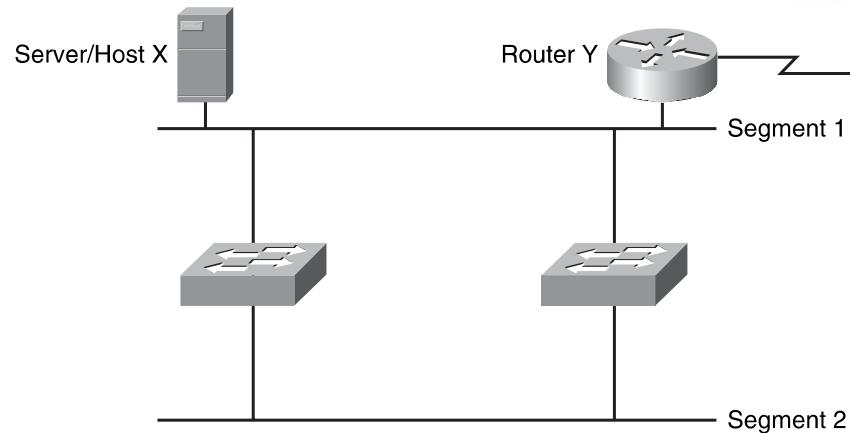


# Configuration and Management of Networks

Pedro Amaral

# Configuration and Management of Networks

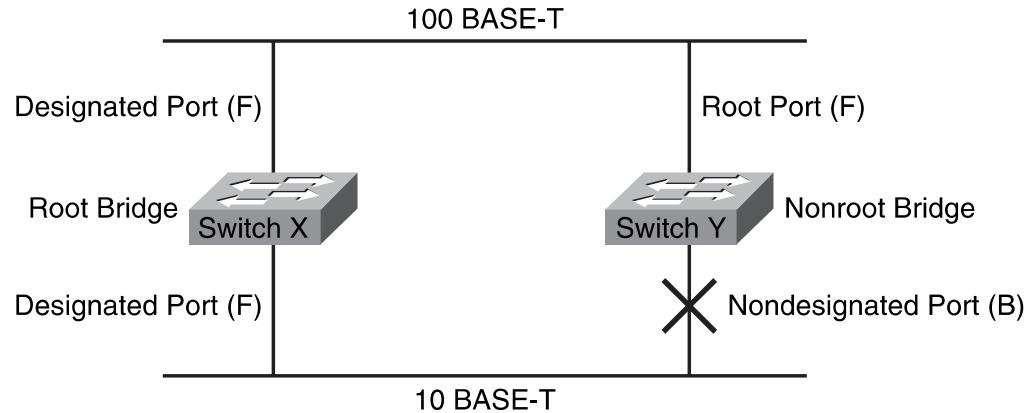
## STP – Redundant topology



- **Broadcast storms:** Each switch or bridge floods broadcasts endlessly. This situation is commonly called a *broadcast storm*.
- **Multiple frame transmission:** Multiple copies of unicast frames may be delivered to destination stations
- **MAC database instability:** Instability in the content of the MAC address table results from copies of the same frame being received on different ports of the switch.

# Configuration and Management of Networks

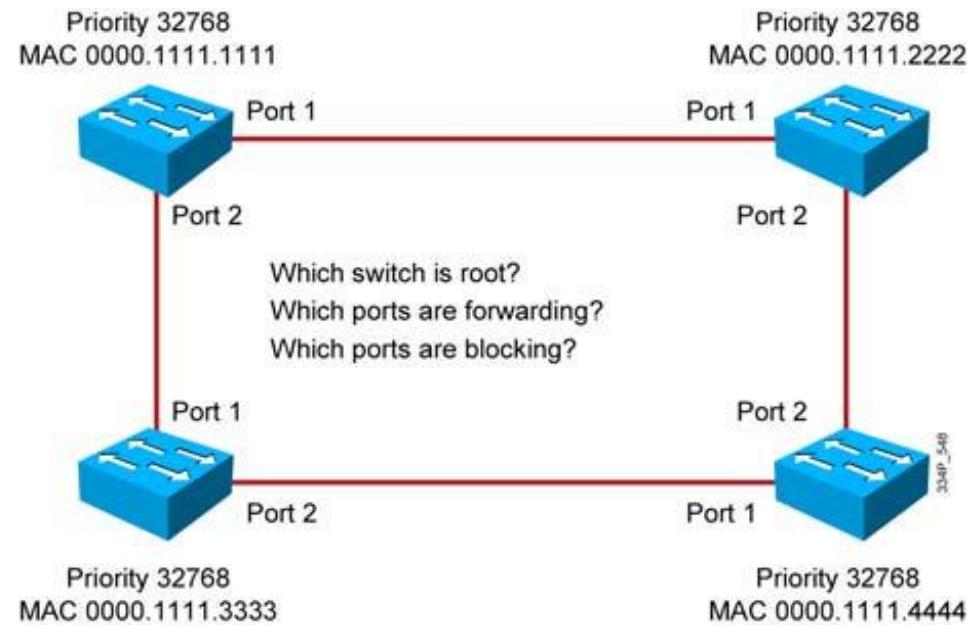
## STP – Loop Avoidance



- **Elects one root bridge:** STP has a process to elect a root bridge. Only one bridge can act as the root bridge in a given network. On the root bridge, all ports are designated ports.
- **Selects the root port on the nonroot bridge:** The root port is the lowest-cost path from the nonroot bridge to the root bridge.
- **Selects the designated port on each segment:** On each segment, STP establishes one designated port. The designated port is selected on the bridge that has the lowest-cost path to the root bridge.

