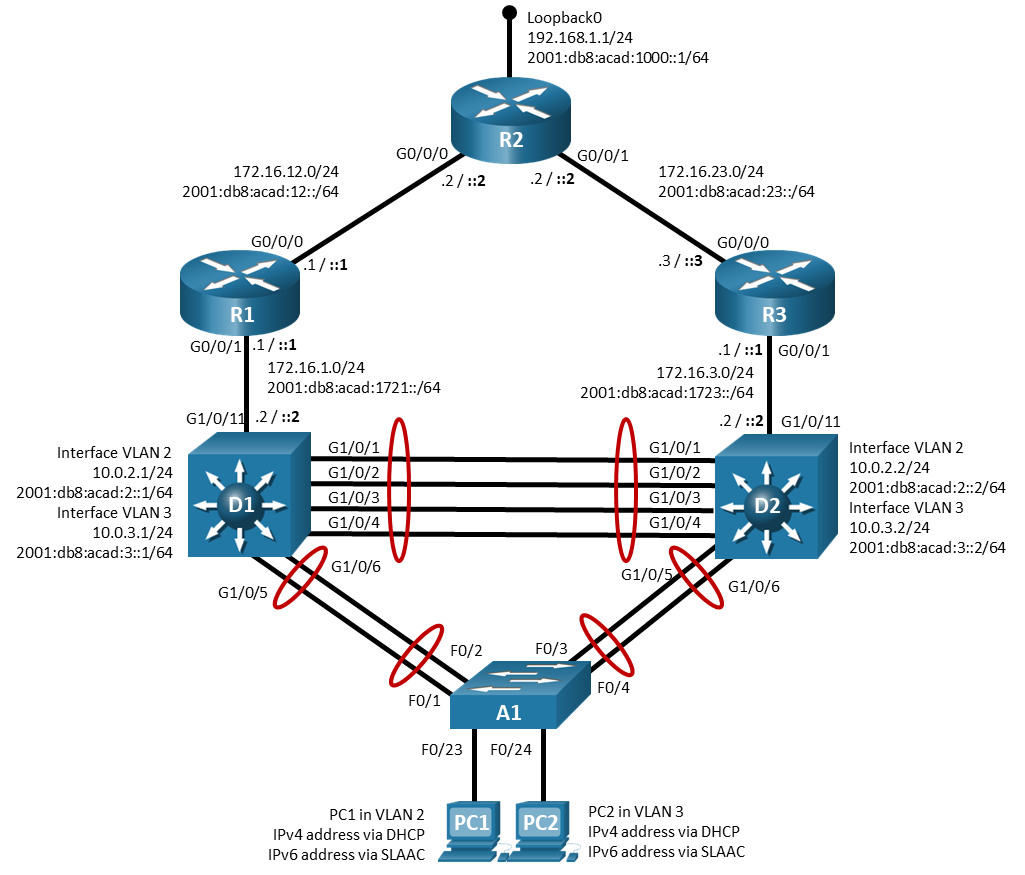
Lab - Implement IP SLA (Instructor Version)

**Instructor Note**: Red font color or gray highlights indicate text that appears in the instructor copy only.

# Topology



# Addressing Table

| Device | Interface | IPv4 Address/Mask | IPv6 Address/Prefix | IPv6 Link Local |
| --- | --- | --- | --- | --- |
| R1 | G0/0/0 | 172.16.12.1/24 | 2001:db8:acad:12::1/64 | fe80::1:1 |
| R1 | G0/0/1 | 172.16.1.1/24 | 2001:db8:acad:1721::1/64 | fe80::1:2 |
| R2 | G0/0/0 | 172.16.12.2/24 | 2001:db8:acad:12::2/64 | fe80::2:1 |
| R2 | G0/0/1 | 172.16.24.2/24 | 2001:db8:acad:23::2/64 | fe80::2:2 |
| R2 | Loopback 0 | 192.168.1.1/24 | 2001:db8:acad:1000::1/64 | fe80::2:3 |
| R3 | G0/0/0 | 172.16.23.3/24 | 2001:db8:acad:23::3/64 | fe80::3:1 |
| R3 | G0/0/1 | 172.16.3.1/24 | 2001:db8:acad:1723::1/64 | fe80::3:2 |
| D1 | G1/0/11 | 172.16.1.2/24 | 2001:db8:acad:1721::2/64 | fe80::d1:1 |
| D1 | VLAN 2 | 10.0.2.1/24 | 2001:db8:acad:2::1/64 | fe80::d1:2 |
| D1 | VLAN 3 | 10.0.3.1/24 | 2001:db8:acad:3::1/64 | fe80::d1:3 |
| D2 | G1/0/11 | 172.16.3.2/24 | 2001:db8:acad:23::3/64 | fe80::d2:1 |
| D2 | VLAN 2 | 10.0.2.2/24 | 2001:db8:acad:2::2/64 | fe80::d2:2 |
| D2 | VLAN 3 | 10.0.3.2/24 | 2001:db8:acad:3::2/64 | fe80::d2:3 |
| A1 | VLAN 2 | 10.0.2.3/24 | 2001:db8:acad:2::3/64 | fe80::a1:1 |
| PC 1 | NIC | DHCP | SLAAC | EUI-64 |
| PC 2 | NIC | DHCP | SLAAC | EUI-64 |

# Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure and Observe IP SLA Operations

Part 3: Configure and Observe HSRP IP SLA Tracking

# Background / Scenario

Cisco IP service level agreements (SLAs) allow users to monitor network performance between Cisco devices (switches or routers), or from a Cisco device to a remote IP device. Cisco IP SLAs can be applied to VoIP and video applications as well as monitoring end-to-end IP network performance.

**Note**: This lab is an exercise in deploying and verifying IP SLAs and does not necessarily reflect networking best practices. The IP SLA itself is an additional task that must be performed by the switch CPU. A large number of intensive SLAs could create a significant burden on the CPU, possibly interfering with other switch functions and having detrimental impact on the overall device performance. Therefore, you should carefully evaluate the benefits of running IP SLAs. The CPU load should be monitored after the SLAs are deployed to verify that they do not stress the device’s CPU above safe limits.

