Switching Basics & Intermediate Routing (LAN Switching and Wireless)

Lecture 4: STP Continued and EtherChannel

CCNA Routing and Switching 3

- Scaling Networks

Feedback on Lab 2 (VTP, DTP & Extended VLANs)

- Overall, very good work so keep it up!
- Recap on VTP (VLAN Trunking Protocol) modes…
  - **Server (default mode)**: You can make changes and propagate those changes out to all other switches in the VTP domain. VTP servers store VLAN information for the entire domain in NVRAM
  - **Client**: Your switch will only receive configurations from other devices and will not allow changes to VLANs to be made on that specific switch
  - **Transparent**: You can set and store VLANs locally on that switch, but those changes are not sent to other switches on the network. You can forward VTP through the switch, but the switch will not participate with VTP
- Recap on DTP (Dynamic Trunking Protocol) trunking modes…

	Dynamic Auto	Dynamic Desirable	Trunk	Access
Dynamic Auto	Access	Trunk	Trunk	Access
Dynamic Desirable	Trunk	Trunk	Trunk	Access
Trunk	Trunk	Trunk	Trunk	Limited Connectivity
Access	Access	Access	Limited Connectivity	Access

Lecture Exam

- Will take place on the 25th Oct or 8th Nov
- Will be worth 35% of the overall CA for the module
- Written exam & will be closed book
- An hour in duration – half of the class will start the exam at 10.50am, the other half will begin at 11.55am
  - Don't be late!
- Can include anything we have covered so far (including this lecture)
- Will also include contend from online Wireless lectures
  - Will be put up on Moodle during 2 weeks of no classes

Recap on last week

- Layer 3 Switching & Troubleshooting Multi-VLAN Issues
  - Use of multilayer switches to support routing using a Routed Port or SVI (Switch Virtual Interface) port
  - Switch & Router configuration problems for VLAN issues
- Issues with Layer 1 Redundancy
  - Can cause an infinite loop leading to MAC Database Instability, Broadcast Storms & Duplicate Unicast Frames
  - Spanning Tree helps solve this by blocking certain ports

Recap on last week (continued)

- STA concepts
  - Root bridge elected (using BID) to act as reference point
  - Port roles assigned based on path cost to root bridge
- STA port roles
  - Can be root ports, designated ports or alternate ports
  - All ports of root bride are automatically designated
  - Port with lowest path cost on each switch is root port
  - Any redundant links blocked on one end (alternate)
- Varieties of Spanning Tree Protocols
  - Examined the varieties of Spanning Tree protocols including PVST+ and Rapid PVST+

Objective for this lecture:

- Spanning Tree Configuration
  - Configure PVST+ and Rapid PVST+ to improve network performance
- Link Aggregation Concepts
  - Explain link aggregation operation in a switched LAN environment
- Link Aggregation Configuration
  - Implement link aggregation to improve performance on high-traffic switch links

Spanning Tree Configuration

PVST+ (Per-VLAN Spanning Tree Plus) Configuration

- Default spanning tree mode is PVST+ on Catalyst 2960
- Two methods to manually configure the Bridge ID to force a specific switch to become the root bridge

