juniper's Real-Time Performance Monitoring (RPM) feature can perform "health checks" on attached network devices and servers using ICMP, HTTP, TCP and UDP probes and requests. These active probes can monitor traffic across the network and investigate network problems. RPM keeps a history of the most recent 50 probes; such monitoring of performance over time can be useful in troubleshooting and capacity planning.

Topology

In this example, a Juniper EX4200 switch uses ICMP probes to monitor round-trip times between it and a Cisco Catalyst 3750-E switch. Note that no RPM-specific commands are needed on the Cisco switch. The same RPM configuration on the Juniper switch will work with any Cisco switch, or indeed any remote device capable of responding to pings (ICMP probe requests).

Figure 10 below illustrates the RPM validation test bed. The Juniper EX4200 switch in this example uses an IP address of 100.0.0.1/24 assigned to interface ge-0/0/22.0. This interface sends ICMP probe requests to a Cisco switch with an address of 100.0.0.2/24. The same RPM configuration would work in a Juniper EX Series switch configuration in which a VLAN is created and an IP address is assigned to the VLAN.

Figure 10: Remote Performance Monitoring Validation Topology

Juniper configuration

1. Assign an IP address of 100.0.0.1/24 to interface ge-0/0/22.0:

```
admin@EX4200> configure
admin@EX4200# set interfaces ge-0/0/22.0 family inet address 100.0.0.1/24
```

2. Define an RPM probe and test for the Cisco switch at 100.0.0.2:

```
admin@EX4200# set services rpm probe myprobe test t1 probe-type icmp-ping-
timestamp
admin@EX4200# set services rpm probe myprobe test t1 target address
100.0.0.2
admin@EX4200# set services rpm probe myprobe test t1 probe-count 10
admin@EX4200# set services rpm probe myprobe test t1 probe-interval 1
admin@EX4200# set services rpm probe myprobe test t1 test-interval 60
admin@EX4200# set services rpm probe myprobe test t1 data-size 128
```

Note that although only ICMP is used here, a single probe can encompass multiple tests using multiple types of health checks.

Cisco configuration

1. Assign an IP address of 100.0.0.2/24 to the monitored interface (in this case GigabitEthernet1/0/1):

```
Cat3750-E# configure terminal
Cat3750-E(config)# interface GigabitEthernet1/0/1
Cat3750-E(config-if)# no switchport
Cat3750-E(config-if)# ip address 100.0.0.2 255.255.255.0
Cat3750-E(config-if)# end
```

No RPM-specific configuration is needed on the Cisco switch or any other device monitored using RPM.

Validation

The command **`show services rpm history-results`** will display up to 50 results of RPM probes and tests:

```
admin@EX4200# run show services rpm history-results
Owner, Test        Probe received                 Round trip time
myprobe, t1        Sun Mar 22 13:49:01 2009       2354 usec
myprobe, t1        Sun Mar 22 13:49:02 2009       1203 usec
myprobe, t1        Sun Mar 22 13:49:03 2009       2399 usec
myprobe, t1        Sun Mar 22 13:49:04 2009       1259 usec
myprobe, t1        Sun Mar 22 13:49:05 2009       2976 usec
```

Redundant Trunk Group (RTG)

Objective

To validate failover functionality of Juniper's Redundant Trunk Group (RTG) feature between Juniper and Cisco switches.

Background

Juniper's Redundant Trunk Group (RTG) feature allows definition of primary and secondary paths between switches and redirects traffic across the secondary trunk if the primary link fails. RTG provides an alternative to spanning tree for redundancy. RTG works in mixed Juniper-Cisco environments with no additional configuration needed on Cisco switch ports. Up to 16 redundant trunk groups can be defined on a standalone switch or virtual chassis.

Topology

In this example, four switches – two apiece from Juniper and Cisco – form a ring topology. All interfaces are VLAN access ports for VLAN ID 20 in this configuration, though VLAN trunk ports could be used as well.

Spirent TestCenter traffic generator/analyzers offer frames to access ports on each switch.

Spanning tree, which is enabled by default on Juniper and Cisco switches, is disabled in this example. Instead RTG configured on the Juniper EX8208 and EX4200 switches sets up primary and secondary traffic paths. When trunk links are configured as part of an RTG, they cannot be part of a spanning tree topology.

Figure 11 below shows the RTG test bed topology.

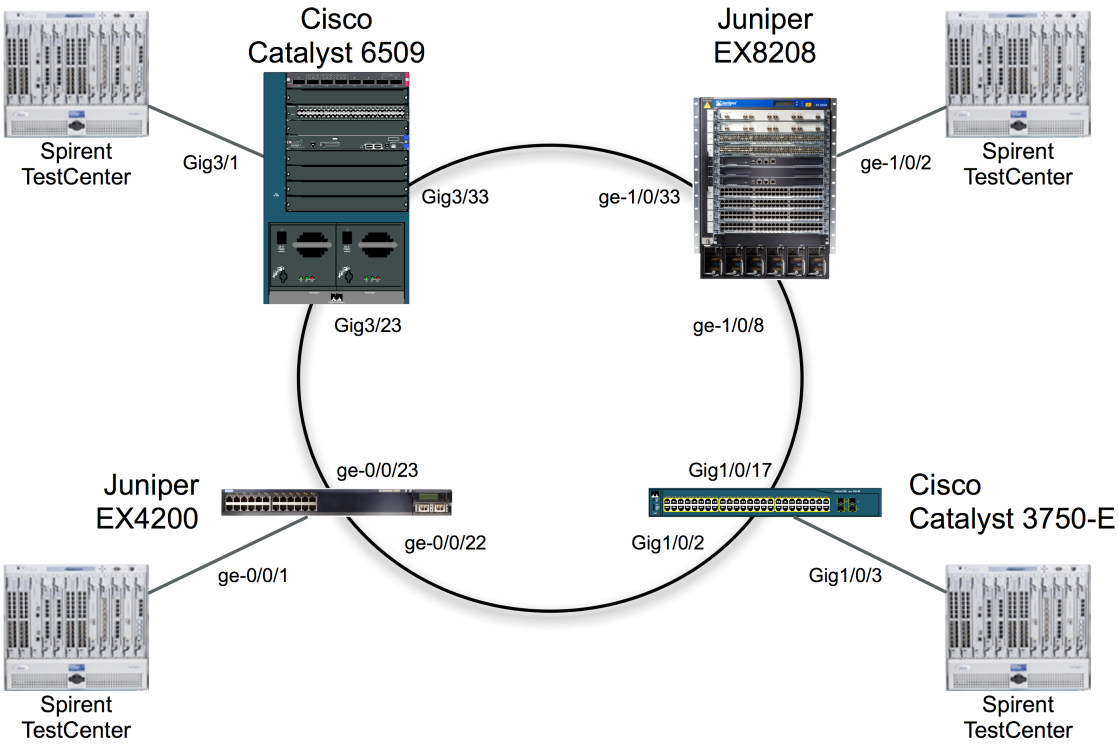

Figure 11: Redundant Trunk Group Validation Topology

Initially, ports ge-1/0/8.0 on the Juniper EX8208 switch and ge-0/0/22.0 on the Juniper EX4200 switch are defined as the primary path for the RTG. Upon link failure for either port, the switches will use the other trunk port on the same switch.

Juniper commands

RTG on the Juniper EX8208 switch:

1. Define VLAN v20 with a VLAN ID of 20:

```
admin@EX8208> configure
admin@EX8208# set vlans v20 vlan-id 20
```

2. Define interfaces ge-1/0/2.0, ge-1/0/8.0 and ge-1/0/33.0 as access ports in VLAN v20:

```
admin@EX8208# set interfaces ge-1/0/2.0 family ethernet-switching vlan
members v20
admin@EX8208# set interfaces ge-1/0/8.0 family ethernet-switching vlan
members v20
admin@EX8208# set interfaces ge-1/0/33.0 family ethernet-switching vlan
members v20
```

Note that this example uses access ports. Trunk ports also can be members of redundant trunk groups.