**Note**: The routers used with CCNP hands-on labs are Cisco 4221 with Cisco IOS XE Release 16.9.4 (universalk9 image). The switches used in the labs are Cisco Catalyst 3650s with Cisco IOS XE Release 16.9.4 (universalk9 image) and Cisco Catalyst 2960s with Cisco IOS Release 15.2(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and the output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

**Note**: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

**Note:** The default Switch Database Manager (SDM) template on a Catalyst 2960 does not support IPv6. You must change the default SDM template to the dual-ipv4-and-ipv6 default template using the **sdm prefer dual-ipv4-and-ipv6 default** global configuration command. Changing the template will require a reboot.

**Instructor Note**: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices

# Required Resources

* 2 Routers (Cisco 4221 with Cisco IOS XE Release 16.9.4 universal image or comparable)
* 2 Switches (Cisco 3650 with Cisco IOS XE Release 16.9.4 universal image or comparable)
* 1 Switch (Cisco 2960 with Cisco IOS Release 15.2(2) lanbasek9 image or comparable)
* 1 PC (Choice of operating system with a terminal emulation program installed)
* Console cables to configure the Cisco IOS devices via the console ports
* Ethernet cables as shown in the topology

# Instructions

## Build the Network and Configure Basic Device Settings and Interface Addressing

In Part 1, you will set up the network topology and configure basic settings and interface addressing.

### Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

### Configure basic settings for each switch.

* + - 1. Console into each switch, enter global configuration mode, and apply the basic settings. The startup configurations for each device are provided below.