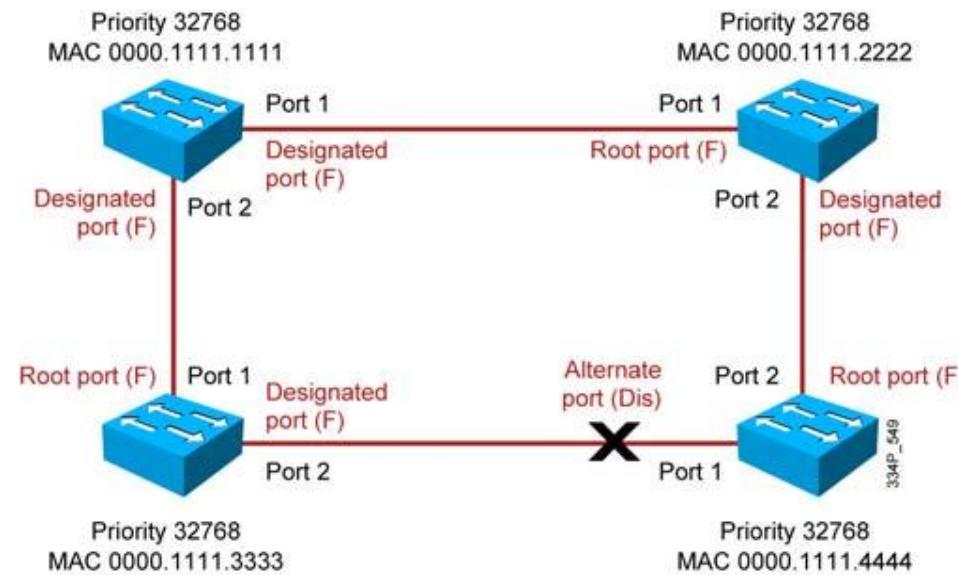
# Configuration and Management of Networks

## STP – Loop Avoidance



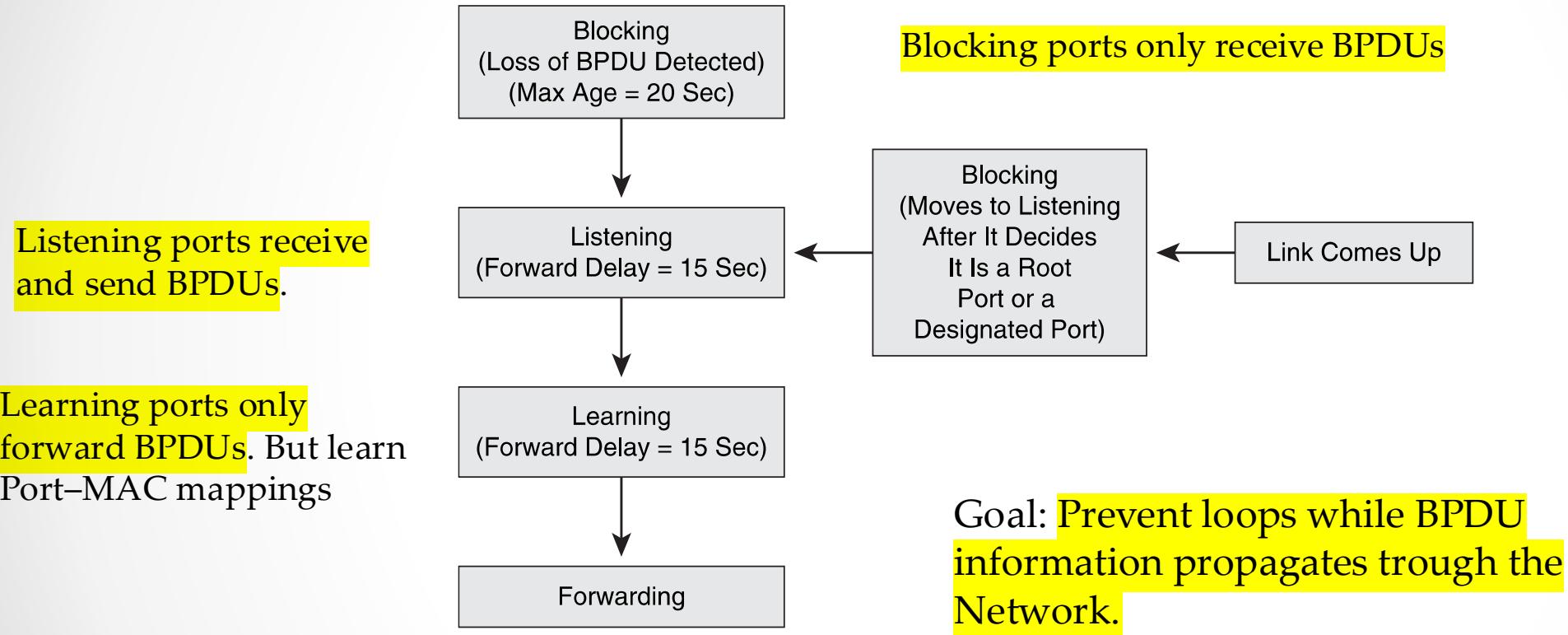
# Configuration and Management of Networks

## STP – Loop Avoidance



# Configuration and Management of Networks

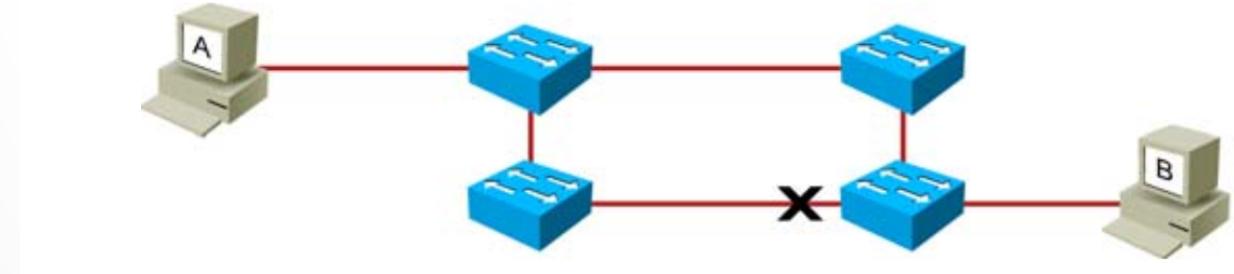
## STP – Port States



# Configuration and Management of Networks

## STP – Standards

- 802.1D-1998: The legacy standard for bridging and STP.
- CST: Assumes one spanning-tree instance for the entire bridged network, regardless of the number of VLANs.
- PVST+: A Cisco enhancement of STP that provides a separate 802.1D spanning-tree instance for each VLAN configured in the network.
- 802.1D-2004: An updated bridging and STP standard.
- 802.1s (MST): Maps multiple VLANs into the same spanning-tree instance.
- 802.1w (RSTP): Improves convergence over 1998 STP by adding roles to ports and enhancing BPDU exchanges.



