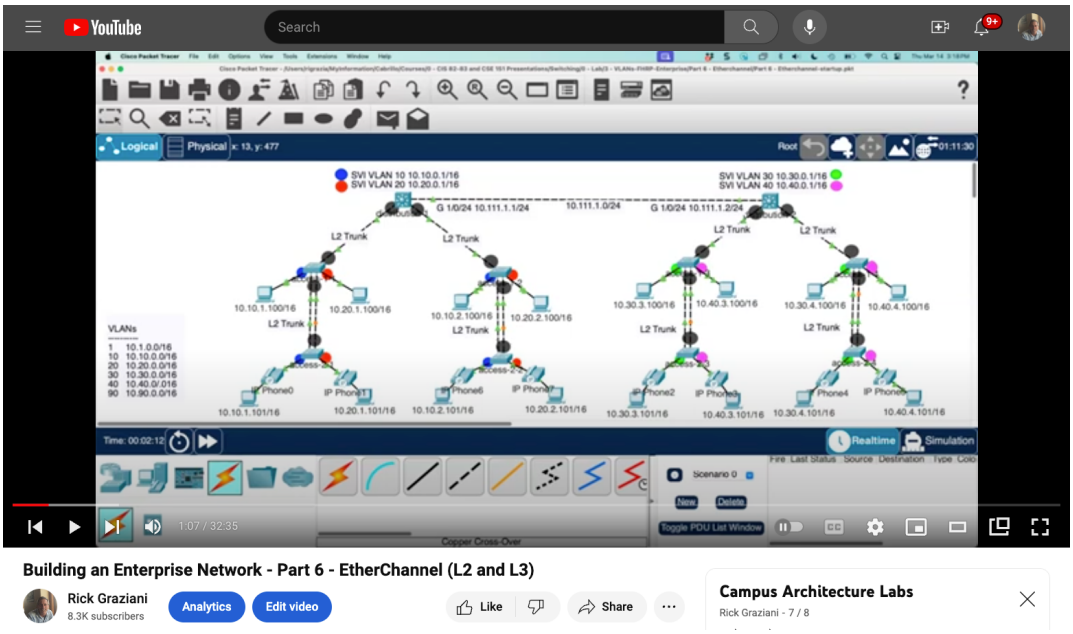
Building an Enterprise Network
Part 6: EtherChannel

Refer to the following YouTube Video:
https://www.youtube.com/watch?v=F7bfon83a3A&list=PLMLm7-g0V0kdkzbfJS-naBrLMQNDubT8p&index=7



Topology from Previous Lab

Begin by using the topology you completed in the previous lab. We currently have configured VLANs, trunking, routed ports and routing in our switch block, so we have complete reachability between all device.

EtherChannel

EtherChannel is a port link aggregation technology or protocol developed by Cisco, which allows the bundling of several physical Ethernet links to form a single logical link between two networking devices. This aggregation enhances the bandwidth by combining multiple links' capacities and provides redundancy for higher network resilience. EtherChannel can operate at both Layer 2 and Layer 3 of the OSI model, enabling flexibility in network design and implementation.

Layer 3 EtherChannel: At Layer 3, EtherChannel aggregates multiple links into a single logical connection that can route IP packets. This is used between routing devices or between routers and switches that support Layer 3 operations. Layer 3 EtherChannel enables the aggregation of

bandwidth and redundancy for routed links, enhancing the performance and reliability of inter-VLAN routing and core network connectivity.

Link Aggregation Control Protocol (LACP): LACP is part of an IEEE standard (802.3ad) that provides a method for automatically creating EtherChannels by dynamically negotiating with connected devices.

Port Aggregation Protocol (PAgP): PAgP is a Cisco proprietary protocol similar to LACP, designed to automatically negotiate the formation of EtherChannel links.

LACP and PAgP facilitate the detection and configuration of links that are capable of aggregation and ensures that only compatible and properly configured links are aggregated. These protocols are highly recommended for its ability to dynamically manage link aggregation, thereby reducing the likelihood of configuration errors and improving network resilience. This facilitates the automatic determination of which links can be combined based on their configurations and ensures consistent configurations on both ends of the EtherChannel. While PAgP offers benefits similar to LACP, its use is limited to Cisco devices.

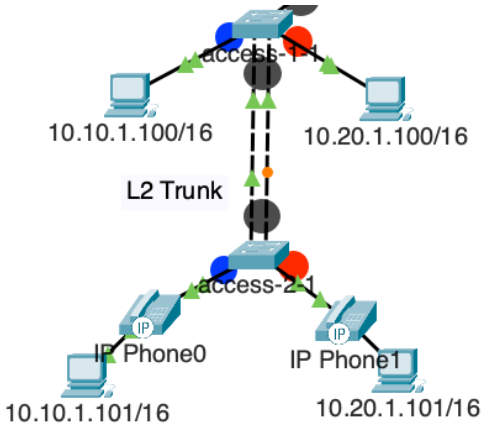
Static Persistence (Manual Configuration): EtherChannel can also be configured statically, without using LACP or PAgP for negotiation. This method requires manual configuration of both ends of the EtherChannel to aggregate the links. While this approach offers simplicity and control, it lacks the dynamic negotiation and configuration verification features of LACP and PAgP, potentially increasing the risk of misconfiguration and operational issues.

Note: In this lab we will be configuring Layer 2 and Layer 3 EtherChannel using LACP.

Layer 2 EtherChannel - LACP

At Layer 2, EtherChannel combines multiple Ethernet links into a single logical link that operates between two switches or between a switch and a server. This configuration is typically used in scenarios where bandwidth aggregation and link redundancy are critical for the operation of access or aggregation layer switches within a data center or campus network.