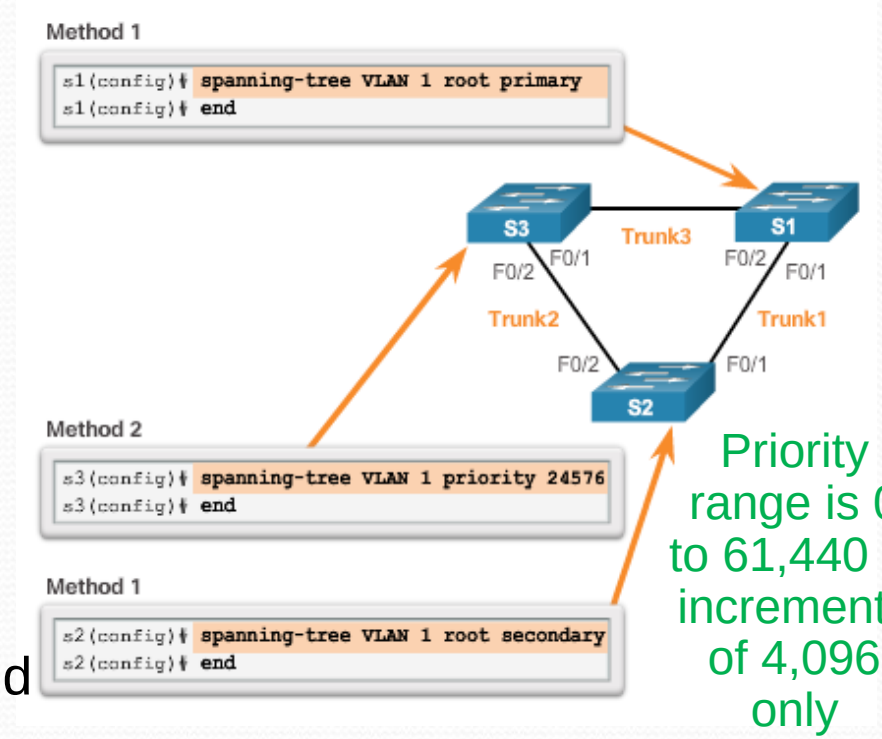
Method 1:

- Use the `spanning-tree vlan vlan-id root primary` global config command

Method 2:

- Use the `spanning-tree vlan vlan-id priority value` global config command

Use `show spanning-tree` command to verify the bridge priority of a switch.

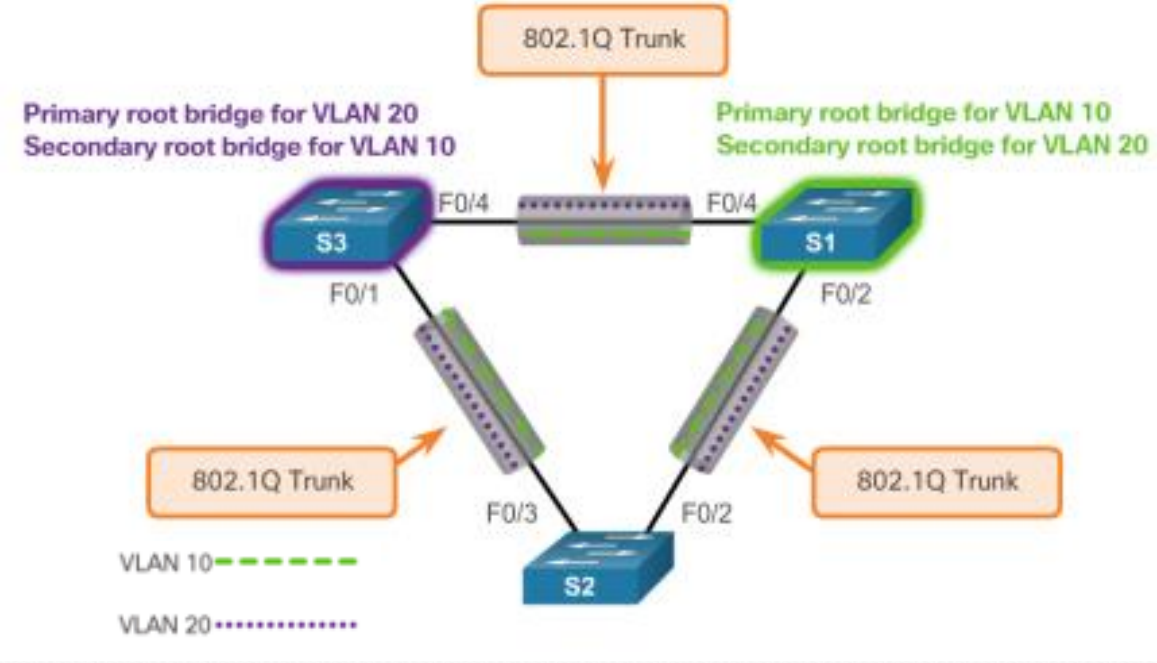


PVST+ Load Balancing

- The goal is to configure two or more root bridges for different sets of VLANs and make use of redundant links

```
S3(config)# spanning-tree vlan 20 root primary
S3(config)# spanning-tree vlan 10 root secondary
S3(config)#
```

```
S1(config)# spanning-tree vlan 10 root primary
S1(config)# spanning-tree vlan 20 root secondary
S1(config)#
```