# Configuration and Management of Networks

## STP – Default configuration

**Default STP (Spanning Tree Protocol) configuration on a Cumulus Linux switch is:**

- STP is enabled by default for both VLAN-aware and traditional bridges.
- By default, Rapid Spanning Tree Protocol (RSTP) mode is used for VLAN-aware bridges.
- Bridges run a single RSTP instance across all VLANs.
- You can configure the STP mode (e.g., to PVRST) if needed.

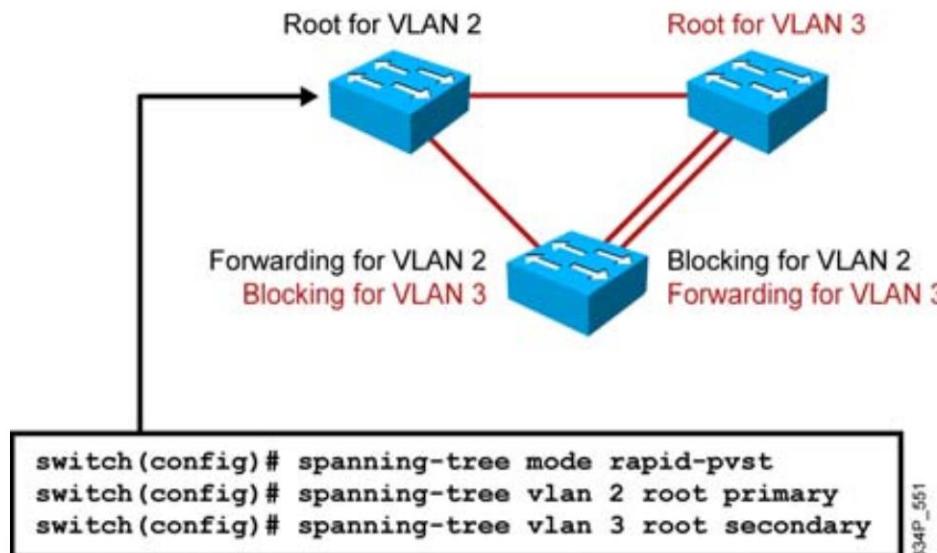
**Cisco Catalyst Switches have as default configuration:**

- PVST
- A separate STP instance for each VLAN
- Same switch is root bridge for all VLANs.

# Configuration and Management of Networks

## STP – implementing PVRST+

- Enable PVRST+ globally.
- Should be configured on all switches in the broadcast domain.
- Configure a switch as the root bridge for each VLAN.
- Configure a switch as the secondary root bridge for each VLAN.
- Load sharing on uplinks.



- The default STP priority per VLAN is 32768.
- Lower values (e.g., 4096 or 8192) make the switch preferred as root bridge.
- Cumulus Linux lets you control this per-VLAN just like Cisco IOS.

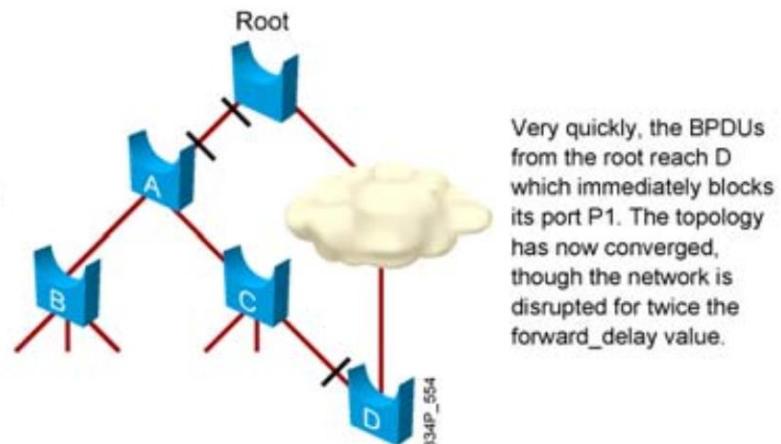
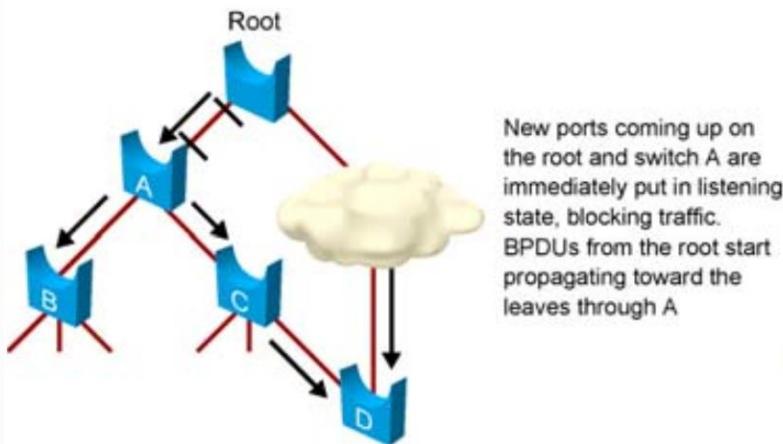
```
nv set bridge domain br_default stp mode pvrst
nv set bridge domain br_default stp vlan 2 priority 4096
```

# Configuration and Management of Networks

## STP – State transitions

- Standard spanning-tree state transitions:

Standard spanning tree has no mechanism to determine when network has converged, blocking all transmissions for twice the forward delay.