Router R1

hostname R1

ipv6 unicast-routing

no ip domain lookup

banner motd # R1, Implement IP SLA #

line con 0

exec-timeout 0 0

logging synchronous

exit

line vty 0 4

privilege level 15

password cisco123

exec-timeout 0 0

logging synchronous

login

exit

interface g0/0/0

ip address 172.16.12.1 255.255.255.0

ipv6 address fe80::1:1 link-local

ipv6 address 2001:db8:acad:12::1/64

no shutdown

exit

interface g0/0/1

ip address 172.16.1.1 255.255.255.0

ipv6 address fe80::1:2 link-local

ipv6 address 2001:db8:acad:1721::1/64

no shutdown

exit

router ospf 4

router-id 1.1.1.4

network 172.16.0.0 0.0.255.255 area 0

exit

ipv6 router ospf 6

router-id 1.1.1.6

exit

interface g0/0/0

ipv6 ospf 6 area 0

exit

interface g0/0/1

ipv6 ospf 6 area 0

exit

end

Router R2

hostname R2

ipv6 unicast-routing

no ip domain lookup

banner motd # R2, Implement IP SLA #

line con 0

exec-timeout 0 0

logging synchronous

exit

line vty 0 4

privilege level 15

password cisco123

exec-timeout 0 0

logging synchronous

login

exit

interface g0/0/1

ip address 172.16.23.2 255.255.255.0

ipv6 address fe80::2:1 link-local

ipv6 address 2001:db8:acad:23::2/64

no shutdown

exit

interface g0/0/0

ip address 172.16.12.2 255.255.255.0

ipv6 address fe80::2:2 link-local

ipv6 address 2001:db8:acad:12::2/64

no shutdown

exit

interface loopback 0

ip address 192.168.1.1 255.255.255.0

ipv6 address fe80::2:3 link-local

ipv6 address 2001:db8:acad:1000::1/64

ip ospf network point-to-point

ipv6 ospf network point-to-point

no shutdown

exit

router ospf 4

router-id 2.2.2.4

network 172.16.0.0 0.0.255.255 area 0

network 192.168.1.0 0.0.0.255 area 0

exit

ipv6 router ospf 6

router-id 2.2.2.6

exit

interface g0/0/0

ipv6 ospf 6 area 0

exit

interface g0/0/1

ipv6 ospf 6 area 0

exit

interface Loopback 0

ipv6 ospf 6 area 0

exit

end

Router R3

hostname R3

ipv6 unicast-routing

no ip domain lookup

banner motd # R3, Implement IP SLA #

line con 0

exec-timeout 0 0

logging synchronous

exit

line vty 0 4

privilege level 15

password cisco123

exec-timeout 0 0

logging synchronous

login

exit

interface g0/0/0

ip address 172.16.23.3 255.255.255.0

ipv6 address fe80::3:1 link-local

ipv6 address 2001:db8:acad:23::3/64

no shutdown

exit

interface g0/0/1

ip address 172.16.3.1 255.255.255.0

ipv6 address fe80::3:2 link-local

ipv6 address 2001:db8:acad:1723::1/64

no shutdown

exit

router ospf 4

router-id 3.3.3.4

network 172.16.0.0 0.0.255.255 area 0

exit

ipv6 router ospf 6

router-id 3.3.3.6

exit

interface g0/0/0

ipv6 ospf 6 area 0

exit

interface g0/0/1

ipv6 ospf 6 area 0

exit

end

Switch D1

hostname D1

ip routing

ipv6 unicast-routing

no ip domain lookup

banner motd # D1, Implement IP SLA #

line con 0

exec-timeout 0 0

logging synchronous

exit

line vty 0 4

privilege level 15

password cisco123

exec-timeout 0 0

logging synchronous

login

exit

interface range g1/0/1-24, g1/1/1-4, g0/0

shutdown

exit

interface range g1/0/1-6

switchport mode trunk

no shutdown

exit

interface range g1/0/1-4

channel-group 12 mode active

exit

interface range g1/0/5-6

channel-group 1 mode active

exit

interface g1/0/11

no switchport

ip address 172.16.1.2 255.255.255.0

ipv6 address fe80::d1:1 link-local

ipv6 address 2001:db8:acad:1721::2/64

no shutdown

exit

vlan 2

name SECOND\_VLAN

exit

vlan 3

name THIRD\_VLAN

exit

spanning-tree vlan 2 root primary

spanning-tree vlan 3 root secondary

interface vlan 2

ip address 10.0.2.1 255.255.255.0

ipv6 address fe80::d1:2 link-local

ipv6 address 2001:db8:acad:2::1/64

no shutdown

exit

interface vlan 3

ip address 10.0.3.1 255.255.255.0

ipv6 address fe80::d1:3 link-local

ipv6 address 2001:db8:acad:3::1/64

no shutdown

exit

interface vlan 2

standby version 2

standby 2 ip 10.0.2.254

standby 2 priority 150

standby 2 preempt

standby 26 ipv6 autoconfig

standby 26 priority 150

standby 26 preempt

exit

interface vlan 3

standby version 2

standby 3 ip 10.0.3.254

standby 3 preempt

standby 36 ipv6 autoconfig

standby 36 preempt

exit

router ospf 4

router-id 0.13.1.4

network 172.16.1.0 0.0.0.255 area 0

network 10.0.0.0 0.0.255.255 area 0

passive-interface vlan 2

passive-interface vlan 3

exit

ipv6 router ospf 6

router-id 0.13.1.6

passive-interface vlan 2

passive-interface vlan 3

exit

interface g1/0/11

ipv6 ospf 6 area 0

exit

interface vlan 2

ipv6 ospf 6 area 0

exit

interface vlan 3

ipv6 ospf 6 area 0

exit

ip dhcp excluded-address 10.0.2.1 10.0.2.5

ip dhcp excluded-address 10.0.2.128 10.0.2.254

ip dhcp pool SECOND\_VLAN\_DHCP\_POOL

network 10.0.2.0 255.255.255.0

default-router 10.0.2.254

exit

ip dhcp excluded-address 10.0.3.1 10.0.3.128

ip dhcp excluded-address 10.0.3.254

ip dhcp pool THIRD\_VLAN\_DHCP\_POOL

network 10.0.3.0 255.255.255.0

default-router 10.0.3.254

exit

end

Switch D2

hostname D2

ip routing

ipv6 unicast-routing

no ip domain lookup

banner motd # D2, Implement IP SLA #

line con 0

exec-timeout 0 0

logging synchronous

exit

line vty 0 4

privilege level 15

password cisco123

exec-timeout 0 0

logging synchronous

login

exit

interface range g1/0/1-24, g1/1/1-4, g0/0

shutdown

exit

interface range g1/0/1-6

switchport mode trunk

no shutdown

exit

interface range g1/0/1-4

channel-group 12 mode active

exit

interface range g1/0/5-6

channel-group 2 mode active

exit

interface g1/0/11

no switchport

ip address 172.16.3.2 255.255.255.0

ipv6 address fe80::d2:1 link-local

ipv6 address 2001:db8:acad:1723::2/64

no shutdown

exit

vlan 2

name SECOND\_VLAN

exit

vlan 3

name THIRD\_VLAN

exit

spanning-tree vlan 2 root secondary

spanning-tree vlan 3 root primary

interface vlan 2

ip address 10.0.2.2 255.255.255.0

ipv6 address fe80::d2:2 link-local

ipv6 address 2001:db8:acad:2::2/64

no shutdown

exit

interface vlan 3

ip address 10.0.3.2 255.255.255.0

ipv6 address fe80::d2:3 link-local

ipv6 address 2001:db8:acad:3::2/64

no shutdown

exit

interface vlan 2

standby version 2

standby 2 ip 10.0.2.254

standby 2 preempt

standby 26 ipv6 autoconfig

standby 26 preempt

exit

interface vlan 3

standby version 2

standby 3 ip 10.0.3.254

standby 3 priority 150

standby 3 preempt

standby 36 ipv6 autoconfig

standby 36 priority 150

standby 36 preempt

exit

router ospf 4

router-id 0.13.2.4

network 172.16.3.0 0.0.0.255 area 0

network 10.0.0.0 0.0.255.255 area 0

passive-interface vlan 2

passive-interface vlan 3

exit

ipv6 router ospf 6

router-id 0.13.2.6

passive-interface vlan 2

passive-interface vlan 3

exit

interface g1/0/11

ipv6 ospf 6 area 0

exit

interface vlan 2

ipv6 ospf 6 area 0

exit

interface vlan 3

ipv6 ospf 6 area 0

exit

ip dhcp excluded-address 10.0.2.1 10.0.2.128

ip dhcp excluded-address 10.0.2.254

ip dhcp pool SECOND\_VLAN\_DHCP\_POOL

network 10.0.2.0 255.255.255.0

default-router 10.0.2.254

exit

ip dhcp excluded-address 10.0.3.1 10.0.3.5

ip dhcp excluded-address 10.0.3.128 10.0.3.254

ip dhcp pool THIRD\_VLAN\_DHCP\_POOL

network 10.0.3.0 255.255.255.0

default-router 10.0.3.254

exit

end

Switch A1

hostname A1

no ip domain lookup

banner motd # A1, Implement IP SLA #

line con 0

exec-timeout 0 0

logging synchronous

exit

line vty 0 4

privilege level 15

password cisco123

exec-timeout 0 0

logging synchronous

login

exit

interface range f0/1-24, g0/1-2

shutdown

exit

interface range f0/1-4

switchport mode trunk

no shutdown

exit

interface range f0/1-2

channel-group 1 mode active

exit

interface range f0/3-4

channel-group 2 mode active

exit

vlan 2

name SECOND\_VLAN

exit

vlan 3

name THIRD\_VLAN

exit

interface f0/23

switchport mode access

switchport access vlan 2

spanning-tree portfast

no shutdown

exit

interface f0/24

switchport mode access

switchport access vlan 3

spanning-tree portfast

no shutdown

exit

interface vlan 2

ip address 10.0.2.3 255.255.255.0

ipv6 address fe80::a1:1 link-local

ipv6 address 2001:db8:acad:2::3/64

no shutdown

exit

ip default-gateway 10.0.2.254

end

* + - 1. Set the clock on each switch to UTC time.
      2. Save the running configuration to startup-config.

### Configure the PCs for network connectivity.

Configure PC1 and PC2 for DHCP and SLAAC.

## Configure and Observe IP SLA Operations

In Part 2 you will configure and observe IP SLA operations. The SLA itself is simply a testing mechanism. Our example will test for simple reachability with an ICMP echo, but SLAs can do a lot more with many other protocols.

For now, all you will do is configure and schedule the IP SLAs and then query their status. This way you see the SLA operation separate from any application it might be used for.

### Create IP SLAs on switch D1.

* + - 1. Create IP SLA 4 using the command **ip sla 4**. The number 4 is locally significant and could be any number between 1 and 2147483647.

Open configuration window

D1(config)# **ip sla 4**

* + - 1. Configure IP SLA 4 to send an icmp-echo to the IPv4 address 192.168.1.1 and set the frequency for the ping to be every 15 seconds.

D1(config-ip-sla)# **icmp-echo 192.168.1.1**

D1(config-ip-sla-echo)# **frequency 15**

D1(config-ip-sla-echo)# **exit**

* + - 1. Create IP SLA 6.