Spanning Tree Mode - Rapid PVST+

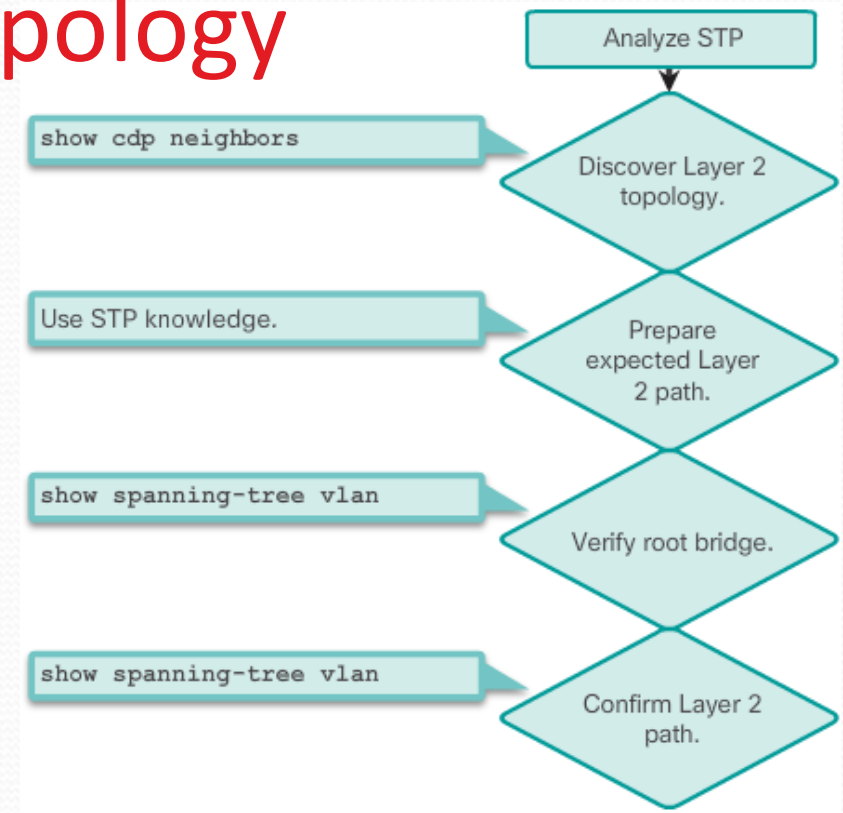
- Rapid PVST+ is the Cisco implementation of RSTP
- It supports RSTP on a per-VLAN basis

```
S1# configure terminal
S1(config)# spanning-tree mode rapid-pvst
S1(config)# interface f0/2
S1(config-if)# spanning-tree link-type point-to-point
S1(config-if)# end
S1# clear spanning-tree detected-protocols
```

```
S1# show spanning-tree vlan 10

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID     Priority    4106
              Address     0019.aa9e.b000
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
```

Analyzing the STP Topology

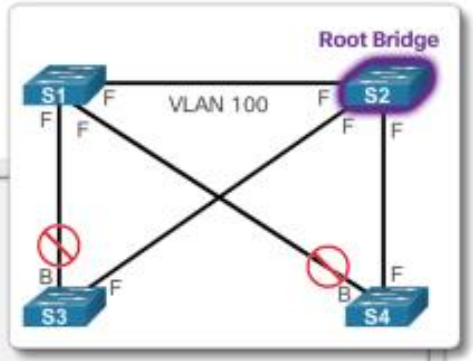
1. Use `show cdp neighbors` to discover topology
2. Use STP knowledge to determine the root switch
3. Use `show spanning-tree vlan` to verify which switch is the root
4. Use `show spanning-tree vlan` on each switch to verify the port status (forwarding or blocking)



Troubleshooting includes comparing the actual state of the network versus expected state and spotting the differences