3. Disable rapid spanning tree, which is enabled by default:

```
admin@EX8208# delete protocols rstp
```

4. Define an RTG named "test" and set interface ge-1/0/8.0 as the primary path:

```
admin@EX8208# set ethernet-switching-options redundant-trunk-group group
test interface ge-1/0/8.0 primary
admin@EX8208# set ethernet-switching-options redundant-trunk-group group
test interface ge-1/0/33.0
admin@EX8208# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

RTG on the Juniper EX4200 switch:

1. Define VLAN v20 with a VLAN ID of 20:

```
admin@EX4200# set vlans v20 vlan-id 20
```

2. Define interfaces ge-0/0/1.0, ge-0/0/22.0 and ge-0/0/23.0 as access ports in VLAN v20:

```
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching vlan
members v20
admin@EX4200# set interfaces ge-0/0/23.0 family ethernet-switching vlan
members v20
```

Note that this example uses access ports. Trunk ports also can be members of redundant trunk groups.

3. Disable rapid spanning tree, which is enabled by default:

```
admin@EX4200# delete protocols rstp
```

4. Define an RTG named "test" and set interface ge-0/0/22.0 as the primary path:

```
admin@EX4200# set ethernet-switching-options redundant-trunk-group group
test interface ge-0/0/22.0 primary
admin@EX4200# set ethernet-switching-options redundant-trunk-group group
test interface ge-0/0/23.0
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

Cisco Catalyst 6509:

1. Cisco switch configuration does not require any RTG-specific commands. Simply define VLAN 20 and assign switch ports to be access-mode members of that VLAN:

```
Cat6509# configure terminal
Cat6509# vlan 20
Cat6509(config-vlan)# exit
Cat6509# no spanning-tree vlan 20
Cat6509# interface GigabitEthernet3/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509# interface GigabitEthernet3/23
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509# interface GigabitEthernet3/33
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# end
```

Cisco Catalyst 3750-E:

1. Cisco switch configuration does not require any RTG-specific commands. Simply define VLAN 20 and assign switch ports to be access-mode members of that VLAN:

```
Cat3750# configure terminal
Cat3750# vlan 20
Cat3750(config-vlan)# exit
Cat3750# no spanning-tree vlan 20
Cat3750# interface GigabitEthernet1/0/2
Cat3750(config-if)# switchport access vlan 20
Cat3750# interface GigabitEthernet1/0/3
Cat3750(config-if)# switchport access vlan 20
Cat3750# interface GigabitEthernet1/0/17
Cat3750(config-if)# switchport access vlan 20
Cat3750(config-if)# end
```

Validation

The **show redundant-trunk-group** command indicates the current RTG state. This example is from the Juniper EX4200 switch:

```
admin@4200# show redundant-trunk-group
Group       Interface   State       Time of last flap     Flap
Name                                                      count

test        ge-0/0/22.0 Up/Pri/Act  Never                 0
            ge-0/0/23.0 Up          Never                 0
```

Note that interface ge-0/0/22.0 is the primary path. After offering traffic from Spirent TestCenter, the packet counters for interfaces ge-0/0/22.0 and ge-0/0/23.0 will indicate that the switch forwarded all traffic to interface ge-0/0/22.0, the primary path in the RTG.

To verify correct operation of RTG redundancy, disable the primary path:

```
admin@EX4200# set interfaces ge-0/0/22 disable
```

Now the `show redundant-trunk-group` command will indicate the primary interface is down while the secondary interface remains up:

```
admin@4200# show redundant-trunk-group
Group       Interface   State       Time of last flap     Flap
Name                                                      count
test        ge-0/0/22.0 Dwn/Pri     2009-03-22 14:00:23 UTC (00:00:19 ago) 1
            ge-0/0/23.0 Up/Act      Never                                  0
```

Note also that the command output indicates when the primary interface went down and that the flap count has incremented by 1.

Again, after offering traffic from Spirent TestCenter, the packet counters for interfaces ge-0/0/22.0 and ge-0/0/23.0 will indicate that the switch forwarded all traffic to interface ge-0/0/23.0, the secondary path in the RTG.

Remote Port Mirroring

Objective

To verify the ability to forward monitored traffic from a Juniper switch to a remote interface on a Cisco switch.
To verify the ability to forward monitored traffic from a Cisco switch to a remote interface on a Juniper switch.

Background

Remote port mirroring allows a network manager to monitor and capture traffic on one switch and view the captured traffic via a port on a different switch. With remote port mirroring, it is possible for a network manager with a protocol analyzer to observe traffic, even when the traffic passes through a switch at a remote location.

Topology

In both examples given here — from Juniper to Cisco switches and vice-versa — note that monitored and monitoring interfaces are members of different VLANs.

In the Juniper-to-Cisco example shown in Figure 12 below, the Juniper EX4200 switch monitors traffic entering and leaving interface ge-0/0/1.0, which is a member of VLAN v20. Instead of copying monitored traffic to an analyzer attached to a local port, the switch instead forwards monitored traffic on VLAN v10, via a trunk port on ge-0/0/22.0, to a Cisco Catalyst 3750. The Cisco switch, in turn, forwards the traffic to an analyzer attached to interface GigabitEthernet1/0/3, also in VLAN 10.

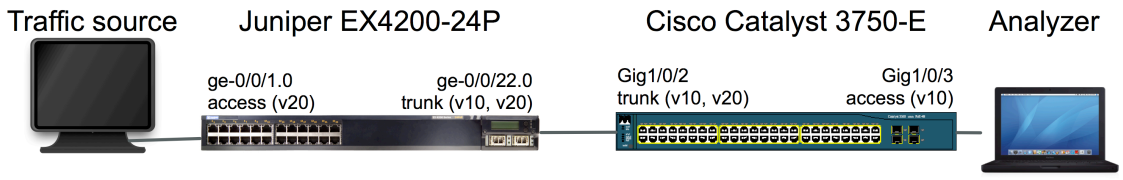

Figure 12: Remote Port Mirroring from Juniper to Cisco

The Cisco-to-Juniper example, shown in Figure 13 below, simply reverses the order. In this case, a Cisco Catalyst 3750-E switch monitors inbound and outbound traffic on interface GigabitEthernet1/0/3, which is an access port in VLAN 10. The Cisco switch forwards the monitored traffic across interface GigabitEthernet1/0/2, a trunk port for VLANs 10 and 20, across to a Juniper EX4200 switch. The Juniper switch forwards the monitored traffic to an analyzer attached to interface ge-0/0/1.0, which is an access port in VLAN 20.

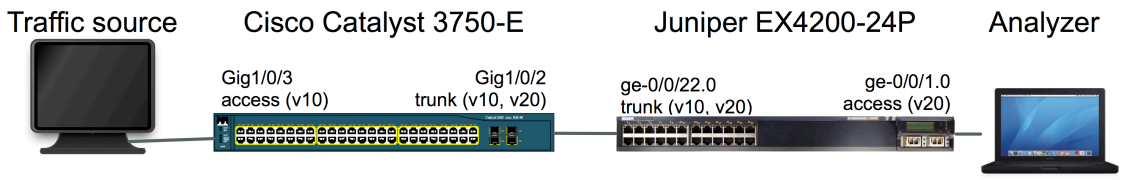

Figure 13: Remote Port Mirroring from Cisco to Juniper

Juniper commands

For remote analysis of traffic from a Juniper EX4200 switch:

1. Define VLANs v10 and v20 with VLAN IDs of 10 and 20, respectively:

```
admin@EX4200> configure
admin@EX4200# set vlans vlan v10 vlan-id 10
admin@EX4200# set vlans vlan v20 vlan-id 20
```

2. Add interface ge-0/0/1.0 as an access port in VLAN v20 and interface ge-0/0/22.0 as a trunk port for VLANs v10 and v20:

```
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
```

3. Configure an analyzer named "test" to monitor ingress and egress traffic on interface ge-0/0/1.0 and forward monitored traffic to VLAN v10:

```
admin@EX4200# set ethernet-switching-options analyzer test input ingress
interface ge-0/0/1.0
admin@EX4200# set ethernet-switching-options analyzer test input egress
interface ge-0/0/1.0
admin@EX4200# set ethernet-switching-options analyzer test output vlan v10
admin@EX4200# commit
```

> **Note:** For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

For remote analysis of traffic from a Cisco Catalyst 3750-E switch:

1. Define VLANs v10 and v20 with VLAN IDs of 10 and 20, respectively:

```
admin@EX4200# set vlans vlan v10 vlan-id 10
```

```
admin@EX4200# set vlans vlan v20 vlan-id 20
```

2. Add interface ge-0/0/1.0 as an access port in VLAN v20 and interface ge-0/0/22.0 as a trunk port for VLANs v10 and v20:

```
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

Note that remote port mirroring does not require any `analyzer` commands on the Juniper switch in the example above.

Cisco commands

For remote analysis of traffic from a Juniper EX4200 switch:

1. Define VLANs 10 and 20:

```
Cat3750-E# configure terminal
Cat3750-E(config)# vlan 10,20
Cat3750-E(config-vlan)# exit
```

2. Define interface GigabitEthernet1/0/2 as a trunk port allowing traffic from VLANs 10 and 20:

```
Cat3750-E(config)# interface GigabitEthernet1/0/2
Cat3750-E(config-if)# switchport trunk encapsulation dot1q
Cat3750-E(config-if)# switchport trunk allowed vlan 10,20
Cat3750-E(config-if)# switchport mode trunk
```

3. Define interface GigabitEthernet1/0/3 as an access port in VLAN 10:

