networktest

HP-Cisco Switching and Routing Interoperability Cookbook

August 2014

TABLE OF CONTENTS

ILLUSTRATIONS

Introduction

Objective

This configuration guide aims to help networking professionals interconnect HP Networking and Cisco Catalyst switches using a variety of protocols commonly found in enterprise campus networks. 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. Further, the procedures decsribed here follow HP's best practices for network design and deployment.

Intended audience

This guide is intended for any network architect, administrator, or engineer who needs to interconnect HP 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 HP Networking and Cisco IOS command-line interfaces (CLIs). No previous experience is assumed for the protocols discussed in this document.

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 multicast topics, *Deploying IP Multicast in the Enterprise* by Thomas A. Maufer is a popular choice.

Devices under test

Using the commands given in this document, Network Test has verified interoperability between these devices:

- HP 10504
- HP 5406R
- HP FlexFabric 5900AF
- HP 5500-HI
- Cisco Catalyst 6509-E
- Cisco Catalyst 4507R
- Catalyst 3850

Appendix B lists software versions used.

Except where specifically noted, command syntax for HP Networking and Cisco Catalyst switches does not change across product lines. In cases where HP Comware and ProVision switches use different command syntax, this is explicitly noted.

Conventions used in this document

The following table lists text and syntax conventions.

Conventions	Description	Examples
Bold Type	Represents user-inputted text.	To enter configuration mode, type the **system-view** command: <HP5900AF> **system-view**
Fixed-width text like this	Represents output that appears on the terminal screen.	<HP10504> **display stp bridge** MSTID Port Role STP State Protection 0 Bridge-Aggregation20 ROOT FORWARDING NONE 0 GigabitEthernet3/0/11 DESI FORWARDING NONE
Italic text like this	• Introduces important new terms • Identifies book titles • Identifies RFC and Internet-draft titles	A policy *term* is a named structure that defines match conditions and actions. *TCP/IP Illustrated Volume 1* by W. Richard Stevens. RFC 4814, *Hash and Stuffing: Overlooked Factors in Network Device Benchmarking*

Interoperability testing

For each protocol tested, this document uses a five-section format consisting of objective, technical background, HP configuration, Cisco configuration, and test validation.

Topology

Except where otherwise noted, engineers used the standard test bed shown in Figure 1 to validate protocol interoperability. The test bed uses the two-tier network design commonly found in campus enterprise networks, with access and core layers represented. In this example network, access switches (HP 5406R, HP FlexFabric 5900AF, HP 5500-HI, Cisco Catalyst 4507R, and Cisco Catalyst C3850) connect to core switches (HP 10504 and Cisco Catalyst 6509-E). For redundancy, multiple connections exist between switch layers.

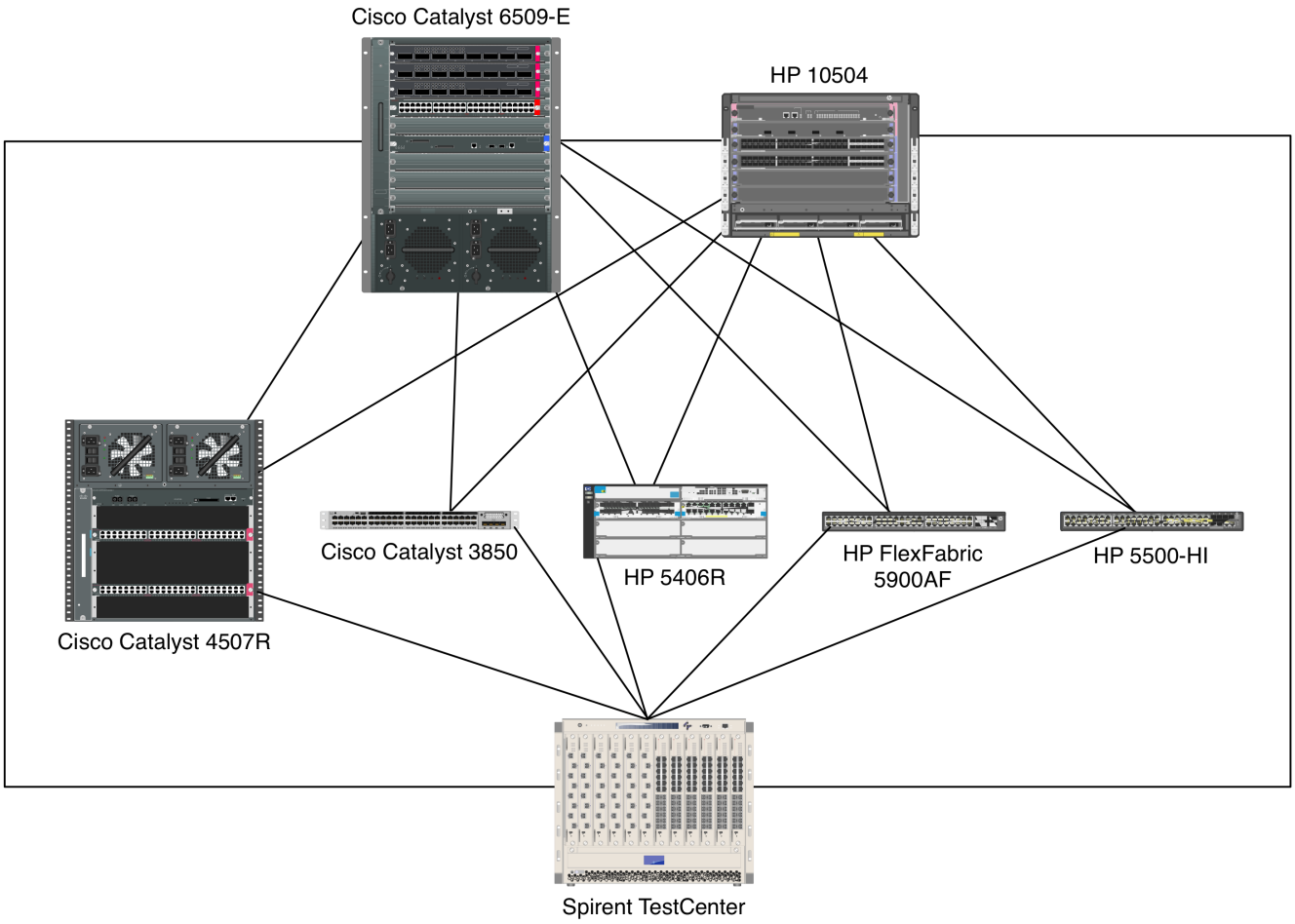

Figure 1: The HP-Cisco interoperability test bed

Border Gateway Protocol (BGP)

Objective

To verify that HP Networking and Cisco Catalyst switches are able to establish Border Gateway Protocol (BGP) connections and exchange topology information.

Background

The Border Gateway Protocol (BGP) is the mechanism that connects organizations to the global Internet. As described in RFC 4271, BGP treats each organization's network as an "autonomous system" (AS) and connects that system to all other such systems on the Internet.

BGP has two variants for connectivity inside and outside an AS. For inter-AS connectivity, there is external BGP (eBGP), where neighboring routers use different AS numbers (ASNs). For intra-AS connectivity, there is internal BGP (iBGP), where neighboring routers use the same ASN.

Topology

Figure 2 shows the BGP interoperability test bed. This example uses eBGP, with each HP and Cisco device using a different ASN. For iBGP configuration, all devices would use the same ASN.

Do not use the ASNs given in this example except in controlled lab networks with no Internet connectivity. For ASNs to use in production networks, contact a regional Internet registry (RIR) such as the American Registry for Internet Numbers (ARIN).

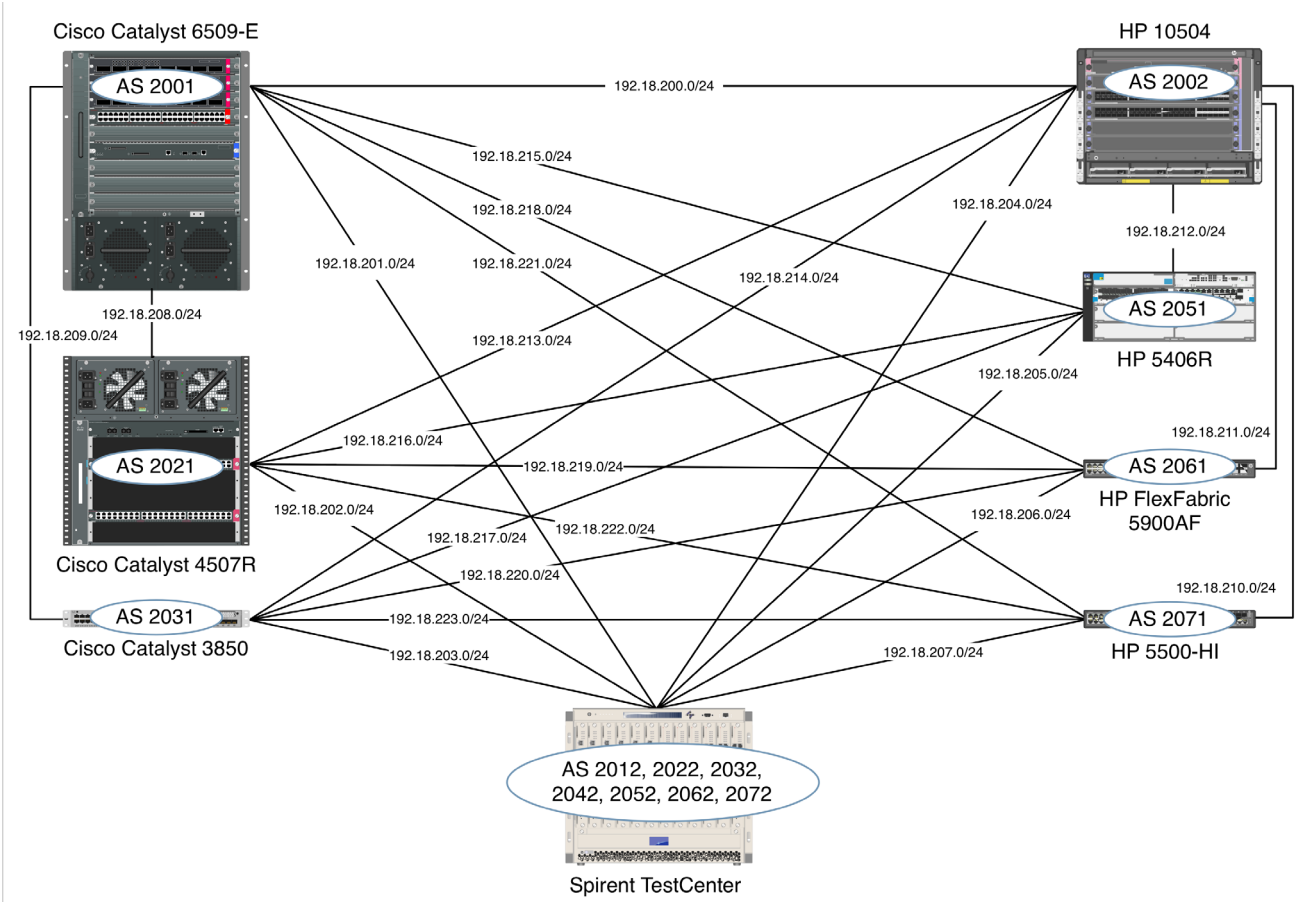

Figure 2: BGP interoperability test bed

Procedure

HP Comware commands

Create a loopback address and assign an IP address to that interface. This step is optional with directly connected devices, but a loopback interface will ensure the BGP session is available regardless of the state of physical interfaces.

```
<HP10504> system-view
[HP10504] interface LoopBack0
[HP10504] ip address 1.1.200.2 255.255.255.255
```

Create VLANs and assign IP addresses to the VLAN interfaces.

```
[HP10504] vlan 200
[HP10504-Vlan] vlan 204
[HP10504-Vlan] vlan 210 to 214
```

```
[HP10504-Vlan] interface Vlan-interface200
[HP10504-Vlan-interface200] ip address 192.18.200.2 255.255.255.0
[HP10504-Vlan-interface200] interface Vlan-interface204
[HP10504-Vlan-interface204] ip address 192.18.204.1 255.255.255.0
[HP10504-Vlan-interface204] interface Vlan-interface210
[HP10504-Vlan-interface210] ip address 192.18.210.1 255.255.255.0
[HP10504-Vlan-interface210] interface Vlan-interface211
[HP10504-Vlan-interface211] ip address 192.18.211.1 255.255.255.0
[HP10504-Vlan-interface211] interface Vlan-interface212
[HP10504-Vlan-interface212] ip address 192.18.212.1 255.255.255.0
[HP10504-Vlan-interface212] interface Vlan-interface213
[HP10504-Vlan-interface213] ip address 192.18.213.2 255.255.255.0
[HP10504-Vlan-interface213] interface Vlan-interface214
[HP10504-Vlan-interface214] ip address 192.18.214.2 255.255.255.0
```

Associate physical interfaces with the VLAN interfaces.

```
[HP10504-Vlan-interface214] interface Ten-GigabitEthernet3/0/1
[HP10504-Ten-GigabitEthernet3/0/1] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/1] description "to HP 5900 1/0/1"
[HP10504-Ten-GigabitEthernet3/0/1] port access vlan 211
[HP10504-Ten-GigabitEthernet3/0/1] interface Ten-GigabitEthernet3/0/2
[HP10504-Ten-GigabitEthernet3/0/2] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/2] description "to HP5500-HI 1/1/1"
[HP10504-Ten-GigabitEthernet3/0/2] port access vlan 210
[HP10504-Ten-GigabitEthernet3/0/2] interface Ten-GigabitEthernet3/0/3
[HP10504-Ten-GigabitEthernet3/0/3] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/3] description "to HP 5406R A1"
[HP10504-Ten-GigabitEthernet3/0/3] port access vlan 212
[HP10504-Ten-GigabitEthernet3/0/3] interface Ten-GigabitEthernet3/0/4
[HP10504-Ten-GigabitEthernet3/0/4] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/4] description "to c6509 t2/1"
[HP10504-Ten-GigabitEthernet3/0/4] port access vlan 200
[HP10504-Ten-GigabitEthernet3/0/4] interface Ten-GigabitEthernet3/0/5
[HP10504-Ten-GigabitEthernet3/0/5] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/5] interface Ten-GigabitEthernet3/0/6
[HP10504-Ten-GigabitEthernet3/0/5] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/5] interface Ten-GigabitEthernet3/0/7
[HP10504-Ten-GigabitEthernet3/0/7] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/7] description "to c3850 t1/1/3"
[HP10504-Ten-GigabitEthernet3/0/7] port access vlan 214
[HP10504-Ten-GigabitEthernet3/0/7] interface Ten-GigabitEthernet3/0/8
[HP10504-Ten-GigabitEthernet3/0/8] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/8] description "to STC 3/3"
[HP10504-Ten-GigabitEthernet3/0/8] port access vlan 204
[HP10504-Ten-GigabitEthernet3/0/8] interface Ten-GigabitEthernet3/0/17
[HP10504-Ten-GigabitEthernet3/0/17] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/17] description "to c4057r g3/3"
[HP10504-Ten-GigabitEthernet3/0/17] port access vlan 213
```

Next, configure BGP. This example uses AS number 2002 and explicitly defines which BGP neighbors can share routing information.

```
[HP10504] bgp 2002
[HP10504-bgp2002] router-id 1.1.200.2
[HP10504-bgp2002] peer 192.18.200.1 as-number 2001
[HP10504-bgp2002] peer 192.18.200.1 description Cisco6500
[HP10504-bgp2002] peer 192.18.200.1 connect-interface Vlan-interface200
[HP10504-bgp2002] peer 192.18.204.2 as-number 2042
[HP10504-bgp2002] peer 192.18.204.2 description Spirent10504-bgp2002
[HP10504-bgp2002] peer 192.18.204.2 connect-interface Vlan-interface204
[HP10504-bgp2002] peer 192.18.210.2 as-number 2071
[HP10504-bgp2002] peer 192.18.210.2 description HP-5500HI
[HP10504-bgp2002] peer 192.18.210.2 connect-interface Vlan-interface210
[HP10504-bgp2002] peer 192.18.211.2 as-number 2061
[HP10504-bgp2002] peer 192.18.211.2 description HP-5900
[HP10504-bgp2002] peer 192.18.211.2 connect-interface Vlan-interface211
[HP10504-bgp2002] peer 192.18.212.2 as-number 2051
[HP10504-bgp2002] peer 192.18.212.2 description HP-5406R
[HP10504-bgp2002] peer 192.18.212.2 connect-interface Vlan-interface212
[HP10504-bgp2002] peer 192.18.213.1 as-number 2021
[HP10504-bgp2002] peer 192.18.213.1 description Cisco4507r
[HP10504-bgp2002] peer 192.18.213.1 connect-interface Vlan-interface213
[HP10504-bgp2002] peer 192.18.214.1 as-number 2031
[HP10504-bgp2002] peer 192.18.214.1 description Cisco3850
[HP10504-bgp2002] peer 192.18.214.1 connect-interface Vlan-interface214
```

Finally, enable the protocols and peers which can use BGP. This example allows IPv4 routing from other routers on the test bed.

```
[HP10504-bgp2002] address-family ipv4 unicast
[HP10504-bgp2002] peer 192.18.200.1 enable
[HP10504-bgp2002] peer 192.18.204.2 enable
[HP10504-bgp2002] peer 192.18.210.2 enable
[HP10504-bgp2002] peer 192.18.211.2 enable
[HP10504-bgp2002] peer 192.18.212.2 enable
[HP10504-bgp2002] peer 192.18.213.1 enable
[HP10504-bgp2002] peer 192.18.214.1 enable
[HP10504-bgp2002] quit
```

HP ProVision commands

Create a loopback address and assign an IP address to that interface. This step is optional with directly connected devices, but a loopback interface will ensure the BGP session is available regardless of the state of physical interfaces.

```
HP5406R# configure
HP5406R(config)# interface loopback 0
HP5406R(config-if)# ip address 1.1.205.1
HP5406R(config-if)# exit
```

Create VLANs and assign physical interfaces and IP addresses to those VLANs.

```
HP5406R(config)# vlan 205
HP5406R(config-vlan205)# name "VLAN205"
HP5406R(config-vlan205)# untagged A3
HP5406R(config-vlan205)# ip address 192.18.205.1 255.255.255.0
HP5406R(config-vlan205)# vlan 212
HP5406R(config-vlan212)# name "VLAN212"
HP5406R(config-vlan212)# untagged A1
HP5406R(config-vlan212)# ip address 192.18.212.2 255.255.255.0
HP5406R(config-vlan212)# vlan 215
HP5406R(config-vlan215)# name "VLAN215"
HP5406R(config-vlan215)# untagged B1
HP5406R(config-vlan215)# ip address 192.18.215.2 255.255.255.0
HP5406R(config-vlan215)# vlan 216
HP5406R(config-vlan216)# name "VLAN216"
HP5406R(config-vlan216)# untagged B3
HP5406R(config-vlan216)# ip address 192.18.216.2 255.255.255.0
HP5406R(config-vlan216)# vlan 217
HP5406R(config-vlan217)# name "VLAN217"
HP5406R(config-vlan217)# untagged B5
HP5406R(config-vlan217)# ip address 192.18.217.2 255.255.255.0
HP5406R(config-vlan217)# exit
```

Next, configure BGP. This example uses AS number 2051 and explicitly defines which BGP neighbors can share routing information.

```
HP5406R(config)# router bgp 2051
HP5406R(config)# enable
HP5406R(config)# bgp router-id 1.1.205.1
HP5406R(config)# neighbor 192.18.205.2 remote-as 2052
HP5406R(config)# neighbor 192.18.205.2 description "Spirent5406R"
HP5406R(config)# neighbor 192.18.212.1 remote-as 2002
HP5406R(config)# neighbor 192.18.212.1 description "HP-10504"
HP5406R(config)# neighbor 192.18.215.1 remote-as 2001
HP5406R(config)# neighbor 192.18.215.1 description "Cisco6509"
HP5406R(config)# neighbor 192.18.216.1 remote-as 2021
HP5406R(config)# neighbor 192.18.216.1 description "Cisco4507r"
```

```
HP5406R(config)# neighbor 192.18.217.1 remote-as 2031
HP5406R(config)# neighbor 192.18.217.1 description “Cisco3850”
HP5406R(config)# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 6509-E. The syntax is similar for Catalyst 3850 and Cisco Catalyst 4507R switches.

One difference with the Cisco Catalyst 3850 is that it requires IPv4 routing to be explicitly enabled. This step is not needed with the Catalyst 6509-E or Catalyst 4507R.