Overview of STP Status

- The `show spanning-tree` command without specifying any additional options provides a quick overview of the status of STP for all VLANs that are defined on a switch
- Use the `show spanning-tree vlan vlan_id` command to get STP information for a particular VLAN




```
S1# show spanning-tree vlan 100

VLAN0100
 Spanning tree enabled protocol rstp
 Root ID     Priority    28772
             Address     0000.0c9f.3127
             Cost        2
             Port        88 (TenGigabit9/1)
             Hello Time  2 sec Max Age 20 sec Forward Delay 15 sec
 Bridge ID   Priority    28772 (priority 28672 sys-id-ext 100)
             Address     0000.0cab.3724
             Hello Time  2 sec Max Age 20 sec Forward Delay 15 sec
             Aging Time  300

Interface        Role Sts Cost      Prio.Nbr Type
---------        ---------------    --------------------------------
Gi3/1            Desg FWD 4         128.72   P2p
Gi3/2            Desg FWD 4         128.80   P2p
Te9/1            Root FWD 2         128.88   P2p
```

Spanning Tree Failures

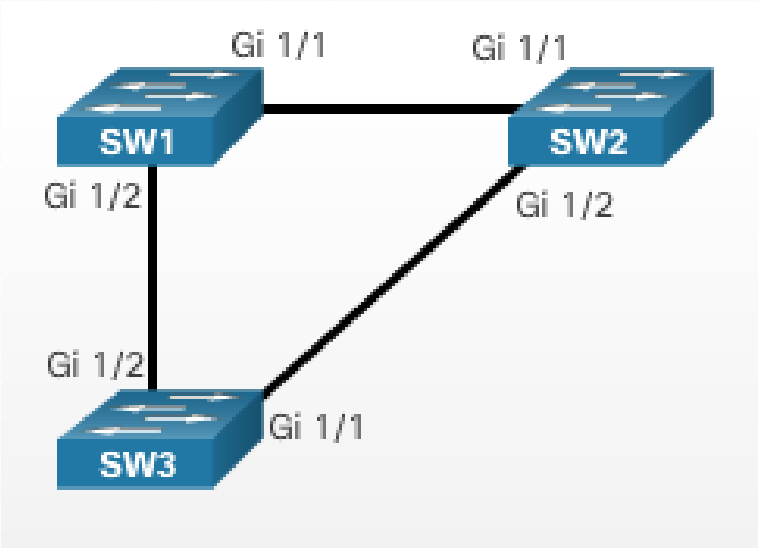
- There are two types of STP failures:

1. STP might incorrectly block ports that should have gone into the forwarding state
2. STP might incorrectly move one or more ports into the forwarding state

- Repairing a Spanning Tree Problem:
  - Manually remove redundant links in the switched network, either physically or through configuration, until all loops are eliminated
  - Chances are that restoring the redundant links will trigger a new broadcast storm
  - Before restoring the redundant links, determine and correct the cause of the spanning tree failure
  - Carefully monitor the network to ensure that the problem is fixed

Exercise

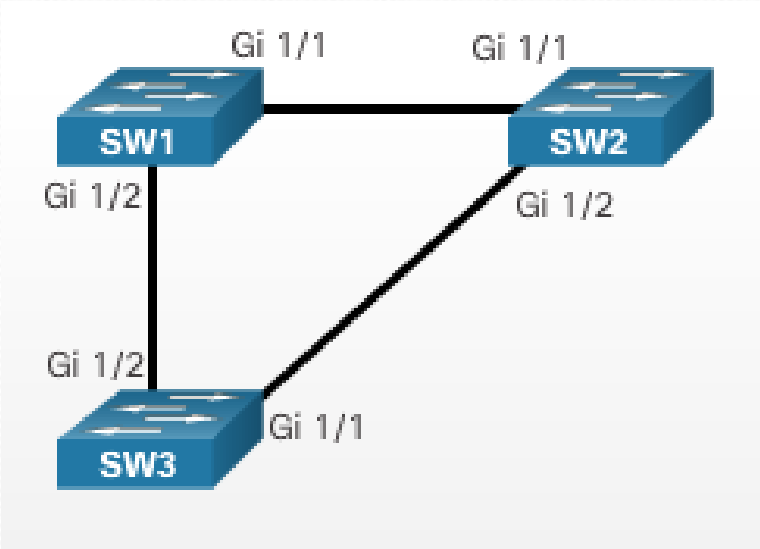
- Which switch is the root bridge based on the show command output?




```
SW1# show spanning-tree vlan 1
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0001.6468.2668

              Hello Time  2 sec  Max Age 20 sec  Forward Delay
15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0001.6468.2668
              Hello Time  2 sec  Max Age 20 sec  Forward Delay
15 sec
              Aging Time  20

Interface        Role    Sts    Cost      Prio.Nbr    Type
---------------- ----    ---    --------- --------    --------
----
Gi1/1            Desg    FWD    4         128.25      P2p
Gi1/2            Desg    FWD    4         128.26      P2p
```