```
Cat3750-E(config-if)# interface GigabitEthernet1/0/3
Cat3750-E(config-if)# switchport access vlan 10
Cat3750-E(config-if)# switchport mode access
Cat3750-E(config-if)# end
```

Note that remote port mirroring does not require any monitoring commands on the Cisco switch in the example above.

For remote analysis of traffic from a Cisco Catalyst 3750-E switch:

1. Define VLANs 10 and 20 and enable remote monitoring of traffic in VLAN 20:

```
Cat3750-E# configure terminal
Cat3750-E(config)# vlan 10
Cat3750-E(config-vlan)# vlan 20
Cat3750-E(config-vlan)# remote-span
Cat3750-E(config-vlan)# exit
```

2. Define interface GigabitEthernet1/0/2 as a trunk port allowing traffic from VLANs 10 and 20:

```
Cat3750-E# interface GigabitEthernet1/0/2
Cat3750-E(config-if)# switchport trunk encapsulation dot1q
Cat3750-E(config-if)# switchport trunk allowed vlan 10,20
Cat3750-E(config-if)# switchport mode trunk
```

3. Define interface GigabitEthernet1/0/3 as an access port in VLAN 10:

```
Cat3750-E(config-if)# interface GigabitEthernet1/0/3
Cat3750-E(config-if)# switchport access vlan 10
Cat3750-E(config-if)# switchport mode access
Cat3750-E(config-if)# exit
```

4. Define monitoring for ingress and egress traffic on interface GigabitEthernet1/0/3, and copying of monitored traffic to VLAN 20:

```
Cat3750-E(config)# monitor session 1 source interface Gi1/0/3
Cat3750-E(config)# monitor session 1 destination remote vlan 20
```

Validation

After offering traffic on the monitored port, a protocol analyzer attached to the remote switch will capture and decode frames seen on the monitored port. However, one caveat applies when using remote port mirroring of tagged VLAN traffic. Cisco Catalyst 3750-E switches will strip off VLAN tags before forwarding traffic to a remote analyzer on a Juniper switch. Juniper EX switches will preserve the VLAN tag when forwarding traffic to Cisco switches for remote analysis. Thus, when remotely monitoring tagged traffic from Cisco switches on analyzers attached to Juniper switches, bear in mind that VLAN tags may be missing.

Spanning tree case 1: Rapid spanning tree protocol (RSTP)

Objective

To verify interoperability of a rapid spanning tree topology between Juniper and Cisco switches.
To measure convergence time of a rapid spanning tree topology between Juniper and Cisco switches after link failure.

Background

The spanning tree protocol is widely used in Ethernet networks for loop prevention and redundancy. Rapid spanning tree, defined in IEEE 802.1w, provides much faster convergence time after a link or device failure than the original 802.1D spanning tree specification.

Topology

This example uses redundant links between two Juniper EX4200 switches and one Cisco Catalyst 6509 switch. JUNOS running on Juniper EX switches supports rapid spanning tree protocol (RSTP) by default. Cisco switches also support spanning tree by default; although Cisco IOS defines the spanning tree mode as that vendor's proprietary "PVST Plus" mode, it is interoperable with other vendors' rapid spanning tree implementations.

Figure 14 below illustrates the RSTP validation test bed. All ports on all switches are access-mode members of the default VLAN. Rapid spanning is enabled by default on the Juniper switches. Cisco's "PVST Plus," enabled by default on the Catalyst 6509, is interoperable with standard rapid spanning tree. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology.

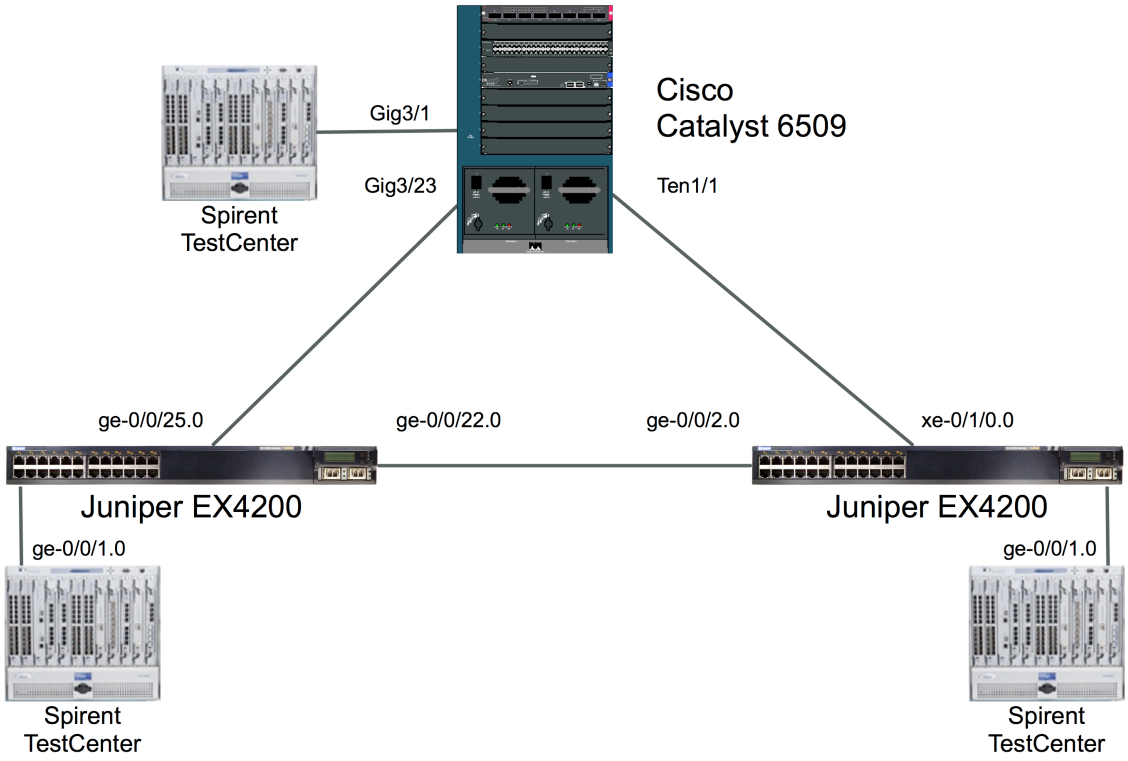

Figure 14: RSTP/PVST+ Validation Topology

Juniper commands

1. For all interfaces on both Juniper EX4200 switches, assign all interfaces to be access-mode members of the default VLAN. Here is the command for interface ge-0/0/0.0; the same command would apply to all interfaces on both Juniper switches:

```
admin@EX4200> config
admin@EX4200# set interfaces ge-0/0/0.0 family ethernet-switching
```

2. Enable rapid spanning tree on both Juniper switches. On a new switch configuration, this step should be unnecessary since rapid spanning tree is enabled by default.

```
admin@EX4200# set protocols rstp
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

Cisco commands

1. Assign all interfaces to be access-mode members of the default VLAN. Here is the command for interface TenGigabitEthernet1/1; the same command would apply to all interfaces participating in the spanning tree topology:

```
Cat6509# configure terminal
Cat6509(config)# interface TenGigabitEthernet1/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

2. Enable PVST Plus. On a new switch configuration, this step should be unnecessary since PVST Plus is enabled by default.

```
Cat6509(config)# spanning-tree mode pvst
Cat6509(config)# exit
```

Validation

The command **`show spanning-tree bridge (brief | detail)`** will display a summary of spanning tree parameters:

```
admin@EX4200> show spanning-tree bridge brief
STP bridge parameters
Context ID : 0
Enabled protocol : RSTP
...
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other source and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then rapid spanning tree convergence time is 47 ms.

Spanning tree case 2: Multiple spanning tree protocol (MSTP)

Objective

To verify interoperability of a multiple spanning tree topology between Juniper and Cisco switches.
To measure convergence time of a multiple spanning tree topology between Juniper and Cisco switches after link failure.

Background

As defined in IEEE specification 802.1s, the multiple spanning tree protocol (MSTP) adds loop prevention and redundancy on a per-VLAN basis. With MSTP, individual spanning tree topologies can be configured for each VLAN.

Topology

This example uses redundant links between two Juniper EX4200 switches and one Cisco Catalyst 6509 switch. VLAN IDs of 10 and 20 have been defined on both the Juniper and Cisco switches, and MSTP is enabled on all switches.