```
Cat3850# configure terminal
Cat3850(config)# ip routing
```

The rest of the commands in this section apply to all three Cisco devices.

Create a loopback address and assign an IP address to that interface. This step is optional with directly connected devices, but a loopback interface will ensure the BGP session is available regardless of the state of physical interfaces.

```
Cat6509-E# configure terminal
Cat6509-E(config)# interface Loopback0
Cat6509-E(config-if)# ip address 1.1.200.1 255.255.255.255
Cat6509-E(config-if)# exit
```

Create VLANs and assign IP addresses to the VLAN interfaces.

```
Cat6509-E(config)# vlan 200-223
Cat6509-E(config-if)# interface Vlan200
Cat6509-E(config-if)# ip address 192.18.200.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan201
Cat6509-E(config-if)# ip address 192.18.201.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan208
Cat6509-E(config-if)# ip address 192.18.208.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan209
Cat6509-E(config-if)# ip address 192.18.209.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan215
Cat6509-E(config-if)# ip address 192.18.215.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan218
Cat6509-E(config-if)# ip address 192.18.218.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan221
Cat6509-E(config-if)# ip address 192.18.221.1 255.255.255.0
```

Associate physical interfaces with the VLAN interfaces.

```
Cat6509-E(config-if)# interface TenGigabitEthernet1/1
Cat6509-E(config-if)# description to c4507R t1/1
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 208
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet1/3
Cat6509-E(config-if)# description to c3850 t1/1/3
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 209
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet2/1
Cat6509-E(config-if)# description to HP 10504 3/0/4
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 200
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet2/3
Cat6509-E(config-if)# description to HP 5500-HI 1/0/53
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 221
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet3/1
Cat6509-E(config-if)# description to HP 5900 1/0/3
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 218
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet3/3
Cat6509-E(config-if)# description to SPT 3/1
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 201
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface GigabitEthernet4/3
Cat6509-E(config-if)# description to HP 5406R B1
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 215
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# exit
```

Next, configure BGP. This example uses AS number 2001 and explicitly defines which BGP neighbors can share routing information.

```
Cat6509-E(config)# router bgp 2001
Cat6509-E(config-rtr)# bgp router-id 1.1.200.1
Cat6509-E(config-rtr)# bgp log-neighbor-changes
Cat6509-E(config-rtr)# neighbor 192.18.200.2 remote-as 2002
Cat6509-E(config-rtr)# neighbor 192.18.200.2 update-source Vlan200
Cat6509-E(config-rtr)# neighbor 192.18.201.2 remote-as 2012
Cat6509-E(config-rtr)# neighbor 192.18.201.2 update-source Vlan201
Cat6509-E(config-rtr)# neighbor 192.18.208.2 remote-as 2021
Cat6509-E(config-rtr)# neighbor 192.18.208.2 update-source Vlan208
Cat6509-E(config-rtr)# neighbor 192.18.209.2 remote-as 2031
Cat6509-E(config-rtr)# neighbor 192.18.209.2 update-source Vlan209
```

```
Cat6509-E(config-rtr)# neighbor 192.18.215.2 remote-as 2051
Cat6509-E(config-rtr)# neighbor 192.18.215.2 update-source Vlan215
Cat6509-E(config-rtr)# neighbor 192.18.218.2 remote-as 2061
Cat6509-E(config-rtr)# neighbor 192.18.218.2 update-source Vlan218
Cat6509-E(config-rtr)# neighbor 192.18.221.2 remote-as 2071
Cat6509-E(config-rtr)# neighbor 192.18.221.2 update-source Vlan221
```

Finally, enable the protocols and peers which can use BGP. This example allows IPv4 routing from other routers on the test bed.

```
Cat6509-E(config-rtr)# address-family ipv4
Cat6509-E(config-rtr)# neighbor 192.18.200.2 activate
Cat6509-E(config-rtr)# neighbor 192.18.201.2 activate
Cat6509-E(config-rtr)# neighbor 192.18.208.2 activate
Cat6509-E(config-rtr)# neighbor 192.18.209.2 activate
Cat6509-E(config-rtr)# neighbor 192.18.215.2 activate
Cat6509-E(config-rtr)# neighbor 192.18.218.2 activate
Cat6509-E(config-rtr)# neighbor 192.18.221.2 activate
Cat6509-E(config-rtr)# no auto-summary
Cat6509-E(config-rtr)# no synchronization
Cat6509-E(config-rtr)# exit-address-family
```

Validation

In Comware v7, the command "**display bgp peer ipv4**" will display information about BGP neighbors. Note that all BGP sessions are in "established" state.

```
<HP10504> display bgp peer ipv4

 BGP local router ID: 1.1.200.2
 Local AS number: 2002
 Total number of peers: 7             Peers in established state: 7

  Peer                    AS  MsgRcvd  MsgSent OutQ PrefRcv Up/Down  State

  192.18.200.1          2001       34       40    0    6000 00:24:32 Established
  192.18.204.2          2042     1167     2971    0    1000 01:22:58 Established
  192.18.210.2          2071       26       31    0    6000 00:19:47 Established
  192.18.211.2          2061       86       74    0    6000 00:40:52 Established
  192.18.212.2          2051       68       72    0    5000 00:45:25 Established
  192.18.213.1          2021       40       52    0    5000 00:28:50 Established
  192.18.214.1          2031       54       61    0    5000 00:33:44 Established
```

In Comware v5, the command "**display bgp peer**" will produce similar output.

In HP ProVision and Cisco devices, the command "**show ip bgp summary**" will display information about BGP neighbors.

```
HP5406R# show ip bgp summary

 Peer Information

  Remote Address  Remote-AS Local-AS State         Admin Status
  --------------- --------- -------- ------------- ------------
  192.18.205.2    2052      2051     Established   Start
  192.18.212.1    2002      2051     Established   Start
  192.18.215.1    2001      2051     Established   Start
  192.18.216.1    2021      2051     Established   Start
  192.18.217.1    2031      2051     Established   Start
```

```
Cat6509-E# show ip bgp summary
BGP router identifier 1.1.200.1, local AS number 2001
BGP table version is 11001, main routing table version 11001
7000 network entries using 819000 bytes of memory
33000 path entries using 1716000 bytes of memory
34/7 BGP path/bestpath attribute entries using 5440 bytes of memory
33 BGP AS-PATH entries using 872 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 2541312 total bytes of memory
BGP activity 7000/0 prefixes, 37000/4000 paths, scan interval 60 secs

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/
PfxRcd
192.18.200.2    4         2002      40       35    11001    0    0 00:25:01     6000
192.18.201.2    4         2012    1054       66    11001    0    0 00:26:04     1000
192.18.208.2    4         2021      37       34    11001    0    0 00:27:00     6000
192.18.209.2    4         2031      45       36    11001    0    0 00:27:18     6000
192.18.215.2    4         2051      31       31    11001    0    0 00:20:38     4000
192.18.218.2    4         2061      40       31    11001    0    0 00:20:07     4000
192.18.221.2    4         2071      26       29    11001    0    0 00:19:32     6000
```

Cisco Discovery Protocol (CDP)

Objective

To verify the ability of HP and Cisco switches to exchange capabilities information using the Cisco Discovery Protocol (CDP).

Background

The proprietary Cisco Discovery Protocol (CDP) allows sharing of information, such as port names, IP addresses, model numbers, and power requirements among connected HP and Cisco devices. Although CDP is a Cisco-proprietary protocol, HP switches understand it and can share information using the protocol.

CDP requires little or no configuration on HP switches. On some models, enabling CDP requires as few as three commands; on others, CDP is enabled by default.

Topology

Figure 3 shows the CDP test bed topology. All HP switches connect to all Cisco switches, as well as the HP 10504 core switch and the Spirent TestCenter instrument.

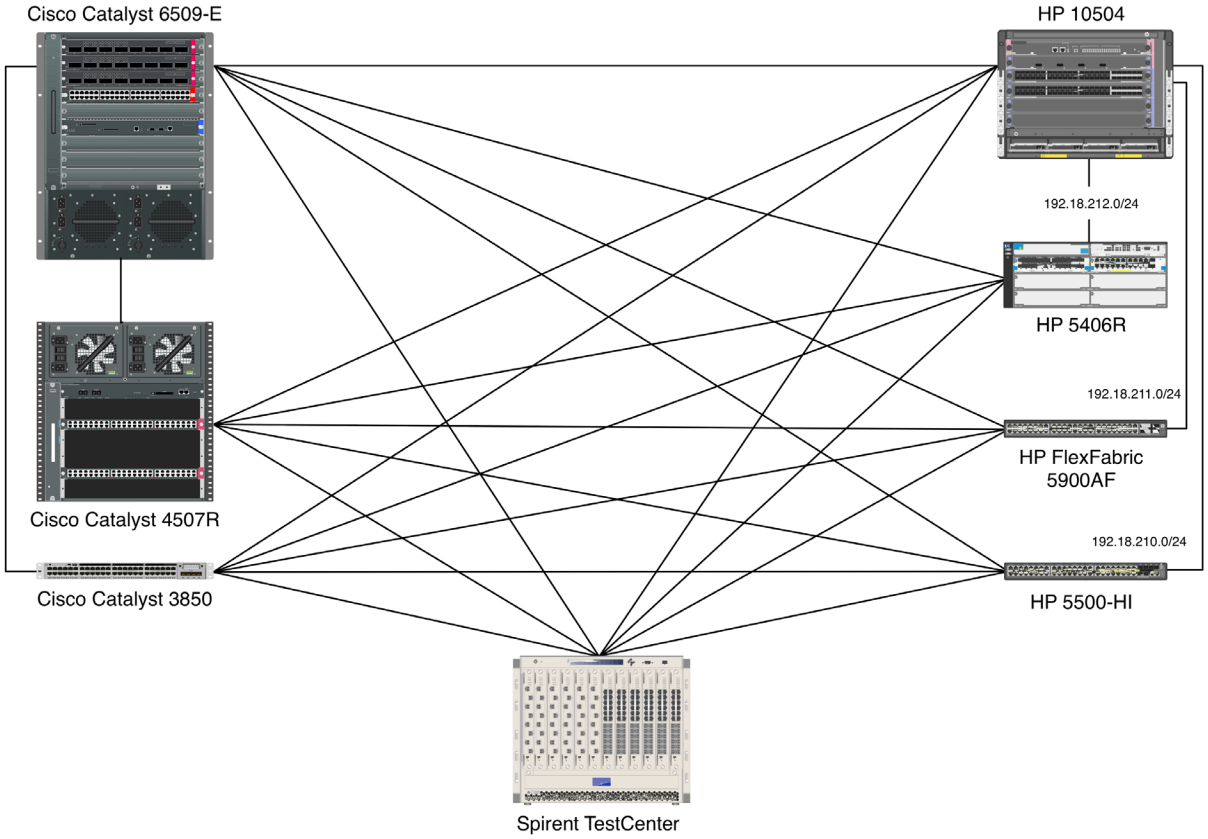

Figure 3: The CDP interoperability test bed

This example uses VLAN trunking and switched virtual interfaces (SVIs), with IP addresses bound to VLAN interfaces instead of physical interfaces. Both are optional; CDP would work equally well without VLAN trunking or SVIs.

Procedure

HP Comware commands

In a global configuration context, enable logical-layer discovery protocol and CDP.

```
<HP10504> system-view
[HP10504] lldp global enable
[HP10504] lldp compliance cdp
```

For each IP subnet/VLAN combination, create the VLAN and assign an IP address to it.

```
[HP10504] vlan 200
[HP10504-Vlan200] interface Vlan-interface200
[HP10504-Vlan-interface200] ip address 192.18.200.2 255.255.255.0
[HP10504-Vlan-interface200] quit
```

Repeat as needed for each VLAN.

Configure one or more physical interfaces to be VLAN members, and enable CDP on each interface. The command "**lldp compliance admin-status cdp txrx**" enables CDP, both in transmit and receive modes.

```
[HP10504] interface Ten-GigabitEthernet3/0/4
[HP10504-interface Ten-GigabitEthernet3/0/4] port link-mode bridge
[HP10504-interface Ten-GigabitEthernet3/0/4] description "to c6509 t2/1"
[HP10504-interface Ten-GigabitEthernet3/0/4] port access vlan 200
[HP10504-interface Ten-GigabitEthernet3/0/4] lldp compliance admin-status cdp txrx
[HP10504-interface Ten-GigabitEthernet3/0/4] quit
```

Repeat as needed for each physical interface that requires CDP.

HP ProVision commands

HP ProVision switches run CDP by default, and require no additional configuration.

Cisco commands

Cisco devices run CDP by default, and require no additional configuration.

Validation

On HP Comware switches, the command "**display lldp neighbor list**" will show information about attached devices running CDP.

```
[HP10504] display lldp neighbor list
Chassis ID : * -- -- Nearest nontpmr bridge neighbor
             # -- -- Nearest customer bridge neighbor
             Default -- -- Nearest bridge neighbor
System Name          Local Interface Chassis ID      Port ID
hp5900_cdp           XGE3/0/1        b8af-67f2-4a24  Ten-GigabitEthernet1/0/1
hp5500_cdp           XGE3/0/2        d07e-28d1-0180  Ten-GigabitEthernet1/1/1
hp5406r_cdp          XGE3/0/3        a048-1cf8-e100  1
-                    XGE3/0/4        c6509_cdp.cisco TenGigabitEthernet2/1
                                     6509.lab.local
-                    XGE3/0/7        c3850_cdp       TenGigabitEthernet1/1/3
-                    XGE3/0/17       c4507r_cdp.cat4 GigabitEthernet3/3
                                     500.lab.local
```

On HP Provision and Cisco devices, the equivalent command is "**show cdp neighbors**". If desired, more information about CDP neighbors is available on HP Provision and Cisco devices with the "**show cdp neighbors detail**" command.

```
HP5406R# show cdp neighbors detail

 CDP neighbors information

  Port : A1
  Device ID : 44 31 92 55 e7 cb
  Address Type : IP
  Address      : 192.18.212.1
  Platform     : HP Comware Platform Software, Software Version 7.1.045, ...
  Capability   : Router Switch
  Device Port  : "to HP 5406R A1,A2"
  Version      : HP Comware Platform Software, Software Version 7.1.045, ...