Exercise

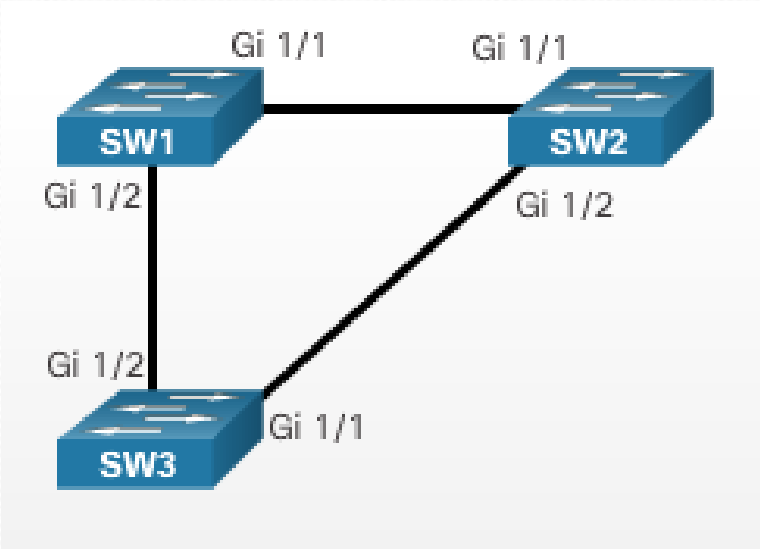
- Which switch and port is in STP blocking state based on the show command output?




```
SW3# sh span
<output omitted>
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
Gi1/1            Desg FWD 4         128.25   P2p
Gi1/2            Root FWD 4         128.26   P2p
```

Exercise

- Which link is not participating in STP between two of the switches based on the show command output?




```
SW2# show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0001.6468.2668
              Cost        8
              Port        26(GigabitEthernet1/2)
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     00D0.BAAD.594B
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  20

Interface        Role   Sts   Cost       Prio.Nbr   Type
---------------- ----   ---   ---------  --------   ---------------
Gi1/2            Root   LRN   4          128.26     P2p
```

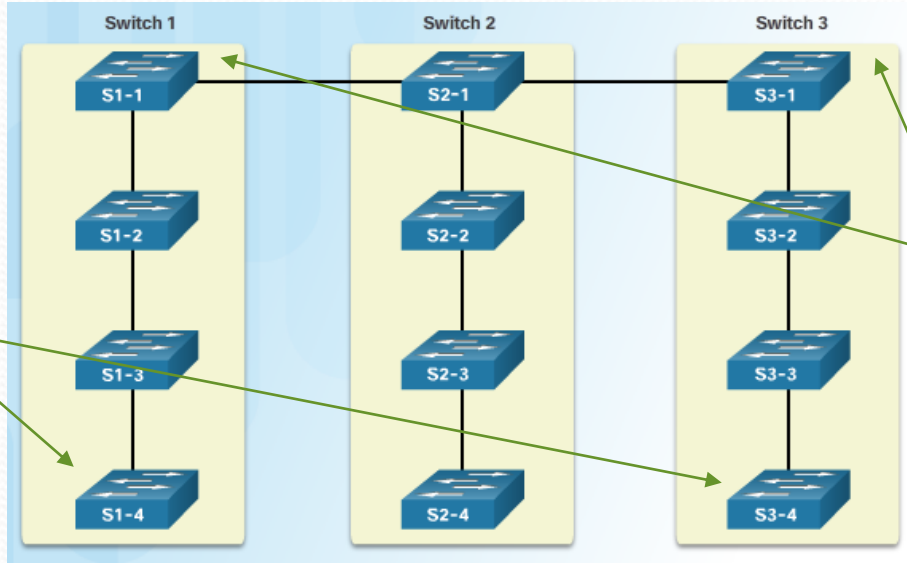
Switch Stacking Concepts

- Consists of several switches (e.g. up to nine Catalyst 3750 switches) which operate as a single logical switch
- The switch is managed as a single switch, through a single IP address, including passwords, VLANs, and interfaces
- One of the switches controls the operation of the stack and is called the stack master
- The other switches in the stack are stack members
- If master switch fails, a new master is elected from the remaining members