Figure 15 below illustrates the MSTP validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from VLAN IDs 10 and 20. Two access-mode ports are configured on each switch: One apiece for VLAN IDs 10 and 20. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

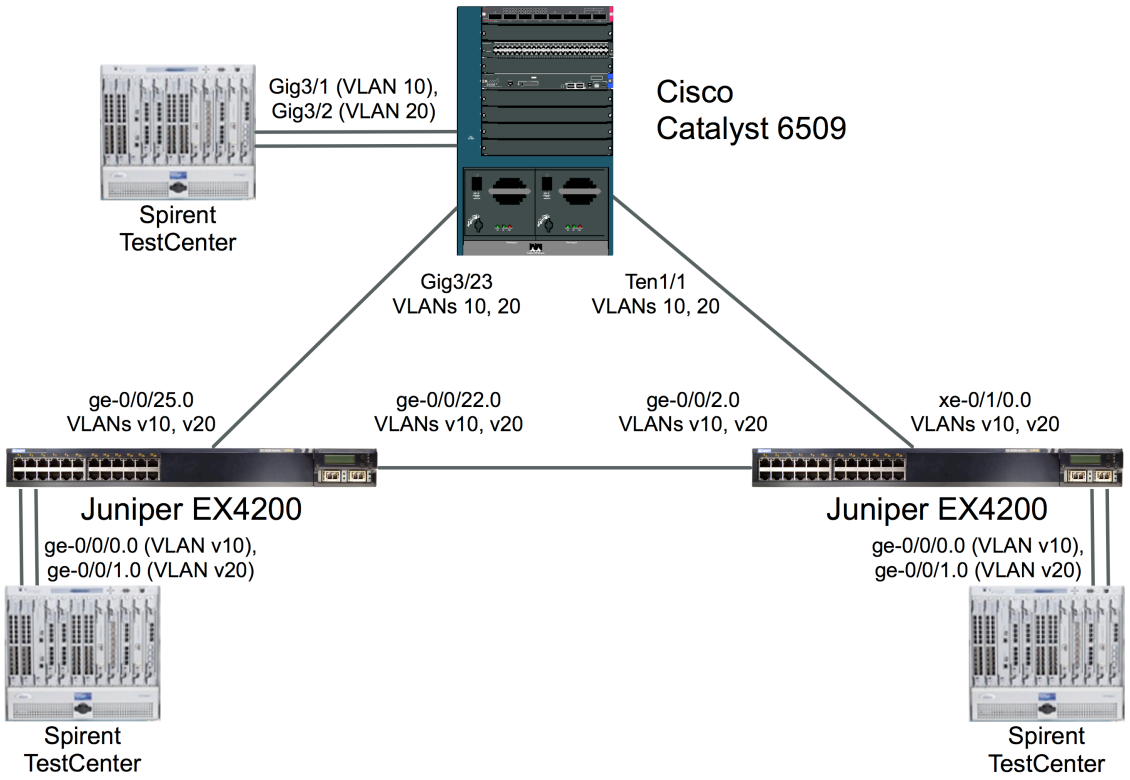

Figure 15: MSTP Validation Topology

Juniper commands

1. On both Juniper EX4200 switches, create VLANs "v10" and "v20":

```
admin@EX4200> config
admin@EX4200# set vlans v10 vlan-id 10
admin@EX4200# set vlans v20 vlan-id 20
```

2. On both Juniper EX4200 switches, configure ports ge-0/0/0.0 and ge-0/0/1.0 as access-mode ports for VLANs v10 and v20, respectively:

```
admin@EX4200# set interfaces ge-0/0/0.0 family ethernet-switching vlan
members v10
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
```

3. Configure trunk ports that allow tagged traffic from VLANs v10 and v20.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces ge-0/0/25.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
```

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/2.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
```

4. Enable multiple spanning tree. This requires deleting rapid spanning tree (if enabled) and then setting both the topology (point-to-point in this example) and one multiple spanning tree instance (MSTI) per VLAN.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols mstp interface ge-0/0/22.0 mode point-to-point
admin@EX4200# set protocols mstp interface ge-0/0/25.0 mode point-to-point
admin@EX4200# set protocols mstp msti vlan v10
admin@EX4200# set protocols mstp msti vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols mstp interface ge-0/0/2.0 mode point-to-point
admin@EX4200# set protocols mstp interface xe-0/1/0.0 mode point-to-point
admin@EX4200# set protocols mstp msti vlan v10
admin@EX4200# set protocols mstp msti vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Create VLANs 10 and 20:

```
Cat3750# configure terminal
Cat3750(config)# vlan 10,20
```

2. Configure ports GigabitEthernet3/1 and GigabitEthernet3/2 as access-mode ports for VLANs 10 and 20, respectively:

```
Cat6509(config)# interface GigabitEthernet3/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 10
Cat6509(config-if)# switchport mode access
Cat6509(config)# interface GigabitEthernet3/2
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

3. Configure ports GigabitEthernet3/23 and TenGigabitEthernet1/1 as trunk ports that allow tagged traffic for VLANs 10 and 20:

```
Cat6509(config)# interface GigabitEthernet3/23
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# interface TenGigabitEthernet1/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)#
```

4. Enable multiple spanning tree. This requires defining multiple spanning tree as the mode of operation and adding one multiple spanning tree instance (MSTI) per VLAN.

```
Cat6509(config)# spanning-tree mode mst
Cat6509(config)# spanning-tree mst configuration
Cat6509(config-mst)# instance 1 vlan 10
Cat6509(config-mst)# instance 2 vlan 20
Cat6509(config-mst)# exit
```

5. (Optional) If desired, spanning tree priority can be defined on a per-MSTI basis. This can be useful in forcing one device in a spanning tree topology to act as the root bridge.

```
Cat6509(config)# spanning-tree mst 0-2 priority 4096
```

Validation

The command **`show spanning-tree bridge (brief | detail)`** will display a summary of spanning tree parameters:

```
admin@EX4200> show spanning-tree bridge brief
STP bridge parameters
Context ID : 0
Enabled protocol : MSTI
...
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other source to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then rapid spanning tree convergence time is 47 ms.

Spanning tree case 3: VLAN spanning tree protocol (VSTP) and Per-VLAN Spanning Tree Plus (PVST+)

Objective

To verify interoperability of Juniper VLAN spanning tree protocol (VSTP) and Cisco per-VLAN spanning tree protocol plus (PVST+) between Juniper and Cisco switches, respectively.
To measure convergence time of a VSTP-PVST+ topology between Juniper and Cisco switches after link failure.

Background

With Juniper's VLAN Spanning Tree Protocol (VSTP), EX Series switches can run one or more spanning tree instances per VLAN. As stated in the JUNOS Software Guide, VSTP "enables more intelligent tree spanning, because each VLAN can have interfaces enabled or disabled depending on the paths available to that specific VLAN."

The goal of this exercise is to demonstrate interoperability in a multiple-VLAN environment using VSTP running on Juniper EX switches and PVST+ running on Cisco Catalyst switches.

At the time of testing to validate the procedures in this document, VSTP was supported on EX4200 but not EX8208 switches. However, JUNOS command syntax should be identical across EX Series switches once VSTP supported is added to that platform.

Topology

This example uses redundant links between two Juniper EX4200 switches and one Cisco Catalyst 6509 switch. VLAN IDs of 10 and 20 have been defined on both the Juniper and Cisco switches. VSTP is enabled on the Juniper EX switches, while the Cisco Catalyst 6509 runs PVST+.

Figure 16 below illustrates the VSTP-PVST+ validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from VLAN IDs 10 and 20. Two access-mode ports are configured on each switch: One apiece for VLAN IDs 10 and 20. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

