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Practical 7

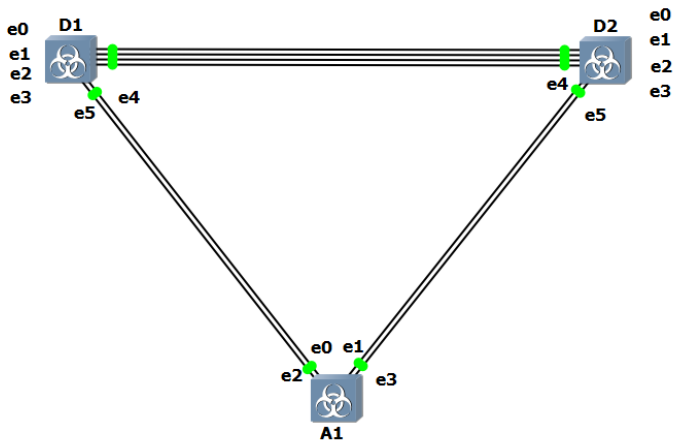
1. Implement EtherChannel
2. Tune and Optimize EtherChannel Operations

1. Implement EtherChannel:

What is EtherChannel?

- EtherChannel is a port link aggregation technology in which multiple physical port links are grouped into one logical link.
- It is used to provide high speed links and redundancy. Maximum of 8 links can be aggregated to form a single logical link.
- EtherChannel protocols - To form an EtherChannel, there are 2 protocols, **port aggregation protocol (PAgP)** and **link aggregation control protocol (LACP).**
- **Port Aggregation Protocol (PAgP) -**
  Port Aggregation Protocol is a Cisco proprietary protocol used to form an EtherChannel.
- **Link aggregation control protocol (LACP) –**
  LACP is an IEEE standard, which is a part of the IEEE 802.3ad specification. It allows the user to combine numerous physical Ethernet links into one logical link.
- There are different modes in which you can configure your interface:
  - **ON**: In this mode, the interface will be a part of EtherChannel, but no negotiation takes place.
  - **OFF**: No EtherChannel configured on the interface.
- PAgP and LACP have desirable/active and auto/passive mode. We shall go through this mode once we configure PAgP and LACP.

Step 1: Build the topology:



Step 2: Configure the network:

If the switches are in their default configuration, this connection between the two switches defaults to be an access port in VLAN 1, which can be seen in the output of interfaces gi0/3 switchport of D1 and interfaces gi0/3 switchport of A1.

Switch D1:

```
vIOS-L2-01>
vIOS-L2-01>sh int gi0/3 switchport
Name: Gi0/3
Switchport: Enabled
Administrative Mode: dynamic desirable
Operational Mode: trunk
Administrative Trunking Encapsulation: negotiate
Operational Trunking Encapsulation: isl
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Capture Mode Disabled
Capture VLANs Allowed: ALL

Appliance trust: none
```

Switch A1:

```
* Prohibited.                                                          *
************************************************************************
vIOS-L2-01>
vIOS-L2-01>sh int gi0/3 switchport
Name: Gi0/3
Switchport: Enabled
Administrative Mode: dynamic desirable
Operational Mode: trunk
Administrative Trunking Encapsulation: negotiate
Operational Trunking Encapsulation: isl
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Capture Mode Disabled
Capture VLANs Allowed: ALL

Appliance trust: none
vIOS-L2-01>en
```

```
vIOS-L2-01#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
vIOS-L2-01(config)#hostname A1
A1(config)#end
A1#
*Jan  6 14:14:15.057: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on
*Jan  6 14:14:15.059: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on
*Jan  6 14:14:16.214: %SYS-5-CONFIG_I: Configured from console by consolesh
A1#show interfaces
*Jan  6 14:14:18.282: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on
*Jan  6 14:14:18.282: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on
A1#show interfaces gi0/0 switchport
Name: Gi0/0
Switchport: Enabled
Administrative Mode: dynamic desirable
Operational Mode: static access
Administrative Trunking Encapsulation: negotiate
Operational Trunking Encapsulation: native
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Capture Mode Disabled
```

Check the interface switchport status and you will see that it is in trunk mode.
The output of show interfaces trunk will show the protocol as desirable.
So if we check A1 and D1 we will get mode as desirable.