Spanning Tree and Switch Stacks

- Another benefit to switch stacking is the ability to add more switches to a single STP instance without increasing the STP diameter
- The diameter is the maximum number of switches that data must cross to connect any two switches
- The IEEE recommends a maximum diameter of seven switches for the default STP timers

Without stacking – switch diameter from S1-4 to S3-4 is nine switches

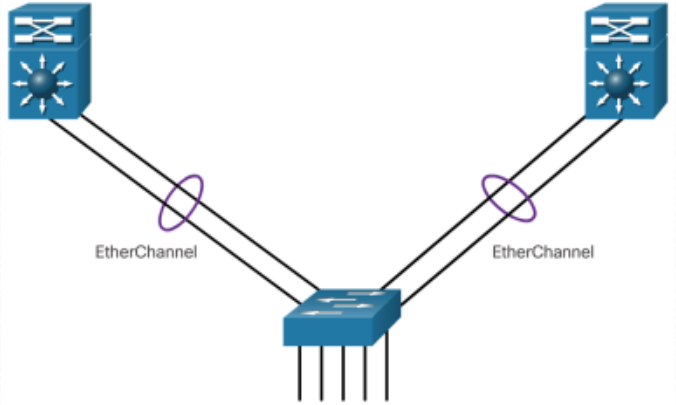


With stacking – switch diameter from S1-4 to S3-4 becomes three

Link Aggregation Concepts

Introduction to Link Aggregation

- Links with higher bandwidth must be available between the access and distribution switches
- Link aggregation combines a number of physical links between the switches to increase the overall bandwidth



- However, by default, STP is enabled on switches & blocks redundant links to prevent routing loops
- Solution: Implement EtherChannel

Advantages of EtherChannel

- Developed by Cisco, an inter switch technique of grouping several Fast Ethernet or Gig ports into one logical channel
- When configured, physical interfaces are bundled together into a virtual interface called a **port channel interface**
- EtherChannel advantages:
  - Configuration tasks configured on port channel ensuring configuration consistency throughout the links
  - Uses existing switch ports therefore no need to upgrade links/switch
  - Load balancing occurs between EtherChannel bundled links
  - EtherChannel works with STP
  - Interfaces do not have to be physically contiguous

Implementation Restrictions

- EtherChannel interface types cannot be mixed
  - E.g. Fast Ethernet & Gigabit Ethernet cannot be mixed in a port channel
- Up to 8 physical ports can be bundled together providing either up to 800 Mb/s (Fast EtherChannel) or 8 Gb/s (Gigabit EtherChannel)
- The Cisco IOS switch currently support up to six EtherChannels
- Individual EtherChannel group member port configuration must be consistent on both devices
  - E.g. If physical ports of one side are configured as trunks, the physical ports of the other side must also be configured as trunks within the same native VLAN

EtherChannel Negotiation Protocols

- There are 2 main protocols used to help configure EtherChannels:

1. Port Aggregation Protocol (PAgP)
2. Link Aggregation Control Protocol (LACP)

- *It is also possible to configure a static or unconditional EtherChannel without PAgP or LACP*

Port Aggregation Protocol (PAgP)

- Cisco-proprietary, used to negotiate forming of a channel
- PAgP sends packets every 30 seconds to check for configuration consistency and manages link additions and failures
- PAgP supports three modes:
  1. **Desirable** – Port actively initiates negotiations with other interfaces by sending PAgP packets
  2. **Auto** – Port passively negotiates state, but does not initiate PAgP negotiation
  3. **On** – Creates a channel member without negotiation (no PAgP)