Layer 2 EtherChannel between two switches allows STP to treat the combined physical links (known as a port channel) as a single logical link. This means all the switchports that are part of the Layer 2 EthernChannel are in the forwarding state.



Examine Current Running-Configs

Examine the current configuration of FastEthernet 0/1 and 0/2 ports on column 1 access layer switches.

```
access-1-1# show running-config
!
interface FastEthernet0/1
switchport trunk native vlan 254
switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
switchport mode trunk
switchport nonegotiate
!
interface FastEthernet0/2
switchport trunk native vlan 254
switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
switchport mode trunk
switchport nonegotiate
!
```

Examine Current Spanning-Tree States

Depending on the MAC addresses of your switches, one of your switches will be the root bridge for all VLANs. In a later lab we will configure the distribution switch to be the STP bridge.

One of the two access switches have one its ports in blocking the sending and receiving for frames for loop prevention. This switch will have its Fa0/2 port in the Blocking state (BLK), Alternate port (Altn role). The Fa0/1 port will be the Root port and be in the Forwarding (FWD) state. In my example, it is access-2-1. The switch with the blocked port in your topology may differ.

Packet Tracer Bug:

VLAN0255 should not be part of the output. VLAN 255 was not included in the **switchport trunk allowed vlan** command as shown in the running-config.

When you configure trunk links on switches and specify which VLANs are allowed on those trunk links using the **switchport trunk allowed vlan** command, you are essentially filtering which VLAN traffic is permitted to traverse the trunk. This means only the VLANs explicitly included in the **allowed vlan** list can pass through the trunk link. Since VLAN 255 is not included in our allowed list (**switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254**), it will not be permitted to traverse the trunk link between the two switches on interface **fa0/1**.

The output of **spanning-tree interface fa0/1**, typically includes only the VLANs that the interface is actively forwarding or blocking for. Since VLAN 255 is not allowed on the trunk link, it should not be included in the STP information for interface **fa0/1**. This means you won't see VLAN 255 in the

spanning-tree interface fa0/1 output because STP operates on VLANs that are allowed and active on the link. If VLAN 255 is not allowed on the trunk, it does not participate in STP calculations or status for that trunk link.

This behavior is consistent across most switch models and configurations, but if you're working with specific hardware or software versions, it's always a good idea to consult the relevant documentation and verify with the appropriate spanning tree commands.

```
access-2-1# show spanning-tree inter fa 0/1
Vlan             Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001         Root FWD 19        128.1     P2p
VLAN0010         Root FWD 19        128.1     P2p
VLAN0020         Root FWD 19        128.1     P2p
VLAN0030         Root FWD 19        128.1     P2p
VLAN0040         Root FWD 19        128.1     P2p
VLAN0090         Root FWD 19        128.1     P2p
VLAN0100         Root FWD 19        128.1     P2p
VLAN0180         Root FWD 19        128.1     P2p
VLAN0254         Root FWD 19        128.1     P2p
VLAN0255         19        128.1     P2p

access-2-1# show spanning-tree inter fa 0/2
Vlan             Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001         Altn BLK 19        128.2     P2p
VLAN0010         Altn BLK 19        128.2     P2p
VLAN0020         Altn BLK 19        128.2     P2p
VLAN0030         Altn BLK 19        128.2     P2p
VLAN0040         Altn BLK 19        128.2     P2p
VLAN0090         Altn BLK 19        128.2     P2p
VLAN0100         Altn BLK 19        128.2     P2p
VLAN0180         Altn BLK 19        128.2     P2p
VLAN0254         Altn BLK 19        128.2     P2p
VLAN0255         19        128.2     P2p
access-2-1#
```

The other switch will have its Fa0/1 and Fa0/2 as Designated (Desg) ports and will be in Forwarding (FWD) state. In my example, it is access-1-1.

```
access-1-1# show spanning-tree interface fa 0/1
Vlan             Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001         Desg FWD 19        128.1     P2p
VLAN0010         Desg FWD 19        128.1     P2p
VLAN0020         Desg FWD 19        128.1     P2p
VLAN0030         Desg FWD 19        128.1     P2p
```

```
VLAN0040         Desg FWD 19        128.1     P2p
VLAN0090         Desg FWD 19        128.1     P2p
VLAN0100         Desg FWD 19        128.1     P2p
VLAN0180         Desg FWD 19        128.1     P2p
VLAN0254         Desg FWD 19        128.1     P2p
VLAN0255         19        128.1     P2p

access-1-1# show spanning-tree interface fa 0/2
Vlan             Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001         Desg FWD 19        128.2     P2p
VLAN0010         Desg FWD 19        128.2     P2p
VLAN0020         Desg FWD 19        128.2     P2p
VLAN0030         Desg FWD 19        128.2     P2p
VLAN0040         Desg FWD 19        128.2     P2p
VLAN0090         Desg FWD 19        128.2     P2p
VLAN0100         Desg FWD 19        128.2     P2p
VLAN0180         Desg FWD 19        128.2     P2p
VLAN0254         Desg FWD 19        128.2     P2p
VLAN0255         19        128.2     P2p
access-1-1#
```

Examine Current Trunking Information

The trunk link consists of two physical interfaces, Fa0/1 and Fa0/2. Remember, because there is a loop, STP is blocking one of the ports on one of the two switches.

```
access-2-1# show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Fa0/1       on           802.1q         trunking      254
Fa0/2       on           802.1q         trunking      254

Port        Vlans allowed on trunk
Fa0/1       1,10,20,30,40,90,100,180,254
Fa0/2       1,10,20,30,40,90,100,180,254

Port        Vlans allowed and active in management domain
Fa0/1       1,10,20,30,40,90,100,180,254
Fa0/2       1,10,20,30,40,90,100,180,254

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/1       1,10,20,30,40,90,100,180,254
Fa0/2       none

access-2-1#
```

Configure EtherChannel Using LACP

Starting with the access switches in column 1, configure these commands on each of the two switches that you want to configure with EtherChannel. This will ensure that both sides of the channel are configured to negotiate the EtherChannel properly and that load balancing is handled in the desired way. Remember, it's essential that both ends of the EtherChannel are configured consistently.