D1(config)# **ip sla 6**

* + - 1. Configure IP SLA 6 to send an icmp-echo to the IPv4 address 2001:db8:acad:1000::1 and set the frequency for the ping to be every 15 seconds.

D1(config-ip-sla)# **icmp-echo 2001:db8:acad:1000::1**

D1(config-ip-sla-echo)# **frequency 15**

D1(config-ip-sla-echo)# **exit**

* + - 1. Use the **ip sla schedule** command to configure both SLA 4 and SLA 6 with a life of forever and to start immediately.

D1(config)# **ip sla schedule 4 life forever start-time now**

D1(config)# **ip sla schedule 6 life forever start-time now**

### Observe IP SLA operation.

* + - 1. Issue the command **show ip sla summary** to see a summarized status of the SLAs now that you have scheduled them.

D1# **show ip sla summary**

IPSLAs Latest Operation Summary

Codes: \* active, ^ inactive, ~ pending

All Stats are in milliseconds. Stats with u are in microseconds

ID Type Destination Stats Return Last

Code Run

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

\*4 icmp-echo 192.168.1.1 RTT=2 OK 12 seconds ago

\*6 icmp-echo 2001:DB8:ACAD:100 RTT=1 OK 12 seconds ago

0::1

* + - 1. To test and see what response the SLAs give in a failure, issue the **shutdown** command on R1 interface G0/0/0, then issue the **show ip sla summary** command again.

D1# **show ip sla summary**

IPSLAs Latest Operation Summary

Codes: \* active, ^ inactive, ~ pending

All Stats are in milliseconds. Stats with u are in microseconds

ID Type Destination Stats Return Last

Code Run

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

\*4 icmp-echo 192.168.1.1 - Timeout 8 seconds ago

\*6 icmp-echo 2001:DB8:ACAD:100 - Timeout 8 seconds ago

0::1

* + - 1. Issue the command **show ip sla configuration 4** to see details on IP SLA 4.

D1# **show ip sla configuration 4**

IP SLAs Infrastructure Engine-III

Entry number: 4

Owner:

Tag:

Operation timeout (milliseconds): 5000

Type of operation to perform: icmp-echo

Target address/Source address: 192.168.1.1/0.0.0.0

Type Of Service parameter: 0x0

Request size (ARR data portion): 28

Data pattern: 0xABCDABCD

Verify data: No

Vrf Name:

Schedule:

Operation frequency (seconds): 15 (not considered if randomly scheduled)

Next Scheduled Start Time: Start Time already passed

Group Scheduled : FALSE

Randomly Scheduled : FALSE

Life (seconds): Forever

Entry Ageout (seconds): never

Recurring (Starting Everyday): FALSE

Status of entry (SNMP RowStatus): Active

Threshold (milliseconds): 5000

Distribution Statistics:

Number of statistic hours kept: 2

Number of statistic distribution buckets kept: 1

Statistic distribution interval (milliseconds): 20

Enhanced History:

History Statistics:

Number of history Lives kept: 0

Number of history Buckets kept: 15

History Filter Type: None

* + - 1. Issue the command **show ip sla statistics 4** to examine statistical information on this IP SLA.

D1# **show ip sla statistics 4**

IPSLAs Latest Operation Statistics

IPSLA operation id: 4

Latest RTT: NoConnection/Busy/Timeout

Latest operation start time: 19:04:46 UTC Fri Feb 7 2020

Latest operation return code: Timeout

Number of successes: 14

Number of failures: 7

Operation time to live: Forever

Close configuration window

* + - 1. Issue the **no shutdown** command on R1 interface G0/0/0.
      2. Configure the same IP SLAs on Switch D2. Verify them in the same manner, issuing the **shutdown** command on R3 interface G0/0/0. When you have verified that SLA is tracking reachability to R2 interface Loopback 0, issue the **no shutdown** command on R3 interface G0/0/0.

## Configure and Observe HSRP IP SLA Tracking

In this part, we will put the IP SLAs that you created into use, and you can see how they work. In this case, our network is operational and HSRP is providing first-hop redundancy. HSRP will react to a directly connected interface that is failing or coming online, as you saw in the tracking section of the HSRP lab. But what if there is an indirect link failure that makes the active HSRP router less desirable? The IP SLA will allow us to handle this scenario. For this example, we will treat R2 interface Loopback 0 as a critical entity on the internet, like a DNS server. The organizational policy is that if that DNS server is not reachable from the gateway, the gateway should not be used.

### Verify HSRPv2 is operational.

* + - 1. Verify that HSRP is active and operating on Switch D1 with the **show standby brief** command.

Open configuration window

D1# **show standby brief**

P indicates configured to preempt.

|

Interface Grp Pri P State Active Standby Virtual IP

Vl2 2 150 P Active local 10.0.2.2 10.0.2.254

Vl2 26 150 P Active local FE80::D2:2 FE80::5:73FF:FEA0:1A

Vl3 3 100 P Standby 10.0.3.2 local 10.0.3.254

Vl3 36 100 P Standby FE80::D2:3 local FE80::5:73FF:FEA0:24

As you can see from the output, switch D1 is the active virtual router for VLAN 2 and the standby for VLAN 3 for both IPv4 and IPv6.

* + - 1. From PC1, start a continuous ping to 192.168.1.1.
      2. On D1, issue the **shutdown** command on interface VLAN 2. You should see that HSRP fails over to D2 as the Active Virtual Router for VLAN 2, and the pings continue to succeed. When verified, issue the **no shutdown** command on switch D1 interface VLAN 2.
      3. From PC2, start a continuous ping to 192.168.1.1.
      4. On D2, issue the **shutdown** command on interface VLAN 3. You should see that HSRP fails over to D1 as the Active Virtual Router for VLAN 3, and the pings continue to succeed. When verified, issue the **no shutdown** command on switch D2 interface VLAN 3.
      5. Now issue the **shutdown** command on R1 interface G0/0/0 and R3 interface G0/0/0. Note that there is no impact on either D1 or D2 regarding HSRP, and the pings start failing. Stop the continuous pings on PC1 and PC2 and issue the **no shutdown** command on R1 interface G0/0/0 and R3 interface G0/0/0.

### Reconfigure HSRP to use the IP SLA.

* + - 1. Create a track object using the command **track [number] ip sla [sla number]**.