A1:

```
A1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       desirable        n-isl          trunking      1
Gi0/1       desirable        n-isl          trunking      1
Gi0/2       desirable        n-isl          trunking      1
Gi0/3       desirable        n-isl          trunking      1

Port        Vlans allowed on trunk
Gi0/0       1-4094
Gi0/1       1-4094
Gi0/2       1-4094
Gi0/3       1-4094

Port        Vlans allowed and active in management domain
Gi0/0       1,100,200,300
Gi0/1       1,100,200,300
Gi0/2       1,100,200,300
Gi0/3       1,100,200,300

Port        Vlans in spanning tree forwarding state and not pruned
Gi0/0       100,200,300
Gi0/1       1,100,200,300
Gi0/2       100,200,300
Gi0/3       100,200,300
A1#
```

D1:

```
D1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       desirable        n-isl          trunking      1
Gi0/1       desirable        n-isl          trunking      1
Gi0/2       desirable        n-isl          trunking      1
Gi0/3       desirable        n-isl          trunking      1
Gi1/0       desirable        n-isl          trunking      1
Gi1/1       desirable        n-isl          trunking      1

Port        Vlans allowed on trunk
Gi0/0       1-4094
Gi0/1       1-4094
Gi0/2       1-4094
Gi0/3       1-4094
Gi1/0       1-4094
Gi1/1       1-4094

Port        Vlans allowed and active in management domain
Gi0/0       1,100,200,300
Gi0/1       1,100,200,300
Gi0/2       1,100,200,300
Gi0/3       1,100,200,300
Gi1/0       1,100,200,300
Gi1/1       1,100,200,300

Port        Vlans in spanning tree forwarding state and not pruned
Gi0/0       1,100,200,300
```

- Packets continue to be sent if the port is set statically to trunk mode.
- However, if the port is set statically to the access mode, both sending and processing on that port are deactivated.
- To see this, configure D1 interface gi1/0 with the switchport mode trunk command.
- After a few moments, you should once again see that A1 has automatically negotiated a trunk, this time between A1's gi0/0 and D1's gi1/0.

D1:

```
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#int gi1/0
D1(config-if)#switchport trunk encapsulation dot1q
D1(config-if)#switchport mode trunk
D1(config-if)#end
D1#
*Nov  5 09:21:27.515: %SYS-5-CONFIG_I: Configured from console by console
```

A1:

```
A1#
A1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       desirable        n-802.1q       trunking      1
Gi0/1       desirable        n-isl          trunking      1
Gi0/2       desirable        n-isl          trunking      1
Gi0/3       desirable        n-isl          trunking      1
```

We see A1 gi0/0 has automatically negotiated a trunk.

- On A1, shutdown interfaces gi0/0 and gi0/1 as they are connected to A1.
- Then go to D1 and configure interfaces gi1/0 and gi1/1 as trunks with the additional command switchport non-negotiate.
- A few moments after you re- enable the interfaces at A1, you will see that they do not form trunks with D1.

A1:

```
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#int range gi0/0-1
A1(config-if-range)#shutdown
A1(config-if-range)#ex
A1(config)#
*Nov  5 09:21:58.471: %LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to administrativ
*Nov  5 09:21:58.472: %LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to administrativ
*Nov  5 09:21:59.484: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed s
*Nov  5 09:21:59.484: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed s
```

D1:

```
*Nov  5 09:21:27.515: %SYS-5-CONFIG_I: Configured from console by console
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#int range gi1/0-1
D1(config-if-range)#switchport trunk encapsulation dot1q
D1(config-if-range)#switchport mode trunk
D1(config-if-range)#end
D1#conf t
```

A1:

```
*Nov  5 09:21:59.484: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state t
*Nov  5 09:21:59.484: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state t
A1(config)#int range gi0/0-1
A1(config-if-range)#no shutdown
A1(config-if-range)#ex
A1(config)#
*Nov  5 09:22:33.458: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Nov  5 09:22:33.458: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
A1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       desirable        n-802.1q       trunking      1
Gi0/1       desirable        n-isl          trunking      1
Gi0/2       desirable        n-802.1q       trunking      1
Gi0/3       desirable        n-isl          trunking      1

Port        Vlans allowed on trunk
Gi0/0       1-4094
Gi0/1       1-4094
Gi0/2       1-4094
Gi0/3       1-4094

Port        Vlans allowed and active in management domain
Gi0/0       1,100,200,300
Gi0/1       1,100,200,300
Gi0/2       1,100,200,300
Gi0/3       1,100,200,300

Port        Vlans in spanning tree forwarding state and not pruned
Gi0/0       none
Gi0/1       none
Gi0/2       none
 --More--
*Nov  5 09:22:40.087: %SYS-5-CONFIG_I: Configured from console by console

A1#sh int gi0/0 switchport | i Mode
Administrative Mode: dynamic desirable
Operational Mode: trunk
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Capture Mode Disabled
```

We have no shutdown the interface we have shutdown a while ago.
And we check the gi0/0 switchport of A1.