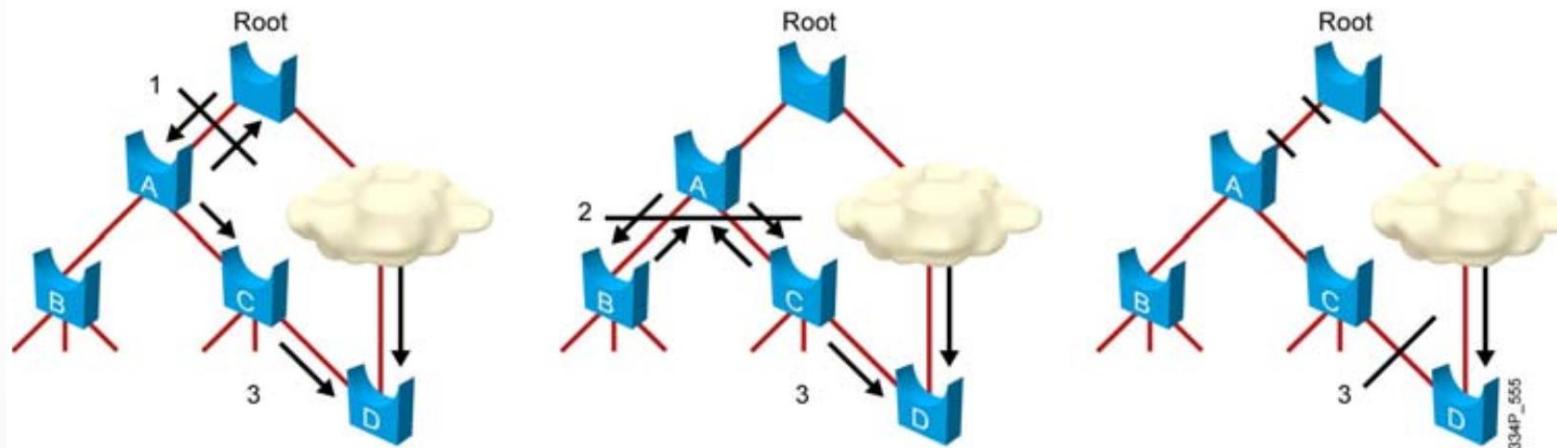


# Configuration and Management of Networks

## STP – State transitions

- RSTP state transitions:

Because RSTP relies on local negotiations, transition occurs as soon as the negotiation is completed.



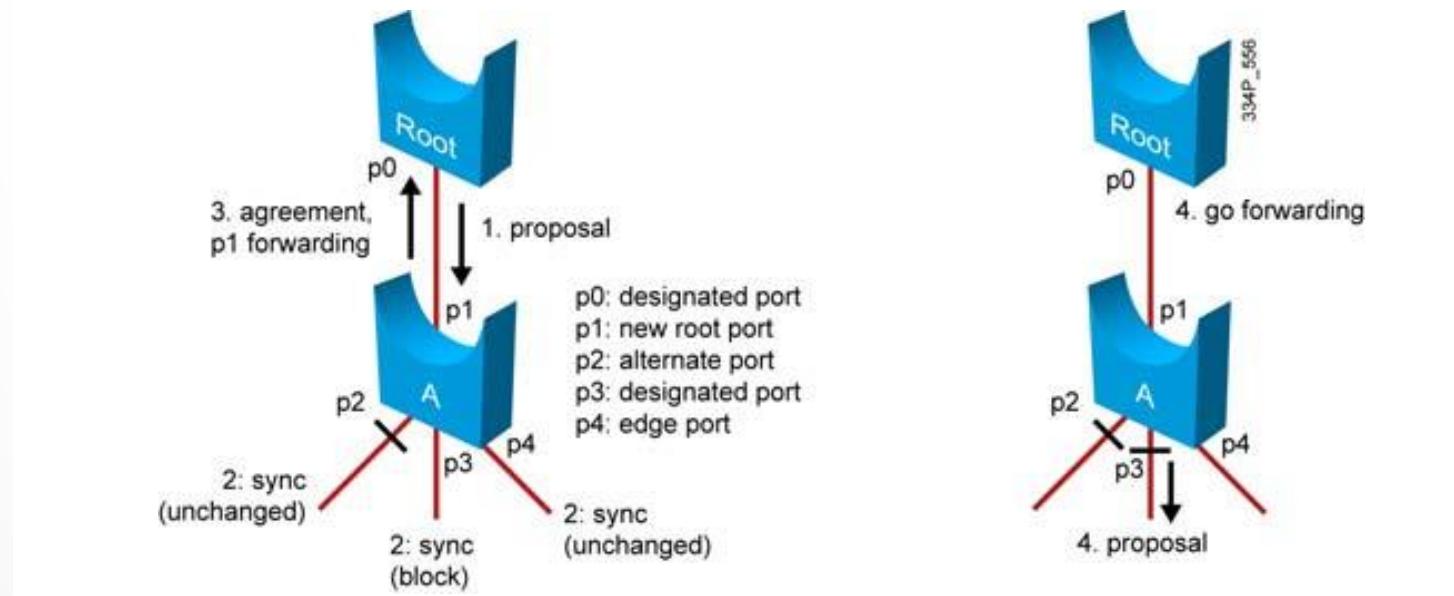
# Configuration and Management of Networks

## STP – State transitions RSTP

Ports negotiate locally as soon as different BPDUs are received.

Transition occurs as soon as negotiation is completed.

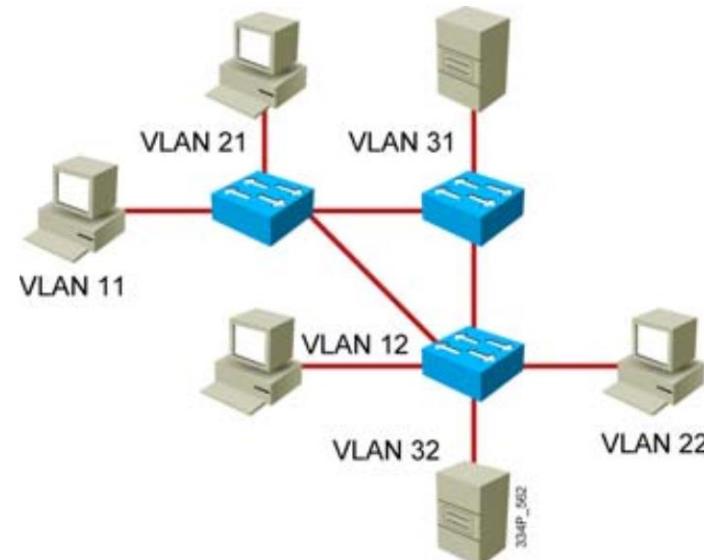
Negotiation is then immediately started on other ports.