--------------------------------------------------------------------------------

  Port : B1
  Device ID : c6509_cdp.cisco6509.lab.local
  Address Type : IP
  Address      : 192.18.215.1
  Platform     : Cisco IOS Software, s72033_rp Software (s72033_rp-ADVIPS...
  Capability   : Router Switch
  Device Port  : GigabitEthernet4/3
  Version      : Cisco IOS Software, s72033_rp Software (s72033_rp-ADVIPS...
```

```
C3850# show cdp neighbors detail
-------------------------
Device ID: c6509_cdp.cisco6509.lab.local
Entry address(es):
  IP address: 192.18.209.1
Platform: cisco WS-C6509-E,  Capabilities: Router Switch IGMP
Interface: TenGigabitEthernet1/1/1,  Port ID (outgoing port): TenGigabitEthernet1/3
Holdtime : 160 sec

Version :
Cisco IOS Software, s72033_rp Software (s72033_rp-ADVIPSERVICESK9_WAN-M), Version
12.2(33)SXI13, RELEASE SOFTWARE (fc3)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2014 by Cisco Systems, Inc.
Compiled Tue 11-Mar-14 04:54 by prod_rel_team

advertisement version: 2
VTP Management Domain: 'test1'
Native VLAN: 209
Duplex: full
Management address(es):
  IP address: 192.18.209.1

-------------------------
Device ID: d07e-28d1-0180
Entry address(es):
  IP address: 192.18.223.2
Platform: JG312A,  Capabilities: Switch
Interface: GigabitEthernet1/0/3,  Port ID (outgoing port): GigabitEthernet1/0/3
Holdtime : 93 sec

Version :
HP Comware Platform Software, Software Version 5.20.99 Release 5501P01
HP A5500-48G-4SFP HI Switch with 2 interface Slots
Copyright (c) 2010-2014 Hewlett-Packard Development Company, L.P.

advertisement version: 2
Native VLAN: 223
Duplex: full
Management address(es):
```

Jumbo frame routing

Objective

To validate the ability of HP Networking and Cisco Catalyst switches to correctly route 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 1518 bytes – remains nonstandard. However, jumbo frames are useful in both routed and switched environments for applications involving bulk data transfer. Further, the open shortest path first (OSPF) routing protocol also requires that both routers use the same MTU before exchanging routing information.

HP Networking and Cisco Catalyst switches both support 9,216-byte jumbo frames, including Ethernet CRC. This section explains how to configure both vendors' devices to exchange jumbo frames using IP routing.

Topology

In this example, all HP and Cisco devices use IP addresses to exchange jumbo frames. In this example, engineers assigned IP addresses to VLANs instead of physical interfaces. However, IP addresses directly assigned to physical addresses also support jumbo frames.

Figure 4 illustrates the configuration used to validate jumbo frame routing. All devices routed traffic at layer 3 in this test.

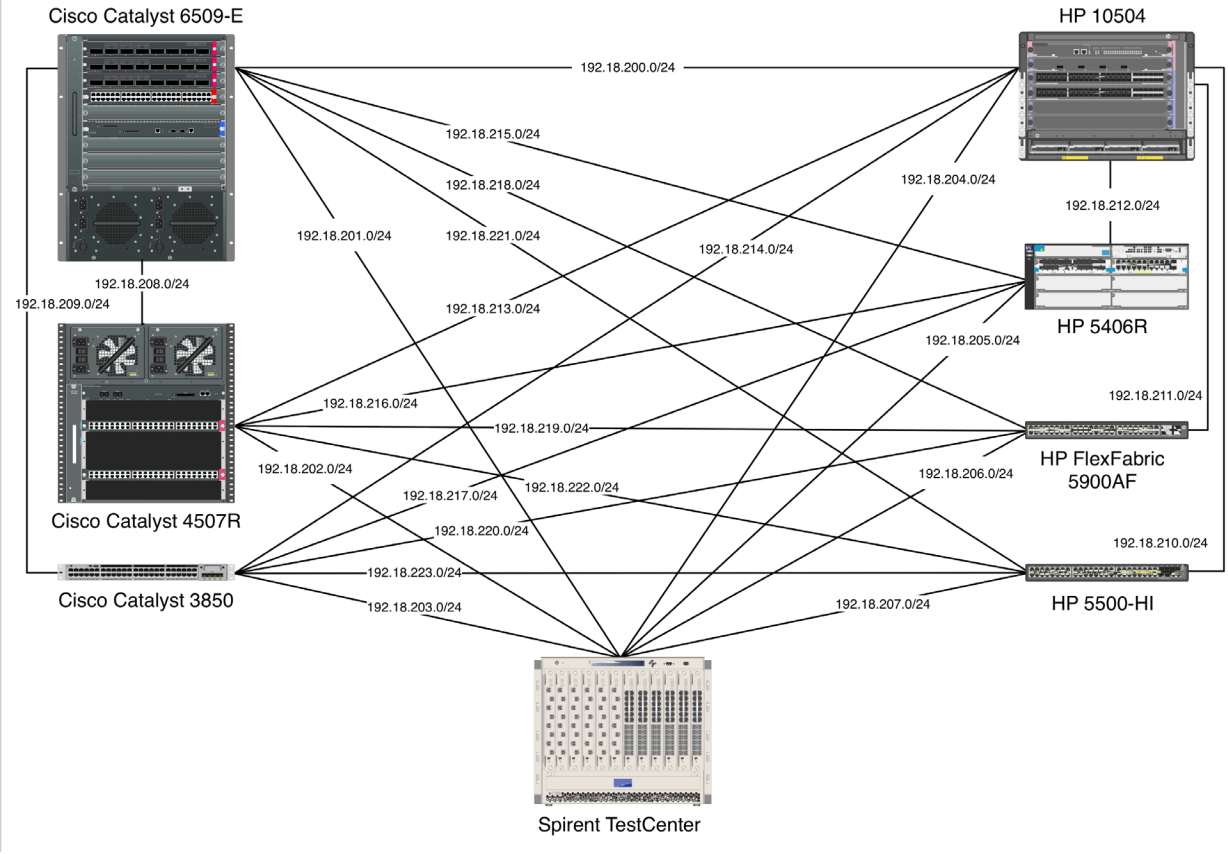

Figure 4: Jumbo routing test bed

Procedure

HP Comware commands

HP Comware switches have jumbo frames enabled by default, so no additional configuration is needed. The following commands are used to explicitly set the maximum transmission unit (MTU), though this step is optional unless some MTU other than 9216 is required. The MTU is set in the interface configuration context.

```
<HP10504> system-view
[HP10504] interface Ten-GigabitEthernet3/0/4
[HP10504-Ten-GigabitEthernet3/0/4] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/4] jumboframe enable 9216
[HP10504-Ten-GigabitEthernet3/0/4] description “to c6509 t2/1-2”
[HP10504-Ten-GigabitEthernet3/0/4] port link-type trunk
[HP10504-Ten-GigabitEthernet3/0/4] undo port trunk permit vlan 1
[HP10504-Ten-GigabitEthernet3/0/4] port trunk permit vlan 200 to 212
[HP10504-Ten-GigabitEthernet3/0/4] quit
```

HP ProVision commands

HP ProVision switches set MTU on a per-VLAN basis. When enabled, all ports on that VLAN will forward jumbo frames.

```
HP5406R# configure
HP5406R(config)# vlan 212
HP5406R(vlan-200)# name "VLAN212"
HP5406R(vlan-200)# tagged A1
HP5406R(vlan-200)# ip address ip address 192.18.212.2 255.255.255.0
HP5406R(vlan-200)# jumbo
HP5406R(vlan-200)# end
```

Cisco commands

On Cisco Catalyst 6509-E and Cisco Catalyst 4507R switches, jumbo frame support varies by line card. For those line cards that support jumbo frames, MTU is set on a per-interface basis.

First, configure the physical interface with jumbo frame support.

```
Cat6509-E# configure terminal
Cat6509-E(config)# interface TenGigabitEthernet2/1
Cat6509-E(config-if)# description to HP 10504 3/0/4
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport trunk encapsulation dot1q
Cat6509-E(config-if)# switchport trunk allowed vlan 200-212
Cat6509-E(config-if)# switchport mode trunk
Cat6509-E(config-if)# mtu 9216
Cat6509-E(config-if)# exit
```

Then set up each VLAN for jumbo frames. This is required to route jumbo frames between VLANs. All interfaces in the VLAN must be set to allow jumbo frames before this command will take effect.

```
Cat6509-E(config)# interface Vlan200
Cat6509-E(config-if)# mtu 9216
Cat6509-E(config-if)# end
```

On Cisco Catalyst 4507R switches, note that the **mtu** command describes the maximum length of the *IP packet,* not the maximum for the *Ethernet frame*. Thus, an MTU of 9,198 bytes is set here for the IP packet, 18 bytes less than the 9,216 bytes covering the entire Ethernet frame.

```
Cat4507R# configure terminal
Cat4507R(config)# interface TenGigabitEthernet1/1
Cat4507R(config-if)# description to c6509 t1/1-2
Cat4507R(config-if)# switchport trunk encapsulation dot1q
Cat4507R(config-if)# switchport trunk allowed vlan 200-211
```

```
Cat4507R(config-if)# switchport mode trunk
Cat4507R(config-if)# mtu 9198
Cat4507R(config-if)# end
```

On Cisco Catalyst 3850 switches, MTU is set systemwide. With IOS-XE, the **mtu** command again covers only the IP packet, not the encapsulating Ethernet frame.

```
C3850# configure terminal
C3850(config)# system mtu 9198
C3850(config)# end
```

Validation

Generating jumbo frames between the attached clients and servers will validate the ability of all devices to route jumbo traffic across an IP network. All switches will forward all jumbo frames with zero frame loss.

Jumbo frame switching

Objective

To validate the ability of HP Networking and Cisco Catalyst switches to correctly forward 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 1518 bytes – remains nonstandard. However, jumbo frames can improve the performance of applications involving bulk data transfer, such as backup and disaster recovery.

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

Topology

In this example, the Spirent TestCenter traffic generator offers 9,216-byte jumbo Ethernet frames using a "partially meshed" topology, meaning all traffic offered to ports on HP switches are destined to ports on Cisco switches and visa-versa. 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 4 illustrates the configuration used to validate jumbo frame switching, although no IP routing was involved in this test. Trunk ports run between the core switches, and between core and access switches. All other ports operate in access mode.

Procedure

HP Comware commands

HP Comware switches have jumbo frames enabled by default, so no additional configuration is needed. The following commands are used to explicitly set the maximum transmission unit (MTU), though this step is optional unless some MTU other than 9216 is required. The MTU is set in the interface configuration context.

```
<HP10504> system-view
[HP10504] interface Ten-GigabitEthernet3/0/4
[HP10504-TenGigabitEthernet3/0/4] port link-mode bridge
[HP10504-TenGigabitEthernet3/0/4] jumboframe enable 9216
[HP10504-TenGigabitEthernet3/0/4] description "to c6509 t2/1"
[HP10504-TenGigabitEthernet3/0/4] port link-type trunk
[HP10504-TenGigabitEthernet3/0/4] undo port trunk permit vlan 1
[HP10504-TenGigabitEthernet3/0/4] port trunk pvid vlan 202
[HP10504-TenGigabitethernet3/0/4] quit
[HP10504] quit
```

HP ProVision commands

HP ProVision switches set the MTU on a per-VLAN basis using the "**jumbo**" keyword. When enabled, all ports on that VLAN will forward jumbo frames.

```
HP5406R# configure
HP5406R(config)# vlan 200
HP5406R(vlan-200)# name "VLAN200"
HP5406R(vlan-200)# untagged A1-A5,A9-A10
HP5406R(vlan-200)# jumbo
HP5406R(vlan-200)# exit
HP5406R(config)# exit
```

Cisco commands

On Cisco Catalyst 6509-E and Cisco Catalyst 4507R switches, jumbo frame support varies by line card. For line cards that support jumbo frames, MTU is set on a per-interface basis.

```
Cat6509-E# configure terminal
Cat6509-E(config)# interface TenGigabitEthernet2/1
Cat6509-E(config-if)# description to HP 10504 3/0/4
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport trunk encapsulation dot1q
Cat6509-E(config-if)# switchport trunk native vlan 202
Cat6509-E(config-if)# switchport trunk allowed vlan 200-202
Cat6509-E(config-if)# switchport mode trunk
Cat6509-E(config-if)# mtu 9216
Cat6509-E(config-if)# end
```

On Cisco Catalyst 3850 switches, MTU is set systemwide.

```
C3850# configure terminal
C3850(config)# system mtu 9198
C3850(config)# end
```

Note that the Catalyst 3850's "**system mtu**" command covers the IP packet length. The Ethernet frame size is 18 bytes larger (9,216 bytes) to allow for 14 bytes of Ethernet header and 4 bytes of Ethernet CRC.

Validation

Generating jumbo frames between the attached clients and servers will validate the ability of the switches to exchange jumbo traffic. All switches will forward all jumbo frames with zero frame loss.

Link aggregation

Objective

To validate the ability of HP Networking and Cisco Catalyst switches to correctly forward traffic over a logical connection created using IEEE 802.1AX link aggregation.

Background

The IEEE 802.1AX link specification 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* (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, 802.3AX-compliant switches can dynamically add or remove LAG members.

Link aggregation is useful for both 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, the HP 10504 core switch uses two-member LAGs to exchange traffic with HP access switches and with the Cisco Catalyst 6509-E switch. The Cisco access switches also use two-member LAGs for connectivity with the Catalyst 6509-E. The maximum number of LAG members varies between platforms and manufacturers. Refer to manufacturers' datasheets for more information.

The HP switches also have LAGs defined to Cisco access switches, but these are disabled to prevent traffic loops.

Figure 5 shows the topology used to validate link aggregation and LACP functionality. This test deviates from the standard test bed with the additional of several link aggregation groups.

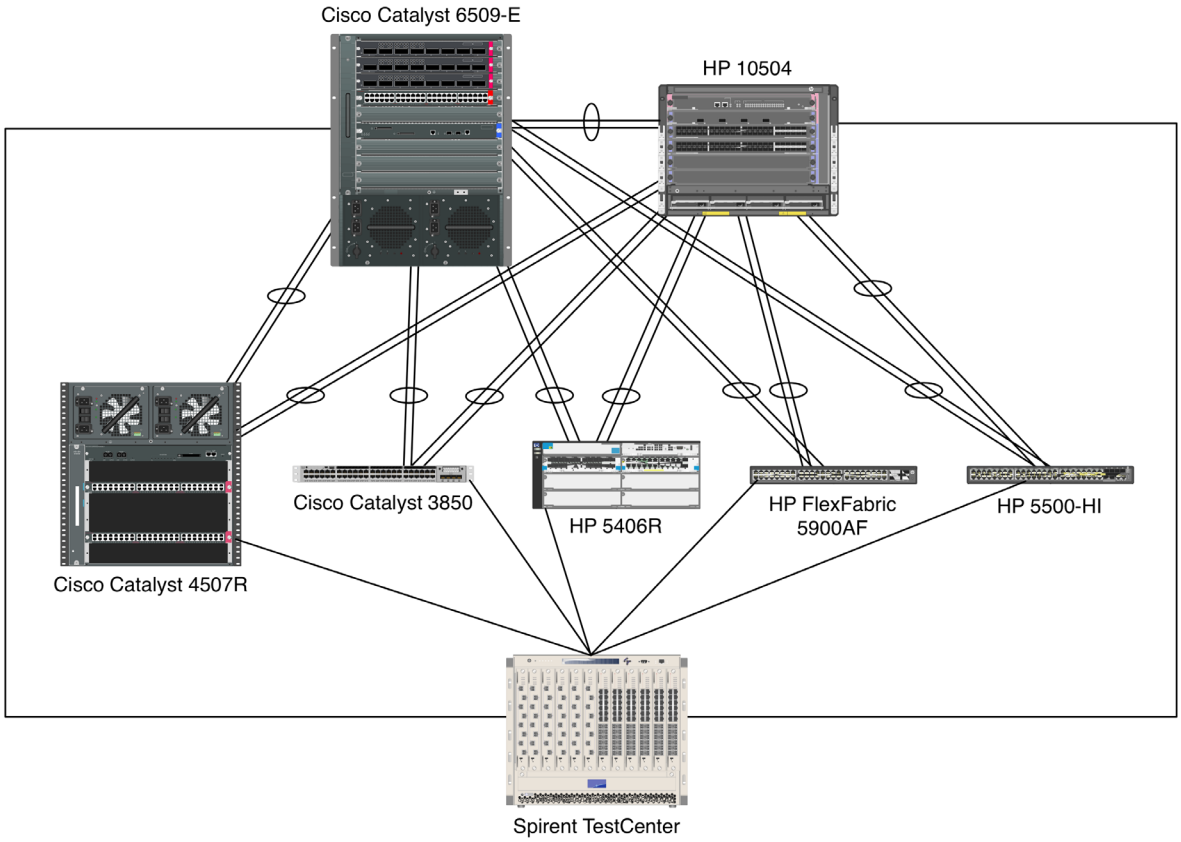

Figure 5: Link aggregation test bed

Procedure

HP Comware commands

On these HP switches, link aggregation is a two-step process. First a virtual *bridge aggregation* interface is created. Then physical interfaces (and optionally, VLANs) are associated with the virtual bridge interface. While this example involves a VLAN trunk, a common use of link aggregation, it is not a requirement. Also, if individual port configuration is not required, link aggregation configuration requires definition of a bridge aggregation group; addition of physical ports; and configuration of VLAN trunk ports.

As noted, this example covers configuration of individual ports. First, create the bridge aggregation interfaces. These examples allow traffic from all VLANs; if desired, selected VLANs can be permitted by explicitly allowing only those VLAN IDs. This example is for the first LAG. The same commands apply for other LAGs, with different **`Bridge-Aggregation`** IDs applied to each.

```
<HP10504> system-view
[HP10504] interface bridge-aggregation1
[HP10504-bridge-aggregation1] link-aggregation mode dynamic
[HP10504-bridge-aggregation1] quit
```

Optionally, configure the hashing algorithm to use for distributing traffic across LAG members. For example, this command uses a hash of destination and source MAC addresses to assign outgoing traffic to LAG members.

```
[HP10504] interface bridge-aggregation1
[HP10504-bridge-aggregation1] link-aggregation load-sharing mode destination-mac
source-mac
[HP10504-bridge-aggregation1] quit
```

Next, assign physical interfaces to the bridge aggregation virtual interface. This example is for the links between the HP 10504 and Cisco Catalyst 6509-E. The same commands apply for LAGs to other switches.

```
[HP10504] interface Ten-Gigabitethernet 3/0/4
[HP10504-Ten-Gigabitethernet3/0/4] description to c6509 t 2/1
[HP10504-Ten-Gigabitethernet3/0/4] link-aggregation group 1
[HP10504-Ten-Gigabitethernet3/0/4] interface Ten-GigabitEthernet 4/0/4
[HP10504-Ten-Gigabitethernet4/0/4] link-aggregation group 1
[HP10504-Ten-Gigabitethernet4/0/4] quit
```

Note that the LAG encompasses interfaces from different modules. This is considered a best practice. Even if one module fails, the LAG can continue to operate.

Next, configure VLAN info and port link type.

```
[HP10504] interface Ten-GigabitEthernet3/0/4
[HP10504-Ten-GigabitEthernet3/0/4] description "to c6509 t2/1"
[HP10504-Ten-GigabitEthernet3/0/4] port link-type trunk
[HP10504-Ten-GigabitEthernet3/0/4] port trunk permit vlan all
[HP10504-Ten-GigabitEthernet3/0/4] interface Ten-GigabitEthernet4/0/4
[HP10504-Ten-GigabitEthernet4/0/4] port link-type trunk
[HP10504-Ten-GigabitEthernet4/0/4] port trunk permit vlan all
[HP10504-Ten-GigabitEthernet4/0/4] quit
[HP10504] quit
```

HP ProVision commands

HP ProVision switches create *trunks* to support LACP. A single command creates the trunk and assigns physical members to the trunk.

```
HP5406R# configure
HP5406R(config)# trunk A1-A2 trk4 lacp
HP5406R(config)# exit
```

Cisco commands

Cisco Catalyst switches, like HP Comware switches, perform a two-step process to create a *Port Channel*. The following commands apply to a Cisco Catalyst 6509-E. The syntax is similar for the Catalyst 3850 switches and Cisco Catalyst 4507R switches.

First, create the link aggregation group. Here we also create a VLAN trunk that allows traffic for all VLANs (due to the lack of an explicit "**switchport trunk allowed**" command). Also, note that the Cisco Catalyst 3850 does not use the "**switchport trunk encapsulation dot1q**" command.

```
Cat6509-E# configure terminal
Cat6509-E(config)# interface Port-channel3
Cat6509-E(config-if)#  description linkagg to hp10504
Cat6509-E(config-if)#  switchport
Cat6509-E(config-if)#  switchport trunk encapsulation dot1q
Cat6509-E(config-if)#  switchport mode trunk
Cat6509-E(config-if)#  exit
```

Next, add interfaces to the link aggregation group. The command "**channel-group 3"** adds an interface to the link aggregation group created in the previous step, while "**mode active"** enables LACP. Again, note that the Catalyst 3580 does not use the "**switchport trunk encapsulation dot1q**" command.