Here's a brief explanation of the commands you will be configuring:

- **port-channel load-balance src-dst-ip**: This command configures the load-balancing method for all EtherChannels on the switch to be based on the source and destination IP addresses. When the switch has to decide which port to use to forward a frame, it will take into account the combination of both source and destination IP addresses.
- **interface range fa 0/1-2**: This command is used to enter the interface range configuration mode for FastEthernet ports 0/1 to 0/2. This allows you to configure multiple interfaces with the same configuration commands simultaneously.
    1. **shutdown** (within interface range configuration mode): This command administratively shuts down the interfaces that are currently being configured (in this case, FastEthernet ports 0/1 to 0/2). This is often done before applying certain configuration changes.
    2. **channel-protocol lacp**: This command sets the Link Aggregation Control Protocol (LACP) as the protocol to be used on the specified interfaces for negotiating the EtherChannel with the connected device. LACP is one of the protocols supported by EtherChannel, the other being PAgP (Port Aggregation Protocol), which is Cisco proprietary.
    3. **channel-group 1 mode active**: This command assigns the selected interfaces to channel-group number 1 and sets them to actively negotiate an LACP EtherChannel with the remote switch. 'Active' means that the port will initiate negotiations with the remote switch to form an LACP EtherChannel.

Note: To avoid inconsistencies and synchronization issues, it is important to shutdown both the interface before configuring EtherChannel. Do not bring up the interface until the other end of the port-channel is either configured or shutdown.

```
access-1-1(config)# port-channel load-balance src-dst-ip
access-1-1(config)# inter range fa 0/1-2
access-1-1(config-if-range)# shutdown
access-1-1(config-if-range)# channel-protocol lacp
access-1-1(config-if-range)# channel-group 1 mode active
```

```
access-1-2(config)# port-channel load-balance src-dst-ip
access-1-2(config)# inter range fa 0/1-2
```

```
access-1-2(config-if-range)# shutdown
access-1-2(config-if-range)# channel-protocol lacp
access-1-2(config-if-range)# channel-group 1 mode active
```

Bring up both interfaces.

```
access-1-1(config)# inter range fa 0/1-2
access-1-1(config-if-range)# no shutdown
```

```
access-1-2(config)# inter range fa 0/1-2
access-1-2(config-if-range)# no shutdown
```

Examine the Running-Config after EtherChannel Configuration

Using the **show running-config** command, examine the new running-config on one of the switches. Notice the new Port-channel1 interface.

The new **Port-channel1** interface is a logical interface on the Cisco switch that represents the EtherChannel itself. EtherChannel aggregates the individual physical links (in this case, FastEthernet0/1 and FastEthernet0/2) into a single logical link, which increases bandwidth and provides redundancy.

The **Port-channel1** interface received these commands, when you use the **channel-group** command on physical interfaces and associate them with a channel-group, the Cisco IOS software automatically creates the corresponding port-channel interface if it does not already exist. The configuration commands applied to the physical interfaces that are members of the channel-group are replicated to the port-channel interface. Thus, it inherits the configuration of its member ports. If the port-channel already exists, the physical interface's configuration must match the port-channel's configuration for the EtherChannel to work correctly.

This means that the **Port-channel1** interface now represents the aggregation of FastEthernet0/1 and FastEthernet0/2, and any configuration applied to **Port-channel1** applies to the traffic across both physical links in the EtherChannel.

```
access-1-2# show running-config

<output omitted>

port-channel load-balance src-dst-ip
```

```
!
interface Port-channel1
 switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
 switchport trunk native vlan 254
 switchport mode trunk
 switchport nonegotiate
!
interface FastEthernet0/1
 switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
 switchport trunk native vlan 254
 switchport mode trunk
 switchport nonegotiate
 channel-protocol lacp
 channel-group 1 mode active
!
interface FastEthernet0/2
 switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
 switchport trunk native vlan 254
 switchport mode trunk
 switchport nonegotiate
 channel-protocol lacp
 channel-group 1 mode active
!
```

Note: 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. This includes and VLAN or trunking commands such as changing the Native VLAN. 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.

Packet Tracer Bug

Problem:

In Packet Tracker, the Port-channel1 interface does not inherit the **switchport trunk allowed vlan** command from the physical interface. You will notice this when you issue the show running-config command. This will give you incorrect output when issuing commands such as **show running-config**, and **show interfaces trunk**.

```
access-1-2# show running-config

<output omitted>

port-channel load-balance src-dst-ip
!
interface Port-channel1
 ! MISSING
 switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
 switchport trunk native vlan 254
 switchport mode trunk
 switchport nonegotiate
```

```
!


access-2-1# show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Po1         on           802.1q         trunking      254

Port        Vlans allowed on trunk
Po1         1-1005

Port        Vlans allowed and active in management domain
Po1         1,10,20,30,40,90,100,180,254,255 ! Should be omitted
```

Solution:

Configure the switchport trunk allowed vlan command to the port-channel interface:

```
access-2-1(config)# interface port-channel1
access-2-1(config-if)# switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
```

Repeat this command on all access layer switches (8 switches) configured for EtherChannel.