# Configuration and Management of Networks

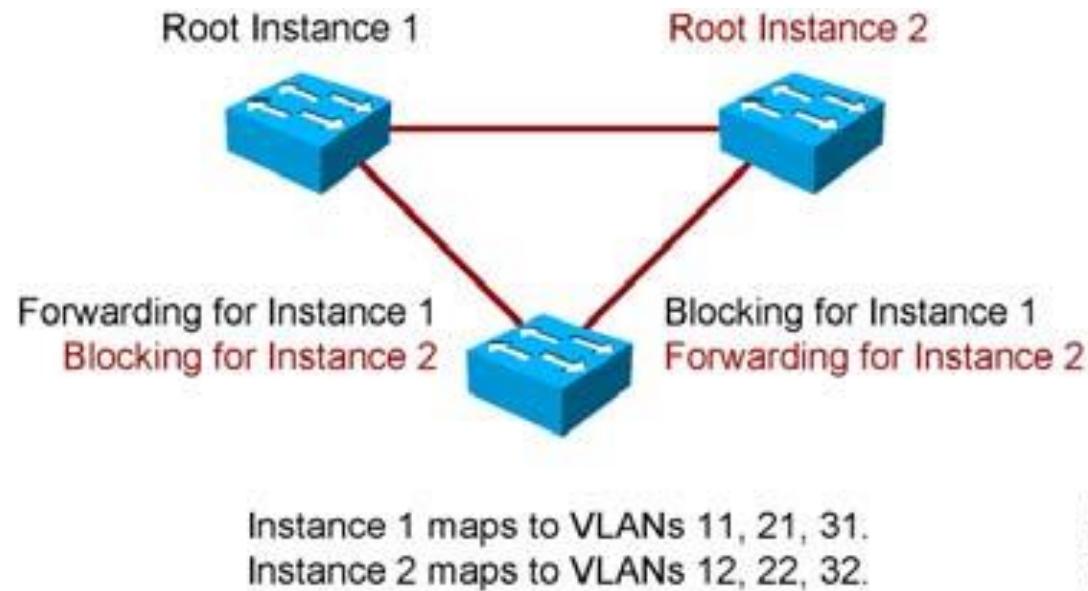
## STP – Multiple Spanning Tree Protocol (MST)

- In some scenarios, many VLANs are spanning several switches.
- PVRST+ would need six instances.
- Grouping instances simplifies the tree structure.



# Configuration and Management of Networks

## STP – MST configuration



# Configuration and Management of Networks

## STP – Recommendations

**Select a spanning-tree implementation:**

- RSTP
- MSTP.
- STP.
- PVST+.

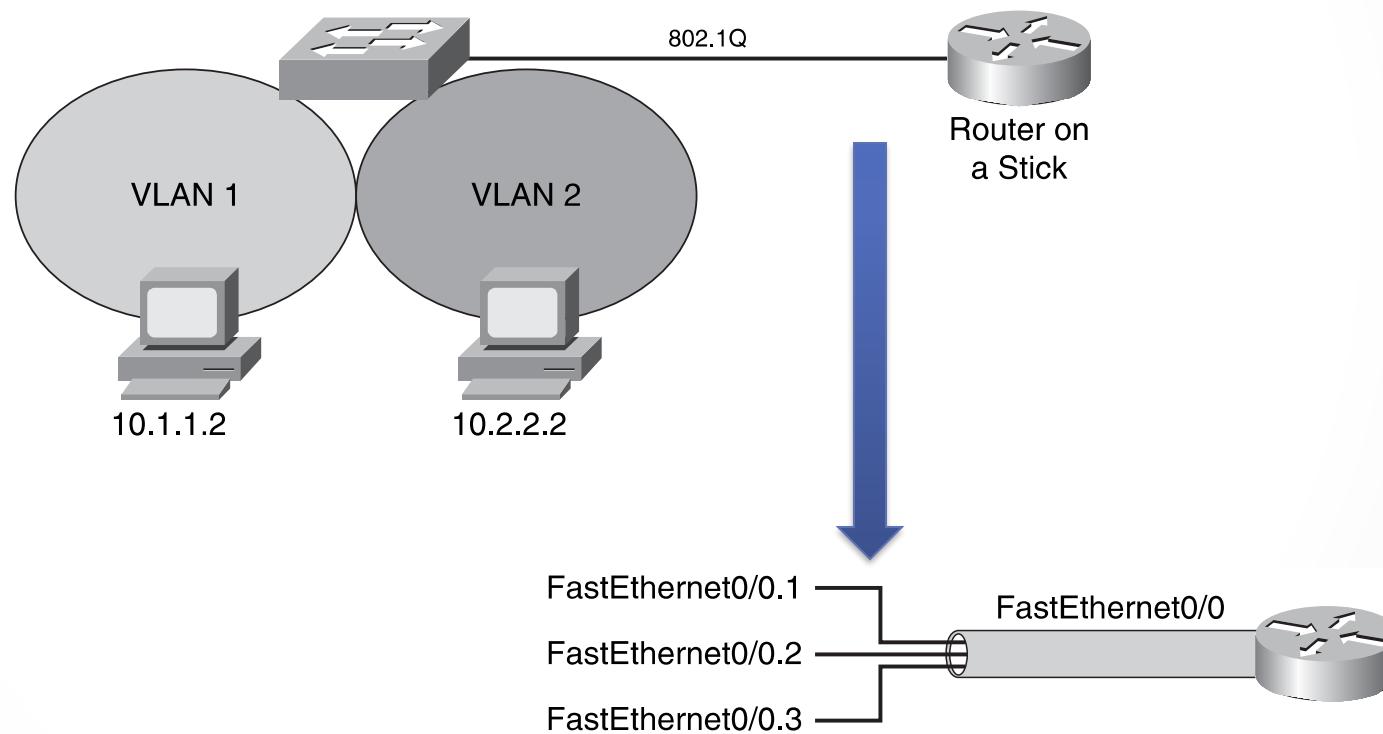
**Recommendations for Campus Networks:**

- Avoid Layer 2 loops, and use Layer 3 protocols to handle load balancing and redundancy.
- Keep the spanning-tree domain as simple as possible.
- Ensure that all links connecting backbone switches are routed links, not VLAN trunks.
- Use multilayer switching to reduce the scope of spanning-tree domains.
- Do not disable STP; keep it enabled to protect against loops.