```
Cat6509-E(config-if)# interface TenGigabitEthernet2/1
Cat6509-E(config-if)# description to HP 10504 3/0/4
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport trunk encapsulation dot1q
Cat6509-E(config-if)# channel-group 3 mode active
Cat6509-E(config-if)# interface TenGigabitEthernet2/2
Cat6509-E(config-if)# description to HP 10504 4/0/4
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport trunk encapsulation dot1q
Cat6509-E(config-if)# channel-group 3 mode active
Cat6509-E(config-if)# end
```

Validation

The command "**display link-aggregation summary"** on HP Comware switches will show the status of the bridge aggregation interfaces. In this example, the LAG called **Bridge-Aggregation1** has two members.

```
[HP10504] display link-aggregation summary
Aggregation Interface Type:
BAGG -- Bridge-Aggregation, RAGG -- Route-Aggregation
Aggregation Mode: S -- Static, D -- Dynamic
Loadsharing Type: Shar -- Loadsharing, NonS -- Non-Loadsharing
Actor System ID: 0x8000, 4431-9255-e7cb

AGG         AGG       Partner ID              Selected  Unselected  Share
Interface   Mode                              Ports     Ports       Type
--------------------------------------------------------------------------------
```

```
BAGG1       D         0x8000, 001c-0e0e-2800   2         0           Shar
```

On HP ProVision switches, the "**show lacp**" command will verify correct operation.

```
HP5406R# show lacp

                                    LACP

          LACP      Trunk     Port                LACP      Admin    Oper
   Port   Enabled   Group     Status    Partner   Status    Key      Key
   -----  -------   -------   -------   -------   -------   ------   ------
   A1     Active    Trk4      Up        Yes       Success   0        389
   A2     Active    Trk4      Up        Yes       Success   0        389
```

On Cisco switches, the "**show lacp neighbor**" command will verify correct operation.

```
Cat6509-E# show lacp neighbor
Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 1 neighbors

Partner's information:

          Partner Partner   LACP Partner  Partner   Partner   Partner     Partner
Port      Flags   State     Port Priority Admin Key Oper Key Port Number Port State
Te1/3     SA      bndl      32768         0x0       0x1      0x136       0x3D
Te1/4     SA      bndl      32768         0x0       0x1      0x137       0x3D

Channel group 2 neighbors
Te2/2     SA      bndl      32768         0x0       0x1      0x108       0x3D
...
```

Link-Layer Discovery Protocol (LLDP)

Objective

To verify the ability of HP and Cisco switches to exchange capabilities information using the Link-Layer Discovery Protocol (LLDP).

Background

LLDP, as described in the IEEE 802.1AB 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.

LLDP requires little or no configuration on HP switches. HP Comware v7 switches require one command to enable LLDP. HP Comware v5 and HP ProVision switches run LLDP by default, with no additional configuration needed. Cisco switches require one global command to enable LLDP.

Topology

The LLDP test bed uses the same topology as the CDP tests, as shown in Figure 3. All HP switches connect to all Cisco switches, as well as the HP 10504 core switch and the Spirent TestCenter instrument.

This example uses VLAN trunking and switched virtual interfaces (SVIs), with IP addresses bound to VLAN interfaces instead of physical interfaces. Both are optional; LLDP would work equally well without VLAN trunking or SVIs.

Procedure

HP Comware commands

On HP Comware v7 switches, enable LLDP in a global configuration context.

```
<HP10504> system-view
[HP10504] lldp global enable
[HP10504] quit
```

HP Comware v5 switches run LLDP by default, and require no additional configuration.

HP ProVision commands

HP ProVision switches run LLDP by default, and require no additional configuration.

Cisco commands

This example is for a Cisco Catalyst 6509-E switch, but the Cisco Catalyst 4507R and Cisco Catalyst 3850 switches use identical commands.

```
Cat6509-E# configure terminal
Cat6509-E(config)# lldp run
Cat6509-E(config)# exit
```

Validation

On HP Comware switches, the command "**display lldp neighbor-information list**" will show information about attached devices running LLDP.

```
[HP10504] display lldp neighbor-information list
Chassis ID : * -- -- Nearest nontpmr bridge neighbor
             # -- -- Nearest customer bridge neighbor
             Default -- -- Nearest bridge neighbor
System Name           Local Interface Chassis ID      Port ID
hp5900_lldp           XGE3/0/1        b8af-67f2-4a24  Ten-GigabitEthernet1/0/1
hp5500_lldp           XGE3/0/2        d07e-28d1-0180  Ten-GigabitEthernet1/1/1
hp5406r_lldp          XGE3/0/3        a048-1cf8-e100  1
c6509_lldp.cisco6509  XGE3/0/4        001c-0e0e-2800  Te2/1
.lab.local
c3850_lldp            XGE3/0/7        5006-0484-c000  Te1/1/3
c4507r_lldp.cat4500.  XGE3/0/17       000d-6558-173f  Gi3/3
lab.local
```

On HP Provision switches, the equivalent command is "**show lldp info remote-device**".

```
HP5406R# show lldp info remote-device

 LLDP Remote Devices Information

  LocalPort | ChassisId                 PortId PortDescr SysName
  --------- + ------------------------ ------ --------- ---------------------
  A1        | 44 31 92 55 e7 cb        Ten... "to HP... hp10504_lldp
  B1        | c6509_lldp.cisco6509.l... Gig...
  B1        | 00 1c 0e 0e 28 00        Gi4/3  Gigabi... c6509_lldp.cisco650...
  B3        | c4507r_lldp.cat4500.la... Gig...
  B3        | 00 0d 65 58 17 3f        Gi3/5  Gigabi... c4507r_lldp.cat4500...
  B5        | 50 06 04 84 c0 00        Gi1... Gigabi... c3850_lldp
  B5        | c3850_lldp               Gig...
```

The equivalent command on Cisco devices is "**show lldp neighbors**".

```
Cat6509-E# show lldp neighbors
Capability codes:
    (R) Router, (B) Bridge, (T) Telephone, (C) DOCSIS Cable Device
    (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other

Device ID           Local Intf     Hold-time  Capability      Port ID
hp5406r_lldp        Gi4/3          120        B,R             33
hp5900_lldp         Te3/1          120        B,R             Ten-GigabitEthernet1/0/3
hp5500_lldp         Te2/3          120        B,R             Ten-GigabitEthernet1/0/53
hp10504_lldp        Te2/1          120        B,R             Ten-GigabitEthernet3/0/4
TME_Lab1_Row11_AccesGi6/1          120        B               22
c3850_lldp          Te1/3          120        B,R             Te1/1/1
c4507r_lldp         Te1/1          120        B,R             Te1/1
```

Multicast routing

Objective

To verify the ability of a network comprised of HP and Cisco devices to learn IP multicast routing information using the PIM-SM protocol.

To verify the ability of a network comprised of HP and Cisco devices to correctly forward IP 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.

Like all multicast protocols, PIM-SM uses reverse path forwarding (RPF) lookups to determine which router interface is closest to the multicast source. Because PIM-SM does not include a mechanism to populate an RPF table, it relies on a unicast routing protocol, such as Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS), for this purpose.

Topology

In this example, the Spirent TestCenter instrument emulates a video server generating multicast traffic to one subnet of the Cisco Catalyst 6509-E. The Cisco device uses PIM-SM to propagate routing information about that network to other networks, including one in which a Cisco Catalyst 3850 switch, also running PIM-SM, is attached.

Both the HP and Cisco devices use 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 (not IGMP snooping) to build a multicast forwarding table.

As in other examples involving routing, the configuration examples given here are in switch virtual interface (SVI) mode, where IP addresses are bound to VLANs, and physical interfaces are then members of those VLANs. Multicast routing configuration also would work with IP addresses directly configured on physical interfaces.

Figure 1 illustrates the topology used to validate IP multicast routing functionality. PIM-SM and OSPF routing is enabled on both HP and Cisco devices.

Procedure

HP Comware commands

First, enable PIM multicast routing and define a rendezvous point (RP). A multicast network using PIM-SM requires an RP to be defined; in this case the RP is the Cisco Catalyst 6509-E.

```
<HP10504> system-view
[HP10504] multicast routing
```

```
[HP10504] pim
[HP10504-pim] static-rp 192.18.200.1
[HP10504-pim] quit
```

Note that the HP 10504 runs Comware v7. On devices running Comware v5, the command to enable multicast routing is "**multicast routing-enable**".

Next, configure VLANs and enable PIM on those VLANs.

```
[HP10504] vlan 200
[HP10504-vlan200] vlan 204
[HP10504-vlan204] vlan 210 to 214
[HP10504-vlan204] vlan 210 to 214
[HP10504-vlan204] interface Vlan-interface200
[HP10504-vlan-interface200] ip address 192.18.200.2 255.255.255.0
[HP10504-vlan-interface200] pim sm
[HP10504-vlan-interface200] interface Vlan-interface204
[HP10504-vlan-interface204] ip address 192.18.204.1 255.255.255.0
[HP10504-vlan-interface204] pim sm
[HP10504-vlan-interface204] igmp enable
[HP10504-vlan-interface204]  igmp version 3
[HP10504-vlan-interface204] interface Vlan-interface210
[HP10504-vlan-interface210] ip address 192.18.210.1 255.255.255.0
[HP10504-vlan-interface210] pim sm
[HP10504-vlan-interface210] interface Vlan-interface211
[HP10504-vlan-interface211] ip address 192.18.211.1 255.255.255.0
[HP10504-vlan-interface211] pim sm
[HP10504-vlan-interface211] interface Vlan-interface212
[HP10504-vlan-interface212] ip address 192.18.212.1 255.255.255.0
[HP10504-vlan-interface212] pim sm
[HP10504-vlan-interface212] interface Vlan-interface213
[HP10504-vlan-interface213] ip address 192.18.213.2 255.255.255.0
[HP10504-vlan-interface213] pim sm
[HP10504-vlan-interface213] interface Vlan-interface214
[HP10504-vlan-interface214] ip address 192.18.214.2 255.255.255.0
[HP10504-vlan-interface214] pim sm
```

Then, assign the interfaces to the respective VLANs.

```
[HP10504] interface Ten-GigabitEthernet3/0/1
[HP10504-Ten-Gigabitethernet3/0/1] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/1] quit
[HP10504-Ten-Gigabitethernet3/0/1] description "to HP 5900 1/0/1"
[HP10504-Ten-Gigabitethernet3/0/1] port access vlan 211
[HP10504-Ten-Gigabitethernet3/0/1] interface Ten-GigabitEthernet3/0/2
[HP10504-Ten-Gigabitethernet3/0/2] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/2] description "to HP5500-HI 1/1/1"
[HP10504-Ten-Gigabitethernet3/0/2] port access vlan 210
[HP10504-Ten-Gigabitethernet3/0/2] interface Ten-GigabitEthernet3/0/3
[HP10504-Ten-Gigabitethernet3/0/3] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/3] description "to HP 5406R A1"
```

```
[HP10504-Ten-GigabitEthernet3/0/3] port access vlan 212
[HP10504-Ten-GigabitEthernet3/0/3] interface Ten-GigabitEthernet3/0/4
[HP10504-Ten-GigabitEthernet3/0/4] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/4] description "to c6509 t2/1"
[HP10504-Ten-GigabitEthernet3/0/4] port access vlan 200
[HP10504-Ten-GigabitEthernet3/0/4] interface Ten-GigabitEthernet3/0/7
[HP10504-Ten-GigabitEthernet3/0/7] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/7] description "to c3850 t1/1/3"
[HP10504-Ten-GigabitEthernet3/0/7] port access vlan 214
[HP10504-Ten-GigabitEthernet3/0/7] interface Ten-GigabitEthernet3/0/8
[HP10504-Ten-GigabitEthernet3/0/8] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/8] description "to STC 3/3"
[HP10504-Ten-GigabitEthernet3/0/8] port access vlan 204
[HP10504-Ten-GigabitEthernet3/0/8] interface Ten-GigabitEthernet3/0/17
[HP10504-Ten-GigabitEthernet3/0/17] port link-mode bridge
[HP10504-Ten-GigabitEthernet3/0/17] description "to c4057r g3/3"
[HP10504-Ten-GigabitEthernet3/0/17] port access vlan 213
[HP10504-Ten-GigabitEthernet3/0/17] quit
```

Finally, enable OSPF. Although this is a multicast routing test, PIM requires a unicast routing protocol for reverse path forwarding to work.

```
[HP10504] ospf 1
[HP10504-ospf] area 0.0.0.0
[HP10504-ospf] network 192.18.0.0 0.0.255.255
[HP10504-ospf] quit
```

HP ProVision commands

First, enable unicast and multicast routing.

```
HP5406R# configure
HP5406R(config)# ip routing
HP5406R(config)# ip multicast-routing
```

Next, enable PIM routing.

```
HP5406R(config)# router pim
HP5406R(config-pim)# enable
HP5406R(config-pim)# rp-address 192.18.200.1 224.0.0.0 240.0.0.0
HP5406R(config-pim)# exit
```

Then enable OSPF. Although this is a multicast routing test, PIM requires a unicast routing protocol for reverse path forwarding to work.

```
HP5406R(config)# router ospf
HP5406R(config-ospf)# area backbone
HP5406R(config-ospf)# enable
HP5406R(config-ospf)# exit
```

Next, set up the VLANs that will be used, and bind physical interfaces, IP addresses, and routing protocols to each VLAN.

```
HP5406R(config)# vlan 205
HP5406R(vlan-205)# name "VLAN205"
HP5406R(vlan-205)# untagged A3
HP5406R(vlan-205)# ip address 192.18.205.1 255.255.255.0
HP5406R(vlan-205)# ip ospf 192.18.205.1 area backbone
HP5406R(vlan-205)# ip pim-sparse
HP5406R(vlan-205-pim)# ip-addr any
HP5406R(vlan-205-pim)# exit
HP5406R(vlan-205)# vlan 212
HP5406R(vlan-212)# name "VLAN212"
HP5406R(vlan-212)# untagged A1
HP5406R(vlan-212)# ip address 192.18.212.2 255.255.255.0
HP5406R(vlan-212)# ip ospf 192.18.212.2 area backbone
HP5406R(vlan-212)# ip pim-sparse
HP5406R(vlan-212-pim)# ip-addr any
HP5406R(vlan-212-pim)# exit
HP5406R(vlan-212)# vlan 215
HP5406R(vlan-215)# name "VLAN215"
HP5406R(vlan-215)# untagged B1
HP5406R(vlan-215)# ip address 192.18.215.2 255.255.255.0
HP5406R(vlan-215)# ip ospf 192.18.215.2 area backbone
HP5406R(vlan-215)# ip pim-sparse
HP5406R(vlan-215-pim)# ip-addr any
HP5406R(vlan-215-pim)# exit
HP5406R(vlan-215)# vlan 216
HP5406R(vlan-216)# name "VLAN216"
HP5406R(vlan-216)# untagged B3
HP5406R(vlan-216)# ip address 192.18.216.2 255.255.255.0
HP5406R(vlan-216)# ip ospf 192.18.216.2 area backbone
HP5406R(vlan-216)# ip pim-sparse
HP5406R(vlan-216-pim)# ip-addr any
HP5406R(vlan-216-pim)# exit
HP5406R(vlan-216)# vlan 217
HP5406R(vlan-217)# name "VLAN217"
HP5406R(vlan-217)# untagged B5
HP5406R(vlan-217)# ip address 192.18.217.2 255.255.255.0
HP5406R(vlan-217)# ip ospf 192.18.217.2 area backbone
HP5406R(vlan-217)# ip pim-sparse
HP5406R(vlan-217-pim)# ip-addr any
HP5406R(vlan-217-pim)# exit
```

```
HP5406R(vlan-217)# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 6509-E. Except where noted, the syntax is similar for Cisco Catalyst 3850 and Cisco Catalyst 4507R switches.

First, enable IP multicast routing.

```
Cat6509-E# configure terminal
Cat6509-E(config)# ip multicast-routing
```

The Cisco Catalyst 3850 requires unicast and multicast routing to be enabled.

```
C3850# configure terminal
C3850(config)# ip routing
C3850(config)# ip multicast-routing
```

Cisco Catalyst 3850, Cisco Catalyst 4507R, and Cisco Catalyst 6509-E switches use similar commands for the remaining steps.

Configure the PIM rendezvous point. This uses the IP address of the VLAN 200 interface, to be configured later in this section.

```
Cat6509-E(config)# ip pim rp-address 192.18.200.1
```

Then, enable OSPF. Although OSPF is not required for IP multicast forwarding, some unicast routing protocol or static routing is required for reverse path forwarding to work.

```
Cat6509-E(config)# router ospf 1
Cat6509-E(config-rtr)# log-adjacency-changes
Cat6509-E(config-rtr)# network 192.18.0.0 0.0.255.255 area 0
Cat6509-E(config-rtr)# exit
```

Next, define VLANs and VLAN interfaces. Each VLAN interface definition includes PIM routing and IGMP.

```
Cat6509-E(config)# vlan 200-223
Cat6509-E(config)# interface Vlan200
Cat6509-E(config-if)# ip address 192.18.200.1 255.255.255.0
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# interface Vlan201
Cat6509-E(config-if)# ip address 192.18.201.1 255.255.255.0
```

```
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# interface Vlan208
Cat6509-E(config-if)# ip address 192.18.208.1 255.255.255.0
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# interface Vlan209
Cat6509-E(config-if)# ip address 192.18.209.1 255.255.255.0
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# interface Vlan215
Cat6509-E(config-if)# ip address 192.18.215.1 255.255.255.0
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# interface Vlan218
Cat6509-E(config-if)# ip address 192.18.218.1 255.255.255.0
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# interface Vlan221
Cat6509-E(config-if)# ip address 192.18.221.1 255.255.255.0
Cat6509-E(config-if)# ip pim sparse-mode
Cat6509-E(config-if)# ip igmp version 3
Cat6509-E(config-if)# end
```

Validation

Once subscribers attached to the HP switches have joined multicast groups by sending IGMP reports with join messages, any multicast traffic for these groups offered to interface VLAN200 on the Catalyst 6509-E will be forwarded to all subscriber ports on the HP and Cisco switches.

The HP Comware command "**`display ip multicast routing-table`**" will verify that the HP and Cisco devices see one another and can exchange multicast information. The HP ProVision command "**`show ip mrouter`**" provides the same verification for HP 5406R Ethernet switches.

Multicast switching

Objective

To verify the ability of HP Networking and Cisco Catalyst switches to correctly forward IP multicast traffic in a switched environment.

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 devices that wish to receive multicast traffic. 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 an IP multicast group address, it will forward it only to those interfaces from which it has heard membership reports.

Topology

In this example, both HP and Cisco switches operate purely in Layer-2 mode, with no multicast or unicast routing protocols configured. This test case assumes routing is handled elsewhere in the network.