S1	S2	Channel Establishment
On	On	Yes
Auto/Desirable	Desirable	Yes
On/Auto/Desirable	Not Configured	No
On	Desirable	No
Auto/On	Auto	No

The modes must be compatible on each side

Notes -> auto-auto will not create an EtherChannel
-> *on* mode only works if both sides set to on

Link Aggregation Control Protocol (LACP)

- IEEE specification (802.3ad) protocol used to negotiate forming of a channel with non-Cisco switches
- LACP supports three modes (similar to PAgP:
  1. **Active** – Port actively initiates negotiations with other interfaces by sending LACP packets
  2. **Passive** – Port passively negotiates state, but does not initiate LACP negotiation
  3. **On** – Creates a channel member without negotiation

S1	S2	Channel Establishment
On	On	Yes
Active/Passive	Active	Yes
On/Active/Passive	Not Configured	No
On	Active	No
Passive/On	Passive	No

Exercise

Match the PAgP and LACP interface negotiation terms to the appropriate descriptions:

Term

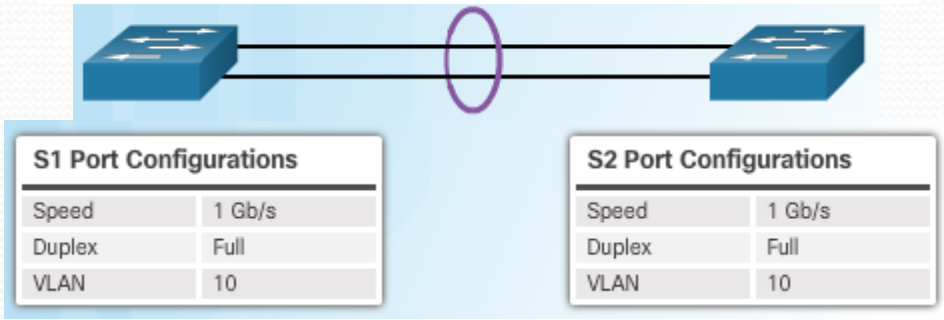
- Desirable
- Auto
- Passive
- On
- Active

PAgP and LACP Negotiation Term Description
Places an interface in a passive, responding state. Does not initiate PAgP negotiations.
Initiates LACP negotiations with other interfaces.
Actively initiates PAgP negotiations with other interfaces.
Forces EtherChannel state without PAgP or LACP initiated negotiations.
Places an interface in a passive, responding state. Does not initiate LACP negotiations.

Link Aggregation Configuration

Configuration Guidelines

- EtherChannel support – Bundle interfaces must support EtherChannel
- Speed and duplex - Configure all bundle interfaces with the same speed & in the same duplex mode
- VLAN match – Assign all bundle interfaces to the same VLAN or configure the bundle as a trunk (most common)
- Range of VLANs – A trunking EtherChannel must allow the same VLAN range otherwise the interfaces do not form an EtherChannel, even when set to auto or desirable mode



Configuring EtherChannel (LACP)

Step 1:

- Specify the interfaces to be included in the EtherChannel group. Use `interface range` *`interface`* to configure several interfaces together
- Good practice to shutdown the interfaces first

Step 2:

- Create port channel interface using `channel-group` *`identifier`* `mode active` command (in interface range config mode)
- `mode active` keywords set this as an LACP EtherChannel configuration

Configuring EtherChannel (LACP) (continued)

Step 3:

- Settings on the port channel interface can then be set/changed by entering port channel interface mode
- To do this use the `interface port-channel` *`identifier`* command

Configuring EtherChannel Example

- Configuring Two Ports as LACP Interfaces on S1

```
S1(config)# interface range fa0/1 - 2
S1(config-if-range)# speed 100
S1(config-if-range)# duplex full
S1(config-if-range)# channel-group 1 mode active
S1(config-if-range)# shutdown
S1(config-if-range)# exit
S1(config)#
S1(config)# interface port-channel 1
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk  native vlan 99
S1(config-if)# switchport trunk allowed vlan 2,20,99
S1(config-if)# exit
S1(config)#
S1(config)# interface range fa0/1 - 2
S1(config-if-range)# no shut
```

Step 1

Step 2

Step 3

Configuring EtherChannel Example (cont.)