# Configuration and Management of Networks

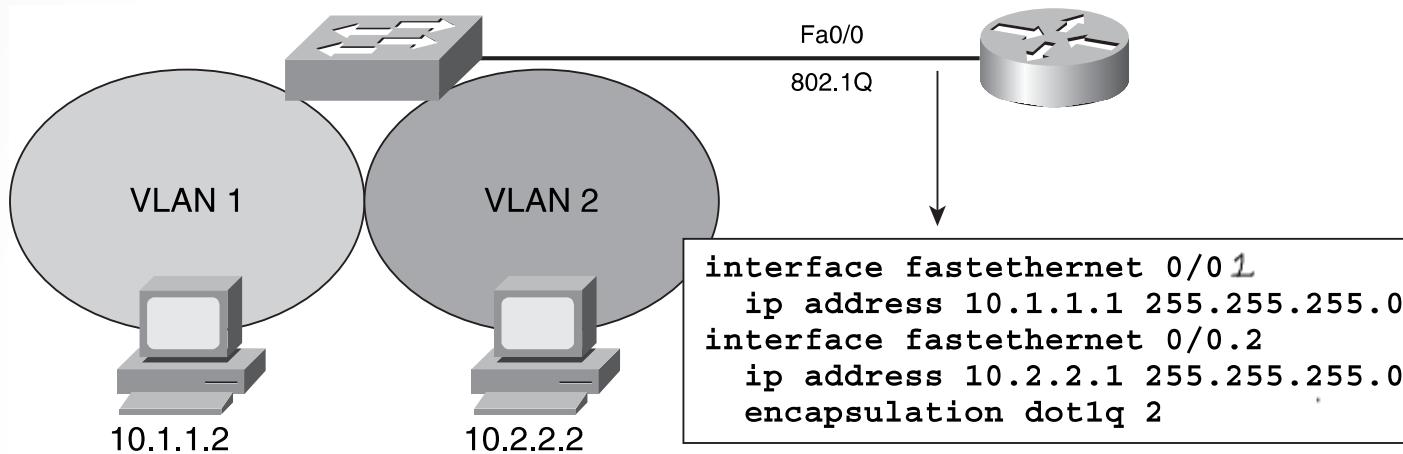
## Inter VLAN routing

Inter-VLAN communication occurs between broadcast domains via a Layer 3 device.



# Configuration and Management of Networks

## Inter VLAN routing configuration



NVDUE is only for L2 components (interfaces, bridges, VLANs, bonds) on the Cumulus Linux switch OS. It supports setting IP addresses on physical interfaces or bridge interfaces but not sub interfaces

```
ip link add link swp2 name swp2.1 type vlan id 1
ip addr add 10.1.1.1/24 dev swp2.1
ip link set swp2.1 up
```

→ Linux commands

```
ip link add link swp2 name swp2.2 type vlan id 2
ip addr add 10.2.2.1/24 dev swp2.2
ip link set swp2.2 up

ip link set swp2 up
```

# Configuration and Management of Networks

## Inter VLAN routing configuration

### Advantages:

- Works with any switch, since Layer 3 services are not required on the switch.
- Implementation is simple.
- The router provides communication between VLANs.

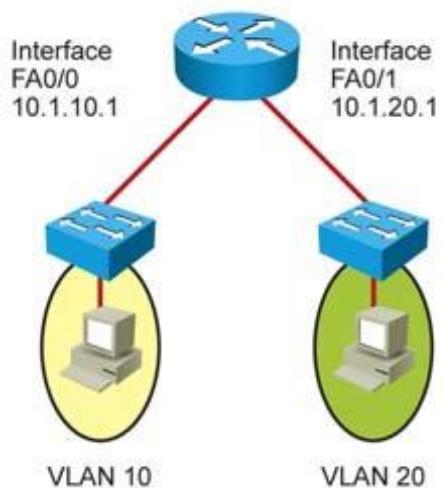
### Disadvantages:

- The router is a single point of failure.
- Single traffic path may become congested.
- Latency may be introduced as frames leave and reenter the switch chassis multiple times, and the router makes software-based routing decisions.

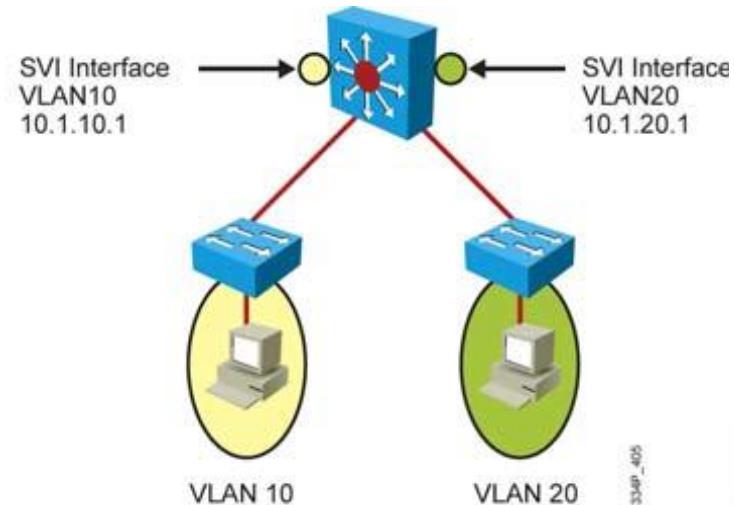
# Configuration and Management of Networks

## Inter VLAN routing Switch virtual interfaces

Routers use interfaces or subinterfaces to interconnect multiple VLANs.



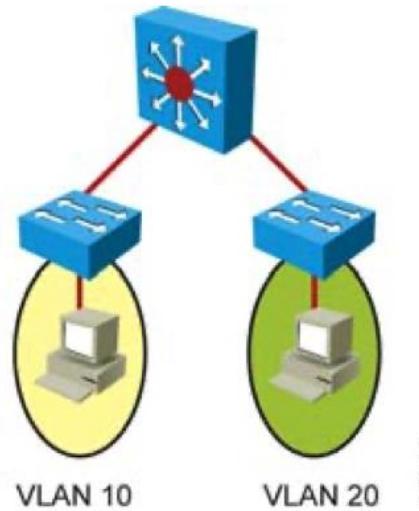
Multilayer switches use SVIs for routing between VLANs.