D1(config)# **track 4 ip sla 4**

* + - 1. Set the delay timers. These are used to help manage changes on flapping links. In this case, R2 interface Loopback 0 is known to D1 and D2 via OSPF, so the delay needs to take OSPF timers into account. The command is setting the SLA up so that it will wait a period of time after the first failed SLA to make sure it is actually down, and it will wait a period of time after it appears to be returned to operation to be sure it is actually operating.

D1(config-track)# **delay down 45 up 20**

D1(config-track)# **exit**

* + - 1. Configure track 6 to pay attention to IP SLA 6 with the same delay values.

D1(config)# **track 6 ip sla 6**

D1(config-track)# **delay down 45 up 20**

D1(config-track)# **exit**

* + - 1. Now that the IP SLAs are being tracked, we must associate the status of the track with the HSRP group. This is done on the VLAN interface using the **standby [group] track [track number]** command. As a part of that command, add a decrement value, which will drop the interface’s HSRP priority should the IP SLA fail.

D1(config)# **interface vlan 2**

D1(config-if)# **standby 2 track 4 decrement 60**

D1(config-if)# **standby 26 track 4 decrement 60**

D1(config-if)# **exit**

D1(config)# **interface vlan 3**

D1(config-if)# **standby 3 track 4 decrement 60**

D1(config-if)# **standby 36 track 4 decrement 60**

D1(config-if)# **exit**

Close configuration window

* + - 1. Repeat the same commands on D2 so that HSRP is tracking IP SLAs there as well.

Open configuration window

D2(config)# **track 4 ip sla 4**

D2(config-track)# **delay down 45 up 20**

D2(config-track)# **exit**

D2(config)# **track 6 ip sla 6**

D2(config-track)# **delay down 45 up 20**

D2(config-track)# **exit**

D2(config)# **interface vlan 2**

D2(config-if)# **standby 2 track 4 decrement 60**

D2(config-if)# **standby 26 track 4 decrement 60**

D2(config-if)# **exit**

D2(config)# **interface vlan 3**

D2(config-if)# **standby 3 track 4 decrement 60**

D2(config-if)# **standby 36 track 4 decrement 60**

D2(config-if)# **exit**

Close configuration window

### Observe and validate HSRPv2 operation with IP SLAs.

* + - 1. On PC1, start a continuous ping to 192.168.1.1.
      2. On R1, shutdown interface G0/0/0.
      3. After about 45 seconds, you should see that HSRP fails over for VLAN 2 from switch D1 to switch D2, and pings from PC1 work again.
      4. Issue the **no shutdown** command on R1 interface G0/0/0.
      5. Switch D1 takes over again as the Active Virtual Router for VLAN 2, and the host is still able to ping 192.168.1.1.
      6. Stop the continuous ping running on PC1.

# Router Interface Summary Table

| Router Model | Ethernet Interface #1 | Ethernet Interface #2 | Serial Interface #1 | Serial Interface #2 |
| --- | --- | --- | --- | --- |
| 1800 | Fast Ethernet 0/0 (F0/0) | Fast Ethernet 0/1 (F0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 1900 | Gigabit Ethernet 0/0 (G0/0) | Gigabit Ethernet 0/1 (G0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 2801 | Fast Ethernet 0/0 (F0/0) | Fast Ethernet 0/1 (F0/1) | Serial 0/1/0 (S0/1/0) | Serial 0/1/1 (S0/1/1) |
| 2811 | Fast Ethernet 0/0 (F0/0) | Fast Ethernet 0/1 (F0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 2900 | Gigabit Ethernet 0/0 (G0/0) | Gigabit Ethernet 0/1 (G0/1) | Serial 0/0/0 (S0/0/0) | Serial 0/0/1 (S0/0/1) |
| 4221 | Gigabit Ethernet 0/0/0 (G0/0/0) | Gigabit Ethernet 0/0/1 (G0/0/1) | Serial 0/1/0 (S0/1/0) | Serial 0/1/1 (S0/1/1) |
| 4300 | Gigabit Ethernet 0/0/0 (G0/0/0) | Gigabit Ethernet 0/0/1 (G0/0/1) | Serial 0/1/0 (S0/1/0) | Serial 0/1/1 (S0/1/1) |

**Note**: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

End of document

# Device Configs - Final

# Router R1

R1# **show run**

Building configuration...

Current configuration : 1592 bytes

!

version 16.9

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

no platform punt-keepalive disable-kernel-core

!

hostname R1

!

boot-start-marker

boot-end-marker

!

no aaa new-model

!

no ip domain lookup

!

login on-success log

!

subscriber templating

!

ipv6 unicast-routing

multilink bundle-name authenticated

!

spanning-tree extend system-id

!

redundancy

mode none

!

interface GigabitEthernet0/0/0

ip address 172.16.12.1 255.255.255.0

negotiation auto

ipv6 address FE80::1:1 link-local

ipv6 address 2001:DB8:ACAD:12::1/64

ipv6 ospf 6 area 0

!

interface GigabitEthernet0/0/1

ip address 172.16.1.1 255.255.255.0

negotiation auto

ipv6 address FE80::1:2 link-local

ipv6 address 2001:DB8:ACAD:1721::1/64

ipv6 ospf 6 area 0

!

interface Serial0/1/0

no ip address

!

interface Serial0/1/1

no ip address

!

router ospf 4

router-id 1.1.1.4

network 172.16.0.0 0.0.255.255 area 0

!

ip forward-protocol nd

no ip http server

ip http secure-server

!

ipv6 router ospf 6

router-id 1.1.1.6

!

control-plane

!

banner motd ^C R1, Implement IP SLA ^C

!

line con 0

exec-timeout 0 0

logging synchronous

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

exec-timeout 0 0

privilege level 15

password cisco123

logging synchronous

login

!

end

# Router R2

R2# **show run**

Building configuration...