Verify with **show running-config** and **show interfaces trunk**

Repeat the EtherChannel Configuration on the other Access Layer Switches

The Packet Tracer bug above is why we waited before configuring LACP on the other access layer switches.

```
access-x-y(config)# port-channel load-balance src-dst-ip

access-x-y(config)# inter range fa 0/1-2
access-x-y(config-if-range)# shutdown
access-x-y(config-if-range)# channel-protocol lacp
access-x-y(config-if-range)# channel-group 1 mode active
access-x-y(config-if-range)# exit

! The following port-channel1 command is only required for Packet Tracer
access-x-y(config)# interface port-channel1
access-x-y(config-if)# switchport trunk allowed vlan 1,10,20,30,40,90,100,180,254
access-x-y(config-if)# exit
```

Examining the EtherChannel Trunk Link

Issue the command **show interfaces trunk**. The **Port-channel1** (often abbreviated as **Po1**) interface represents the logical EtherChannel link that aggregates the two physical interfaces (FastEthernet0/1 and FastEthernet0/2). When you configure the **channel-group** command on these interfaces and specify the **mode active** with LACP, the switch automatically creates a port-channel interface if it doesn't already exist.

The `Port-channel1` interface received its configuration from the member ports' configuration due to the `channel-group` command. When you configure the member ports as trunk ports with specific VLANs and native VLAN, that configuration is automatically applied to the `Port-channel` interface once the EtherChannel is formed. It's essential to have identical configurations on all member ports to form an EtherChannel successfully.

Packet Tracer Bug: If you did not add the switchport trunk allowed vlan commands to port-channel1 above, you will see VLAN 255 in the allowed VLANs.

```
access-2-1# show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Po1         on           802.1q         trunking      254

Port        Vlans allowed on trunk
Po1         1-1005

Port        Vlans allowed and active in management domain
Po1         1,10,20,30,40,90,100,180,254

Port        Vlans in spanning tree forwarding state and not pruned
Po1         1,10,20,30,40,90,100,180,254

access-2-1#
```

Examining Spanning-Tree after EtherChannel Configuration

Before configuring EtherChannel, Spanning Tree blocked one of the two ports on one of the ends of the two switches.

Here was the output prior to configuring EtherChannel. The switch with the blocked port in your topology may differ. (The output below is from Packet Tracer and VLAN0255 should not be included.)

```
! Spanning-Tree BEFORE EtherChannel
```

```
access-2-1# show spanning-tree inter fa 0/1
Vlan              Role Sts Cost      Prio.Nbr Type
----------------  ---- --- --------- -------- --------------------------------
VLAN0001          Root FWD 19        128.1     P2p
VLAN0010          Root FWD 19        128.1     P2p
VLAN0020          Root FWD 19        128.1     P2p
VLAN0030          Root FWD 19        128.1     P2p
VLAN0040          Root FWD 19        128.1     P2p
VLAN0090          Root FWD 19        128.1     P2p
VLAN0100          Root FWD 19        128.1     P2p
VLAN0180          Root FWD 19        128.1     P2p
VLAN0254          Root FWD 19        128.1     P2p
VLAN0255          19        128.1     P2p

access-2-1# show spanning-tree inter fa 0/2
Vlan              Role Sts Cost      Prio.Nbr Type
----------------  ---- --- --------- -------- --------------------------------
VLAN0001          Altn BLK 19        128.2     P2p
VLAN0010          Altn BLK 19        128.2     P2p
VLAN0020          Altn BLK 19        128.2     P2p
VLAN0030          Altn BLK 19        128.2     P2p
VLAN0040          Altn BLK 19        128.2     P2p
VLAN0090          Altn BLK 19        128.2     P2p
VLAN0100          Altn BLK 19        128.2     P2p
VLAN0180          Altn BLK 19        128.2     P2p
VLAN0254          Altn BLK 19        128.2     P2p
VLAN0255          19        128.2     P2p
access-2-1#
```

After configuring EtherChannel, Spanning Tree Protocol (STP) now treats the previously individual FastEthernet0/1 and FastEthernet0/2 ports as a single logical link, known as Port-channel1. As a result, STP no longer needs to block one of the ports to prevent potential loops, because the aggregation technology ensures that the combined physical links operate as a unified connection. This single logical path is managed by STP as if it were a single port, which means all the ports within the EtherChannel bundle are placed in a forwarding state, enhancing bandwidth utilization and redundancy without the risk of broadcast storms or loops that STP is designed to prevent. This unified behavior is key to EtherChannel's effectiveness, as it allows for both ports on each switch to actively forward traffic, doubling the link capacity while maintaining a loop-free network topology.

Here is the same Spanning Tree output after configuring Etherchannel. (The output below is from Packet Tracer and VLAN0255 should not be included.)

```
! Spanning-Tree AFTER EtherChannel

access-2-1# show spanning-tree interface fa 0/1
Vlan Role Sts Cost Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001 Desg FWD 19 128.1 P2p
VLAN0010 Desg FWD 19 128.1 P2p
VLAN0020 Desg FWD 19 128.1 P2p
VLAN0030 Desg FWD 19 128.1 P2p
```

```
VLAN0040 Desg FWD 19 128.1 P2p
VLAN0090 Desg FWD 19 128.1 P2p
VLAN0100 Desg FWD 19 128.1 P2p
VLAN0180 Desg FWD 19 128.1 P2p
VLAN0254 Desg FWD 19 128.1 P2p
VLAN0255 FWD 19 128.1 P2p

access-2-1# show spanning-tree interface fa 0/2
Vlan Role Sts Cost Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001 Desg FWD 19 128.2 P2p
VLAN0010 Desg FWD 19 128.2 P2p
VLAN0020 Desg FWD 19 128.2 P2p
VLAN0030 Desg FWD 19 128.2 P2p
VLAN0040 Desg FWD 19 128.2 P2p
VLAN0090 Desg FWD 19 128.2 P2p
VLAN0100 Desg FWD 19 128.2 P2p
VLAN0180 Desg FWD 19 128.2 P2p
VLAN0254 Desg FWD 19 128.2 P2p
VLAN0255 FWD 19 128.2 P2p
access-2-1#
```