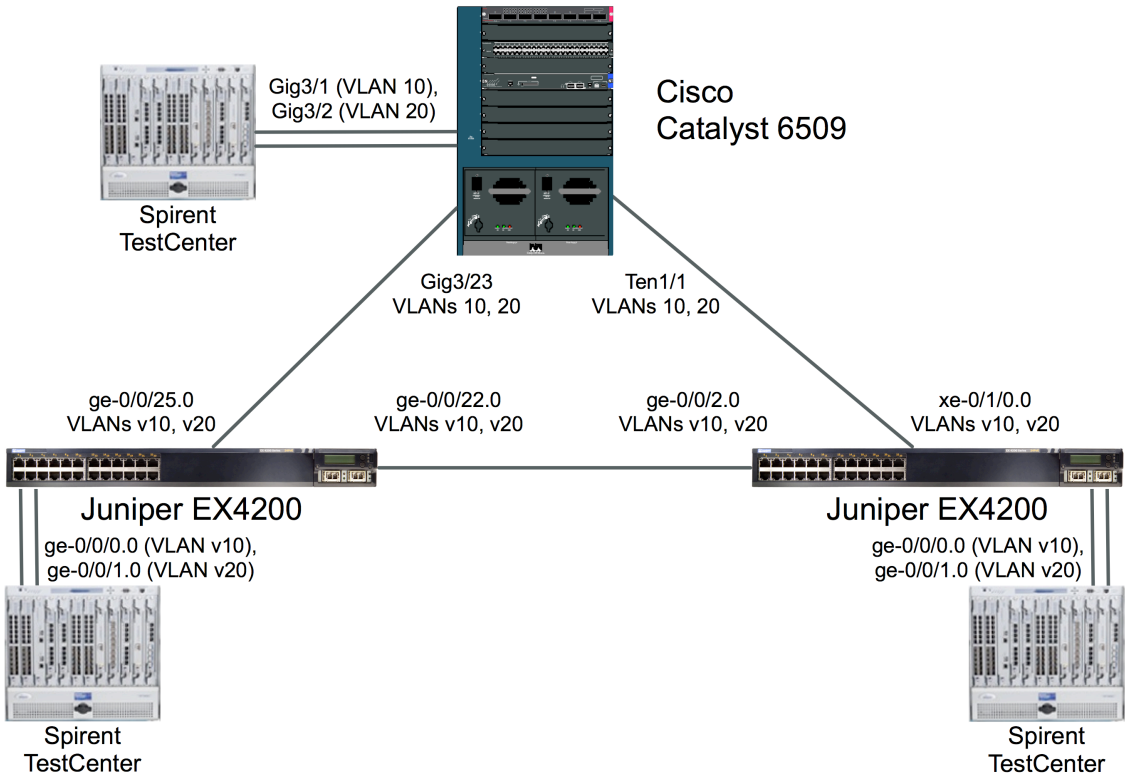

Figure 16: VSTP-PVST+ Validation Topology

Juniper commands

1. On both Juniper EX4200 switches, create VLANs "v10" and "v20":

```
admin@EX4200> config
admin@EX4200# set vlans v10 vlan-id 10
admin@EX4200# set vlans v20 vlan-id 20
```

2. On both Juniper EX4200 switches, configure ports ge-0/0/0.0 and ge-0/0/1.0 as access-mode ports for VLANs v10 and v20, respectively:

```
admin@EX4200# set interfaces ge-0/0/0.0 family ethernet-switching vlan
members v10
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
```

3. Configure trunk ports that allow tagged traffic from VLANs v10 and v20.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces ge-0/0/25.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
```

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/2.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
```

4. Enable VLAN spanning tree protocol. This requires deleting rapid spanning tree (if enabled) and then enabling VSTP for each VLAN.

On both Juniper EX4200 switches shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols vstp vlan v10
admin@EX4200# set protocols vstp vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Create VLANs 10 and 20:

```
Cat3750# configure terminal
Cat3750(config)# vlan 10,20
```

2. Configure ports GigabitEthernet3/1 and GigabitEthernet3/2 as access-mode ports for VLANs 10 and 20, respectively:

```
Cat6509(config)# interface GigabitEthernet3/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 10
Cat6509(config-if)# switchport mode access
Cat6509(config)# interface GigabitEthernet3/2
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

3. Configure ports GigabitEthernet3/23 and TenGigabitEthernet1/1 as trunk ports that allow tagged traffic for VLANs 10 and 20:

```
Cat6509(config)# interface GigabitEthernet3/23
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
```

```
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# interface TenGigabitEthernet1/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)#
```

4. Enable PVST+. On a new switch configuration, this step should be unnecessary since PVST+ is enabled by default.

```
Cat6509(config)# spanning-tree mode pvst
Cat6509(config)# exit
```

Validation

The command **`show spanning-tree bridge (brief | detail)`** will display a summary of spanning tree parameters:

```
admin@EX4200> show spanning-tree bridge brief
STP bridge parameters
Context ID : 0
Enabled protocol : VSTP
...
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other source to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then rapid spanning tree convergence time is 47 ms.

Spanning tree case 4: MSTP-PVST+ Interoperability

Objective

To verify interoperability of multiple spanning tree protocol (MSTP) and per-VLAN spanning tree protocol plus (PVST+) between Juniper and Cisco switches, respectively
To measure convergence time of an MSTP-PVST+ topology between Juniper and Cisco switches after link failure

Background

As defined in IEEE specification 802.1s, the multiple spanning tree protocol (MSTP) adds loop prevention and redundancy on a per-VLAN basis. With MSTP, individual spanning tree topologies can be configured for each VLAN.

The goal of this exercise is to demonstrate interoperability in a multiple-VLAN environment where the Juniper and Cisco switches use different variations of spanning tree: MSTP on Juniper EX switches and PVST+ on a Cisco Catalyst switch.

Topology

This example uses redundant links between two Juniper EX4200 switches and one Cisco Catalyst 6509 switch. VLAN IDs of 10 and 20 have been defined on both the Juniper and Cisco switches. MSTP is enabled on the Juniper EX switches, while the Cisco Catalyst 6509 runs PVST+.

Figure 17 below illustrates the MSTP-PVST+ validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from VLAN IDs 10 and 20. Two access-mode ports are configured on each switch: One apiece for VLAN IDs 10 and 20. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

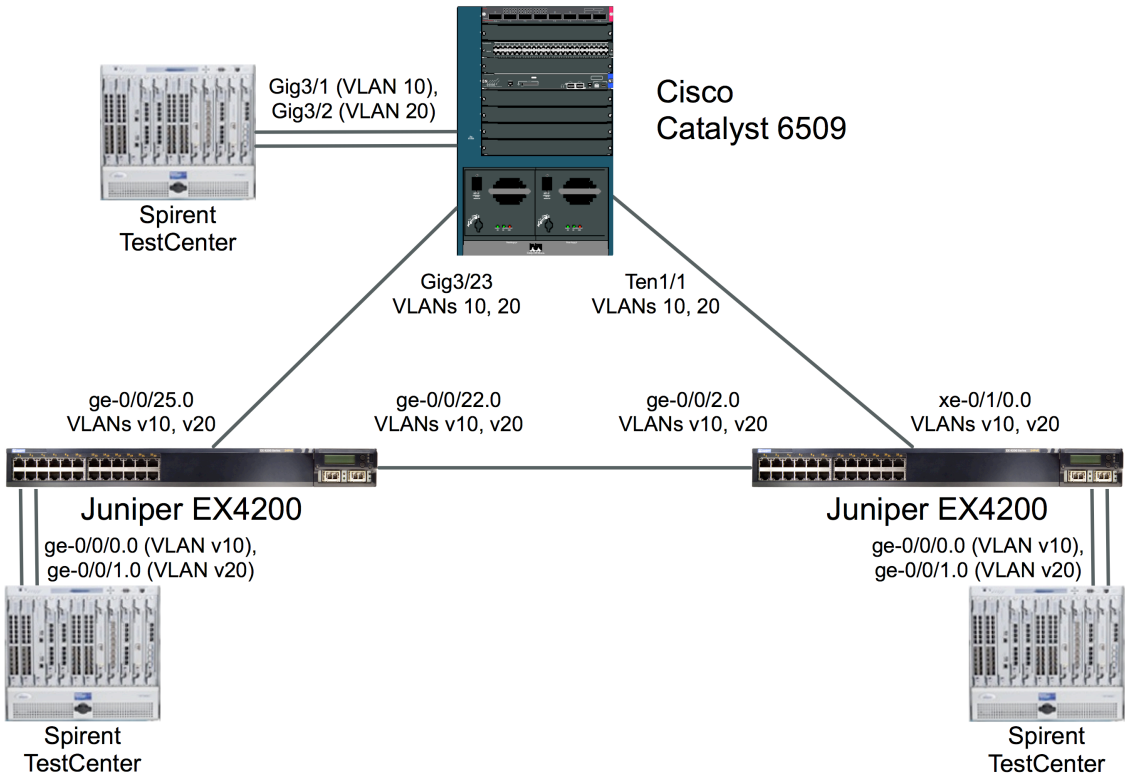

Figure 17: MSTP-PVST+ Validation Topology

Juniper commands

1. On both Juniper EX4200 switches, create VLANs "v10" and "v20":

```
admin@EX4200> config
admin@EX4200# set vlans v10 vlan-id 10
admin@EX4200# set vlans v20 vlan-id 20
```

2. On both Juniper EX4200 switches, configure ports ge-0/0/0.0 and ge-0/0/1.0 as access-mode ports for VLANs v10 and v20, respectively:

```
admin@EX4200# set interfaces ge-0/0/0.0 family ethernet-switching vlan
members v10
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
```

3. Configure trunk ports that allow tagged traffic from VLANs v10 and v20.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces ge-0/0/25.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
```

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/2.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
```

4. Enable multiple spanning tree. This requires deleting rapid spanning tree (if enabled) and then setting both the topology (point-to-point in this example) and one multiple spanning tree instance (MSTI) per VLAN.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols mstp interface ge-0/0/22.0 mode point-to-point
admin@EX4200# set protocols mstp interface ge-0/0/25.0 mode point-to-point
admin@EX4200# set protocols mstp msti vlan v10
admin@EX4200# set protocols mstp msti vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols mstp interface ge-0/0/2.0 mode point-to-point
admin@EX4200# set protocols mstp interface xe-0/1/0.0 mode point-to-point
admin@EX4200# set protocols mstp msti vlan v10
admin@EX4200# set protocols mstp msti vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Create VLANs 10 and 20:

```
Cat3750# configure terminal
Cat3750(config)# vlan 10,20
```

2. Configure ports GigabitEthernet3/1 and GigabitEthernet3/2 as access-mode ports for VLANs 10 and 20, respectively:

```
Cat6509(config)# interface GigabitEthernet3/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 10
Cat6509(config-if)# switchport mode access
Cat6509(config)# interface GigabitEthernet3/2
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

3. Configure ports GigabitEthernet3/23 and TenGigabitEthernet1/1 as trunk ports that allow tagged traffic for VLANs 10 and 20:

```
Cat6509(config)# interface GigabitEthernet3/23
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# interface TenGigabitEthernet1/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# exit
```

4. Enable PVST+. On a new switch, PVST+ already is enabled by default.