The Spirent TestCenter instrument emulates a streaming video server generating traffic on specific multicast addresses to the Cisco Catalyst 6509-E. All switches then use IGMP snooping tables to determine which ports should and should not receive multicast traffic.

The emulated streaming video server sends traffic to 10 multicast group addresses in the range of 225.0.1.0 through 225.0.1.9. Subscribers attached to the HP and Cisco switches join all 10 multicast groups.

Figure 1 illustrates the topology used to validate IP multicast switching functionality. Both the HP and Cisco switches use IGMP snooping.

Procedure

HP Comware commands

In this example, all interfaces use the default VLAN for untagged traffic and IGMP snooping is enabled for that VLAN. Further, this test will use IGMPv3, the most recent version of the protocol.

First, globally enable IGMP snooping. This example also uses "fast leave" on VLAN 1, which tells the switch to remove group membership entries from the IGMP snooping table as soon as it receives an IGMP leave message.

```
<HP10504> system-view
[HP10504] igmp-snooping
[HP10504-igmp-snooping] fast-leave vlan 1
[HP10504-igmp-snooping] quit
```

IGMP snooping also must be enabled on a per-VLAN basis. Only one VLAN is used in this switching example.

```
<HP10504> system-view
[HP10504] vlan 1
[HP10504-Vlan1] igmp-snooping enable
[HP10504-Vlan1] igmp-snooping version 3
[HP10504-Vlan1] quit
```

HP ProVision commands

On HP ProVision switches, IGMP snooping also is enabled on a per-VLAN basis. This example also uses IGMP fast leave for VLAN 1.

```
HP5406R# configure
HP5406R(config)# vlan 1
HP5406R(vlan-1)# name "DEFAULT_VLAN"
HP5406R(vlan-1)# untagged A1-A8,B1-B22
HP5406R(vlan-1)# ip igmp
HP5406R(vlan-1)# ip igmp forcedfastleave A1-A8,B1-B22
HP5406R(vlan-1)# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 6509-E. Except where noted, the syntax is similar for the Catalyst 3850 switches and Cisco Catalyst 4507R switches.

Enable IGMP snooping. IGMP snooping is enabled by default on Cisco Catalyst switches for all VLANs. In case it is disabled, it can be enabled with these commands:

```
Cat6509-E# configure terminal
Cat6509-E(config)# ip igmp snooping
```

Optionally, enable an IGMP querier. Only one querier should be defined across all switches that share a common VLAN ID. A querier must be present to prevent IGMP snooping table entries from expiring. Normally, a multicast router would act as a querier. This step is included only because this test bed is switched, not routed. Also, while this example uses a Cisco device, the HP devices also could have also acted as an IGMP querier.

```
Cat6509-E(config)# interface Vlan1
Cat6509-E(config-if)# ip address 192.18.200.1 255.255.255.0
Cat6509-E(config-if)# ip igmp snooping querier
Cat6509-E(config-if)# end
```

Validation

Once subscribers attached to the switches have joined multicast groups by sending IGMP reports with join messages, multicast traffic for these groups will be forwarded to all subscriber ports.

The HP Comware switch command "**`display igmp-snooping group`**" also will verify that switches can see one another and exchange IGMP membership information.

The HP ProVision switch command "**`show ip igmp`**" also will verify that switches can see one another and exchange IGMP membership information.

OSPFv2 (OSPF for IPv4)

Objective

To verify that HP Networking and Cisco Catalyst switches are able to establish open shortest path first version 2 (OSPFv2) connections, exchange topology information, and forward traffic to networks learned using OSPF.

Background

Intended for use on IPv4 networks, OSPFv2 supports IP subnetting and redistribution of routing information learned via other protocols. OSPF optionally allows session authentication and uses IP multicast for distribution of routing updates. RFC 2328 describes OSPFv2.

OSPF uses areas to segment traffic, with area 0 designated as the backbone network. OSPF typically involves coordination among multiple internal routers; area border routers (ABRs) connected to multiple areas; and autonomous system boundary routers (ASBRs).

In addition to standard areas, OSPFv2 also defines two special types of areas: Stubs are areas into which information on external routes is not sent. Instead, the area border router (ABR) generates a default external route into the stub area. A Not-So-Stubby-Area (NSSA) is like a stub area, but it can import external routes into the area for redistribution via OSPF.

Topology

In this example, all HP and Cisco devices are partially meshed, meaning all HP devices are connected to all Cisco devices, and vice-versa. All devices also connected to the Spirent TestCenter test instrument. Each HP and Cisco switch is configured with multiple networks, which were then advertised by OSPF to its neighbors.

Figure 6 illustrates the OSPFv2 test bed. The Spirent TestCenter traffic generator/analyzer also runs OSPFv2, and advertises networks "behind" each device. By sending traffic to all these advertised networks, Spirent TestCenter verifies that all routers correctly learn and forward traffic.

Although not required, the configuration examples given here are in switch virtual interface (SVI) mode, where IP addresses are bound to VLAN interfaces rather than physical interfaces. OSPF routing would work equally well with IP addresses configured directly on physical interfaces.

Note that all IP addresses use the 192.18.x.0/24 format, with a unique third byte for each network. This third byte is also the VLAN ID. For example, interfaces in the 192.18.200.0/24 network are also members of VLAN 200.

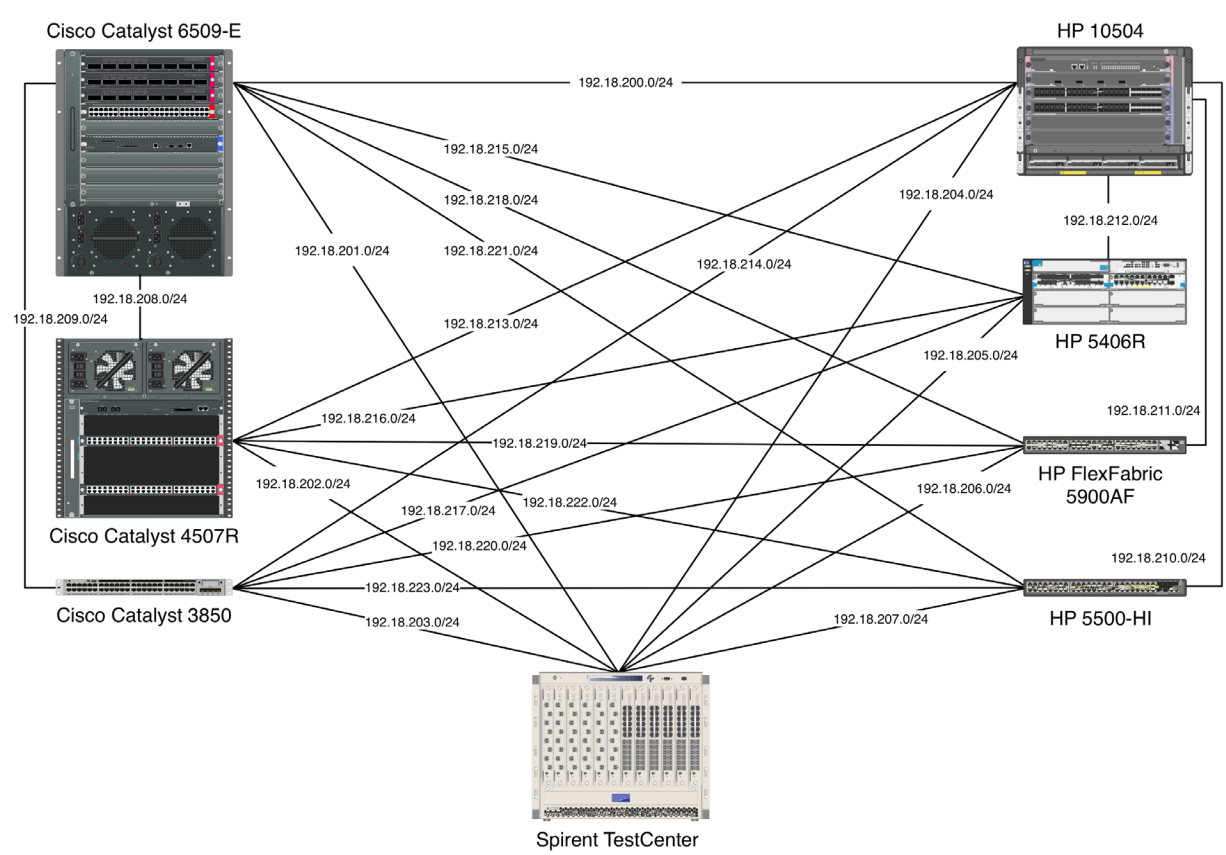

Figure 6: OSPFv2 test bed

Procedure

HP Comware commands

In this example, switched virtual interfaces (SVIs) are created using VLAN interfaces. Physical interfaces are then mapped to the VLAN interfaces. Routing is done between VLAN interfaces on each switch.

Create the VLANs.

```
<HP10504> system-view
[HP10504] vlan 200
[HP10504] vlan 204
[HP10504] vlan 210 to 214
```

Create the switched virtual interfaces. Where an HP and Cisco device share a common link, the Cisco device uses the ".1" address and the HP device uses the ".2" address. In all other cases, the HP device uses the ".1" address.

```
[HP10504] interface Vlan-interface200
```

```
[HP10504-vlan-interface200] ip address 192.18.200.2 255.255.255.0
[HP10504-vlan-interface200] interface Vlan-interface204
[HP10504-vlan-interface204] ip address 192.18.204.1 255.255.255.0
[HP10504-vlan-interface204] interface Vlan-interface210
[HP10504-vlan-interface210] ip address 192.18.210.1 255.255.255.0
[HP10504-vlan-interface210] interface Vlan-interface211
[HP10504-vlan-interface211] ip address 192.18.211.1 255.255.255.0
[HP10504-vlan-interface211] interface Vlan-interface212
[HP10504-vlan-interface212] ip address 192.18.212.1 255.255.255.0
[HP10504-vlan-interface212] interface Vlan-interface213
[HP10504-vlan-interface213] ip address 192.18.213.2 255.255.255.0
[HP10504-vlan-interface213] interface Vlan-interface214
[HP10504-vlan-interface214] ip address 192.18.214.2 255.255.255.0
[HP10504-vlan-interface214] quit
```

Associate the physical interfaces with the corresponding SVIs.

```
[HP10504] interface Ten-GigabitEthernet3/0/1
[HP10504-Ten-Gigabitethernet3/0/1] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/1] description "to HP 5900AF 1/0/1"
[HP10504-Ten-Gigabitethernet3/0/1] port access vlan 211
[HP10504-Ten-Gigabitethernet3/0/1] interface Ten-GigabitEthernet3/0/2
[HP10504-Ten-Gigabitethernet3/0/2] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/2] description "to HP5500-HI 1/1/1"
[HP10504-Ten-Gigabitethernet3/0/2] port access vlan 210
[HP10504-Ten-Gigabitethernet3/0/2] interface Ten-GigabitEthernet3/0/3
[HP10504-Ten-Gigabitethernet3/0/3] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/3] description "to HP 5406R A1"
[HP10504-Ten-Gigabitethernet3/0/3] port access vlan 212
[HP10504-Ten-Gigabitethernet3/0/3] interface Ten-GigabitEthernet3/0/4
[HP10504-Ten-Gigabitethernet3/0/4] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/4] description "to c6509 t2/1"
[HP10504-Ten-Gigabitethernet3/0/4] port access vlan 200
[HP10504-Ten-Gigabitethernet3/0/4] interface Ten-GigabitEthernet3/0/7
[HP10504-Ten-Gigabitethernet3/0/7] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/7] description "to HP c3850 t1/1/3"
[HP10504-Ten-Gigabitethernet3/0/7] port access vlan 214
[HP10504-Ten-Gigabitethernet3/0/7] interface Ten-GigabitEthernet3/0/8
[HP10504-Ten-Gigabitethernet3/0/8] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/8] description "to STC 3/3"
[HP10504-Ten-Gigabitethernet3/0/8] port access vlan 204
[HP10504-Ten-Gigabitethernet3/0/8] interface Ten-GigabitEthernet3/0/17
[HP10504-Ten-Gigabitethernet3/0/17] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/17] description "to c4057r g3/3"
[HP10504-Ten-Gigabitethernet3/0/17] port access vlan 213
[HP10504-Ten-Gigabitethernet3/0/17] quit
```

Configure OSPF routing. Note the use of route summarization; the command "**network 192.18.0.0 0.0.255.255**" covers all networks in the 192.18.0.0/16 space. If any peers were in noncontiguous address space (for example, 192.18.1.0/24 and 192.18.3.0/24), then individual "**network**" statements would be required.

```
[HP10504] ospf 1
[HP10504-ospf] area 0.0.0.0
[HP10504-ospf] network 192.18.0.0 0.0.255.255
[HP10504-ospf] quit
[HP10504] quit
```

HP ProVision commands

For the HP ProVision switches, a single command sets up VLANs and assigns physical interfaces to those VLANs.

Enable IP routing .

```
HP5406R# configure
HP5406R(config)# ip routing
```

Enable OSPF routing for area 0.

```
HP5406R(config)# ip router-id 192.18.205.1
HP5406R(config)# router ospf
HP5406R(ospf)# area backbone
HP5406R(ospf)# enable
HP5406R(ospf)# exit
```

Create the switched virtual interfaces and enable OSPF on each interface. Where an HP and Cisco device share a common link, the Cisco device uses the ".1" address and the HP device uses the ".2" address. In all other cases, the HP device uses the ".1" address.

```
HP5406R(config)# vlan 205
HP5406R(vlan-205)# name "VLAN205"
HP5406R(vlan-205)# untagged A3
HP5406R(vlan-205)# ip address 192.18.205.1 255.255.255.0
HP5406R(vlan-205)# ip ospf 192.18.205.1 area backbone
HP5406R(vlan-205)# exit
HP5406R(vlan-205)# vlan 212
HP5406R(vlan-212)# name "VLAN212"
HP5406R(vlan-212)# untagged A1
HP5406R(vlan-212)# ip address 192.18.212.2 255.255.255.0
HP5406R(vlan-212)# ip ospf 192.18.212.2 area backbone
HP5406R(vlan-212)# exit
HP5406R(vlan-212)# vlan 215
HP5406R(vlan-215)# name "VLAN215"
```

```
HP5406R(vlan-215)# untagged B1
HP5406R(vlan-215)# ip address 192.18.215.2 255.255.255.0
HP5406R(vlan-215)# ip ospf 192.18.215.2 area backbone
HP5406R(vlan-215)# exit
HP5406R(vlan-215)# vlan 216
HP5406R(vlan-216)# name "VLAN216"
HP5406R(vlan-216)# untagged B3
HP5406R(vlan-216)# ip address 192.18.216.2 255.255.255.0
HP5406R(vlan-216)# ip ospf 192.18.216.2 area backbone
HP5406R(vlan-216)# exit
HP5406R(vlan-216)# vlan 217
HP5406R(vlan-217)# name "VLAN217"
HP5406R(vlan-217)# untagged B5
HP5406R(vlan-217)# ip address 192.18.217.2 255.255.255.0
HP5406R(vlan-217)# ip ospf 192.18.217.2 area backbone
HP5406R(vlan-217)# exit
```

Cisco commands

On Cisco Catalyst switches, like HP Comware switches, create the VLANs first and then assign physical interfaces to the VLAN interfaces. The following commands apply to a Cisco Catalyst 6509-E. The syntax is similar for Cisco Catalyst 3850 switches and Cisco Catalyst 4507R switches.

One difference with the Cisco Catalyst 3850 is that it requires IPv4 routing to be explicitly enabled. This step is not needed with the Catalyst 6509-E or Catalyst 4507R.

```
Cat3850# configure terminal
Cat3850(config)# ip routing
```

Next, create VLANs and VLAN interfaces and assign IP addresses to those interfaces.

```
Cat6509-E# configure terminal
Cat6509-E(config)# vlan 200-223
Cat6509-E(config-vlan)# interface Vlan200
Cat6509-E(config-if)# ip address 192.18.200.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan201
Cat6509-E(config-if)# ip address 192.18.201.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan208
Cat6509-E(config-if)# ip address 192.18.208.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan209
Cat6509-E(config-if)# ip address 192.18.209.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan215
Cat6509-E(config-if)# ip address 192.18.215.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan218
Cat6509-E(config-if)# ip address 192.18.218.1 255.255.255.0
Cat6509-E(config-if)# interface Vlan221
Cat6509-E(config-if)# ip address 192.18.221.1 255.255.255.0
Cat6509-E(config-if)# exit
```

Next, assign physical interfaces to the VLANs.

```
Cat6509-E(config)# interface TenGigabitEthernet1/1
Cat6509-E(config-if)# description to c4507R t1/1
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 208
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet1/3
Cat6509-E(config-if)# description to c3850 t1/1/3
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 209
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet2/1
Cat6509-E(config-if)# description to HP 10504 3/0/4
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 200
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet2/3
Cat6509-E(config-if)# description to HP 5500-HI 1/0/53
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 221
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet3/1
Cat6509-E(config-if)# description to HP 5900 1/0/3
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 218
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet3/3
Cat6509-E(config-if)# description to STC 3/1
Cat6509-E(config-if)# switchport
Cat6509-E(config-if)# switchport access vlan 201
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# exit
```

Finally, enable OSPF routing.

```
Cat6509-E(config)# router ospf 1
Cat6509-E(config-ospf)# log-adjacency-changes
Cat6509-E(config-ospf)#  network 192.18.0.0 0.0.255.255 area 0
Cat6509-E(config-ospf)#  end
```

Validation

If the HP and Cisco devices are unable to complete OSPF negotiation, routing adjacencies will remain in the ExStart state. Fully functional adjacencies will be in the Full state. On a Comware device, the "**display ospf peer**" command will verify that an OSPF adjacency has entered OSPF Full state.

```
<hp10504> display ospf peer

                OSPF Process 1 with Router ID 15.234.147.153
                        Neighbor Brief Information

 Area: 0.0.0.0
 Router ID       Address         Pri Dead-Time Interface       State
 15.234.147.146  192.18.200.1    1   39        Vlan200         Full/BDR
 192.18.204.2    192.18.204.2    0   39        Vlan204         Full/DROther
 15.234.147.152  192.18.210.2    1   34        Vlan210         Full/BDR
 15.234.147.149  192.18.211.2    1   34        Vlan211         Full/BDR
 15.234.147.154  192.18.212.2    1   38        Vlan212         Full/BDR
 15.234.147.147  192.18.213.1    1   34        Vlan213         Full/BDR
 15.234.147.145  192.18.214.1    1   39        Vlan214         Full/BDR
```

The equivalent command on HP ProVision and Cisco devices is "**show ip ospf neighbor**".