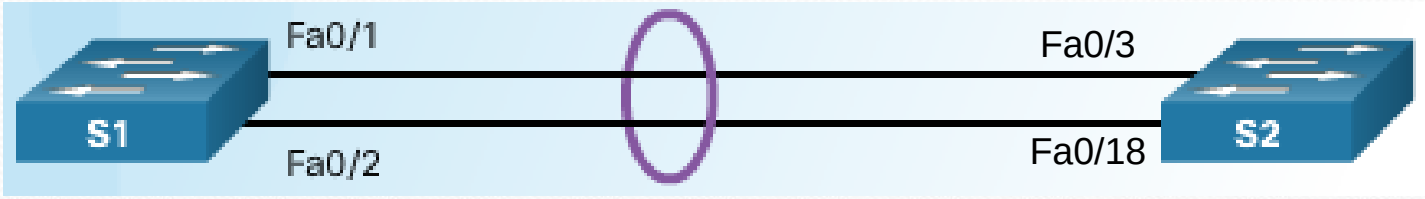
- Configuring Two Ports as LACP Interfaces on S2

```
S2(config)# interface range fa0/3, fa0/18
S2(config-if-range)# speed 100
S2(config-if-range)# duplex full
S2(config-if-range)# channel-group 1 mode active
S2(config-if-range)# shutdown
S2(config-if-range)# exit
S2(config)#
S2(config)# interface port-channel 1
S2(config-if)# switchport mode trunk
S2(config-if)# switchport trunk  native vlan 99
S2(config-if)# switchport trunk allowed vlan 2,20,99
S2(config-if)# exit
S2(config)#
S2(config)# interface range fa0/3, fa0/18
S2(config-if-range)# no shut
```

Step 1

Step 2

Step 3



Verifying EtherChannel

- Use `show interfaces port-channel` *`identifier`* to display general status information of the port channel

```
S1# show interfaces port-channel 1
Port-channel1 is up, line protocol is up (connected)
  Hardware is EtherChannel, address is 0cd9.96e8.8a02 (bia 0cd9.96e8.8a02)
  MTU 1500 bytes, BW 200000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
<Output omitted>
```

- Use the `show etherchannel port-channel` command to display information about a specific port channel interface

Verifying EtherChannel (continued)

- Use the `show interfaces` *`interface`* `etherchannel` command to provide information about the role of the interface in the EtherChannel
- Use the `show etherchannel summary` command to view the overall status and general port channel information

```
S1# 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
        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)           LACP   Fa0/1(P) Fa0/2(P)
S1#
```

Troubleshooting EtherChannel

- All interfaces within an EtherChannel must have the same configuration of speed and duplex mode, native and allowed VLANs on trunks, and access VLAN on access ports
- The dynamic negotiation options for PAgP and LACP must be compatibly configured on both ends of the EtherChannel
- Good practice to disable port channel interface using the shutdown interface command before changes are made to it & then re-enable using no shutdown command
- EtherChannel and spanning tree must interoperate. STP errors can occur if changes are made to an existing port channel. If STP errors occur, it is recommended that the port channel be deleted and recreated.

Summary

- PVST+ runs one instance of STP per VLAN. Default configuration on Cisco switches
- Rapid PVST+ can also be implemented which is newer & faster-converging STP
- Switch stacking allows connection several switches to be configured and presented to the network as a single entity. STP views the switch stack as a single switch
  - This helps ensure the IEEE recommended maximum diameter of seven switches
- EtherChannel aggregates multiple switched links together to load balance over redundant paths between two devices
  - All ports on EtherChannel must have same speed, duplex & VLAN info on both ends
  - Settings configured in the port channel interface configuration mode will also be applied to the individual interfaces in that EtherChannel
- PAgP is a Cisco-proprietary protocol that aids in the automatic creation of EtherChannel links
  - PAgP modes are on, PAgP desirable, and PAgP auto.
- LACP is part of an IEEE specification that also allows multiple physical ports to be bundled into one logical channel. The LACP modes are on, LACP active and LACP passive
- The on mode creates an EtherChannel unconditionally, without the use of PAgP or LACP
- The default for EtherChannel is that no mode is configured