At each switch, issue the global configuration command default interface range to reset the interfaces back to their defaults.

A1:

```
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#default int range gi0/0-1
A1(config)#ex
% Ambiguous command:  "ex"
A1(config)#exit
A1#
*Nov  5 09:23:01.779: %SYS-5-CONFIG_I: Configured from console by console
*Nov  5 09:23:02.279: %LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to reset
*Nov  5 09:23:02.280: %LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to reset
A1#
```

D1:

```
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#
*Nov  5 09:22:49.810: %SYS-5-CONFIG_I: Configured from console by console
D1(config)#default int range gi1/0-1
D1(config)#end
D1#
*Nov  5 09:22:59.789: %SYS-5-CONFIG_I: Configured from console by console
D1#
D1#
D1#
*Nov  5 09:23:01.303: %LINK-5-CHANGED: Interface GigabitEthernet1/0, changed state to reset
*Nov  5 09:23:01.304: %LINK-5-CHANGED: Interface GigabitEthernet1/1, changed state to reset
*Nov  5 09:23:02.398: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0, changed state
*Nov  5 09:23:02.398: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/1, changed state
```

Step 3: Configure Basic Device Settings

D1:

```
*Nov  5 09:23:02.398: %LINEPROTO-5-UPDOWN: Line protocol on Interface Gigab
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#line con 0
D1(config-line)#exec-timeout 0 0
D1(config-line)#logging synchronous
D1(config-line)#exit
D1(config)#int range gi0/0-3
D1(config-if-range)#switchport trunk encapsultion dot1q
                                                ^
% Invalid input detected at '^' marker.

D1(config-if-range)#switchport trunk encapsulation dot1q
D1(config-if-range)#switchport mode trunk
D1(config-if-range)#no shut
D1(config-if-range)#ex
D1(config)#int range gi1/0-1
D1(config-if-range)#switchport trunk encapsulation dot1q
D1(config-if-range)#switchport mode trunk
D1(config-if-range)#no shut
D1(config-if-range)#ex
```

D2:

```
vIOS-L2-01> restarted --
Cisco IOS Software, vios_l2 Software (vios_l2-ADVENTERPRISEK9-M), Version 15.0(TTC_20140605)FLO_DSGS7, E
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2014 by Cisco Systems, Inc.
Compiled Thu 05-Jun-14 05:35 by jsfeng
vIOS-L2-01>
vIOS-L2-01>EN
vIOS-L2-01#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
vIOS-L2-01(config)#hostname D2
D2(config)#
D2(config)#
D2(config)#line con 0
D2(config-line)#exec-timeout 0 0
D2(config-line)#logging synchronous
D2(config-line)#exit
D2(config)#int range gi0/0-1
D2(config-if-range)#switchport trunk encapsulation dot1q
D2(config-if-range)#switchport mode trunk
D2(config-if-range)#no shut
D2(config-if-range)#ex
D2(config)#int range gi1/0-1
D2(config-if-range)#switchport trunk encapsulation dot1q
D2(config-if-range)#switchport mode trunk
D2(config-if-range)#no shut
D2(config-if-range)#ex
```

A1:

```
A1#
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#line con 0
A1(config-line)#exec-timeout 0 0
A1(config-line)#logging synchronous
A1(config-line)#ex
% Ambiguous command:  "ex"
A1(config-line)#exit
A1(config)#int range gi0/0-3
A1(config-if-range)#switchport trunk encapsulation dot1q
A1(config-if-range)#switchport mode trunk
A1(config-if-range)#no shut
A1(config-if-range)#ex
A1(config)#
A1(config)#
A1(config)#end
```

Step 4: Configure Static EtherChannel:

In this part, you will configure an EtherChannel without a protocol. The focus for this part is to establish the process for creating and modifying the EtherChannel bundle.

For this part you will work with D2 and A1.

Step 5: Configure and verify trunking between D2 and A1.

Configure the ports interconnecting D2 and A1 as static trunk ports with the switchport nonegotiate command.

Verify the trunks have formed.

```
A1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       on               802.1q         trunking      1
Gi0/1       on               802.1q         trunking      1
Gi0/2       on               802.1q         trunking      1
Gi0/3       on               802.1q         trunking      1
```

- **Configure and verify a static EtherChannel link between D2 and A1.**

Add the command channel-group 1 mode on to all the trunk interfaces between D2 and A1.

