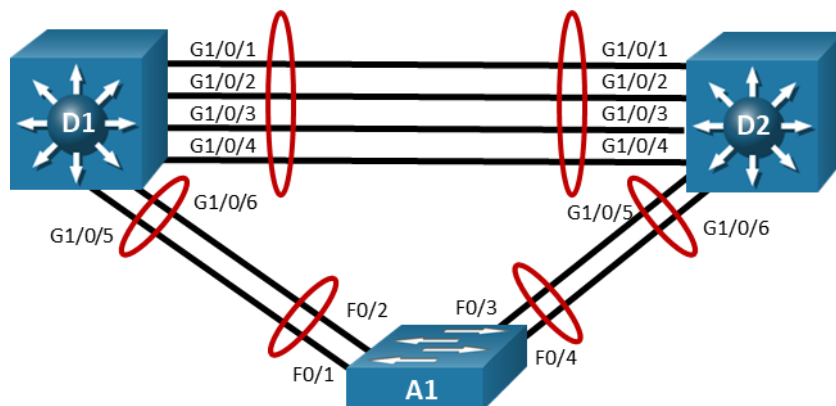


## Lab - Implement EtherChannel

### Topology



### Objectives

**Part 1: Build the Network and Explore Dynamic Trunking Protocol**

**Part 2: Configure Basic Device Settings**

**Part 3: Configure Static EtherChannel**

**Part 4: Implement EtherChannel Using PAgP**

**Part 5: Implement EtherChannel Using LACP**

### Background / Scenario

Our topology includes several links between sets of switches. By default, only one of these links is used and Spanning Tree blocks the rest of the connections between two switches to prevent a bridging loop from occurring. The other connections provide a fallback if the primary connection fails, but do not provide any additional full-time data bandwidth between the switches.

In this lab, you explore various methods of Link Aggregation, which will combine the connections into a single logical channel group. Port Aggregation Protocol (PAgP), a Cisco EtherChannel protocol, and Link Aggregation Control Protocol (LACP), an open standard version of EtherChannel, are signaling protocols. They allow two switches to negotiate the use of selected physical ports as members of a single EtherChannel bundle. EtherChannel can also be configured statically (without a negotiation protocol). EtherChannel allows up to eight redundant links to be bundled together into one logical link. Throughout this lab, we will be using the term EtherChannel to refer to a logical bundling of multiple physical links, and the term Port-channel to refer to a virtual interface that represents an EtherChannel bundle in the Cisco IOS configuration.

Before exploring EtherChannel, you will examine Dynamic Trunking Protocol, a Cisco proprietary protocol for automatically forming trunks. You will learn how to turn the protocol off and why you should do so.

**Note:** This lab is an exercise in deploying and verifying EtherChannel and does not necessarily reflect networking best practices.

**Note:** The switches used with CCNP hands-on labs are Cisco 3650 with Cisco IOS XE release 16.9.4 (universalk9 image) and Cisco 2960+ with IOS release 15.2 (lanbase image). Other routers 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.

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

### Required Resources

- 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 lanbase image or comparable)
- 1 PC (Windows with a terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

### Instructions

#### Part 1: Build the Network and Explore Dynamic Trunking Protocol

In Part 1, you will set up the network topology and then examine how DTP works and how to manipulate it.

##### Step 1: Cable the network as shown in the topology.

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

##### Step 2: Examine the default port status and manipulate DTP.

For this step, we will focus on the connections between D1 and A1.

- a. 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 **show interfaces g1/0/5 switchport** and **show interfaces f0/1 switchport**.

##### Switch D1

```
Switch# config t
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# hostname D1
D1(config)# end
D1#
D1# show interfaces g1/0/5 switchport
Name: Gi1/0/5
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: disabled
Voice VLAN: none
<output omitted>
```

##### Switch A1

```
Switch# config t
Enter configuration commands, one per line.  End with CNTL/Z.
```

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```
Switch(config)# hostname A1
A1(config)# end
A1#
A1# show interfaces f0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
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
<output omitted>
```

Carefully examining the output from the two switches, you see that the Administrative Mode is reported as Dynamic Auto on both sides. This mode is one of the options supported by Dynamic Trunking Protocol (DTP). Also note that the Automatic Negotiation of Trunking setting is On.

DTP is used by Cisco switches to automatically negotiate whether the port should be put into access or trunk mode and what trunking protocol (802.1Q or ISL) should be used. It is meant both to ease the initial deployment of a switched network and to minimize configuration errors that result from mismatched port configuration on an interconnection between two switches.

- b. Change the administrative mode of interface f0/1 on A1 to Dynamic Desirable with the interface configuration command **switchport mode dynamic desirable**. After a few moments, 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. The output of **show interfaces trunk** on D1 will show auto.