Current configuration : 1771 bytes

!

version 16.9

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

no platform punt-keepalive disable-kernel-core

!

hostname R2

!

boot-start-marker

boot-end-marker

!

no aaa new-model

!

no ip domain lookup

!

login on-success log

!

subscriber templating

!

ipv6 unicast-routing

multilink bundle-name authenticated

!

spanning-tree extend system-id

!

redundancy

mode none

!

interface Loopback0

ip address 192.168.1.1 255.255.255.0

ip ospf network point-to-point

ipv6 address FE80::2:3 link-local

ipv6 address 2001:DB8:ACAD:1000::1/64

ipv6 ospf 6 area 0

ipv6 ospf network point-to-point

!

interface GigabitEthernet0/0/0

ip address 172.16.12.2 255.255.255.0

negotiation auto

ipv6 address FE80::2:2 link-local

ipv6 address 2001:DB8:ACAD:12::2/64

ipv6 ospf 6 area 0

!

interface GigabitEthernet0/0/1

ip address 172.16.23.2 255.255.255.0

negotiation auto

ipv6 address FE80::2:1 link-local

ipv6 address 2001:DB8:ACAD:23::2/64

ipv6 ospf 6 area 0

!

router ospf 4

router-id 2.2.2.4

network 172.16.0.0 0.0.255.255 area 0

network 192.168.1.0 0.0.0.255 area 0

!

ip forward-protocol nd

no ip http server

ip http secure-server

!

ipv6 router ospf 6

router-id 2.2.2.6

!

control-plane

!

banner motd ^C R2, Implement IP SLA ^C

!

line con 0

exec-timeout 0 0

logging synchronous

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

exec-timeout 0 0

privilege level 15

password cisco123

logging synchronous

login

!

end

# Router R3

R3# **show run**

Building configuration...

Current configuration : 1592 bytes

!

version 16.9

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

no platform punt-keepalive disable-kernel-core

!

hostname R3

!

boot-start-marker

boot-end-marker

!

no aaa new-model

!

no ip domain lookup

!

login on-success log

!

subscriber templating

!

ipv6 unicast-routing

multilink bundle-name authenticated

!

spanning-tree extend system-id

!

redundancy

mode none

!

interface GigabitEthernet0/0/0

ip address 172.16.23.3 255.255.255.0

negotiation auto

ipv6 address FE80::3:1 link-local

ipv6 address 2001:DB8:ACAD:23::3/64

ipv6 ospf 6 area 0

!

interface GigabitEthernet0/0/1

ip address 172.16.3.1 255.255.255.0

negotiation auto

ipv6 address FE80::3:2 link-local

ipv6 address 2001:DB8:ACAD:1723::1/64

ipv6 ospf 6 area 0

!

interface Serial0/1/0

no ip address

!

interface Serial0/1/1

no ip address

!

router ospf 4

router-id 3.3.3.4

network 172.16.0.0 0.0.255.255 area 0

!

ip forward-protocol nd

no ip http server

ip http secure-server

!

ipv6 router ospf 6

router-id 3.3.3.6

!

control-plane

!

banner motd ^C R3, Implement IP SLA ^C

!

line con 0

exec-timeout 0 0

logging synchronous

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

exec-timeout 0 0

privilege level 15

password cisco123

logging synchronous

login

!

end

# Switch D1

D1# **show run**

Building configuration...

Current configuration : 8360 bytes

!

version 16.9

no service pad

service timestamps debug datetime msec

service timestamps log datetime msec

! Call-home is enabled by Smart-Licensing.

service call-home

no platform punt-keepalive disable-kernel-core

!

hostname D1

!

vrf definition Mgmt-vrf

!

address-family ipv4

exit-address-family

!

address-family ipv6

exit-address-family

!

no aaa new-model

switch 1 provision ws-c3650-24ps

!

ip routing

!

no ip domain lookup

ip dhcp excluded-address 10.0.2.1 10.0.2.5

ip dhcp excluded-address 10.0.2.128 10.0.2.254

ip dhcp excluded-address 10.0.3.1 10.0.3.128

ip dhcp excluded-address 10.0.3.254

!

ip dhcp pool SECOND\_VLAN\_DHCP\_POOL

network 10.0.2.0 255.255.255.0

default-router 10.0.2.254

!

ip dhcp pool THIRD\_VLAN\_DHCP\_POOL

network 10.0.3.0 255.255.255.0

default-router 10.0.3.254

!

login on-success log

ipv6 unicast-routing

!

license boot level ipservicesk9

!

diagnostic bootup level minimal

!

spanning-tree mode rapid-pvst

spanning-tree extend system-id

spanning-tree vlan 2 priority 24576

spanning-tree vlan 3 priority 28672

!

redundancy

mode sso

!

transceiver type all

monitoring

!

track 4 ip sla 4

delay down 45 up 20

!

track 6 ip sla 6

delay down 45 up 20

!

class-map match-any system-cpp-police-topology-control

description Topology control

class-map match-any system-cpp-police-sw-forward

description Sw forwarding, L2 LVX data, LOGGING

class-map match-any system-cpp-default

description Inter FED, EWLC control, EWLC data

class-map match-any system-cpp-police-sys-data

description Learning cache ovfl, High Rate App, Exception, EGR Exception, NFLSAMPLED DATA, RPF Failed

class-map match-any system-cpp-police-punt-webauth

description Punt Webauth

class-map match-any system-cpp-police-l2lvx-control

description L2 LVX control packets

class-map match-any system-cpp-police-forus

description Forus Address resolution and Forus traffic

class-map match-any system-cpp-police-multicast-end-station

description MCAST END STATION

class-map match-any system-cpp-police-multicast

description Transit Traffic and MCAST Data

class-map match-any system-cpp-police-l2-control

description L2 control

class-map match-any system-cpp-police-dot1x-auth

description DOT1X Auth

class-map match-any system-cpp-police-data

description ICMP redirect, ICMP\_GEN and BROADCAST

class-map match-any system-cpp-police-stackwise-virt-control

description Stackwise Virtual

class-map match-any non-client-nrt-class

class-map match-any system-cpp-police-routing-control

description Routing control and Low Latency

class-map match-any system-cpp-police-protocol-snooping

description Protocol snooping

class-map match-any system-cpp-police-dhcp-snooping

description DHCP snooping

class-map match-any system-cpp-police-system-critical

description System Critical and Gold Pkt

!

policy-map system-cpp-policy

!

interface Port-channel1

switchport mode trunk

!

interface Port-channel12

switchport mode trunk

!

interface GigabitEthernet0/0

vrf forwarding Mgmt-vrf

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet1/0/1

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/2

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/3

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/4

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/5

switchport mode trunk

channel-group 1 mode active

!

interface GigabitEthernet1/0/6

switchport mode trunk

channel-group 1 mode active

!

interface GigabitEthernet1/0/7

shutdown

!

interface GigabitEthernet1/0/8

shutdown

!

interface GigabitEthernet1/0/9

shutdown

!

interface GigabitEthernet1/0/10

shutdown

!