D2:

```
D2(config-if-range)#ex
D2(config)#int range gi1/0-1
D2(config-if-range)#channel-group 1 mode on
Creating a port-channel interface Port-channel 1

D2(config-if-range)#exit
D2(config)#
```

A1:

```
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#int range gi0/2-3
A1(config-if-range)#channel-group 1 mode on
Creating a port-channel interface Port-channel 1

A1(config-if-range)#exit
A1(config)#
*Nov  5 09:26:45.325: %LINEPROTO-5-UPDOWN: Line protocol on Interface Po
A1(config)#end
```

Verify the EtherChannel has formed by examining the output of the show EtherChannel summary command.
Also check the spanning tree status. You will see that there is a change to the topology because Po1 replaced interfaces gi0/2 and gi0/3 with a lower cost.

A1:

```
A1(config)#end
A1#sh
*Nov  5 09:26:52.062: %SYS-5-CONFIG_I: Configured from console by consoleetherc
A1#sh etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SU)          -       Gi0/2(P)    Gi0/3(P)

A1#sh spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0cf8.e869.0000
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0cf8.e869.0000
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  15  sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi0/0               Desg FWD 4         128.1    Shr
Gi0/1               Desg FWD 4         128.2    Shr
Po1                 Desg LRN 3         128.65   Shr
```

You will notice the 2 port which are connected with D2 are now in Port channel 2 and the cost is lower.

Make a change to the EtherChannel.
With very few exceptions, changes to the EtherChannel configuration must be made at the port-channel level.
Changes you make directly to the member interfaces of a port-channel may create synchronization issues that will cause the group to fail or underperform.

On D2 and A1, create VLAN 999 with the name Sadiq_VLAN.

D2:

```
D2(config)#
D2(config)#vlan 999
D2(config-vlan)#name Sadiq_VLAN
D2(config-vlan)#exit
D2(config)#
```

A1:

```
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#vlan 999
A1(config-vlan)#name Sadiq_VLAN
A1(config-vlan)#exit
```

On D2 and A1, modify interface port-channel 1 so that it uses VLAN 999 as the native VLAN.

D2:

```
D2(config)#
*Nov  5 09:26:43.110: %ATA-3-DEV_ERROR: Failure on device 0x1F0, state timeout
D2(config)#int port-channel 1
D2(config-if)#switchport trunk native vlan 999
D2(config-if)#end
```

A1:

```
A1(config-vlan)#name Sadiq_VLAN
A1(config-vlan)#exit
A1(config)#int port-channel 1
A1(config-if)#switchport trunk native vlan 999
A1(config-if)#end
A1#
```

Verify the change has been applied by examining the output of show interfaces trunk.

```
A1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       on               802.1q         trunking      1
Gi0/1       on               802.1q         trunking      1
Po1         on               802.1q         trunking      999

Port        Vlans allowed on trunk
Gi0/0       1-4094
Gi0/1       1-4094
Po1         1-4094

Port        Vlans allowed and active in management domain
Gi0/0       1,100,200,300,999
Gi0/1       1,100,200,300,999
Po1         1,100,200,300,999

Port        Vlans in spanning tree forwarding state and not pruned
Gi0/0       1,100,200,300
Gi0/1       1,100,200,300
Po1         1,100,200,300
A1#
A1#
*Nov  5 09:28:49.325: %PLATFORM-5-SIGNATURE_VERIFIED: Image 'flash0:/vios_l2-adventerprisek9-m' pas
A1#
```

Step 5: Implement EtherChannel Using PAgP:

- In this part you will configure an EtherChannel using the Cisco proprietary Port Aggregation Protocol, or PAgP. PAgP works between Cisco switches only.
- The protocol has two modes - Desirable or Auto.
- These modes work in a fashion similar to modes of the same name in Dynamic Trunking Protocol; **Desirable actively communicates** a desire to build an EtherChannel bundle, while **Auto passively agrees** to a bundle if the switch at the other end desires it.
- Therefore, if both ends are configured in Auto mode, the bundle will not form.
- Additionally, PAgP can be configured for non-silent operation. Normally, PAgP operates in silent mode, and will add interfaces to a bundle without having received PAgP packets from the connected device.

Configure and verify trunking between D1 and A1:
Verify the trunks are still working.

A1:

```
*Nov  5 09:28:49.325: %PLATFORM-5-SIGNATURE_VERIFIED: Image 'flash0:/vios_l2-
A1#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       on               802.1q         trunking      1
Gi0/1       on               802.1q         trunking      1
Po1         on               802.1q         trunking      999

Port        Vlans allowed on trunk
```

Configure and verify an EtherChannel using PAgP between D1 and A1.
Add the command channel-group 2 mode desirable non-silent to all the trunk interfaces between D1 and A1.