The command **show spanning-tree interface port-channel 1** would display the Spanning Tree Protocol (STP) status and information specifically for the Port-channel 1 interface, which represents the aggregated EtherChannel. In the context of Layer 2 (L2) EtherChannel, **Po1** logically bundles the member physical ports together, such as FastEthernet0/1 and FastEthernet0/2, allowing them to be treated as a single STP entity.

```
access-2-1# show spanning-tree interface port-channel 1
Vlan             Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
VLAN0001         Root FWD 12        128.28    Shr
VLAN0010         Root FWD 12        128.28    Shr
VLAN0020         Root FWD 12        128.28    Shr
VLAN0030         Root FWD 12        128.28    Shr
VLAN0040         Root FWD 12        128.28    Shr
VLAN0090         Root FWD 12        128.28    Shr
VLAN0100         Root FWD 12        128.28    Shr
VLAN0180         Root FWD 12        128.28    Shr
VLAN0254         Root FWD 12        128.28    Shr
VLAN0255         Root FWD 12        128.28    Shr
access-2-1#
```

Verifying Layer 2 EtherChannel

Verify L2 EtherChannel with show etherchannel

The **show etherchannel** command on a Cisco switch provides information about the EtherChannel configuration and status:

- **Group: 1**: This indicates the EtherChannel group number, which is a numeric identifier for the specific EtherChannel. You can have multiple EtherChannels on a switch, and they would be distinguished by their group numbers.
- **Group state = L2**: This shows that the EtherChannel is operating as a Layer 2 link (at the data link layer), which means it's functioning as a switchport and can carry VLAN traffic.
- **Ports: 2 Maxports = 16**: This indicates that there are currently 2 physical ports (interfaces) bundled into this EtherChannel group. The maximum number of ports that could be bundled in this EtherChannel (or any EtherChannel on this switch) is 16.
- **Port-channels: 1 Max Port-channels = 16**: This tells you that there's currently 1 logical Port-channel interface formed from the bundled ports. The switch can have up to 16 such Port-channel interfaces.
- **Protocol: LACP**: Indicates that the Link Aggregation Control Protocol (LACP) is the protocol being used for this EtherChannel. LACP is a negotiation protocol that allows the automatic bundling of links by exchanging packets between the switches involved in the EtherChannel.

The **show etherchannel** command output is helpful for verifying the number of ports in a channel, understanding what state the channel group is in (Layer 2 or Layer 3), checking the protocol used (LACP or PAgP if it's Cisco proprietary), and for troubleshooting purposes to ensure that the EtherChannel is operating as expected.

```
access-1-1# show etherchannel
                Channel-group listing:
                ----------------------

Group: 1
----------
Group state = L2
Ports: 2 Maxports = 16
Port-channels: 1 Max Port-channels = 16
Protocol:   LACP

access-1-1#
```

Verify L2 EtherChannel with show etherchannel summary

The **show etherchannel summary** command provides a concise overview of the EtherChannel configuration on the Cisco switch:

- **Flags**: This part explains the meaning of various single-letter flags that can appear next to the ports in the summary:
    - **P** indicates that the port is part of a port-channel.
    - **S** indicates that the port is operating at Layer 2.
    - **U** means the port is currently in use.

- **Number of channel-groups in use**: This shows how many EtherChannel groups are active on the switch. Here it's 1, which means there's only one EtherChannel configured and in use.
- **Number of aggregators**: This is the number of logical port-channel interfaces or aggregators created from the EtherChannel groups. Again, it's 1, meaning there is one Port-channel interface corresponding to the single EtherChannel group.
- **Group Port-channel Protocol Ports**:
    - **1**: The number here represents the EtherChannel group number.
    - **Po1(SU)**: **Po1** is the name of the Port-channel interface. The flags **(SU)** mean that this Port-channel is operating at Layer 2 (**S**) and is currently in use (**U**).
    - **LACP**: This is the protocol in use for the EtherChannel. LACP is a standard protocol that enables the automatic creation of EtherChannels by exchanging packets between the ports of the involved switches.
    - **Fa0/1(P) Fa0/2(P)**: The ports listed are the members of the EtherChannel. **Fa0/1** and **Fa0/2** are both part of the Port-channel (**P**), meaning they are both active in the EtherChannel and are forwarding traffic.

This summary is quite useful for quickly verifying the status and configuration of EtherChannels. In this particular output, you can see that both FastEthernet ports 0/1 and 0/2 are bundled together in a single Port-channel interface using LACP, both are active and in use, and the logical link is operating as a Layer 2 interface.

```
access-1-1# show etherchannel summary
Flags:  D - down        P - 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
        u - unsuitable for bundling
        <omitted>

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

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------

1      Po1(SU)           LACP    Fa0/1(P) Fa0/2(P)

access-1-1#
```

Verify L2 EtherChannel with show port-channel

The **show etherchannel port-channel** command provides detailed information about the specified EtherChannel group and its member ports:

- **Port-channel: Po1 (Primary Aggregator)**: This indicates that Port-channel 1 (Po1) is the primary aggregator, which means it is the logical interface representing the EtherChannel.
- **Age of the Port-channel = 00d:00h:06m:28s**: This shows how long the Port-channel has been up and running. In this case, it has been up for 6 minutes and 28 seconds.
- **Logical slot/port = 2/1 Number of ports = 2**: This provides the virtual slot and port number of the Port-channel and indicates that there are 2 physical ports bundled into this Port-channel.
- **GC = 0x00000000 HotStandBy port = null**: GC likely refers to a group capability indicator, which in this case is not set (**0x00000000**). There is no hot standby port specified, which would be used if the EtherChannel were configured to support a standby link.
- **Port state = Port-channel**: The state of the port-channel indicates that it is active and functioning as a combined Port-channel.
- **Protocol = LACP**: This confirms that the Link Aggregation Control Protocol (LACP) is the protocol used to form this EtherChannel.
- **Port Security = Disabled**: Port security, which can restrict input to an interface by limiting and identifying MAC addresses of the workstations allowed to access the port, is turned off for this Port-channel.
- **Ports in the Port-channel**: This section lists the individual ports that are members of the Port-channel.
- **Index Load Port EC state No of bits**: This header introduces the columns below, which list the member ports and their state.
    - **Fa0/2** and **Fa0/1** are listed with an EC state of **Active**, meaning they are actively participating in the EtherChannel and are forwarding traffic.
    - **Load** refers to load-balancing and since it's **00**, it could indicate that either load-balancing is equally distributed or not specifically configured.
    - **No of bits** likely refers to how the load-balancing algorithm is applied, which in this case shows **0**, indicating no special bit-level manipulation in load-distribution decisions.
- **Time since last port bundled: 00d:00h:06m:14s Fa0/1**: This indicates the time elapsed since the last port (in this case, FastEthernet0/1) was added to the EtherChannel.

Overall, this output is useful for verifying the status and configuration of individual ports within an EtherChannel, ensuring they're all active and participating in load-balancing traffic across the Port-channel.

```
access-1-1# show etherchannel port-channel <some output omitted for brevity>
Port-channels in the group:

Port-channel: Po1    (Primary Aggregator)
------------
Age of the Port-channel   = 00d:00h:06m:28s
Logical slot/port   = 2/1       Number of ports = 2
GC                  = 0x00000000      HotStandBy port = null
Port state          = Port-channel
Protocol            =   LACP
Port Security       = Disabled

Ports in the Port-channel:
```

```
Index   Load   Port     EC state         No of bits
------+------+------+------------------+-----------
  0     00     Fa0/2    Active             0
  0     00     Fa0/1    Active             0
Time since last port bundled:    00d:00h:06m:14s    Fa0/1

access-1-1#
```

Verify L2 EtherChannel with show load-balance

The **show etherchannel load-balance** command displays the current load-balancing method that the switch is using for EtherChannel. This method determines how the switch distributes frames over the EtherChannel member links.

Here's what each line means:

- **EtherChannel Load-Balancing Operational State (src-dst-ip)**: Indicates the operational state of load-balancing for EtherChannel and specifies the algorithm being used, which in this case is based on the combination of source and destination IP addresses (**src-dst-ip**).
- **Non-IP: Source XOR Destination MAC address**: For non-IP traffic, the switch uses an exclusive OR (XOR) operation on the source and destination MAC addresses to determine which port to use for forwarding frames. This helps distribute non-IP traffic across the available links in the EtherChannel evenly.
- **IPv4: Source XOR Destination IP address**: For IPv4 traffic, the switch performs an XOR operation on the source and destination IP addresses to spread the traffic across the member links.
- **IPv6: Source XOR Destination IP address**: Similarly, for IPv6 traffic, the switch also uses an XOR of the source and destination IP addresses for load distribution.

This load-balancing approach aims to evenly distribute traffic over the EtherChannel links to prevent any single link from becoming a bottleneck, thus making efficient use of the aggregated bandwidth. The XOR operation provides a simple way to achieve a balanced distribution for a wide variety of traffic patterns.

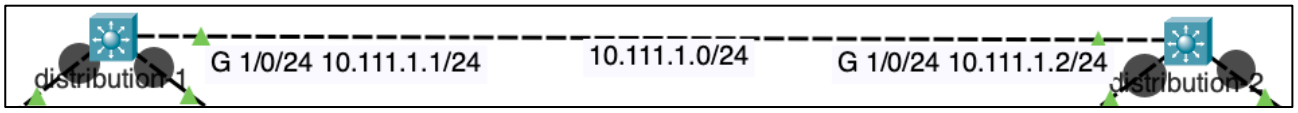
```
access-1-1# show etherchannel load-balance
EtherChannel Load-Balancing Operational State (src-dst-ip):
Non-IP: Source XOR Destination MAC address
  IPv4: Source XOR Destination IP address
  IPv6: Source XOR Destination IP address

access-1-1#
```

Layer 3 EtherChannel - LACP

Layer 3 EtherChannel is an aggregates multiple physical links between two Layer 3 devices—such as routers or Layer 3 switches—into a single logical link that operates at the network layer. By assigning an IP address to the combined Port-channel interface, this EtherChannel can route packets and participate in IP-based routing protocols, enhancing both the bandwidth and redundancy of the connection. It's ideal for critical high-speed links that carry substantial inter-VLAN traffic or for connecting core network infrastructure, ensuring consistent high availability and load balancing across multiple physical paths, making the network more resilient to individual link failures.

Examining the Routed Port Before EtherChannel



Verify Current Layer 3 with show running-config

Both Layer 3 switches, distribution-1 and distribution-2 have their adjacent gig 1/0/24 configured as a routed port.

```
distribution-1# show running-config

!
interface GigabitEthernet 1/0/24
 no switchport
 ip address 10.111.1.1 255.255.255.0
!

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

distribution-2# show running-config

!
interface GigabitEthernet 1/0/24no switchport
 no switchport
 ip address 10.111.1.2 255.255.255.0
!
```