# Configuration and Management of Networks

## Inter VLAN routing SVI configuration

- Enable IP routing.
- Configure an SVI for each VLAN.
- Configure an IP address.
- Enable the SVI.
- Configure the routing protocol.



```
Switch(config) # ip routing
Switch(config) # interface vlan10
Switch(config-if) # ip address 10.1.10.1 255.255.255.0
Switch(config-if) # no shutdown
Switch(config) # interface vlan 20
Switch(config-if) # ip address 10.1.20.1 255.255.255.0
Switch(config-if) # no shutdown
```

```
nv set interface vlan10 type svi
nv set interface vlan10 base-interface br_default
nv set interface vlan10 ip address 10.1.10.1/24
```

```
nv set interface vlan20 type svi
nv set interface vlan20 base-interface br_default
nv set interface vlan20 ip address 10.1.20.1/24
```

```
nv config apply
```

# Configuration and Management of Networks

## Inter VLAN routing SVI configuration

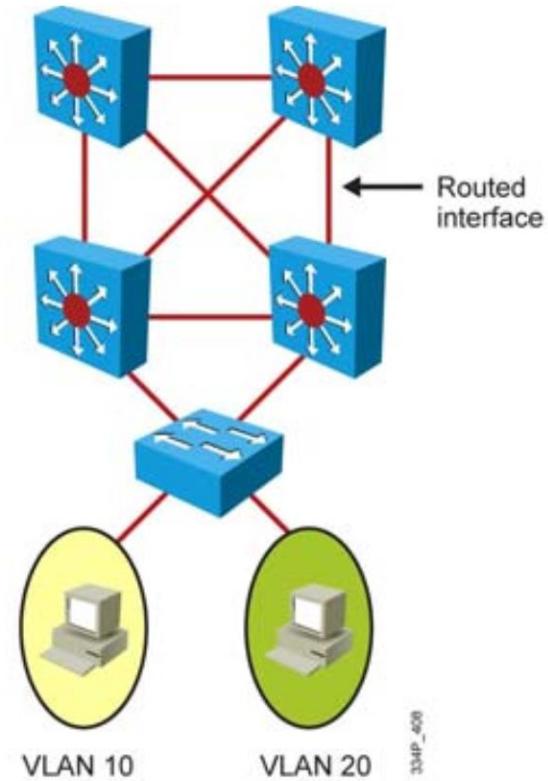
The line state of an SVI is in the up state when:

- The VLAN exists and is active in the VLAN database on the switch  
(in the bridge domain in an Cumulus linux switch)
- The VLAN interface exists and is not administratively down
- At least one Layer 2 (access or trunk) port exists, has a link in the up state on this VLAN, and is in the spanning-tree forwarding state on the VLAN

# Configuration and Management of Networks

## Inter VLAN routing - routed ports in multilayer Switches

- Physical switch port with Layer 3 capability
- Not associated with any VLAN
- Requires removal of Layer 2 port functionality
- Configured like a router interface but does not support VLAN subinterfaces
- Used when a switch has one port per VLAN or subnet only
- Useful for point-to-point Layer 3 switch links



# Configuration and Management of Networks

## Inter VLAN routing - routed ports configuration

- Enable IP routing.
- Disable Layer 2 processing on interface.
- Configure IP address.

In cumulus Linux interfaces are routed by default:

```
#If the interface was previously set to a bridge domain  
sudo nv unset interface swp2 bridge domain br_default
```

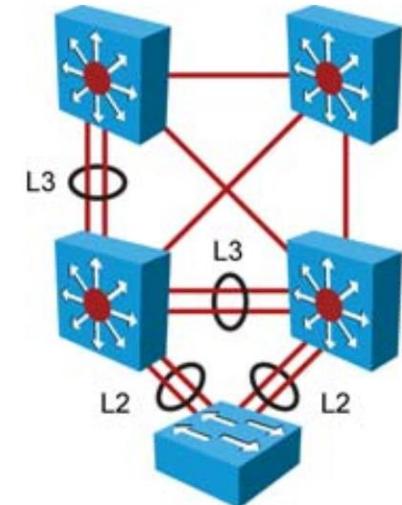
```
sudo nv set interface swp2 ip address 10.1.10.1/24
```



# Configuration and Management of Networks

## Inter VLAN routing - Layer 3 EtherChannel

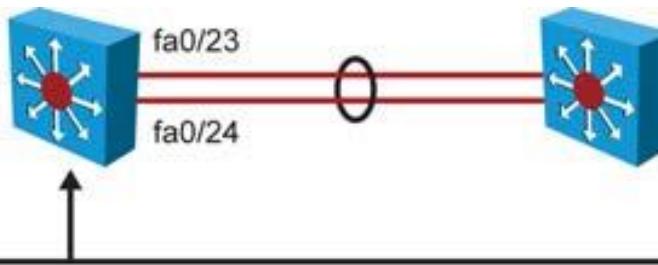
- Layer 2 EtherChannel bundles access or trunk ports between switches or other devices (e.g., servers).
- Layer 3 EtherChannel bundles routed ports between switches.



# Configuration and Management of Networks

## Inter VLAN routing - Layer 3 EtherChannel

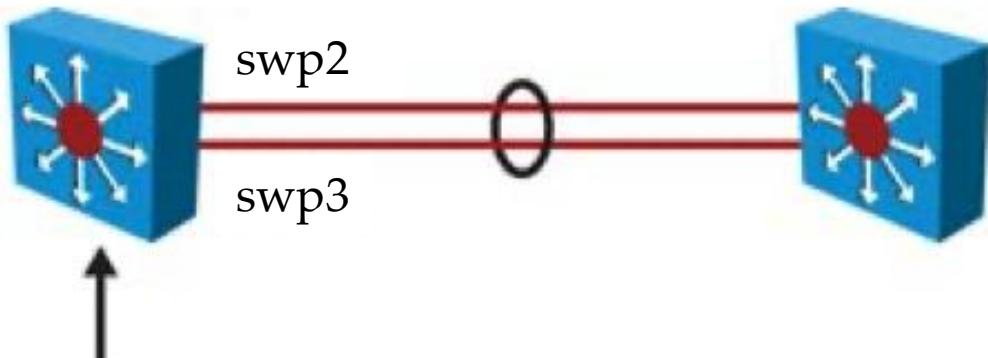
The **no switchport** command is applied both on the physical ports and on the EtherChannel interface.



```
switch(config)# interface fastethernet 0/23
switch(config-if)# no switchport
switch(config-if)# channel-group 1 mode on
switch(config)# interface fastethernet 0/24
switch(config-if)# no switchport
switch(config-if)# channel-group 1 mode on
switch(config)# interface port-channel 1
switch(config-if)# no switchport
switch(config-if)# ip address 10.1.20.1 255.255.255.0
```