```
HP5406R # show ip ospf neighbor

 OSPF Neighbor Information

                                                          Rxmt          Helper
  Router ID       Pri IP Address      NbIfState State     QLen  Events  Status
  --------------- --- --------------- --------- -------- ----- ------ ------
  192.18.205.2    0   192.18.205.2              FULL     0     6       None
  15.234.147.153  1   192.18.212.1    DR        FULL     0     6       None
  15.234.147.146  1   192.18.215.1    BDR       FULL     0     27      None
  15.234.147.147  1   192.18.216.1    DR        FULL     0     6       None
  15.234.147.145  1   192.18.217.1    BDR       FULL     0     11      None
```

```
Cat6509-E# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
15.234.147.153    1   FULL/DR         00:00:31    192.18.200.2    Vlan200
15.234.147.154    1   FULL/DR         00:00:39    192.18.215.2    Vlan215
15.234.147.149    1   FULL/DR         00:00:34    192.18.218.2    Vlan218
15.234.147.152    1   FULL/BDR        00:00:35    192.18.221.2    Vlan221
192.18.201.2      0   FULL/DROTHER    00:00:32    192.18.201.2    Vlan201
15.234.147.147    1   FULL/BDR        00:00:37    192.18.208.2    Vlan208
15.234.147.145    1   FULL/BDR        00:00:37    192.18.209.2    Vlan209
```

To validate the ability of all devices to forward traffic to routes learned via OSPF, the Spirent TestCenter instrument advertised 10 networks to each devices, and then offered traffic to networks "behind" all other devices. The ability of all devices to forward this traffic without loss is a positive indicator that OSPF routing works as intended.

OSPFv3 (OSPF for IPv6)

Objective

To verify that HP Networking and Cisco Catalyst switches are able to establish open shortest path first version 3 (OSPFv3) connections, exchange topology information, and forward traffic to networks learned using OSPF.

Background

OSPFv3 updates the routing protocol for use on IPv6 networks. In a mixed IPv4/IPv6 environment, OSPFv2 must be used in conjunction with OSPFv3.

While the basic mechanics of OSPF are identical in both versions, OSPFv3 introduces new link-state advertisement (LSA) types; removes addressing semantics from OSPF headers; generalizes flooding; and removes OSPF-layer authentication, among other changes. RFC 5340 describes OSPFv3.

Topology

In this example, all HP and Cisco devices are partially meshed, meaning all HP devices are connected to all Cisco devices, and vice-versa. All devices also connected to the Spirent TestCenter test instrument. Each HP and Cisco switch is configured with multiple networks, which were then advertised by OSPF to its neighbors.

Figure 7 illustrates the OSPFv3 test bed. The Spirent TestCenter traffic generator/analyzer also runs OSPFv3, and advertises networks "behind" each device. By sending traffic to all these advertised networks, Spirent TestCenter verifies that all routers correctly learn and forward traffic.

Although not required, the configuration examples given here are in switch virtual interface (SVI) mode, where IP addresses are bound to VLAN interfaces rather than physical interfaces. OSPF routing would work equally well with IP addresses configured directly on physical interfaces.

Also, for simplicity this section covers only IPv6 and OSPFv3 configuration. Where required, dual-stack environments can concurrently run OSPFv2 by configuring IPv4 addresses and enabling OSPFv2 as described in the "OSPFv2 (OSPF for IPv4)" section.

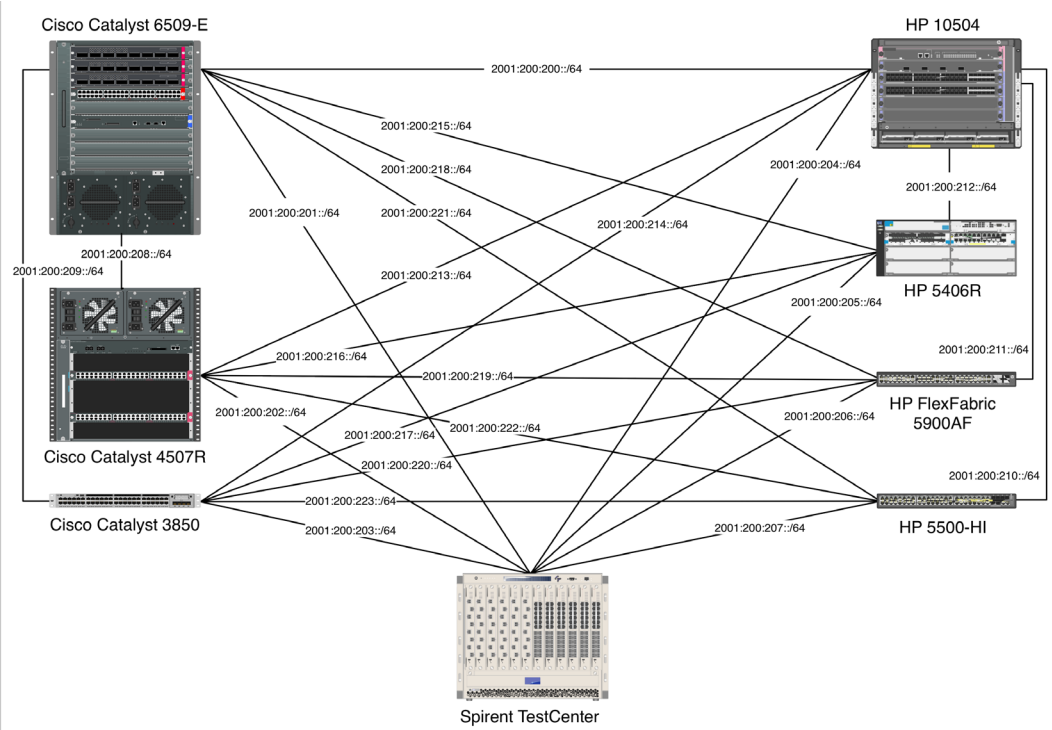

Figure 7: OSPFv3 test bed

Procedure

HP Comware commands

In this example, switched virtual interfaces (SVIs) are created using VLAN interfaces. Physical interfaces are then mapped to the VLAN interfaces. Routing is done between VLAN interfaces on each switch. Unlike OSPFv2, OSPv3 configuration is done on the actual routable interface.

Comware v5 devices such as the HP5500-HI require IPv6 to be explicitly enabled. This step is not required for the Comware v7 devices such as the HP 10504 and HP FlexFabric 5900AF.

```
<HP5500-HI> system-view
[HP5500-HI] ipv6
```

The rest of this example uses the HP 10504. The commands are identical for Comware v7 and Comware v5 devices. The command "**undo ipv6 nd ra halt**" command enables IPv6 router advertisement messages. Here, the command is given only on the interface connected with the Spirent TestCenter instrument to allow replies to neighbor discovery messages. This command should be used wherever neighbor discovery is required.

Where an HP and Cisco device share a common link, the Cisco device uses the address ending in "**::1**" and the HP device uses the address ending in "**::2**". In all other cases, the HP device uses the "**::1**" address.

```
<HP10504> system-view
[HP10504] interface Vlan-interface200
[HP10504-vlan-interface200] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface200] ipv6 address 2001:200:200::2/64
[HP10504-vlan-interface200] interface Vlan-interface204
[HP10504-vlan-interface204] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface204] ipv6 address 2001:200:204::1/64
[HP10504-vlan-interface204] undo ipv6 nd ra halt
[HP10504-vlan-interface204] interface Vlan-interface210
[HP10504-vlan-interface210] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface210] ipv6 address 2001:200:210::1/64
[HP10504-vlan-interface210] interface Vlan-interface211
[HP10504-vlan-interface211] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface211] ipv6 address 2001:200:211::1/64
[HP10504-vlan-interface211] interface Vlan-interface212
[HP10504-vlan-interface212] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface212] ospfv3 network-type broadcast
[HP10504-vlan-interface212] ipv6 address 2001:200:212::1/64
[HP10504-vlan-interface212] interface Vlan-interface213
[HP10504-vlan-interface213] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface213] ipv6 address 2001:200:213::2/64
[HP10504-vlan-interface213] interface Vlan-interface214
[HP10504-vlan-interface214] ospfv3 1 area 0.0.0.0
[HP10504-vlan-interface214] ipv6 address 2001:200:214::2/64
[HP10504-vlan-interface214] quit
```

Next, assign the physical interfaces to the VLANs.

```
[HP10504] interface Ten-GigabitEthernet3/0/1
[HP10504-Ten-Gigabitethernet3/0/1] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/1] description "to HP 5900 1/0/1"
[HP10504-Ten-Gigabitethernet3/0/1] port access vlan 211
[HP10504-Ten-Gigabitethernet3/0/1] interface Ten-GigabitEthernet3/0/2
[HP10504-Ten-Gigabitethernet3/0/2] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/2] description "to HP5500-HI 1/1/1"
[HP10504-Ten-Gigabitethernet3/0/2] port access vlan 210
[HP10504-Ten-Gigabitethernet3/0/2] interface Ten-GigabitEthernet3/0/3
[HP10504-Ten-Gigabitethernet3/0/3] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/3] description "to HP 5406R A1,A2"
[HP10504-Ten-Gigabitethernet3/0/3] port access vlan 212
[HP10504-Ten-Gigabitethernet3/0/3] interface Ten-GigabitEthernet3/0/4
[HP10504-Ten-Gigabitethernet3/0/4] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/4] description "to c6509 t2/1-2"
[HP10504-Ten-Gigabitethernet3/0/4] port access vlan 200
[HP10504-Ten-Gigabitethernet3/0/4] interface Ten-GigabitEthernet3/0/7
[HP10504-Ten-Gigabitethernet3/0/7] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/7] description "to c3850 t1/1/3-4"
[HP10504-Ten-Gigabitethernet3/0/7] port access vlan 214
[HP10504-Ten-Gigabitethernet3/0/7] interface Ten-GigabitEthernet3/0/8
[HP10504-Ten-Gigabitethernet3/0/8] port link-mode bridge
```

```
[HP10504-Ten-Gigabitethernet3/0/8] description “to STC 3/3-4”
[HP10504-Ten-Gigabitethernet3/0/8] port access vlan 204
[HP10504-Ten-Gigabitethernet3/0/8] interface Ten-GigabitEthernet3/0/17
[HP10504-Ten-Gigabitethernet3/0/17] port link-mode bridge
[HP10504-Ten-Gigabitethernet3/0/17] description “to c4057r g3/3-4”
[HP10504-Ten-Gigabitethernet3/0/17] port access vlan 213
[HP10504-Ten-Gigabitethernet3/0/17] quit
```

Finally, configure OSPFv3 routing. This example defines OSPFv3 with a process ID of 1.

```
[HP10504] ospfv3 1
[HP10504-ospfv3] router-id 15.234.147.153
[HP10504-ospfv3] area 0.0.0.0
[HP10504-ospfv3] quit
[HP10504] quit
```

HP ProVision commands

For HP ProVision switches, a single command sets up VLANs and assigns physical interfaces to the VLANs. First, enable routing.

```
HP5406R# configure
HP5406R(config)# ipv6 unicast-routing
```

Create the switched virtual interfaces and enable OSPF on each interface. Where an HP and Cisco device share a common link, the Cisco device uses the address ending in “**::1**” and the HP device uses the address ending in “**::2**”. In all other cases, the HP device uses the “**::1**” address.

```
HP5406R(config)# vlan 205
HP5406R(vlan-205)# name “VLAN205”
HP5406R(vlan-205)# untagged A3
HP5406R(vlan-205)# ipv6 address 2001:200:205::1/64
HP5406R(vlan-205)# ipv6 ospf3 area backbone
HP5406R(vlan-205)# vlan 212
HP5406R(vlan-212)# name “VLAN212”
HP5406R(vlan-212)# untagged A1
HP5406R(vlan-212)# ipv6 address 2001:200:212::2/64
HP5406R(vlan-212)# ipv6 ospf3 area backbone
HP5406R(vlan-212)# vlan 215
HP5406R(vlan-215)# name “VLAN215”
HP5406R(vlan-215)# untagged B1
HP5406R(vlan-215)# ipv6 address 2001:200:215::2/64
HP5406R(vlan-215)# ipv6 ospf3 area backbone
HP5406R(vlan-215)# vlan 216
HP5406R(vlan-216)# name “VLAN216”
HP5406R(vlan-216)# untagged B3
HP5406R(vlan-217)# ip address 192.18.216.2 255.255.255.0
HP5406R(vlan-216)# ip ospf 192.18.216.2 area backbone
HP5406R(vlan-216)# ipv6 address 2001:200:216::2/64
HP5406R(vlan-216)# ipv6 ospf3 area backbone
```

```
HP5406R(vlan-216)# name “VLAN217”
HP5406R(vlan-217)# untagged B5
HP5406R(vlan-217)# ipv6 address 2001:200:217::2/64
HP5406R(vlan-217)# ipv6 ospf3 area backbone
HP5406R(vlan-217)# exit
```

Then, configure the OSPF processes.

```
HP5406R(config)# router ospf3
HP5406R(ospf3)# area backbone
HP5406R(ospf3)# enable
HP5406R(ospf3)# exit
```

Cisco commands

On Cisco Catalyst switches, like HP Comware switches, create the VLANs first and then assign physical interfaces to the VLAN instances. The following commands apply to a Cisco Catalyst 6509-E. Except where noted, the syntax is similar for the Cisco Catalyst 3850 and Cisco Catalyst 4507R switches.

First, enable IPv6 routing.

```
Cat6509-E# configure terminal
Cat6509-E(config)# ipv6 unicast-routing
```

Next, configure VLANs and define IPv6 addresses and OSPFv3 routing on those VLANs.

```
Cat6509-E(config)# interface Vlan203
Cat6509-E(config-if)# ipv6 address 2001:200:203::1/64
Cat6509-E(config-if)# ipv6 ospf 1 area 0
Cat6509-E(config-if)# interface Vlan209
Cat6509-E(config-if)# ipv6 address 2001:200:209::2/64
Cat6509-E(config-if)# ipv6 ospf 1 area 0
Cat6509-E(config-if)# interface Vlan214
Cat6509-E(config-if)# ipv6 address 2001:200:214::1/64
Cat6509-E(config-if)# ipv6 ospf 1 area 0
Cat6509-E(config-if)# interface Vlan217
Cat6509-E(config-if)# ipv6 address 2001:200:217::1/64
Cat6509-E(config-if)# ipv6 ospf 1 area 0
Cat6509-E(config-if)# interface Vlan220
Cat6509-E(config-if)# ipv6 address 2001:200:220::1/64
Cat6509-E(config-if)# ipv6 ospf 1 area 0
Cat6509-E(config-if)# interface Vlan223
Cat6509-E(config-if)# ipv6 address 2001:200:223::1/64
Cat6509-E(config-if)# ipv6 ospf 1 area 0
```

Finally, configure the OSPF router process. This example defines OSPFv3 with a process ID of 1.

```
Cat6509-E(config)# ipv6 router ospf 1
Cat6509-E(config-ipv6-ospf)# router-id 15.234.147.145
Cat6509-E(config-ipv6-ospf)# log-adjacency-changes
Cat6509-E(config-ipv6-ospf)# end
```

Validation

If the HP and Cisco devices are unable to complete OSPF negotiation, routing adjacencies will remain in the ExStart state. Fully functional adjacencies will be in the Full state. On an HP Comware device, the "**display ospfv3 peer**" command will verify that an OSPFv3 adjacency has entered OSPF Full state.

```
<HP10504> display ospfv3 peer

              OSPFv3 Process 1 with Router ID 15.234.147.153

 Area: 0.0.0.0
--------------------------------------------------------------------------
 Router ID       Pri State             Dead-Time Interface         Inst ID
 15.234.147.146  1   Full/DR           00:00:33  Vlan200           0
 191.0.0.5       0   Full/DROther      00:00:33  Vlan204           0
 15.234.147.152  1   Full/BDR          00:00:32  Vlan210           0
 15.234.147.149  1   Full/BDR          00:00:39  Vlan211           0
 15.234.147.154  1   Full/DR           00:00:34  Vlan212           0
 15.234.147.147  1   Full/DR           00:00:31  Vlan213           0
 15.234.147.145  1   Full/DR           00:00:33  Vlan214           0
```

The equivalent command on HP ProVision and Cisco switches is "**show ipv6 ospf neighbor**".