A1:

```
A1#
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#int range gi0/0-1
A1(config-if-range)#channel-group 2 mode desirable non-silent
Creating a port-channel interface Port-channel 2

A1(config-if-range)#end
A1#
```

Verify the EtherChannel has formed by examining the output of the show etherchannel summary command.

```
A1#sh etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 2
Number of aggregators:           2

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SU)          -        Gi0/2(P)    Gi0/3(P)
2      Po2(SD)         PAgP      Gi0/0(I)    Gi0/1(I)
```

Make a change to the EtherChannel:
Changes to the EtherChannel configuration must be made at the port-channel level. Changes you make directly to the member interfaces of a port-channel may create synchronization issues that will cause the group to fail or underperform.
On D1, create VLAN 999 with the name Sadiq_VLAN.

D1:

```
D1(config)#conf t
                ^
% Invalid input detected at '^' marker.

D1(config)#vlan 999
D1(config-vlan)#name Sadiq_VLAN
D1(config-vlan)#exit
```

On D1 and A1, modify interface port-channel 2 so that it uses VLAN 999 as the native VLAN.

```
D1(config)#interface port-channel 3
D1(config-if)#switchport trunk native vlan 999
D1(config-if)#end
D1#
```

A1:

```
A1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)#int range gi0/0-1
A1(config-if-range)#channel-group 3 mode desirable non-silent
Creating a port-channel interface Port-channel 3

A1(config-if-range)#end
A1#
```

Verify the change has been applied by examining the output of 'show interfaces trunk | i Port| Po3' on D1:

```
D1(config-if)#end
D1#sh int trunk |
*Nov  5 09:59:00.524: %SYS-5-CONFIG_I: Configured from console by console
D1#sh int trunk | i Port| Po3
Port        Mode             Encapsulation  Status        Native vlan
Port        Vlans allowed on trunk
Port        Vlans allowed and active in management domain
Port        Vlans in spanning tree forwarding state and not pruned
D1#
```

Step 6: Implement EtherChannel using LACP:

- In this part, you will configure an EtherChannel using the open standard Link Aggregation Control Protocol, or LACP.
- This protocol also has two modes – **Active and Passive.** These modes work in a similar fashion to modes of PAgP; the **Active mode actively communicates** a desire to build an EtherChannel bundle, while the **Passive mode passively agrees** to a bundle if the switch at the other end initiates it.
- Therefore, if both ends are configured in passive mode, the bundle will not form. For this part you will work with D1 and D2.

Configure and verify trunking between D1 and D2:
Verify the trunks are still operational.

D2:

```
D2#sh int trunk

Port        Mode             Encapsulation  Status        Native vlan
Gi0/0       on               802.1q         trunking      1
Gi0/1       on               802.1q         trunking      1
Gi0/2       desirable        n-802.1q       trunking      1
Gi0/3       desirable        n-802.1q       trunking      1
Po1         on               802.1q         trunking      999
```

Configure and verify an EtherChannel using LACP between D1 and D2:
Add the command channel-group 4 mode active to all the trunk interfaces between D1 and D2.

D1:

```
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#int range gi0/0-3
D1(config-if-range)#channel-group 4 mode active
Creating a port-channel interface Port-channel 4

D1(config-if-range)#
```

D2:

```
D2#
D2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D2(config)#int range gi0/0-3
D2(config-if-range)#channel-group 4 mode active
Creating a port-channel interface Port-channel 4

D2(config-if-range)#
```

- Verify the EtherChannel has formed by examining the output of the show etherchannel summary command.
- Also check the spanning tree status. You will see that the two interfaces are no longer referenced by Spanning Tree, but the port-channel is.
- Because there is only one (logical) trunk between D1 and D1, there are no Spanning Tree blocked ports.

D1:

```
*Nov  5 10:01:03.105: %SYS-5-CONFIG_I: Configured from console by console sum
D1#show etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 3
Number of aggregators:           3

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
3      Po3(RD)          -
4      Po4(SU)         LACP      Gi0/0(P)    Gi0/1(P)    Gi0/2(s)
                                 Gi0/3(s)
5      Po5(RD)          -

D1#
```

D2:

```
*Nov  5 09:38:40.123: %SYS-5-CONFIG_I: Configured from console by console
D2#show etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 2
Number of aggregators:           2

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SU)         -        Gi1/0(P)    Gi1/1(P)
4      Po4(SU)         LACP     Gi0/0(P)    Gi0/1(P)    Gi0/2(s)
                                Gi0/3(s)

D2#conf t
```

Make a change to the EtherChannel:

- Once again, it is important to understand that changes to the EtherChannel configuration must be made at the port-channel level.
- Changes you make directly to the member interfaces of a port-channel may create synchronization issues that will cause the group to fail or underperform.
- On D1 and D2, modify interface port-channel 4 so that it uses VLAN 999 as the native VLAN.