```
Cat6509(config)# spanning-tree mode pvst
Cat6509(config)# exit
```

Validation

The command **`show spanning-tree bridge (brief | detail)`** will display a summary of spanning tree parameters:

```
admin@EX4200> show spanning-tree bridge brief
STP bridge parameters
Context ID : 0
Enabled protocol : MSTI
...
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other traffic

generator to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if generating at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then rapid spanning tree convergence time is 47 ms.

Spanning tree case 5: MSTP-Rapid PVST+ Interoperability

Objective

To verify interoperability of multiple spanning tree protocol (MSTP) and rapid per-VLAN spanning tree protocol plus (Rapid PVST+) between Juniper and Cisco switches, respectively
To measure convergence time of an MSTP-Rapid PVST+ topology between Juniper and Cisco switches after link failure

Background

As defined in IEEE specification 802.1s, the multiple spanning tree protocol (MSTP) adds loop prevention and redundancy on a per-VLAN basis. With MSTP, individual spanning tree topologies can be configured for each VLAN.

Rapid PVST+ is Cisco's implementation of the rapid spanning tree protocol. It provides much faster convergence after link failure than standard spanning tree, and also allows creation of separate spanning tree topologies for each defined VLAN.

The goal of this exercise is to demonstrate interoperability in a multiple-VLAN environment where the Juniper and Cisco switches use different variations of spanning tree: MSTP on Juniper EX switches and Rapid PVST+ on a Cisco Catalyst switch.

Topology

This example uses redundant links between two Juniper EX4200 switches and one Cisco Catalyst 6509 switch. VLAN IDs of 10 and 20 have been defined on both the Juniper and Cisco switches. MSTP is enabled on the Juniper EX switches, while the Cisco Catalyst 6509 runs rapid PVST+.

Figure 18 below illustrates the MSTP-rapid PVST+ validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from VLAN IDs 10 and 20. Two access-mode ports are configured on each switch: One apiece for VLAN IDs 10 and 20. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

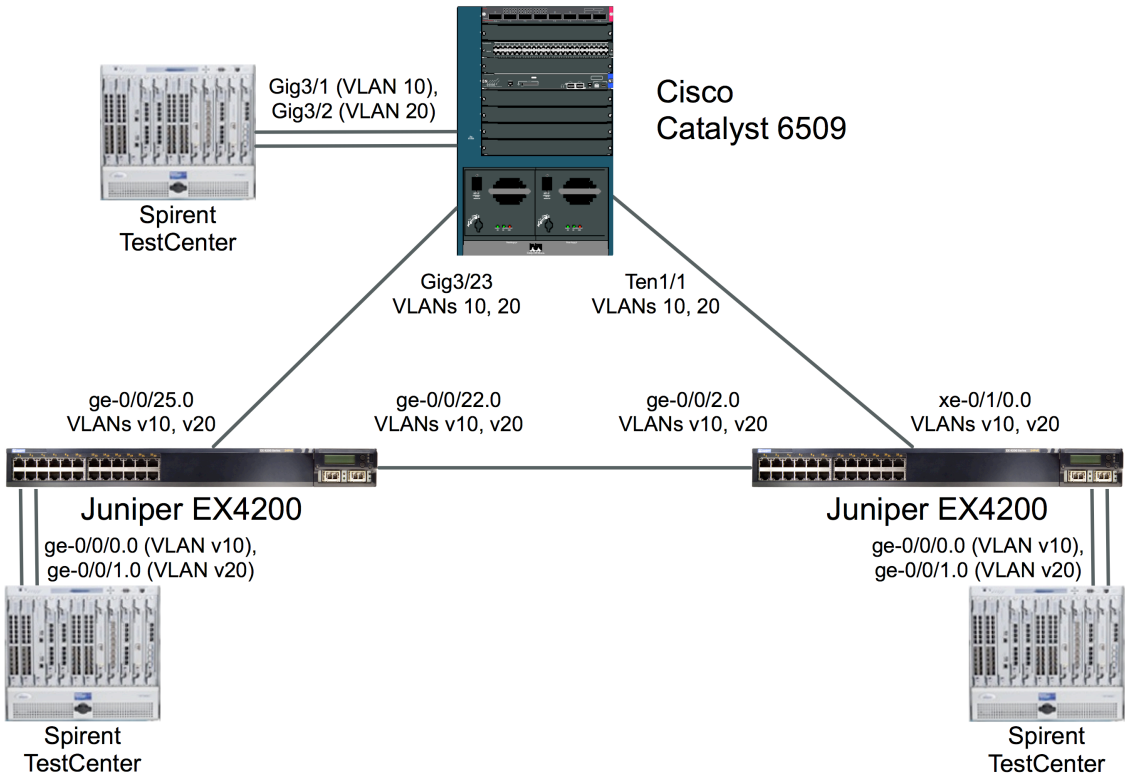

Figure 18: MSTP-Rapid PVST+ Validation Topology

Juniper commands

1. On both Juniper EX4200 switches, create VLANs "v10" and "v20":

```
admin@EX4200> config
admin@EX4200# set vlans v10 vlan-id 10
admin@EX4200# set vlans v20 vlan-id 20
```

2. On both Juniper EX4200 switches, configure ports ge-0/0/0.0 and ge-0/0/1.0 as access-mode ports for VLANs v10 and v20, respectively:

```
admin@EX4200# set interfaces ge-0/0/0.0 family ethernet-switching vlan
members v10
admin@EX4200# set interfaces ge-0/0/1.0 family ethernet-switching vlan
members v20
```

3. Configure trunk ports that allow tagged traffic from VLANs v10 and v20.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/22.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces ge-0/0/25.0 family ethernet-switching port-
mode trunk vlan members [ v10 v20 ]
```

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# set interfaces ge-0/0/2.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
admin@EX4200# set interfaces xe-0/1/0.0 family ethernet-switching port-mode
trunk vlan members [ v10 v20 ]
```

4. Enable multiple spanning tree. This requires deleting rapid spanning tree (if enabled) and then setting both the topology (point-to-point in this example) and one multiple spanning tree instance (MSTI) per VLAN.

On the left-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols mstp interface ge-0/0/22.0 mode point-to-point
admin@EX4200# set protocols mstp interface ge-0/0/25.0 mode point-to-point
admin@EX4200# set protocols mstp msti vlan v10
admin@EX4200# set protocols mstp msti vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

On the right-hand Juniper EX4200 switch shown in the topology diagram above:

```
admin@EX4200# delete protocols rstp
admin@EX4200# set protocols mstp interface ge-0/0/2.0 mode point-to-point
admin@EX4200# set protocols mstp interface xe-0/1/0.0 mode point-to-point
admin@EX4200# set protocols mstp msti vlan v10
admin@EX4200# set protocols mstp msti vlan v20
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Create VLANs 10 and 20:

```
Cat3750# configure terminal
Cat3750(config)# vlan 10,20
```

2. Configure ports GigabitEthernet3/1 and GigabitEthernet3/2 as access-mode ports for VLANs 10 and 20, respectively:

```
Cat6509(config)# interface GigabitEthernet3/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 10
Cat6509(config-if)# switchport mode access
Cat6509(config)# interface GigabitEthernet3/2
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 20
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

3. Configure ports GigabitEthernet3/23 and TenGigabitEthernet1/1 as trunk ports that allow tagged traffic for VLANs 10 and 20:

```
Cat6509(config)# interface GigabitEthernet3/23
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# interface TenGigabitEthernet1/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk allowed vlan 10,20
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# exit
```