```
A1# conf t
Enter configuration commands, one per line. End with CNTL/Z.
A1(config)# interface f0/1
A1(config-if)# switchport mode dynamic desirable
A1(config-if)# end
Jan 7 14:39:33.138: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/1, changed state to down
A1#
Jan 7 14:39:34.581: %SYS-5-CONFIG_I: Configured from console by console
Jan 7 14:39:36.158: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/1, changed state to up
A1# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	desirable	802.1q	trunking	1

Port	Vlans allowed on trunk
Fa0/1	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1

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```
Port          Vlans in spanning tree forwarding state and not pruned
Fa0/1         1
```

```
D1# show interfaces trunk
```

```
Port          Mode          Encapsulation  Status        Native vlan
Gi1/0/5       auto          802.1q         trunking     1
<output omitted>
```

- c. DTP datagrams 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 DTP datagrams on that port are deactivated. To see this, configure D1 interface g1/0/6 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 f0/2 and D1 g1/0/6.

```
D1# config t
```

```
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
D1(config)# interface g1/0/6
```

```
D1(config-if)# switchport mode trunk
```

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

```
A1# show interfaces trunk
```

```
Port          Mode          Encapsulation  Status        Native vlan
Fa0/1         desirable    802.1q         trunking     1
Fa0/2         auto         802.1q         trunking     1
<output omitted>
```

DTP is not secure, which means that a device could send false DTP packets and cause a switchport to become an unauthorized trunk port, giving the attacker access to all VLANs allowed on that trunk. Therefore, it is a best practice to set the mode statically and deactivate the DTP protocol on a port using the command **switchport nonegotiate** (this command is necessary only for trunk ports).

- d. On A1, shutdown interfaces f0/1 and f0/2 if necessary. Then go to D1 and configure interfaces g1/0/5 and g1/0/6 as trunks with the additional command **switchport nonegotiate**. A few moments after you re-enable the interfaces at A1, you will see that they do not form trunks with D1.

```
D1# config t
```

```
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
D1(config)# interface range g1/0/5-6
```

```
D1(config-if-range)# switchport mode trunk
```

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

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

```
A1(config-if-range)# no shutdown
```

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

```
A1# show interfaces trunk
```

```
A1# show interfaces f0/1 switchport | i Mode
```

```
Administrative Mode: dynamic desirable
```

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Operational Mode: static access

Access Mode VLAN: 1 (default)

Trunking Native Mode VLAN: 1 (default)

Capture Mode Disabled

- e. At each switch, issue the global configuration command **default interface range** *first-int-id - last-int-id* to reset the interfaces back to their defaults.

```
A1# config t
```

```
Enter configuration commands, one per line. End with CNTL/Z.
```

```
A1(config)# default interface range f0/1-2
```

### Step 3: Configure Basic Device Settings

- a. Console into each switch, enter global configuration mode, and apply the basic settings using the following startup configurations for each device.

#### Switch D1

```
hostname D1
banner motd # D1, Implement EtherChannel #
line con 0
  exec-timeout 0 0
  logging synchronous
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
```

#### Switch D2

```
hostname D2
banner motd # D2, Implement EtherChannel #
line con 0
  exec-timeout 0 0
  logging synchronous
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
```

#### Switch A1

```
hostname A1
banner motd # A1, Implement EtherChannel#
```

## Lab - Implement EtherChannel

---

```
line con 0
  exec-timeout 0 0
  logging synchronous
  exit
interface range f0/1-24, g0/1-2
  shutdown
  exit
interface range f0/1-4
  switchport mode trunk
  no shutdown
  exit
```

- b. Set the clock on each switch to UTC time.
- c. Save the running configuration to startup-config.

## Part 2: Configure Static EtherChannel

In this part, you will configure an EtherChannel without a negotiation protocol. This is against best practices because there is no health check mechanism when the port-channel is statically set to on. 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 1: Configure and verify trunking between D2 and A1.

- a. Configure the ports interconnecting D2 and A1 as static trunk ports with the **switchport nonegotiate** command (the startup configuration has the commands to make them a trunk).

```
D2# config t
Enter configuration commands, one per line.  End with CNTL/Z.
D2(config)# interface range g1/0/5-6
D2(config-if-range)# switchport nonegotiate
D2(config-if-range)# end
```

- b. Verify the trunks have formed.

```
A1# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1
Fa0/2	on	802.1q	trunking	1
Fa0/3	on	802.1q	trunking	1
Fa0/4	on	802.1q	trunking	1

<output omitted>

### Step 2: Configure and verify a static EtherChannel link between D2 and A1.

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

```
D2# config t
Enter configuration commands, one per line.  End with CNTL/Z.
D2(config)# interface range g1/0/5-6
D2(config-if-range)# channel-group 1 mode on
Creating a port-channel interface Port-channel 1
```

## Lab - Implement EtherChannel

```
A1# config t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)# interface range f0/3-4
A1(config-if-range)# channel-group 1 mode on
Creating a port-channel interface Port-channel 1
A1#
Jan  7 15:01:37.641: %SYS-5-CONFIG_I: Configured from console by console
A1#
Jan  7 15:01:39.562: %LINK-3-UPDOWN: Interface Port-channell1, changed state
to up
A1#
Jan  7 15:01:40.568: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-
channell1, changed state to up
```