D1:

```
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#int port-channel 4
D1(config-if)#switchport trunk native vlan 999
D1(config-if)#end
D1#
```

D2:

```
D2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D2(config)#int port-channel 4
D2(config-if)#switchport trunk native vlan 999
D2(config-if)#end
D2#
```

Verify the change has been applied by examining the output of show interfaces trunk | i Port|Po4 on D1 and D2

D1:

```
*Nov  5 10:01:51.118: %SYS-5-CONFIG_I: Configured from console by console
D1#show int trunk | i Port|Po4
Port        Mode             Encapsulation  Status        Native vlan
Po4         on               802.1q         trunking      999
Port        Vlans allowed on trunk
Po4         1-4094
Port        Vlans allowed and active in management domain
Po4         1,100,200,300,999
Port        Vlans in spanning tree forwarding state and not pruned
Po4         1,100,200,300,999
D1#
```

D2:

```
D2#
D2#sh int trunk | i Port|Po4
Port        Mode             Encapsulation  Status        Native vlan
Po4         on               802.1q         trunking      999
Port        Vlans allowed on trunk
Po4         1-4094
Port        Vlans allowed and active in management domain
Po4         1,100,200,300,999
Port        Vlans in spanning tree forwarding state and not pruned
Po4         1,100,200,300,999
D2#
```

2. Tune and Optimize EtherChannel Operations.

Step 1: Design the Topology.

Step 2: Configure the network.

Switch D1:

```
% Prohibited.
********************************************************************
vIOS-L2-01>
vIOS-L2-01>en
vIOS-L2-01#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
vIOS-L2-01(config)#hostname D1
D1(config)#spanning-tree mode rapid-pvst
D1(config)#line con 0
D1(config-line)#exec-timeout 0 0
D1(config-line)#logging synchronous
D1(config-line)#exit
D1(config)#int range gi0/0-3
D1(config-if-range)#switchport trunk encapsulation dot1q
D1(config-if-range)#switchport mode trunk
D1(config-if-range)#no shut
D1(config-if-range)#exit
D1(config)#
D1(config)#
```

Switch D2:

```
********************************************************************
vIOS-L2-01>
vIOS-L2-01>en
vIOS-L2-01#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
vIOS-L2-01(config)#hostanme D2
                   ^
% Invalid input detected at '^' marker.

vIOS-L2-01(config)#hostname D2
D2(config)#spanning-tree mode rapid-pvst
D2(config)#line con 0
D2(config-line)#exec-timeout 0 0
D2(config-line)#logging synchronous
D2(config-line)#exit
D2(config)#int range gi0/0-3
D2(config-if-range)#switchport mode trunk
Command rejected: An interface whose trunk encapsulation is "Auto" can not be configured to "trunk" mode.
% Range command terminated because it failed on GigabitEthernet0/0
D2(config-if-range)#switchport trunk encapsulation dot1q
D2(config-if-range)#switchport mode trunk
D2(config-if-range)#no shut
D2(config-if-range)#exit
D2(config)#end
```

Step 3: Tune LACP-based EtherChannels

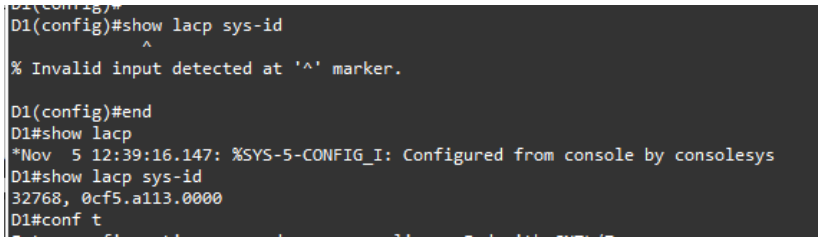
- An EtherChannel bundle using LACP as its negotiation protocol can have as many as 16 assigned members with 8 active ports passing traffic, and the other 8 ports on standby.
- The minimum and maximum number of ports allowed to be involved in a port channel can be managed through configuration as well.
- For the group of links connecting D1 and D2, you will set up an EtherChannel bundle using LACP as the negotiation protocol, with a minimum of 2 links and a maximum of 3.
- As a part of this configuration, you will control which switch is the master. Next, you will enable LACP fast packets, reducing the time out period from 30 seconds to 1 second.

Configure master switch criteria.