Verify Current Layer 3 with show ip interface brief

Using the **show ip interface brief** command, examine the IPv4 address other information associated with the physical interface, the routed port Gig 1/0/24.

```
distribution-1# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet1/0/1   unassigned      YES unset  up                    up
GigabitEthernet1/0/2   unassigned      YES unset  up                    up
GigabitEthernet1/0/3   unassigned      YES unset  administratively down down
GigabitEthernet1/0/4   unassigned      YES unset  administratively down down
GigabitEthernet1/0/5   unassigned      YES unset  administratively down down
GigabitEthernet1/0/6   unassigned      YES unset  administratively down down
<omitted>
GigabitEthernet1/0/20  unassigned      YES unset  administratively down down
GigabitEthernet1/0/21  unassigned      YES unset  administratively down down
GigabitEthernet1/0/22  unassigned      YES unset  administratively down down
GigabitEthernet1/0/23  unassigned      YES unset  administratively down down
GigabitEthernet1/0/24  10.111.1.1      YES manual up                    up
<omitted>
Vlan10                 10.10.0.1       YES manual up                    up
Vlan20                 10.20.0.1       YES manual up                    up
Vlan180                10.180.1.1      YES manual up                    up
distribution-1#
```

Verify Current Layer 3 with show ip route

The **show ip route** command verifies that the Layer 3 switch is directly connected to the 10.111.1.0/24 network using the physical interface, gig 1/024/

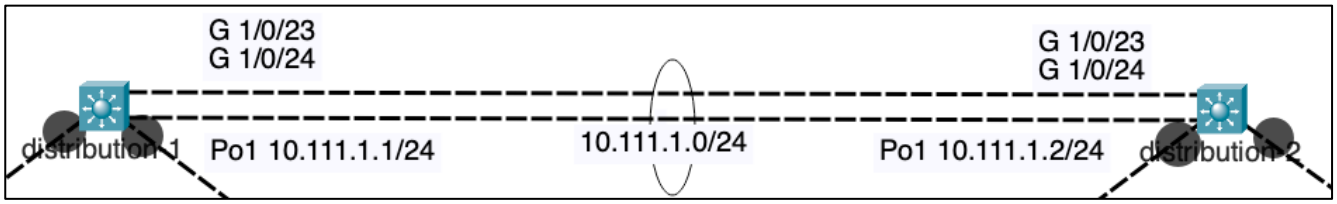
```
distribution-1# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
C       10.10.0.0/16 is directly connected, Vlan10
C       10.20.0.0/16 is directly connected, Vlan20
S       10.30.0.0/16 [1/0] via 10.111.1.2
S       10.40.0.0/16 [1/0] via 10.111.1.2
C       10.111.1.0/24 is directly connected, GigabitEthernet1/0/24
C       10.180.1.0/24 is directly connected, Vlan180
S       10.180.2.0/24 [1/0] via 10.111.1.2

distribution-1#
```

Add a Second Routed Port between Distribution Switches



Add another physical connection between distribution-1 and distribution-2 using the GigabitEthernet 1/0/23 ports.

Configuring Layer 3 EtherChannel using LACP

These are the commands for configuring a Layer 3 EtherChannel on a Layer 3 switch (or router).

Here's the step-by-step explanation:

- **interface g 1/0/24**: Enters the configuration mode for the interface GigabitEthernet 1/0/24.
    1. **no ip address**: Removes any existing IP address from the interface, ensuring it's not treated as a standalone Layer 3 interface.
    2. **exit**: Exits from the interface configuration mode back to the global configuration mode.
- **interface Port-channel2**: Enters the configuration mode for the logical Port-channel2, which will represent the EtherChannel.
    1. **no switchport**: Converts the logical Port-channel2 from a Layer 2 interface (switchport) to a Layer 3 interface (routed port).
    2. **ip address 10.111.1.1 255.255.255.0**: Assigns an IP address and subnet mask to Port-channel2, enabling it to route packets.
    3. **no shutdown**: Enables the Port-channel1, changing its state to up.
- **interface range gig 1/0/23-24**: Selects a range of interfaces, in this case, GigabitEthernet 1/0/23 to 1/0/24, to be configured next.
    1. **no switchport**: Changes the selected physical interfaces from Layer 2 switchports to Layer 3 interfaces, preparing them to be part of a Layer 3 EtherChannel.
    2. **channel-group 2 mode active**: Adds the selected interfaces to channel-group 2 and sets them to actively negotiate an EtherChannel using the LACP protocol.
    3. **no shutdown**: Ensures that the interfaces in the range are active and can form the EtherChannel.

The configuration sets up a Layer 3 EtherChannel using LACP for dynamic negotiation. The GigabitEthernet interfaces 1/0/23 and 1/0/24 are bundled into a single logical interface (Port-channel1) that can route IP traffic with the address 10.111.1.1/24. This configuration is often used for high-availability, high-bandwidth interconnections between important network devices, like core and distribution layer switches, or between switches and routers.

Configure distribution-1 switch.

```
distribution-1(config)# inter g 1/0/24
distribution-1(config-if)# no ip address
distribution-1(config-if)# exit

distribution-1(config)# interface Port-channel2
distribution-1(config-if)# no switchport
distribution-1(config-if)# ip address 10.111.1.1 255.255.255.0
distribution-1(config-if)# no shutdown
distribution-1(config-if)# exit

distribution-1(config)# interface range gig 1/0/23-24
distribution-1(config-if-range)# no switchport
distribution-1(config-if-range)# channel-protocol lacp
distribution-1(config-if-range)# channel-group 2 mode active
distribution-1(config-if-range)# no shutdown
distribution-1(config-if-range)# end
distribution-1#
```

Perform similar commands on distribution-2 switch, using its IPv4 address for the port-channel.

```
distribution-2(config)# inter g 1/0/24
distribution-2(config-if)# no ip address
distribution-2(config-if)# exit

distribution-2(config)# interface Port-channel1
distribution-2(config-if)# no switchport
distribution-2(config-if)# ip address 10.111.1.2 255.255.255.0
distribution-2(config-if)# no shutdown
distribution-2(config-if)# exit

distribution-2(config)# interface range gig 1/0/23-24
distribution-2(config-if-range)# no switchport
distribution-2(config-if-range)# channel-protocol lacp
distribution-2(config-if-range)# channel-group 2 mode active
distribution-2(config-if-range)# no shutdown
distribution-2(config-if-range)# end
distribution-2#
```

Changes to the Port-Channel

After you have configured a Layer 3 EtherChannel, any configuration changes related to the IP address or Layer 3 behavior should be made on the Port-channel interface, not on the individual member interfaces. The Port-channel interface is the logical interface that represents the aggregated link, and changes to this interface affect all member ports.