4. Enable rapid PVST+:

```
Cat6509(config)# spanning-tree mode rapid-pvst
Cat6509(config)# exit
```

Validation

The command **`show spanning-tree bridge (brief | detail)`** will display a summary of spanning tree parameters:

```
admin@EX4200> show spanning-tree bridge brief
STP bridge parameters
Context ID : 0
Enabled protocol : MSTI
...
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames. To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames. Convergence time can be derived from frame loss. For example, if generating at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then rapid spanning tree convergence time is 47 ms.

Virtual LAN (VLAN) trunking

Objective

To verify interoperability of IEEE 802.1Q VLAN trunking between Juniper EX Series and Cisco Catalyst switches using tagged traffic
To verify interoperability of IEEE 802.1Q VLAN trunking between Juniper EX Series and Cisco Catalyst switches using untagged (native) traffic

Background

The IEEE 802.1Q specification defines a method for defining virtual broadcast domains. A 4-byte VLAN header, usually called a "tag," allows definition of broadcast domains that may differ from physical switch topology. Without VLANs, all switch ports are members of the same broadcast domain; with VLAN tagging, a network manager can set up multiple broadcast domains across switches, and restrict broadcasts for different VLANs on different ports.

Topology

This configuration example will validate VLAN trunking interoperability between Juniper EX Series and Cisco Catalyst switches in three ways:

- The switches will forward allowed tagged traffic from multiple VLANs across a trunk port
- The switches will forward allowed untagged traffic from a native VLAN across a trunk port
- The switches will not forward disallowed tagged traffic across a trunk port

The final example above is a negative test to verify that switches with VLAN trunking will forward only traffic explicitly permitted by the switch configurations.

Figure 19 below illustrates the test bed used to verify VLAN trunking operation. In this example, a VLAN trunk carries allowed VLAN traffic between a Juniper EX8208 and a Cisco Catalyst 6509. Both switches use 10-gigabit Ethernet interfaces for the trunk port in this example, though VLAN trunking also would work on any matched pair of Ethernet interfaces. The trunk ports on each switch will allow tagged traffic with VLAN IDs from 2001 through 2003, and untagged traffic from ports with a VLAN ID of 2004. A fifth VLAN, with an ID of 2005, is also defined but the trunk port is configured not to allow that traffic.

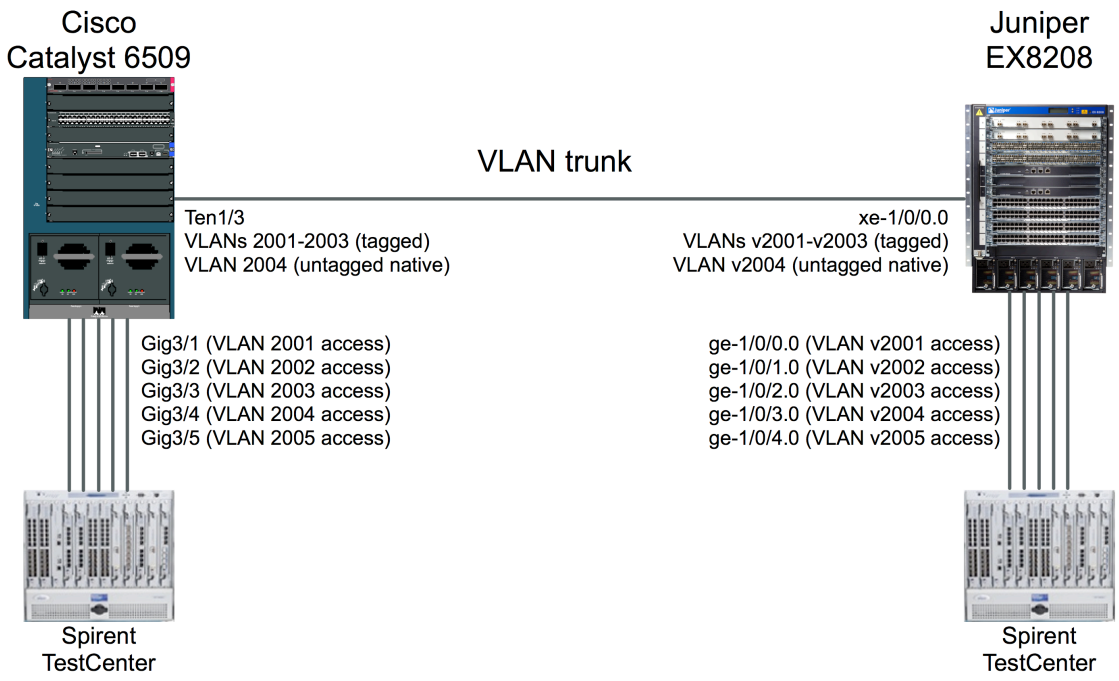

Figure 19: VLAN Trunking Validation Test Bed

Juniper commands

1. Define VLANs v2001 through v2005 with VLAN IDs of 2001 through 2005 respectively:

```
admin@EX8208> config
admin@EX8208# set vlans v2001 vlan-id 2001
admin@EX8208# set vlans v2002 vlan-id 2002
admin@EX8208# set vlans v2003 vlan-id 2003
admin@EX8208# set vlans v2004 vlan-id 2004
admin@EX8208# set vlans v2005 vlan-id 2005
```

2. Define a VLAN trunk port that allows tagged traffic from VLANs v2001 through v2003 and untagged traffic from VLAN v2004:

```
admin@EX8208# set interfaces xe-1/0/0.0 family ethernet-switching port-mode
trunk members [ v2001 v2002 v2003 v2004 ]
```

3. On the VLAN trunk port, allow native untagged traffic from VLAN v2004. Note that the **native-vlan-id** command takes the VLAN ID and not the VLAN name as an argument:

```
admin@EX8208# set interfaces xe-1/0/0.0 family ethernet-switching native-
vlan-id 2004
```

4. Define access-mode interfaces allowing untagged traffic from VLANs v2001 through v2005:

```
admin@EX8208# set interfaces ge-1/0/0.0 family ethernet-switching vlan
members v2001
admin@EX8208# set interfaces ge-1/0/1.0 family ethernet-switching vlan
members v2002
admin@EX8208# set interfaces ge-1/0/2.0 family ethernet-switching vlan
members v2003
admin@EX8208# set interfaces ge-1/0/3.0 family ethernet-switching vlan
members v2004
admin@EX8208# set interfaces ge-1/0/4.0 family ethernet-switching vlan
members v2005
admin@EX8208# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **commit synchronize** command instead of **commit**.

Cisco commands

1. Define VLANs 2001 through 2005:

```
Cat6509# configure terminal
Cat6509(config)# vlan 2001-2005
```

2. Define a VLAN trunk port that allows tagged traffic from VLANs 2001 through 2003 and native untagged traffic from VLAN 2004:

```
Cat6509# configure terminal
Cat6509(config)# vlan 2001-2005
Cat6509(config)# interface TenGigabitEthernet1/3
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk native vlan 2004
Cat6509(config-if)# switchport trunk allowed vlan 2001-2004
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# exit
```

3. Define access-mode interfaces allowing untagged traffic from VLANs v2001 through v2005:

```
Cat6509(config)# interface GigabitEthernet3/1
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 2001
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
Cat6509(config)# interface GigabitEthernet3/2
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 2002
Cat6509(config-if)# switchport mode access
```

```
Cat6509(config-if)# exit
Cat6509(config)# interface GigabitEthernet3/3
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 2003
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
Cat6509(config)# interface GigabitEthernet3/4
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 2004
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
Cat6509(config)# interface GigabitEthernet3/5
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 2005
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# exit
```

Validation

The Spirent TestCenter traffic generator/analyzer can be configured to offer bidirectional traffic between pairs of access-mode interfaces on each switch. In all cases – involving unicast, broadcast or multicast traffic – traffic will stay local to the VLAN in which it is defined. For example, traffic offered to VLAN v2001 on the Juniper switch will be forwarded only to interfaces in VLAN 2001 on the Cisco switch and vice-versa.

If desired, port mirroring can be enabled on either switch to verify that the trunk ports carry tagged traffic for VLAN IDs 2001 through 2003 and untagged traffic for VLAN ID 2004. As a final verification that VLANs limit broadcast domains, Spirent TestCenter can be configured to offer traffic to the access ports with an VLAN ID of 2005. The trunk ports on both switches will not forward this traffic.

Virtual Router Redundancy Protocol (VRRP) Interoperability

Objective

To validate failover functionality of the virtual router redundancy protocol (VRRP) between Juniper and Cisco switches configured as routers

Background

Two or more routers can make use of VRRP to enhance network availability. With VRRP, all routers share a single virtual IP address. One router acts as the master (active) device, while all others act as backups. If the master router fails (or if a link fails on the interface configured with the virtual IP address), one of the backup routers takes over as master.