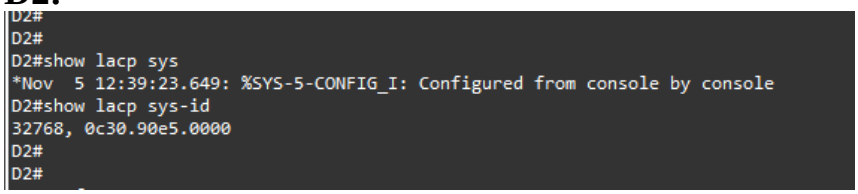
- Each switch connected using LACP has a system ID value. Those numbers are compared, and the switch with the lowest number is considered the master.
- The system ID value is a combination of a system priority that defaults to 32768 and the base MAC address.

Use the show lacp sys-id privileged EXEC command to see what the sys-id value is for D1 and D2.
Based on the output shown below, we can deduce that D1 would be the bundle master if all default values remained unchanged.

D1:



D2:



On D2, modify the lacp sys-id by changing the system priority. Use the lacp system-priority value global configuration command to set the value to 1, and then verify that the value has been changed.

D2:

```
D2#
D2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D2(config)#lacp system-priority 1
D2(config)#exit
D2#show
*Nov  5 12:39:38.039: %SYS-5-CONFIG_I: Configured from console by consolelacp
D2#show lacp sys-id
1, 0c30.90e5.0000
D2#
D2#
```

You can see the priority is 1 now.

Configure bundle size and member preferences.

- By default, interfaces are selected to be included in the active bundle based on their interface id.
- For a given configuration, the lower numbered interfaces are added to the bundle until the bundle has reached its maximum size.
- Any interfaces that remain are put in hot standby mode.

Issue the shutdown command for the interfaces connecting D1 and D2.

D1:

```
D1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D1(config)#int range gi0/0-3
D1(config-if-range)#shut
D1(config-if-range)#
*Nov  5 12:39:51.246: %LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to administratively down
*Nov  5 12:39:51.511: %LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to administratively down
*Nov  5 12:39:51.511: %LINK-5-CHANGED: Interface GigabitEthernet0/2, changed state to administratively down
*Nov  5 12:39:51.511: %LINK-5-CHANGED: Interface GigabitEthernet0/3, changed state to administratively down
*Nov  5 12:39:52.415: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to down
D1(config-if-range)#
*Nov  5 12:39:52.740: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to down
*Nov  5 12:39:52.740: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/2, changed state to down
*Nov  5 12:39:52.740: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/3, changed state to down
```

D2:

```
D2#
D2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
D2(config)#int range gi0/0-3
D2(config-if-range)#shut
D2(config-if-range)#
*Nov  5 12:40:03.948: %LINK-5-CHANGED: Interface GigabitEthernet0/0, changed state to administratively down
*Nov  5 12:40:04.313: %LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to administratively down
*Nov  5 12:40:04.313: %LINK-5-CHANGED: Interface GigabitEthernet0/2, changed state to administratively down
*Nov  5 12:40:04.313: %LINK-5-CHANGED: Interface GigabitEthernet0/3, changed state to administratively down
*Nov  5 12:40:05.066: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to down
D2(config-if-range)#
*Nov  5 12:40:05.433: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to down
*Nov  5 12:40:05.433: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/2, changed state to down
```

Configure the connections between D1 and D2 into a single LACP EtherChannel bundle.
Use Channel Group number 12 and the Active mode.
Configure the interfaces for LACP Fast.
Then issue the no shutdown command for the interfaces connecting D1 and D2.

D1:

```
D1(config-if-range)#channel-group 12 mode active
Creating a port-channel interface Port-channel 12

D1(config-if-range)#no shut
D1(config-if-range)#ex
D1(config)#
*Nov  5 12:40:34.888: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Nov  5 12:40:34.889: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
*Nov  5 12:40:34.889: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to up
*Nov  5 12:40:34.889: %LINK-3-UPDOWN: Interface GigabitEthernet0/3, changed state to up
*Nov  5 12:40:36.225: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up
*Nov  5 12:40:36.225: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to up
*Nov  5 12:40:36.225: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/2, changed state to up
*Nov  5 12:40:36.225: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/3, changed state to up
D1(config)#
```

D2:

```
D2(config-if-range)#channel-group 12 mode active
Creating a port-channel interface Port-channel 12

D2(config-if-range)#no shut
D2(config-if-range)#ex
D2(config)#
*Nov  5 12:40:26.259: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Nov  5 12:40:26.259: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
*Nov  5 12:40:26.259: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to up
*Nov  5 12:40:26.259: %LINK-3-UPDOWN: Interface GigabitEthernet0/3, changed state to up
*Nov  5 12:40:27.612: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up
*Nov  5 12:40:27.612: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to up
*Nov  5 12:40:27.612: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/2, changed state to up
*Nov  5 12:40:27.612: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/3, changed state to up
D2(config)#
```

On D1 and D2, configure the port-channel 12 interface with a LACP minimum bundle size of 2 interfaces, and the maximum bundle size of 3 interfaces.