interface GigabitEthernet1/0/11

no switchport

ip address 172.16.1.2 255.255.255.0

ipv6 address FE80::D1:1 link-local

ipv6 address 2001:DB8:ACAD:1721::2/64

ipv6 ospf 6 area 0

!

interface GigabitEthernet1/0/12

shutdown

!

interface GigabitEthernet1/0/13

shutdown

!

interface GigabitEthernet1/0/14

shutdown

!

interface GigabitEthernet1/0/15

shutdown

!

interface GigabitEthernet1/0/16

shutdown

!

interface GigabitEthernet1/0/17

shutdown

!

interface GigabitEthernet1/0/18

shutdown

!

interface GigabitEthernet1/0/19

shutdown

!

interface GigabitEthernet1/0/20

shutdown

!

interface GigabitEthernet1/0/21

shutdown

!

interface GigabitEthernet1/0/22

shutdown

!

interface GigabitEthernet1/0/23

shutdown

!

interface GigabitEthernet1/0/24

shutdown

!

interface GigabitEthernet1/1/1

shutdown

!

interface GigabitEthernet1/1/2

shutdown

!

interface GigabitEthernet1/1/3

shutdown

!

interface GigabitEthernet1/1/4

shutdown

!

interface Vlan1

no ip address

!

interface Vlan2

ip address 10.0.2.1 255.255.255.0

standby version 2

standby 2 ip 10.0.2.254

standby 2 priority 150

standby 2 preempt

standby 2 track 4 decrement 60

standby 26 ipv6 autoconfig

standby 26 priority 150

standby 26 preempt

standby 26 track 4 decrement 60

ipv6 address FE80::D1:2 link-local

ipv6 address 2001:DB8:ACAD:2::1/64

ipv6 ospf 6 area 0

!

interface Vlan3

ip address 10.0.3.1 255.255.255.0

standby version 2

standby 3 ip 10.0.3.254

standby 3 preempt

standby 3 track 4 decrement 60

standby 36 ipv6 autoconfig

standby 36 preempt

standby 36 track 4 decrement 60

ipv6 address FE80::D1:3 link-local

ipv6 address 2001:DB8:ACAD:3::1/64

ipv6 ospf 6 area 0

!

router ospf 4

router-id 0.13.1.4

passive-interface Vlan2

passive-interface Vlan3

network 10.0.0.0 0.0.255.255 area 0

network 172.16.1.0 0.0.0.255 area 0

!

ip forward-protocol nd

ip http server

ip http secure-server

!

ip sla 4

icmp-echo 192.168.1.1

frequency 15

ip sla schedule 4 life forever start-time now

ip sla 6

icmp-echo 2001:DB8:ACAD:1000::1

frequency 15

ip sla schedule 6 life forever start-time now

ipv6 router ospf 6

router-id 0.13.1.6

passive-interface Vlan2

passive-interface Vlan3

!

control-plane

service-policy input system-cpp-policy

!

banner motd ^C D1, Implement IP SLA ^C

!

line con 0

exec-timeout 0 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

exec-timeout 0 0

privilege level 15

password cisco123

logging synchronous

login

line vty 5 15

login

!

end

# Switch D2

D2# **show run**

Building configuration...

Current configuration : 8360 bytes

!

version 16.9

no service pad

service timestamps debug datetime msec

service timestamps log datetime msec

! Call-home is enabled by Smart-Licensing.

service call-home

no platform punt-keepalive disable-kernel-core

!

hostname D2

!

vrf definition Mgmt-vrf

!

address-family ipv4

exit-address-family

!

address-family ipv6

exit-address-family

!

no aaa new-model

switch 1 provision ws-c3650-24ps

!

ip routing

!

no ip domain lookup

ip dhcp excluded-address 10.0.2.1 10.0.2.128

ip dhcp excluded-address 10.0.2.254

ip dhcp excluded-address 10.0.3.1 10.0.3.5

ip dhcp excluded-address 10.0.3.128 10.0.3.254

!

ip dhcp pool SECOND\_VLAN\_DHCP\_POOL

network 10.0.2.0 255.255.255.0

default-router 10.0.2.254

!

ip dhcp pool THIRD\_VLAN\_DHCP\_POOL

network 10.0.3.0 255.255.255.0

default-router 10.0.3.254

!

login on-success log

ipv6 unicast-routing

!

license boot level ipservicesk9

!

diagnostic bootup level minimal

!

spanning-tree mode rapid-pvst

spanning-tree extend system-id

spanning-tree vlan 2 priority 28672

spanning-tree vlan 3 priority 24576

!

redundancy

mode sso

!

transceiver type all

monitoring

!

track 4 ip sla 4

delay down 45 up 20

!

track 6 ip sla 6

delay down 45 up 20

!

class-map match-any system-cpp-police-topology-control

description Topology control

class-map match-any system-cpp-police-sw-forward

description Sw forwarding, L2 LVX data, LOGGING

class-map match-any system-cpp-default

description Inter FED, EWLC control, EWLC data

class-map match-any system-cpp-police-sys-data

description Learning cache ovfl, High Rate App, Exception, EGR Exception, NFLSAMPLED DATA, RPF Failed

class-map match-any system-cpp-police-punt-webauth

description Punt Webauth

class-map match-any system-cpp-police-l2lvx-control

description L2 LVX control packets

class-map match-any system-cpp-police-forus

description Forus Address resolution and Forus traffic

class-map match-any system-cpp-police-multicast-end-station

description MCAST END STATION

class-map match-any system-cpp-police-multicast

description Transit Traffic and MCAST Data

class-map match-any system-cpp-police-l2-control

description L2 control

class-map match-any system-cpp-police-dot1x-auth

description DOT1X Auth

class-map match-any system-cpp-police-data

description ICMP redirect, ICMP\_GEN and BROADCAST

class-map match-any system-cpp-police-stackwise-virt-control

description Stackwise Virtual

class-map match-any non-client-nrt-class

class-map match-any system-cpp-police-routing-control

description Routing control and Low Latency

class-map match-any system-cpp-police-protocol-snooping

description Protocol snooping

class-map match-any system-cpp-police-dhcp-snooping

description DHCP snooping

class-map match-any system-cpp-police-system-critical

description System Critical and Gold Pkt

!

policy-map system-cpp-policy

!

interface Port-channel2

switchport mode trunk

!

interface Port-channel12

switchport mode trunk

!