```
HP5406R# show ipv6 ospf neighbor

 OSPFv3 Neighbor Information

  Interface   Router ID       Pri   State      Rxmt QLen  Events
  ----------- --------------- ----- ---------- ---------- ----------
  vlan-205    191.0.0.7       0     FULL       0          0
  vlan-212    15.234.147.153  1     FULL       0          0
  vlan-215    15.234.147.146  1     FULL       0          0
  vlan-216    15.234.147.147  1     FULL       0          0
  vlan-217    15.234.147.145  1     FULL       0          0
```

```
Cat6509-E# show ipv6 ospf neighbor

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
15.234.147.145    1   FULL/DR         00:00:35    65              Vlan209
15.234.147.153    1   FULL/BDR        00:00:34    5001            Vlan200
15.234.147.154    1   FULL/DR         00:00:37    888             Vlan215
15.234.147.149    1   FULL/BDR        00:00:33    973             Vlan218
15.234.147.152    1   FULL/DR         00:00:34    87687388        Vlan221
191.0.0.4         0   FULL/DROTHER    00:00:39    0               Vlan201
15.234.147.147    1   FULL/DR         00:00:34    86              Vlan208
```

To validate the ability of all devices to forward traffic to routes learned via OSPFv3, the Spirent TestCenter instrument advertised 10 networks to each devices, and then offered traffic to networks "behind" all other devices. The ability of all devices to forward this traffic without loss is a positive indicator that OSPF routing works as intended.

Spanning tree case 1: PVST+

Objective

To verify loop prevention between HP Networking and Cisco Catalyst switches using Per-VLAN Spanning Tree protocol (PVST+).

To verify PVST+ reconvergence between HP and Cisco switches after a link failure.

Background

The spanning tree protocol is widely used in campus enterprise networks for loop prevention and redundancy. Most HP Networking switches support Cisco's proprietary per-VLAN spanning tree plus (PVST+) mode. Both the "rapid" version of PVST+ and standards-based rapid spanning tree, defined in IEEE 802.1w, provide much faster convergence time after a link or device failure than the original 802.1D spanning tree specification.

Topology

This example uses redundant paths between all HP Networking and Cisco Catalyst switches in the test bed. The default spanning tree mode in all switches is Cisco's proprietary rapid PVST+; although RPVST+ is interoperable with other vendors' rapid spanning tree implementations, most HP Networking switches also natively support PVST+. One exception is the HP 10504, which ran multiple spanning tree protocol (MSTP) for this test case.

Figure 8 shows the PVST+ validation test bed. In this example, all switches use VLAN trunking for inter-switch connectivity, but this is optional. All versions of spanning tree would also work when switch ports are in access mode. The "VLAN trunking" section of this document covers VLAN configuration. Note that when VLAN trunking is used, trunk ports must allow traffic from VLAN 1 to allow spanning tree bridging protocol data unit (BPDU) frames to pass between switches.

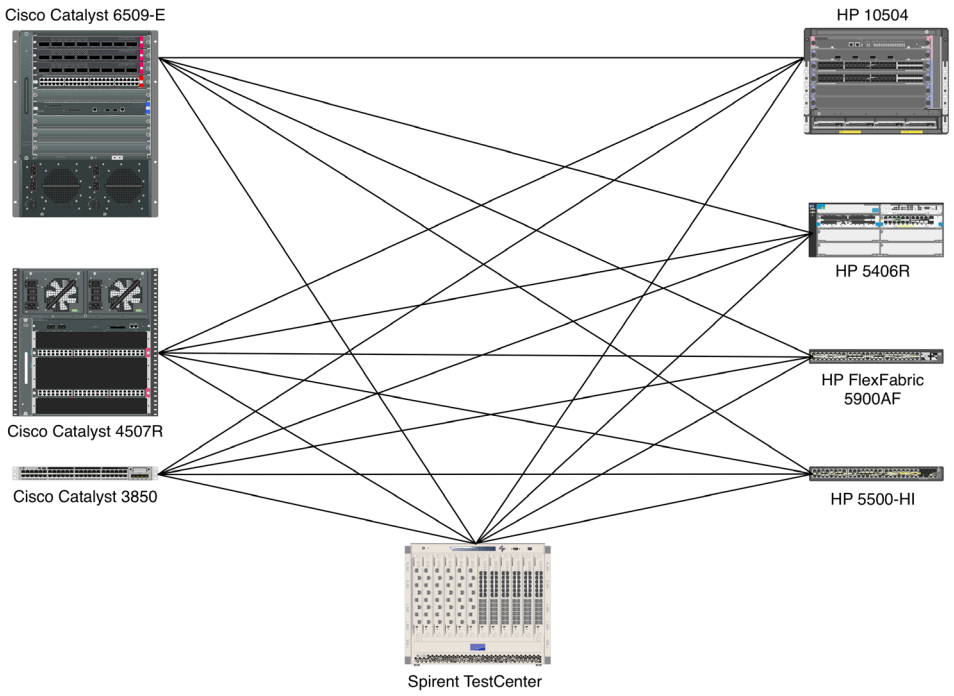

Figure 8: Spanning tree protocol test bed

All switches run PVST+ except the HP 10504, which runs MSTP. Traffic offered from the Spirent TestCenter generator/analysis verifies the spanning tree topology.

Procedure

HP Comware commands

First, enable PVST+ on the HP FlexFabric 5900AF and HP 5500-HI switches.

```
<HP5900AF> system-view
[HP5900AF] stp mode pvst
[HP5900AF] stp global enable
[HP5900AF] quit
```

On the HP 5500-HI running Comware v5, the command to enable spanning tree is "**stp enable**".

Next, enable MSTP on the HP 10504 switches. While the HP 10504 does not support the PVST+, its implementation of MSTP will interoperate with the rest of the test bed running PVST+. This example defines separate spanning tree instances for VLANs 200 through 202.

```
<HP10504> system-view
```

```
[HP10504] stp global enable
[HP10504] stp region-configuration
[HP10504-mst-region] instance 1 vlan 200
[HP10504-mst-region] instance 2 vlan 201
[HP10504-mst-region] instance 3 vlan 202
[HP10504-mst-region] active region-configuration
```

HP ProVision commands

Enable Rapid PVST+ on the HP 5406R.

```
HP5406R# configure
HP5406R(config)# spanning-tree
HP5406R(config)# spanning-tree instance 1 vlan 200
HP5406R(config)# spanning-tree instance 2 vlan 201
HP5406R(config)# spanning-tree instance 3 vlan 202
HP5406R(config)# spanning-tree mode rapid-pvst
HP5406R(config)# exit
```

Cisco commands

Enable rapid-pvst mode on the Cisco switches.

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

Validation

HP Comware switches can use the command "**display stp brief**" to verify the state of rapid spanning tree. In this example, note that some ports will forward traffic and some are in a blocking ("discarding") state.

```
[HP5900AF] display stp brief
 VLAN ID  Port                                Role  STP State   Protection
 200      Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
 200      Ten-GigabitEthernet1/0/3            ALTE  DISCARDING  NONE
 200      Ten-GigabitEthernet1/0/5            DESI  FORWARDING  NONE
 201      Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
 201      Ten-GigabitEthernet1/0/3            ALTE  DISCARDING  NONE
 201      Ten-GigabitEthernet1/0/5            DESI  FORWARDING  NONE
 202      Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
```

```
202      Ten-GigabitEthernet1/0/3            ALTE  DISCARDING  NONE
202      Ten-GigabitEthernet1/0/6            DESI  FORWARDING  NONE
```

HP ProVision and Cisco switches use the command "**show spanning-tree**" to display spanning-tree state.

```
HP5406R# show spanning-tree

 Spanning Tree Information

  STP Enabled          [No] : Yes
  Mode                      : RPVST
  Extended System ID        : Enabled
  Ignore PVID Inconsistency : Disabled
  RPVST Enabled VLANs       : 1,200-202


  Switch MAC Address        : a0481c-f8e100
  Root Guard Ports          :
  Loop Guard Ports          :
  TCN Guard Ports           :
  BPDU Protected Ports      :
  BPDU Filtered Ports       :
  Auto Edge Ports           : A1-A8,B1-B22

  Admin Edge Ports          :

  VLAN  Root Mac         Root       Root       Root                 Hello
  ID    Address          Priority   Path-Cost  Port                 Time(sec)
  ----- ---------------- ---------- ---------- -------------------- ---------
  1     a0481c-f8e100    32,768     0          This switch is root  2
```

```
  200    001c0e-0e28c8    32,768      2000        A1                    2
  201    001c0e-0e28c9    32,768      2000        A1                    2
  202    001c0e-0e28ca    32,768      2000        A1                    2


Cat6509-E# show spanning-tree

VLAN0200
  Spanning tree enabled protocol rstp
  Root ID     Priority    32768
              Address     001c.0e0e.28c8
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768
              Address     001c.0e0e.28c8
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time 300

Interface            Role Sts Cost      Prio.Nbr Type
-------------------- ---- --- --------- -------- --------------------------------
Te1/1                Desg FWD 2          128.1    P2p
Te1/3                Desg FWD 2          128.3    P2p
Te2/1                Desg FWD 2          128.129  P2p
Te2/3                Desg FWD 2          128.131  P2p
Te3/1                Desg FWD 2          128.257  P2p
Te3/3                Desg FWD 2          128.259  P2p
Gi4/3                Desg FWD 4          128.387  P2p
```

To verify all switches only send traffic 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.

Also, the CLI commands given in this section will verify that one port previously in forwarding state is now in blocking state, and that one or more other ports have changed from blocking to forwarding state.

Spanning tree case 2: MSTP/PVST+

Objective

To verify interoperability of multiple spanning tree protocol (MSTP) and per-VLAN spanning tree protocol plus (PVST+) between HP Networking and Cisco Catalyst switches, respectively.

To verify MSTP/PVST+ reconvergence between HP and Cisco switches after a 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 when the HP Networking and Cisco Catalyst switches use different variations of spanning tree: MSTP on HP switches and PVST+ on Cisco Catalyst switches.

Topology

This example uses the same topology as the first spanning tree test, as shown in Figure 7. There are redundant paths and multiple VLANs configured on all switches. The VLAN IDs in use are 200 to 202. MSTP is enabled on all the HP switches, and Rapid PVST+ is enabled on all the Cisco switches.

The links interconnecting each switch are VLAN trunk ports. The "VLAN trunking" section of this document covers VLAN configuration. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

Procedure

HP Comware commands

MSTP is the default mode on HP Comware switches. Configuration involves definition of one multiple spanning tree instance per VLAN.

```
[HP5900AF] stp enable
[HP5900AF] stp region-configuration
[HP5900AF] region-name hp-mstp
[HP5900AF-mst-region]  instance 1 vlan 200
[HP5900AF-mst-region]  instance 2 vlan 201
[HP5900AF-mst-region]  instance 3 vlan 202
```

```
[HP5900AF-mst-region]  active region-configuration
[HP5900AF-mst-region]  quit
[HP5900AF]  quit
```

HP ProVision commands

HP ProVision switches also run MSTP by default. Create the MSTP instances and assign one VLAN to each instance.

```
HP5406R(config)# spanning-tree
HP5406R(config)# spanning-tree config-name "hp-mstp"
HP5406R(config)# spanning-tree instance 1 vlan 200
HP5406R(config)# spanning-tree instance 2 vlan 201
HP5406R(config)# spanning-tree instance 3 vlan 202
HP5406R(config)# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 3850 switch. The syntax is identical for Cisco Catalyst 6509-E and Cisco Catalyst 4507R switches.

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

```
C3850# configure terminal
C3850(config)# spanning-tree mode rapid-pvst
C3850(config)# end
```

Validation

HP Comware switches use the command "**display stp brief**" to verify the state of spanning tree bridges.

```
[HP5900AF] display stp brief
 MST ID   Port                                Role  STP State   Protection
 0        Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
 0        Ten-GigabitEthernet1/0/3            DESI  FORWARDING  NONE
 0        Ten-GigabitEthernet1/0/5            DESI  FORWARDING  NONE
 0        Ten-GigabitEthernet1/0/6            DESI  FORWARDING  NONE
 1        Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
 1        Ten-GigabitEthernet1/0/3            DESI  FORWARDING  NONE
 1        Ten-GigabitEthernet1/0/5            DESI  FORWARDING  NONE
 2        Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
 2        Ten-GigabitEthernet1/0/3            DESI  FORWARDING  NONE
 2        Ten-GigabitEthernet1/0/5            DESI  FORWARDING  NONE
```

```
3        Ten-GigabitEthernet1/0/1            ROOT  FORWARDING  NONE
3        Ten-GigabitEthernet1/0/3            DESI  FORWARDING  NONE
3        Ten-GigabitEthernet1/0/6            DESI  FORWARDING  NONE
```

HP ProVision and Cisco switches use the command "**show spanning-tree**" to display spanning tree bridge state.

```
HP5406R# show spanning-tree

 Multiple Spanning Tree (MST) Information

  STP Enabled   : Yes
  Force Version : MSTP-operation
  IST Mapped VLANs : 1-199,203-4094
  Switch MAC Address : a0481c-f8e100
  Switch Priority    : 32768
  Max Age  : 20
  Max Hops : 20
  Forward Delay : 15

  Topology Change Count  : 11
  Time Since Last Change : 18 mins

  CST Root MAC Address : 443192-55e7cb
  CST Root Priority    : 32768
  CST Root Path Cost   : 0
  CST Root Port        : A1

  IST Regional Root MAC Address : 443192-55e7cb
  IST Regional Root Priority    : 32768
  IST Regional Root Path Cost   : 2000
  IST Remaining Hops            : 19

  Root Guard Ports     :
  Loop Guard Ports     :
  TCN Guard Ports      :
  BPDU Protected Ports :
  BPDU Filtered Ports  :
  PVST Protected Ports :
  PVST Filtered Ports  :

  Root Inconsistent Ports  :
  Loop Inconsistent Ports  :

                   |           Prio                | Designated    Hello
  Port   Type      | Cost      rity State          | Bridge        Time PtP Edge
  ------ --------- + --------- ---- ------------ + ------------- ---- --- ----
  A1     SFP+SR    | 2000      128  Forwarding   | 443192-55e7cb 2    Yes No
  A2     SFP+SR    | Auto      128  Disabled     |               2    Yes No
  A3     SFP+SR    | 2000      128  Forwarding   | a0481c-f8e100 2    Yes Yes
  A4     SFP+SR    | 2000      128  Forwarding   | a0481c-f8e100 2    Yes Yes
  A5     SFP+SR    | Auto      128  Disabled     |               2    Yes No
  A6     SFP+SR    | Auto      128  Disabled     |               2    Yes No
  A7     SFP+SR    | Auto      128  Disabled     |               2    Yes No
  A8     SFP+SR    | Auto      128  Disabled     |               2    Yes No
```

```
  B1     100/1000T | 20000     128  Forwarding   | a0481c-f8e100 2    Yes No
  B2     100/1000T | Auto      128  Disabled     |               2    Yes No
  B3     100/1000T | Auto      128  Disabled     |               2    Yes No
  B4     100/1000T | Auto      128  Disabled     |               2    Yes No
```

```
Cat6509-E# show spanning-tree

VLAN0200
  Spanning tree enabled protocol rstp
  Root ID    Priority    32768
             Address     001c.0e0e.28c8
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768
             Address     001c.0e0e.28c8
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2         128.1    P2p
Te1/3               Desg FWD 2         128.3    P2p
Te2/1               Desg FWD 2         128.129  P2p
Te2/3               Back BLK 2         128.131  P2p
Te3/1               Back BLK 2         128.257  P2p
Te3/3               Desg FWD 2         128.259  P2p
Gi4/3               Back BLK 4         128.387  P2p


VLAN0201
  Spanning tree enabled protocol rstp
  Root ID    Priority    32768
             Address     001c.0e0e.28c9
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768
             Address     001c.0e0e.28c9
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2         128.1    P2p
Te1/3               Desg FWD 2         128.3    P2p
Te2/1               Desg FWD 2         128.129  P2p
Te2/3               Back BLK 2         128.131  P2p
Te3/1               Back BLK 2         128.257  P2p
Te3/3               Desg FWD 2         128.259  P2p
Gi4/3               Back BLK 4         128.387  P2p


VLAN0202
  Spanning tree enabled protocol rstp
  Root ID    Priority    32768
```

```
             Address     001c.0e0e.28ca
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768
             Address     001c.0e0e.28ca
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2         128.1    P2p
Te1/3               Desg FWD 2         128.3    P2p
Te2/1               Desg FWD 2         128.129  P2p
Te2/3               Back BLK 2         128.131  P2p
```

```
Te3/1               Back BLK 2          128.257  P2p
Te3/4               Desg FWD 2          128.260  P2p
Gi4/3               Back BLK 4          128.387  P2p
```

Spanning tree case 3: MSTP/MSTP

Objective

To verify interoperability of a multiple spanning tree topology between HP Networking and Cisco Catalyst switches.

To verify MSTP reconvergence between HP and Cisco switches after a 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, a separate spanning tree topology can be configured for each VLAN.

MSTP is the default spanning tree protocol for HP Networking switches. MSTP is enabled by default on HP Comware switches, and disabled by default on HP ProVision switches.

Topology

This test bed is identical to that used in the previous spanning tree examples (see Figure 7), with one important exception: MSTP runs on all HP and Cisco switches.

This example uses redundant paths between the HP Networking and Cisco Catalyst switches. VLAN IDs of 200 to 202 have been defined on all switches.

Procedure

HP Comware commands

Enable multiple spanning tree. This requires enabling MSTP (the default on HP Comware switches) and configuring one multiple spanning tree instance per VLAN.

```
[HP5900AF] stp enable
[HP5900AF] stp region-configuration
[HP5900AF] region-name hp-mstp
[HP5900AF-mst-region] instance 1 vlan 200
[HP5900AF-mst-region] instance 2 vlan 201
```

```
[HP5900AF-mst-region] instance 3 vlan 202
[HP5900AF-mst-region] active region-configuration
[HP5900AF-mst-region] quit
[HP5900AF] quit
```

HP ProVision commands

Create the MSTP instances and assign one VLAN to each instance.

```
HP5406R(config)# spanning-tree
HP5406R(config)# spanning-tree config-name “hp-mstp”
HP5406R(config)# spanning-tree instance 1 vlan 200
HP5406R(config)# spanning-tree instance 2 vlan 201
HP5406R(config)# spanning-tree instance 3 vlan 202
HP5406R(config)# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 3850. The syntax is identical for the Catalyst 6509-E switches and Cisco Catalyst 4507R switches.

Enable multiple spanning tree. This requires enabling MSTP and configuring one multiple spanning tree instance per VLAN.

```
C3850# configure terminal
C3850(config)# spanning-tree mode mst
C3850(config)# spanning-tree mst configuration
C3850(config-mst)#  name hp-mstp
C3850(config-mst)#  instance 1 vlan 200
C3850(config-mst)#  instance 2 vlan 201
C3850(config-mst)#  instance 3 vlan 202
C3850(config-mst)#  end
```

Validation

HP Comware switches use the command “**display stp brief**” to examine spanning tree bridge state.

```
<HP10504> display stp brief
 MSTID  Port                                    Role  STP State   Protection
 0      Ten-GigabitEthernet3/0/1                DESI  FORWARDING  NONE
 0      Ten-GigabitEthernet3/0/2                DESI  FORWARDING  NONE
 0      Ten-GigabitEthernet3/0/3                DESI  FORWARDING  NONE
 0      Ten-GigabitEthernet3/0/4                ROOT  FORWARDING  NONE
 0      Ten-GigabitEthernet3/0/7                DESI  FORWARDING  NONE
 0      Ten-GigabitEthernet3/0/8                DESI  FORWARDING  NONE
 0      Ten-GigabitEthernet3/0/17               DESI  FORWARDING  NONE
 0      Ten-GigabitEthernet4/0/8                DESI  FORWARDING  NONE
```

```
1       Ten-GigabitEthernet3/0/1            DESI  FORWARDING  NONE
1       Ten-GigabitEthernet3/0/2            DESI  FORWARDING  NONE
1       Ten-GigabitEthernet3/0/3            DESI  FORWARDING  NONE
1       Ten-GigabitEthernet3/0/4            DESI  FORWARDING  NONE
1       Ten-GigabitEthernet3/0/7            DESI  FORWARDING  NONE
1       Ten-GigabitEthernet3/0/8            DESI  FORWARDING  NONE
1       Ten-GigabitEthernet3/0/17           DESI  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/1            DESI  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/2            DESI  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/3            DESI  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/4            ROOT  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/7            DESI  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/8            DESI  FORWARDING  NONE
2       Ten-GigabitEthernet3/0/17           DESI  FORWARDING  NONE
3       Ten-GigabitEthernet3/0/1            DESI  FORWARDING  NONE
3       Ten-GigabitEthernet3/0/2            DESI  FORWARDING  NONE
3       Ten-GigabitEthernet3/0/3            DESI  FORWARDING  NONE
3       Ten-GigabitEthernet3/0/4            DESI  FORWARDING  NONE
3       Ten-GigabitEthernet3/0/7            DESI  FORWARDING  NONE
3       Ten-GigabitEthernet3/0/17           DESI  FORWARDING  NONE
3       Ten-GigabitEthernet4/0/8            DESI  FORWARDING  NONE
```

HP ProVision and Cisco switches use the command "**show spanning-tree**" to display spanning tree bridge state.