- b. 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 F0/3 and F0/4 with a lower cost.

```
A1# 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: 1
Number of aggregators:          1

Group  Port-channel  Protocol    Ports
-----+-----+-----+-----
1      Po1 (SU)        -           Fa0/3 (P)  Fa0/4 (P)
```

```
A1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
            Address    d8b1.9028.af80
            Cost        16
            Port        64 (Port-channell1)
            Hello Time  2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID  Priority    32769   (priority 32768 sys-id-ext 1)
```

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```
Address      f078.1647.4580
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time   300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Altn	BLK	19	128.1	P2p
Fa0/2	Altn	BLK	19	128.2	P2p
Po1	Root	FWD	12	128.64	P2p

### Step 3: Make a change to the EtherChannel.

With very few exceptions, changes to the EtherChannel configuration (whether a negotiation protocol is used or not) 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 NATIVE\_VLAN.
- On D2 and A1, modify interface port-channel 1 so that it uses VLAN 999 as the native VLAN.

```
A1# config t
Enter configuration commands, one per line.  End with CNTL/Z.
A1(config)# interface port-channel 1
A1(config-if)# switchport trunk native vlan 999
A1(config-if)# end
```

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

```
A1# show interfaces trunk

Port        Mode          Encapsulation  Status        Native vlan
Fa0/1       on            802.1q         trunking      1
Fa0/2       on            802.1q         trunking      1
Po1         on            802.1q         trunking      999
<output omitted>
```

## Part 3: 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. An example might be when you are connecting a PAgP bundle to a file server. The file server is not sending traffic, and so the bundle will never be formed. Silent mode, which is the default, would allow the switch to build and use the bundle. The recommended configuration is to add the non-silent option when building connections between PAgP-capable devices. For this part you will work with D1 and A1.

### Step 1: Configure and verify trunking between D1 and A1.

- Configure the ports interconnecting D1 and A1 as static trunk ports with the **switchport nonegotiate** command (the startup configuration has the commands to make them a trunk).
- Verify the trunks are still working.



### Step 2: 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(config)# interface range f0/1-2
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#
```

```
Jan 7 15:10:12.483: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channel2, changed state to up
```

```
Jan 7 15:10:14.253: %LINK-3-UPDOWN: Interface Port-channel2, changed state to up
```

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

```
A1# 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)	-	Fa0/3 (P) Fa0/4 (P)
2	Po2 (SU)	PAgP	Fa0/1 (P) Fa0/2 (P)

### Step 3: Make a change to the EtherChannel.

Re-iterating step 3 in Part 2, 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 D1, create VLAN 999 with the name NATIVE\_VLAN.
- On D1 and A1, modify interface port-channel 2 so that it uses VLAN 999 as the native VLAN.

```
D1# config t
```

```
Enter configuration commands, one per line. End with CNTL/Z.
```

```
D1(config)# interface port-channel 2
```

```
D1(config-if)# switchport trunk native vlan 999
```

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

- c. Verify the change has been applied by examining the output of **show interfaces trunk | i Port|Po2**.

```
D1# show interfaces trunk | i Port|Po2
```

```
Port          Mode          Encapsulation  Status        Native vlan
Po2           on            802.1q         trunking      999
<output omitted>
```

### Part 4: 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.

#### Step 1: Configure and verify trunking between D1 and D2.

- a. Configure the ports interconnecting D1 and D2 as static trunk ports with the **switchport nonegotiate** command (the startup configuration has the commands to make them a trunk).
- b. Verify the trunks are still operational.

```
D2# show interfaces trunk
```

```
Port          Mode          Encapsulation  Status        Native vlan
Gi1/0/1       on            802.1q         trunking      1
Gi1/0/2       on            802.1q         trunking      1
Gi1/0/3       on            802.1q         trunking      1
Gi1/0/4       on            802.1q         trunking      1
Po1           on            802.1q         trunking      999
<output omitted>
```

#### Step 2: Configure and verify an EtherChannel using LACP between D1 and D2.

- a. Add the command **channel-group 3 mode active** to all the trunk interfaces between D1 and D2.

```
D2# config t
```

```
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
D2(config)# interface range g1/0/1-4
```

```
D2(config-if-range)# channel-group 3 mode active
```

```
Creating a port-channel interface Port-channel 3
```

- b. 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.

```
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
```

## Lab - Implement EtherChannel

---

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

A - formed by Auto LAG

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

Group	Port-channel	Protocol	Ports	
1	Po1 (SU)	-	Gi1/0/5 (P)	Gi1/0/6 (P)
3	Po3 (SU)	LACP	Gi1/0/1 (P)	Gi1/0/2 (P) Gi1/0/3 (P)
			Gi1/0/4 (P)	

### Step 3: 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 3 so that it uses VLAN 999 as the native VLAN.

```
D1# config t
```

```
Enter configuration commands, one per line. End with CNTL/Z.
```

```
D1(config)# interface port-channel 3
```

```
D1(config-if)# switchport trunk native vlan 999
```

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

```
D1(config)# end
```

- Verify the change has been applied by examining the output of **show interfaces trunk | i Port|Po3**

```
D1# show interfaces trunk | i Port|Po3
```

Port	Mode	Encapsulation	Status	Native vlan
Po3	on	802.1q	trunking	999

```
<output omitted>
```