Topology

In this example, a Juniper EX4200 switch and Cisco Catalyst 6509 switch are both configured to route IP traffic. The interfaces connecting the switches each have unique IP addresses configured – 10.0.0.2/24 for the Juniper EX4200 and 10.0.0.1/24 for the Cisco Catalyst 6509. However, the Juniper and Cisco devices also share a single virtual IP address of 10.0.0.10/24, with the Juniper device initially acting as VRRP master.

The PCs attached to the Juniper and Cisco devices each use the virtual IP address of 10.0.0.10/24 as their default route. In the event of a failure of the master (Juniper) device, the backup (Cisco) device will take over as master.

Figure 20 below illustrates the VRRP validation test bed. In this example, both the Juniper and Cisco devices advertise the virtual IP address of 10.0.0.10/24. The Juniper switch assigns an IP address to VLAN “v10” and then assigns interface xe-0/1/0.0 to be a member of that VLAN. However, VRRP also would work if an IP address were assigned directly to the physical interface, as it is with the Cisco Catalyst 6509.

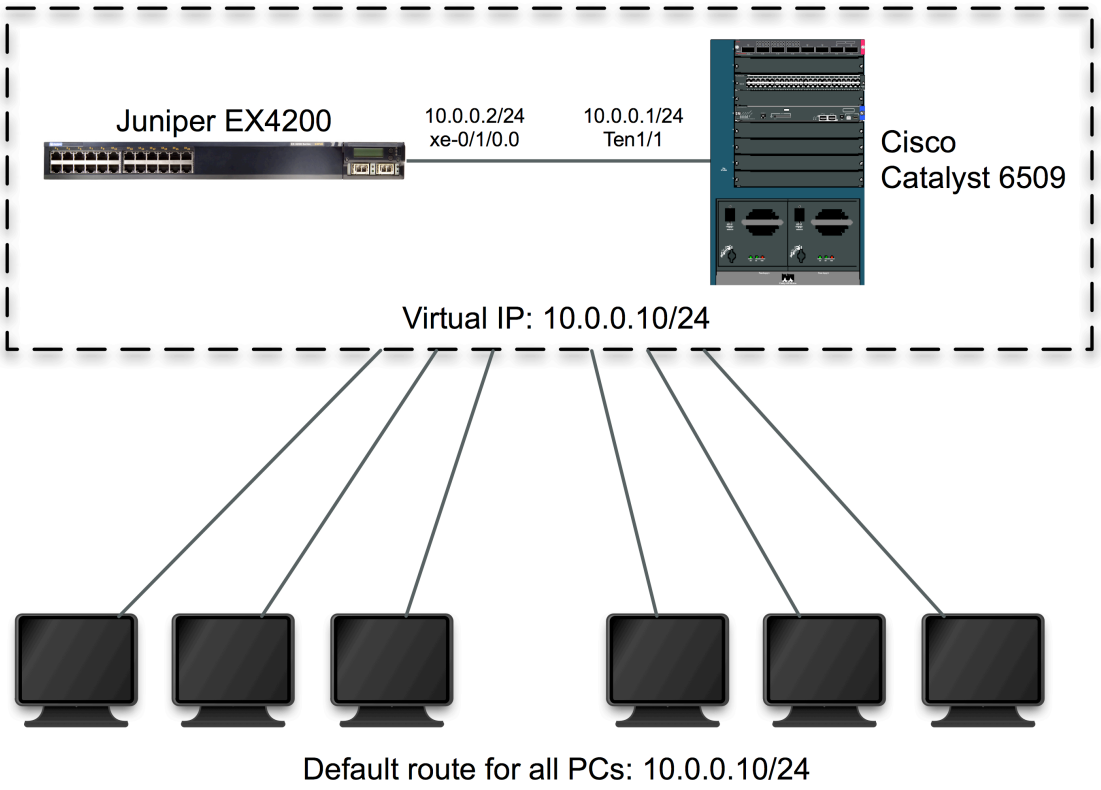

Figure 20: VRRP Validation Test Bed

Juniper commands

1. Define a VLAN called "v10" and configure the VLAN for layer-3 operation:

```
admin@EX4200> config
admin@EX4200# set vlans v10 vlan-id 10 l3-interface vlan.10
```

2. Configure an IP address for the VLAN interface created in the previous step, and also define **`vrrp-group 1`** on that interface:

```
admin@EX4200# set interfaces vlan.10 family inet address 10.0.0.2/24 vrrp-
group 1 virtual-address 10.0.0.10 priority 255
admin@EX4200# commit
```

Note: For Juniper EX4200 Series switches interconnected as a Virtual Chassis or for Juniper EX8200 Series switches using redundant Switch Fabric and Routing Engine (SRE) modules, use the **`commit synchronize`** command instead of **`commit`**.

In the command above, the optional **priority 255** statement forces the Juniper switch's virtual IP address to become the master VRRP instance, assuming the Cisco Catalyst 6509 device uses a lower priority value. The legal range of VRRP priorities is 1 though 255, with 255 being highest. The Cisco Catalyst 6509 initially uses a VRRP priority of 250.

Cisco commands

1. Define interface and VRRP virtual IP addresses on interface TenGigabitEthernet1/1:

```
Cat6509# configure terminal
Cat6509(config)# interface TenGigabitEthernet1/1
Cat6509(config-if)# no switchport
Cat6509(config-if)# ip address 10.0.0.1 255.255.255.0
Cat6509(config-if)# vrrp 1 ip 10.0.0.10
```

Validation

Both Juniper JUNOS and Cisco IOS support the **show vrrp** command, which will indicate the current VRRP state on each system. In the following examples, the Juniper EX4200 acts as VRRP master and the Cisco Catalyst 6509 acts as a backup.

On the Juniper EX4200:

```
admin@EX4200# show vrrp
Interface     State       Group   VR state    Timer    Type   Address
vlan.10       up              1   master      A  0.801 lcl    10.0.0.2
                                                        vip    10.0.0.10
```

On the Cisco Catalyst 6509:

```
Cat6509# show vrrp
TenGigabitEthernet1/1 - Group 1
  State is Backup
  Virtual IP address is 10.0.0.10
  Virtual MAC address is 0000.5e00.0101
  Advertisement interval is 1.000 sec
  Preemption enabled
  Priority is 100
  Master Router is 10.0.0.2, priority is 250
  Master Advertisement interval is 1.000 sec
  Master Down interval is 3.609 sec (expires in 2.729 sec)
```

Note that both devices agree the master router is 10.0.0.2 (on the Juniper EX4200), and both use a virtual IP address of 10.0.0.10.

If a router or link fails, the backup router should take over as the master. In this example, the Cisco Catalyst is promoted to master statement by reducing the Juniper EX4200's priority to 10. Since the Cisco Catalyst 6509 uses a priority of 250 by default, it should take over as master once this Juniper EX4200 configuration change is committed:

```
admin@EX4200# set interfaces vlan.10 family inet address 10.0.0.2/24 vrrp-
group 1 virtual-address 10.0.0.10 priority 10
```

After this change, the Juniper VRRP status changes to backup router, and the master router is now 10.0.0.1 on the Cisco device:

```
admin@EX4200# run show vrrp
Interface     State       Group   VR state    Timer    Type   Address
vlan.10       up              1   backup      D  3.579 lcl    10.0.0.2
                                                        vip    10.0.0.10
                                                        mas    10.0.0.1
```

The Cisco device also agrees that it is now the VRRP master:

```
Cat6509# show vrrp
TenGigabitEthernet1/1 - Group 1
  State is Master
  Virtual IP address is 10.0.0.10
  Virtual MAC address is 0000.5e00.0101
  Advertisement interval is 1.000 sec
  Preemption enabled
  Priority is 100
  Master Router is 10.0.0.1 (local), priority is 100
  Master Advertisement interval is 1.000 sec
  Master Down interval is 3.609 sec
```

Appendix A: Sample Configuration Files

This appendix lists URLs for the Juniper and Cisco switch configuration files used to verify interoperability. These files are freely available for download from a public Network Test server.

A copy of this document, a brief interoperability report and all Juniper and Cisco configuration files are available at http://networktest.com/jnpriop.

Appendix B: Software Versions Tested

This appendix lists the software versions tested on all Juniper and Cisco switches in this project.

Juniper EX4200: JunOS 9.4R1.8
Juniper EX8208: JunOS 9.4R1.8
Cisco Catalyst 3750-E: IOS 12.2(40)SE
Cisco Catalyst 4948: IOS 12.2(44)SE
Cisco Catalyst 6509: IOS 12.2(33)SXH1

Appendix C: Disclaimer

Network Test Inc. has made every attempt to ensure that all test procedures were conducted with the utmost precision and accuracy, but acknowledges that errors do occur. Network Test Inc. shall not be held liable for damages which may result for the use of information contained in this document.

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