For instance, if you need to change the IP address, update the routing protocol configuration, or adjust other Layer 3 parameters, you should apply these changes to the Port-channel interface. This ensures that the EtherChannel behaves consistently as a single unit. Member interfaces should only be configured for their participation in the EtherChannel (e.g., with the **channel-group** command), and not for Layer 3 parameters, which are centralized at the Port-channel interface.

Verifying Layer 2 EtherChannel

Verify L3 EtherChannel with show etherchannel

The **show etherchannel** command displays similar to the output using the same command previously for Layer 2 EtherChannel, notice the difference with Layer 3 EtherChannel.

- **Group state = L3**: The **L3** state means that this EtherChannel is configured for Layer 3 operations, which differs from a Layer 2 EtherChannel. Layer 3 EtherChannels can have IP addresses assigned and participate in routing, whereas Layer 2 EtherChannels are used for switching purposes and do not have IP addresses.

In contrast to a Layer 2 EtherChannel where the **Group state** would be **L2**, this Layer 3 EtherChannel is capable of routing and requires that the member interfaces are configured with **no switchport** to operate as routed ports rather than switchports. This enables the logical Port-channel to have an IP address and function as a router interface, allowing it to forward IP packets and use routing protocols.

```
distribution-1# show etherchannel

<output omitted>

Group: 1
----------
Group state = L3
Ports: 2 Maxports = 16
Port-channels: 1 Max Port-channels = 16
Protocol:   LACP

distribution-1#
```

Verify L3 EtherChannel with show etherchannel summary

The **show etherchannel** summary command is similar to that for layer 2 EtherChannel.

The key distinction here between Layer 3 and Layer 2 EtherChannel configurations is indicated by the **R** flag next to **Po1**. In a Layer 2 EtherChannel, you would see an **S** instead.

Layer 3 EtherChannel interfaces act as routed ports and are typically used to connect different subnets and enable routing between them, while Layer 2 EtherChannels operate within the same VLAN and are used to increase bandwidth and provide redundancy on switching paths.

```
distribution-1# show etherchannel summary
Flags:  D - down        P - 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
<output omitted>

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

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(RU)           LACP   Gig1/0/23(P) Gig1/0/24(P)
```

Verify L3 EtherChannel with show ip interface brief

The **show ip interface brief** command now indicates the IPv4 address is no longer assigned to the physical interface GigabitEthernet 1/0/24, but is now assigned to the port-channel.

This is because, in a Layer 3 EtherChannel, the IP address is assigned to the logical Port-channel interface, not to the individual physical interfaces. The physical interfaces act as the underlying support for the Port-channel, which handles the routing and Layer 3 traffic.

```
distribution-1# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
Port-channel1          10.111.1.1      YES manual up                    up
GigabitEthernet1/0/1   unassigned      YES unset  up                    up
GigabitEthernet1/0/2   unassigned      YES unset  up                    up
GigabitEthernet1/0/3   unassigned      YES unset  administratively down down
GigabitEthernet1/0/4   unassigned      YES unset  administratively down down
GigabitEthernet1/0/5   unassigned      YES unset  administratively down down
GigabitEthernet1/0/6   unassigned      YES unset  administratively down down
<omitted>
GigabitEthernet1/0/20  unassigned      YES unset  administratively down down
GigabitEthernet1/0/21  unassigned      YES unset  administratively down down
GigabitEthernet1/0/22  unassigned      YES unset  administratively down down
GigabitEthernet1/0/23  unassigned      YES unset  up                    up
GigabitEthernet1/0/24  unassigned      YES unset  up                    up
<omitted>
Vlan10                 10.10.0.1       YES manual up                    up
Vlan20                 10.20.0.1       YES manual up                    up
Vlan180                10.180.1.1      YES manual up                    up
```

```
distribution-1#
```

Verify L3 EtherChannel with show ip route

The **show ip route** command verifies that the network **10.111.1.0/24** is directly connected to the router via the **Port-channel1** interface. This entry shows that the Port-channel1 is being used as a routed interface because of the Layer 3 EtherChannel configuration, which allows it to route traffic for the **10.111.1.0/24** network.

```
distribution-1# show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
C       10.10.0.0/16 is directly connected, Vlan10
C       10.20.0.0/16 is directly connected, Vlan20
S       10.30.0.0/16 [1/0] via 10.111.1.2
S       10.40.0.0/16 [1/0] via 10.111.1.2
C       10.111.1.0/24 is directly connected, Port-channel1
C       10.180.1.0/24 is directly connected, Vlan180
S       10.180.2.0/24 [1/0] via 10.111.1.2
distribution-1#
```

Verify L3 EtherChannel with ping

The final verification that everything works is using **ping** to verify our Layer2 and Layer 3 EthernChannels are operating as expected.

From PC with IPv4 address 10.10.1.100, ping 10.30.4.101. This frame/packet will need to be forwarded across both Layer 2 and Layer 3 EtherChannels.

```
C:\> ping 10.30.4.101

Pinging 10.30.4.101 with 32 bytes of data:

Request timed out.
Reply from 10.30.4.101: bytes=32 time<1ms TTL=126
Reply from 10.30.4.101: bytes=32 time<1ms TTL=126
Reply from 10.30.4.101: bytes=32 time<1ms TTL=126
```

```
Ping statistics for 10.30.4.101:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>
```