interface GigabitEthernet0/0

vrf forwarding Mgmt-vrf

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet1/0/1

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/2

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/3

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/4

switchport mode trunk

channel-group 12 mode active

!

interface GigabitEthernet1/0/5

switchport mode trunk

channel-group 2 mode active

!

interface GigabitEthernet1/0/6

switchport mode trunk

channel-group 2 mode active

!

interface GigabitEthernet1/0/7

shutdown

!

interface GigabitEthernet1/0/8

shutdown

!

interface GigabitEthernet1/0/9

shutdown

!

interface GigabitEthernet1/0/10

shutdown

!

interface GigabitEthernet1/0/11

no switchport

ip address 172.16.3.2 255.255.255.0

ipv6 address FE80::D2:1 link-local

ipv6 address 2001:DB8:ACAD:1723::2/64

ipv6 ospf 6 area 0

!

interface GigabitEthernet1/0/12

shutdown

!

interface GigabitEthernet1/0/13

shutdown

!

interface GigabitEthernet1/0/14

shutdown

!

interface GigabitEthernet1/0/15

shutdown

!

interface GigabitEthernet1/0/16

shutdown

!

interface GigabitEthernet1/0/17

shutdown

!

interface GigabitEthernet1/0/18

shutdown

!

interface GigabitEthernet1/0/19

shutdown

!

interface GigabitEthernet1/0/20

shutdown

!

interface GigabitEthernet1/0/21

shutdown

!

interface GigabitEthernet1/0/22

shutdown

!

interface GigabitEthernet1/0/23

shutdown

!

interface GigabitEthernet1/0/24

shutdown

!

interface GigabitEthernet1/1/1

shutdown

!

interface GigabitEthernet1/1/2

shutdown

!

interface GigabitEthernet1/1/3

shutdown

!

interface GigabitEthernet1/1/4

shutdown

!

interface Vlan1

no ip address

!

interface Vlan2

ip address 10.0.2.2 255.255.255.0

standby version 2

standby 2 ip 10.0.2.254

standby 2 preempt

standby 2 track 4 decrement 60

standby 26 ipv6 autoconfig

standby 26 preempt

standby 26 track 4 decrement 60

ipv6 address FE80::D2:2 link-local

ipv6 address 2001:DB8:ACAD:2::2/64

ipv6 ospf 6 area 0

!

interface Vlan3

ip address 10.0.3.2 255.255.255.0

standby version 2

standby 3 ip 10.0.3.254

standby 3 priority 150

standby 3 preempt

standby 3 track 4 decrement 60

standby 36 ipv6 autoconfig

standby 36 priority 150

standby 36 preempt

standby 36 track 4 decrement 60

ipv6 address FE80::D2:3 link-local

ipv6 address 2001:DB8:ACAD:3::2/64

ipv6 ospf 6 area 0

!

router ospf 4

router-id 0.13.2.4

passive-interface Vlan2

passive-interface Vlan3

network 10.0.0.0 0.0.255.255 area 0

network 172.16.3.0 0.0.0.255 area 0

!

ip forward-protocol nd

ip http server

ip http secure-server

!

ip sla 4

icmp-echo 192.168.1.1

frequency 15

ip sla schedule 4 life forever start-time now

ip sla 6

icmp-echo 2001:DB8:ACAD:1000::1

frequency 15

ip sla schedule 6 life forever start-time now

ipv6 router ospf 6

router-id 0.13.2.6

passive-interface Vlan2

passive-interface Vlan3

!

control-plane

service-policy input system-cpp-policy

!

banner motd ^C D2, Implement IP SLA ^C

!

line con 0

exec-timeout 0 0

logging synchronous

stopbits 1

line aux 0

stopbits 1

line vty 0 4

exec-timeout 0 0

privilege level 15

password cisco123

logging synchronous

login

line vty 5 15

login

!

end

# Switch A1

A1# **show run**

Building configuration...

Current configuration : 3917 bytes

!

version 15.2

no service pad

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname A1

!

boot-start-marker

boot-end-marker

!

no aaa new-model

system mtu routing 1500

!

no ip domain-lookup

!

spanning-tree mode rapid-pvst

spanning-tree extend system-id

!

vlan internal allocation policy ascending

!

interface Port-channel1

switchport mode trunk

!

interface Port-channel2

switchport mode trunk

!

interface FastEthernet0/1

switchport mode trunk

channel-group 1 mode active

!

interface FastEthernet0/2

switchport mode trunk

channel-group 1 mode active

!

interface FastEthernet0/3

switchport mode trunk

channel-group 2 mode active

!

interface FastEthernet0/4

switchport mode trunk

channel-group 2 mode active

!

interface FastEthernet0/5

shutdown

!

interface FastEthernet0/6

shutdown

!

interface FastEthernet0/7

shutdown

!

interface FastEthernet0/8

shutdown

!

interface FastEthernet0/9

shutdown

!

interface FastEthernet0/10

shutdown

!

interface FastEthernet0/11

shutdown

!

interface FastEthernet0/12

shutdown

!

interface FastEthernet0/13

shutdown

!

interface FastEthernet0/14

shutdown

!

interface FastEthernet0/15

shutdown

!

interface FastEthernet0/16

shutdown

!

interface FastEthernet0/17

shutdown

!

interface FastEthernet0/18

shutdown

!

interface FastEthernet0/19

shutdown

!

interface FastEthernet0/20

shutdown

!

interface FastEthernet0/21

shutdown

!

interface FastEthernet0/22

shutdown

!

interface FastEthernet0/23

switchport access vlan 2

switchport mode access

spanning-tree portfast edge

!

interface FastEthernet0/24

switchport access vlan 3

switchport mode access

spanning-tree portfast edge

!

interface GigabitEthernet0/1

shutdown

!

interface GigabitEthernet0/2

shutdown

!

interface Vlan1

no ip address

shutdown

!

interface Vlan2

ip address 10.0.2.3 255.255.255.0

ipv6 address FE80::A1:1 link-local

ipv6 address 2001:DB8:ACAD:2::3/64

!

ip default-gateway 10.0.2.254

ip http server

ip http secure-server

!

banner motd ^C A1, Implement IP SLA ^C

!

line con 0

exec-timeout 0 0

logging synchronous

line vty 0 4

exec-timeout 0 0

privilege level 15

password cisco123

logging synchronous

login

line vty 5 15

login

!

end