```
HP5406R# show spanning-tree

 Multiple Spanning Tree (MST) Information

  STP Enabled    : Yes
  Force Version : MSTP-operation
  IST Mapped VLANs : 1-199,203-4094
  Switch MAC Address : a0481c-f8e100
  Switch Priority     : 32768
  Max Age  : 20
  Max Hops : 20
  Forward Delay : 15

  Topology Change Count   : 29
  Time Since Last Change : 25 mins

  CST Root MAC Address : 001c0e-0e2800
  CST Root Priority     : 0
  CST Root Path Cost    : 0
  CST Root Port         : B1

  IST Regional Root MAC Address : 001c0e-0e2800
  IST Regional Root Priority     : 0
  IST Regional Root Path Cost    : 2000
  IST Remaining Hops             : 19
```

```
  Root Guard Ports     :
  Loop Guard Ports     :
  TCN Guard Ports      :
  BPDU Protected Ports :
  BPDU Filtered Ports  :
  PVST Protected Ports :
  PVST Filtered Ports  :

  Root Inconsistent Ports  :
  Loop Inconsistent Ports  :

                    |            Prio                | Designated    Hello
  Port   Type       | Cost       rity State          | Bridge        Time PtP Edge
  ------ --------- + ---------- ---- ------------ + ------------- ---- --- ----
  A1     SFP+SR     | 2000       128  Blocking     | 443192-55e7cb 2    Yes No
  A2     SFP+SR     | Auto       128  Disabled     |               2    Yes No
  A3     SFP+SR     | 2000       128  Forwarding   | a0481c-f8e100 2    Yes Yes
  A4     SFP+SR     | 2000       128  Forwarding   | a0481c-f8e100 2    Yes Yes
  A5     SFP+SR     | Auto       128  Disabled     |               2    Yes No
  A6     SFP+SR     | Auto       128  Disabled     |               2    Yes No
  A7     SFP+SR     | Auto       128  Disabled     |               2    Yes No
  A8     SFP+SR     | Auto       128  Disabled     |               2    Yes No
  B1     100/1000T  | 2000       128  Forwarding   | 001c0e-0e2800 2    Yes No
  B2     100/1000T  | 2000       128  Disabled     |               2    Yes No
  B3     100/1000T  | Auto       128  Disabled     |               2    Yes No
  B4     100/1000T  | Auto       128  Disabled     |               2    Yes No
```

```
Cat6509-E# show spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID    Priority    0
             Address     001c.0e0e.2800
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    0      (priority 0 sys-id-ext 0)
             Address     001c.0e0e.2800
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2000      128.1    P2p
Te1/3               Desg FWD 2000      128.3    P2p
Te2/1               Desg FWD 2000      128.129  P2p
Te2/3               Desg FWD 2000      128.131  P2p
Te3/1               Desg FWD 2000      128.257  P2p
Te3/3               Desg FWD 2000      128.259  P2p
Te3/4               Desg FWD 2000      128.260  P2p
```

```
Gi4/3               Desg FWD 20000     128.387  P2p


MST1
  Spanning tree enabled protocol mstp
  Root ID    Priority    1
             Address     4431.9255.e7cb
             Cost        2000
             Port        129 (TenGigabitEthernet2/1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     001c.0e0e.2800
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2000      128.1    P2p
Te1/3               Desg FWD 2000      128.3    P2p
Te2/1               Root FWD 2000      128.129  P2p
Te2/3               Desg FWD 2000      128.131  P2p
Te3/1               Desg FWD 2000      128.257  P2p
Te3/3               Desg FWD 2000      128.259  P2p
Gi4/3               Desg FWD 20000     128.387  P2p


MST2
  Spanning tree enabled protocol mstp
  Root ID    Priority    2
             Address     001c.0e0e.2800
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    2      (priority 0 sys-id-ext 2)
             Address     001c.0e0e.2800
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2000      128.1    P2p
Te1/3               Desg FWD 2000      128.3    P2p
Te2/1               Desg FWD 2000      128.129  P2p
Te2/3               Desg FWD 2000      128.131  P2p
Te3/1               Desg FWD 2000      128.257  P2p
Te3/3               Desg FWD 2000      128.259  P2p
Gi4/3               Desg FWD 20000     128.387  P2p


MST3
  Spanning tree enabled protocol mstp
  Root ID    Priority    3
             Address     4431.9255.e7cb
             Cost        2000
             Port        129 (TenGigabitEthernet2/1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32771  (priority 32768 sys-id-ext 3)
```

```
              Address     001c.0e0e.2800
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Te1/1               Desg FWD 2000      128.1    P2p
Te1/3               Desg FWD 2000      128.3    P2p
Te2/1               Root FWD 2000      128.129  P2p
Te2/3               Desg FWD 2000      128.131  P2p
Te3/1               Desg FWD 2000      128.257  P2p
Te3/4               Desg FWD 2000      128.260  P2p
Gi4/3               Desg FWD 20000     128.387  P2p
```

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 spanning tree convergence time is 47 ms.

Also, the CLI commands given in this section will verify that one port previously in forwarding state is now in blocking state, and that one or more other ports have changed from blocking to forwarding state.

Virtual router redundancy protocol (VRRP)

Objective

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

Background

Two or more routers can make use of VRRP to add redundancy and 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 interfaces configured with the virtual IP address), one of the backup routers takes over as master.

Topology

Network Test verified VRRP functionality in three tests using the HP 10504, the HP 5406R, and the HP FlexFabric 5900AF, each paired with the Cisco Catalyst 6509-E. Since the HP 10504 and HP FlexFabric 5900AF both run Comware v7, the commands for both are identical. This section gives configuration instructions for VRRP using Comware v7 and with ProVision.

In all test cases, the interfaces connecting the switches each have unique IP addresses, and share a virtual IP address of 192.18.215.3 for VRRP, with the HP switch initially acting as the master.

Procedure

HP Comware commands

VRRP configuration is done in the interface configuration context. Here, it is done on the VLAN interface. This example uses VRRP instance 1, though other IDs can be used if multiple VRRP instances are required. Also, setting a priority of 254 ensures the HP 10504 will act as VRRP master.

```
<HP10504> system-view
[HP10504] vlan 200
[HP10504-vlan] interface Vlan-interface200
[HP10504-Vlan-interface200] interface Vlan-interface200
[HP10504-Vlan-interface200]  ip address 192.18.200.2 255.255.255.0
[HP10504-Vlan-interface200]  vrrp vrid 1 virtual-ip 192.18.200.3
[HP10504-Vlan-interface200]  vrrp vrid 1 priority 254
[HP10504-Vlan-interface200]  quit
[HP10504] quit
```

HP ProVision commands

First, create and configure the VLAN interface. Setting a priority of 254 ensures the HP 5406R will act as VRRP master.

```
HP5406R# configure
HP5406R(config)# vlan 215
HP5406R(vlan-215)# name "VLAN215"
HP5406R(vlan-215)# untagged B1
HP5406R(vlan-215)# ip address 10.0.215.1 255.255.255.0
HP5406R(vlan-215)# exit
```

Next, configure VRRP.

```
HP5406R(config)# router vrrp
HP5406R(config-vrrp)# virtual-ip-ping
HP5406R(config-vrrp)# ipv4 enable
HP5406R(config-vrrp)# exit
HP5406R(config)# vlan 215
HP5406R(vlan-215)# vrrp vrid 2
HP5406R(vlan-215-vrid-2)# virtual-ip-address 192.18.215.3
HP5406R(vlan-215-vrid-2)# priority 254
HP5406R(vlan-215-vrid-2)# enable
HP5406R(vlan-215-vrid-2)# exit
HP5406R(vlan-215)# exit
HP5406R# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 6509-E. The syntax is similar for Catalyst 3850 and Cisco Catalyst 4507R switches.

VRRP configuration is done in the interface configuration context. Note the VRRP priority of 90; since 90 is less than the priority of 254 set on the HP devices, the Cisco device will assume the VRRP backup role.

```
Cat6509-E# configure terminal
Cat6509-E(config)# vlan 215
Cat6509-E(config-vlan)# interface Vlan215
Cat6509-E(config-if)# ip address 192.18.215.1 255.255.255.0
```

```
Cat6509-E(config-if)# vrrp 1 description vrrp to HP
Cat6509-E(config-if)# vrrp 1 ip 192.18.215.3
Cat6509-E(config-if)# vrrp 1 timers learn
Cat6509-E(config-if)# no vrrp 1 preempt
Cat6509-E(config-if)# vrrp 1 priority 90
Cat6509-E(config-if)# end
```

Validation

The Comware v7 command "**display vrrp**" will indicate the current VRRP state on each system.

```
[HP10504] display vrrp
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
 Interface          VRID  State        Running Adver   Auth     Virtual
                                       Pri     Timer   Type        IP
 -----------------------------------------------------------------------
 Vlan200            1     Master       254     100     None     192.18.200.3
```

If a link fails, the HP 10504 will transition from Master to Backup roles:

```
[HP10504] display vrrp
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
 Interface          VRID  State        Running Adver   Auth     Virtual
                                       Pri     Timer   Type        IP
 -----------------------------------------------------------------------
 Vlan200            1     Backup       254     100     None     192.18.200.3
```

Both the HP 5406R and Cisco Catalyst 6509-E support the "**show vrrp**" command, which will indicate the current VRRP state on each system.

```
HP5406R# show vrrp

 VRRP Global Statistics Information

  VRRP Enabled           : Yes
  Invalid VRID Pkts Rx   : 0
  Checksum Error Pkts Rx : 0
  Bad Version Pkts Rx    : 0
  Virtual Routers Respond To Ping Requests : Yes


 VRRP Virtual Router Statistics Information

  Vlan ID                  : 215
  Virtual Router ID        : 2
  Protocol Version         : 2
```

```
  State                     : Master
  Up Time                   : 9 mins
  Virtual MAC Address       : 00005e-000102
  Master's IP Address       : 192.18.215.2
  Associated IP Addr Count  : 1          Near Failovers            : 0
  Advertise Pkts Rx         : 0          Become Master             : 1

  Zero Priority Rx          : 0          Zero Priority Tx          : 0

  Bad Length Pkts           : 0          Bad Type Pkts             : 0

  Mismatched Interval Pkts  : 0          Mismatched Addr List Pkts : 0

  Mismatched IP TTL Pkts    : 0          Mismatched Auth Type Pkts : 0
```

```
Cat6509-E# show vrrp
Vlan200 - Group 1
vrrp case 1
  State is Backup
  Virtual IP address is 192.18.200.3
  Virtual MAC address is 0000.5e00.0101
  Advertisement interval is 1.000 sec
  Preemption disabled
```

```
Priority is 100
Master Router is unknown, priority is unknown
Master Advertisement interval is unknown
Master Down interval is 3.609 sec (expires in 0.941 sec)
```

Virtual LAN (VLAN) trunking

Objective

To verify interoperability of IEEE 802.1Q VLAN trunking between HP Networking and Cisco Catalyst switches using tagged traffic.

To verify interoperability of IEEE 802.1Q VLAN trunking between HP Networking and Cisco Catalyst switches using untagged traffic.

Background

The IEEE 802.1Q specification defines a method for creating virtual broadcast domains. A 4-byte VLAN header, usually called a "tag," allows definition of broadcast domains that may differ from physical switch topology. With 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 HP Networking 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 switch 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.

This test used the standard test bed (see Figure 1). In this example, all interswitch communication is done via VLAN trunks. The trunk ports on each switch will allow tagged traffic with VLAN IDs 200 and 201, and untagged traffic from ports with VLAN ID of 202. A fourth VLAN, with an ID of 203, is also defined but the trunk ports are configured not to allow traffic from that VLAN.

Procedure

HP Comware commands

First, define VLANs 200 to 203.

```
<HP5900AF> system-view
[HP5900AF] vlan 200 to 203
```

Then, define a VLAN trunk port that allows tagged traffic from VLANs 200-201, and native untagged traffic on VLAN 202.

```
[HP5900AF] interface TenGigabitEthernet1/0/1
[HP5900AF-TenGigabitEthernet1/0/1] port link-mode bridge
[HP5900AF-TenGigabitEthernet1/0/1] port link-type trunk
[HP5900AF-TenGigabitEthernet1/0/1] undo port trunk permit vlan 1
[HP5900AF-TenGigabitEthernet1/0/1] port trunk permit vlan 200 to 201
[HP5900AF-TenGigabitEthernet1/0/1] port trunk pvid vlan 202
[HP5900AF-TenGigabitEthernet1/0/1] quit
```

Next, define access-mode interfaces allowing untagged traffic for VLANs 200-203.

```
[HP5900AF] interface TenGigabitEthernet1/0/2
[HP5900AF-TenGigabitEthernet1/0/2] port link-mode bridge
[HP5900AF-TenGigabitEthernet1/0/2] port access vlan 200
[HP5900AF-TenGigabitEthernet1/0/2] interface TenGigabitEthernet1/0/3
[HP5900AF-TenGigabitEthernet1/0/3] port link-mode bridge
[HP5900AF-TenGigabitEthernet1/0/3] port access vlan 201
[HP5900AF-TenGigabitEthernet1/0/3] interface TenGigabitEthernet1/0/4
[HP5900AF-TenGigabitEthernet1/0/4] port link-mode bridge
[HP5900AF-TenGigabitEthernet1/0/4] port access vlan 202
[HP5900AF-TenGigabitEthernet1/0/4] interface TenGigabitEthernet1/0/5
[HP5900AF-TenGigabitEthernet1/0/5] port link-mode bridge
[HP5900AF-TenGigabitEthernet1/0/5] port access vlan 203
[HP5900AF-TenGigabitEthernet1/0/5] quit
[HP5900AF] quit
```

HP ProVision commands

HP ProVision switches combine trunk creation, access ports, and VLAN assignment together into a single VLAN construct. A port that is a member of a single VLAN carrying only untagged traffic is an access port (ports A1-A5 in this example). A port that is a member of multiple VLANs that carries both tagged and untagged traffic is a VLAN trunk port (ports A9-A10 in this example). Here we define VLANs 200-203 and assign ports to them.

```
HP5406R# configure
HP5406R(config)# vlan 200
HP5406R(vlan-200)# name “VLAN200”
HP5406R(vlan-200)# untagged A1,A9-A10
HP5406R(vlan-200)# exit
HP5406R(config)# vlan 201
```

```
HP5406R(vlan-201)# name “VLAN201”
HP5406R(vlan-201)# untagged A2
HP5406R(vlan-201)# tagged A9-A10
HP5406R(vlan-201)# exit
HP5406R(config)# vlan 202
HP5406R(vlan-202)# name “VLAN202”
HP5406R(vlan-202)# untagged A3
HP5406R(vlan-202)# tagged A9-A10
HP5406R(vlan-202)# exit
HP5406R(config)# vlan 203
HP5406R(vlan-203)# name “VLAN203”
HP5406R(vlan-203)# untagged A4
HP5406R(vlan-203)# exit
HP5406R(config)# exit
```

Cisco commands

The following commands apply to a Cisco Catalyst 6509-E. The syntax is similar for the Catalyst 3x50 switches and Cisco Catalyst 450x switches. Note, however, that IOS-XE software running on the Cisco Catalyst 3850 no longer requires the “**switchport trunk encapsulation dot1q**” command.

First, define VLANs 200 to 203.

```
Cat6509-E# configure terminal
Cat6509-E(config)# vlan 200-203
```

Then, define a VLAN trunk port that allows tagged traffic from VLANs 200-201 and native untagged traffic on VLAN 202.

```
Cat6509-E(config)# interface TenGigabitEthernet2/1
Cat6509-E(config-if)#  switchport
Cat6509-E(config-if)#  switchport trunk encapsulation dot1q
Cat6509-E(config-if)#  switchport trunk native vlan 202
Cat6509-E(config-if)#  switchport trunk allowed vlan 200-201
Cat6509-E(config-if)#  switchport mode trunk
Cat6509-E(config-if)#  exit
```

Next, define access-mode interfaces allowing untagged traffic from VLANs 200-203.

```
Cat6509-E(config)# interface TenGigabitEthernet2/2
Cat6509-E(config-if)# switchport access vlan 200
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet2/3
Cat6509-E(config-if)# switchport access vlan 201
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface TenGigabitEthernet2/4
Cat6509-E(config-if)# switchport access vlan 202
```

```
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# interface GigabitEthernet3/1
Cat6509-E(config-if)# switchport access vlan 203
Cat6509-E(config-if)# switchport mode access
Cat6509-E(config-if)# end
```

Validation

The Spirent TestCenter traffic generator/analyzer can be configured to offer traffic between pairs of access-mode interfaces on each switch. In all cases – involving unicast, multicast, or broadcast traffic – traffic will stay local to the VLAN in which it is defined. For example, traffic offered to VLAN 200 on the HP switches will be forwarded only to interfaces in VLAN 200 on the Cisco switches and vice-versa.

If desired, port mirroring can be enabled on either HP or Cisco switches to verify that the trunk ports carry tagged traffic VLAN IDs 200-201 and untagged traffic for VLAN ID 202. As a final verification that VLANs limit broadcast domains, Spirent TestCenter can be configured to offer traffic on access ports with VLAN 203. The trunk ports on all switches will not forward this traffic because the trunk ports do not explicitly allow it.

Appendix A: About Network Test

Network Test is an independent third-party test lab and engineering services consultancy. Our core competencies are performance, security, and conformance assessment of networking equipment and live networks. Our clients include equipment manufacturers, large enterprises, service providers, industry consortia, and trade publications.

Appendix B: Sample Configuration Files

This appendix lists URLs for the HP and Cisco switch files used to verify interoperability. These files are freely available for download from a public Network Test server. This document, a brief interoperability report, and all HP and Cisco configuration files are available at http://networktest.com/hpiop.

Appendix C: Software Releases Tested

This appendix describes the software versions used on the test bed. Network Test conducted all benchmarks in May 2014 at HP's labs in Roseville, California, USA.

Component	Version
HP 10504	Comware Software, Version 7.1.045, Release 2111P02
HP 5406R	ProVision Software, KB.15.15.0006
HP FlexFabric 5900AF	Comware Software, Version 7.1.045, Release 2307
HP 5500-HI	Comware Software, Version 5.20.99, Release 5501P01
Cisco Catalyst 6509-E	IOS 12.2(33)SXI13
Cisco Catalyst 4507R	IOS 15.0(2)SG7
Cisco Catalyst 3850	IOS-XE 03.02.03.SE
Spirent TestCenter	4.41

Appendix D: 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. All trademarks mentioned in this document are property of their respective owners.

networktest

Network Test Inc.

31324 Via Colinas, Suite 113 • Westlake Village, CA 91362-6761 • USA
+1-818-889-0011 • http://networktest.com • info@networktest.com