D1:

```
D1(config)#int port-channel 12
D1(config-if)#
*Nov  5 12:40:48.152: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel12, changed state to up
D1(config-if)#lacp max-bundle 3
D1(config-if)#end
D1#
*Nov  5 12:40:54.323: %SYS-5-CONFIG_I: Configured from console by console
D1#
*Nov  5 12:40:56.238: %LINK-3-UPDOWN: Interface Port-channel12, changed state to down
*Nov  5 12:40:57.285: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel12, changed state to down
D1#
*Nov  5 12:40:59.057: %IDBMAN-3-INVALIDAGGPORTBANDWIDTH: Port-channel12(16 / 0) has an invalid bandwidth value of 0
*Nov  5 12:41:00.015: %IDBMAN-3-INVALIDAGGPORTBANDWIDTH: Port-channel12(16 / 0) has an invalid bandwidth value of 0
```

D2:

```
D2(config)#int port-channel 12
D2(config-if)#lacp max
*Nov  5 12:40:47.694: %IDBMAN-3-INVALIDAGGPORTBANDWIDTH: Port-channel12(16 / 0) has an invalid bandwidth value of 0
*Nov  5 12:40:48.635: %IDBMAN-3-INVALIDAGGPORTBANDWIDTH: Port-channel12(16 / 0) has an invalid bandwidth value of 0-bundle
D2(config-if)#lacp max-bundle 3
D2(config-if)#end
D2#
```

Verify that the EtherChannel bundle has formed and take note of the ports that are included versus the port that is in hot standby mode.

D1:

```
*Nov  5 12:41:05.111: %IDBMAN-3-INVALIDAGGPORTBANDWIDTH: Port-channel12(16 / 0) has an i
D1#sh etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
12     Po12(SU)        LACP      Gi0/0(P)    Gi0/1(P)    Gi0/2(P)
                                 Gi0/3(H)
```

D2:

```
D2#sh etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
12     Po12(SU)        LACP      Gi0/0(P)    Gi0/1(P)    Gi0/2(P)
                                 Gi0/3(H)

D2#
```

Verify the mode, state, and rate of LACPDU being sent for port members on D1 and D2:

D1:

```
D1#sh lacp internal
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 12
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi0/0     SA      bndl      32768         0xC       0xC     0x1         0x3D
Gi0/1     SA      bndl      32768         0xC       0xC     0x2         0x3D
Gi0/2     SA      bndl      32768         0xC       0xC     0x3         0x3D
Gi0/3     SA      hot-sby   32768         0xC       0xC     0x4         0x5
D1#
D1#
```

D2:

```
D2#
D2#sh lacp internal
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 12
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi0/0     SA      bndl      32768         0xC       0xC     0x1         0x3D
Gi0/1     SA      bndl      32768         0xC       0xC     0x2         0x3D
Gi0/2     SA      bndl      32768         0xC       0xC     0x3         0x3D
Gi0/3     SA      hot-sby   32768         0xC       0xC     0x4         0x5
D2#
D2#
```

Step 4: Explore EtherChannel Load Balancing.

The load balancing method used to send traffic through an EtherChannel is a global setting on the switch.

All EtherChannel's on a given switch will use the method selected for that switch.

The load balancing methods used at either end of an EtherChannel bundle do not have to match.

D1:

```
D1#
D1#sh etherchannel load-balance
EtherChannel Load-Balancing Configuration:
        src-dst-ip

EtherChannel Load-Balancing Addresses Used Per-Protocol:
Non-IP: Source XOR Destination MAC address
  IPv4: Source XOR Destination IP address
  IPv6: Source XOR Destination IP address

D1#
```

D2:

```
D2#
D2#sh etherchannel load-balance
EtherChannel Load-Balancing Configuration:
        src-dst-ip

EtherChannel Load-Balancing Addresses Used Per-Protocol:
Non-IP: Source XOR Destination MAC address
  IPv4: Source XOR Destination IP address
  IPv6: Source XOR Destination IP address

D2#
D2#
D2#
```

Select a channel-group and specify the source and destination address (in the form of a MAC, IP, or Port number) and the switch tells you what the exit port will be.

The example that follows shows that traffic with the same source MAC always exits using the same interface.

Use this command on your switches to verify how the default load-balancing scheme is working, and then try out the other load-balancing mechanisms to see how the behaviour changes.