## Configuration and Management of Networks

### Inter VLAN routing - Layer 3 EtherChannel



```
sudo nv set interface bond30 bond member swp2  
sudo nv set interface bond30 bond member swp3  
sudo nv set interface bond30 bond mode lacp  
sudo nv set interface bond30 ip address 10.1.20.1/24
```

# Configuration and Management of Networks

## Inter VLAN routing - Routing verification

```
switch# show ip route
Codes: C - connected, S - static, 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
      i - IS-IS, su - IS-IS summary, 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, 13 subnets, 2 masks
D        10.1.3.0/24 [90/28416] via 10.1.10.10, 08:09:49, vlan10
D        10.1.2.0/24 [90/28416] via 10.1.10.10, 08:09:49, vlan10
C        10.1.10.0/24 is directly connected, vlan10
```

# Configuration and Management of Networks

## Inter VLAN routing - Routing verification

**sudo nv show interface vlan2**

Interface vlan2

type	svi
admin	up
oper	up
base-interface	br_default
vlan-id	2
ip4	10.8.2.1/24
mac	44:38:39:ff:02:02

**sudo nv show interface vlan3**

Interface vlan3

type	svi
admin	up
oper	up
base-interface	br_default
vlan-id	3
ip4	10.8.3.1/24
mac	44:38:39:ff:02:03

## Configuration and Management of Networks

### Inter VLAN routing - Routing verification

**sudo nv show interface vlan2-3 ip address**

Interface	Address	State
vlan2	10.8.2.1/24	up
vlan3	10.8.3.1/24	up

**sudo nv show vrf default router rib**

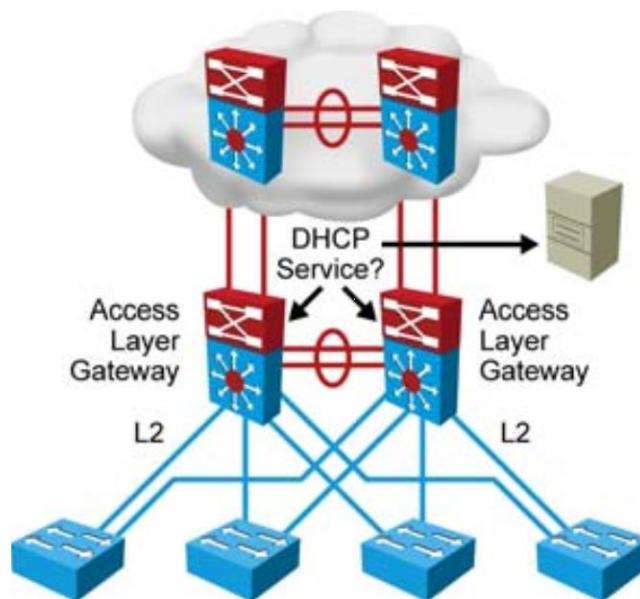
Prefix	Age	Next Hop	Type	Interface
10.8.2.0/24	00:10:10	directly	connected	vlan2
10.8.3.0/24	00:10:10	directly	connected	vlan3
127.0.0.0/8	00:10:10	directly	connected	lo

# Configuration and Management of Networks

## Inter VLAN routing - DHCP Service

Clients in access VLANs need DHCP service.

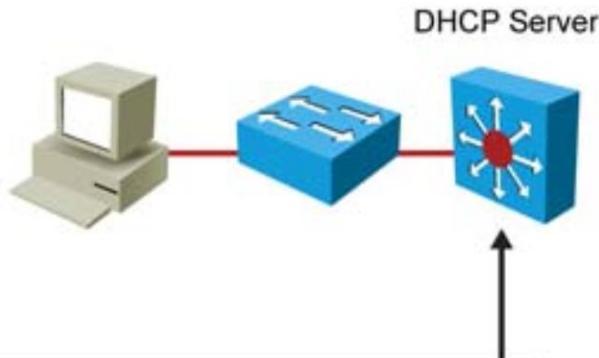
DHCP service can be provided by the distribution switches, acting as gateways, or external DHCP server elsewhere in the network.



# Configuration and Management of Networks

## Inter VLAN routing - DHCP Configuration

- Configure DHCP pool with network, mask, and other parameters.
- Configure excluded addresses.
- Pool is selected when DHCP request is received from matching subnet.

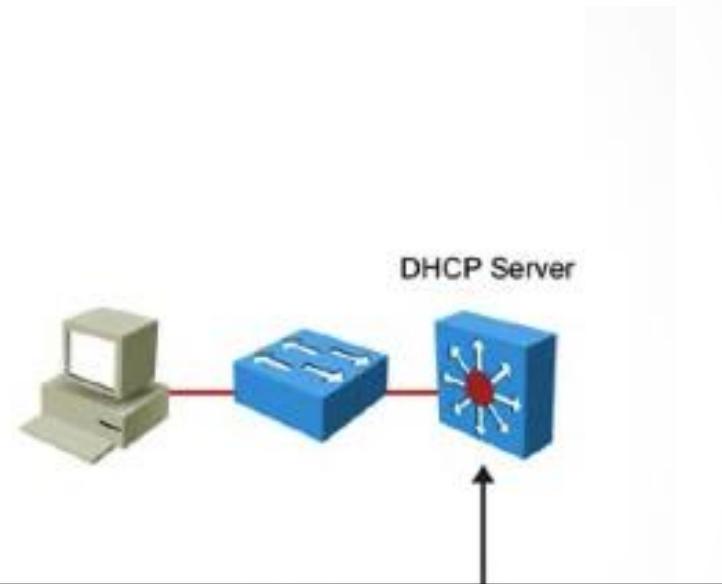


```
sw(config)# ip dhcp excluded-address 10.1.10.1 10.1.10.20
sw(config)# ip dhcp pool XYZ10
sw(config-dhcp)# network 10.1.10.0 255.255.255.0
sw(config-dhcp)# default-router 10.1.10.1
sw(config-dhcp)# option 150 10.1.1.50 → TFTP Server !
sw(config-dhcp)# lease 0 8 0
sw(config-dhcp)# ! 0 days 8 hours 0 minutes
sw(config)# interface vlan10
sw(config-if)# ip address 10.1.10.1 255.255.255.0
```

# Configuration and Management of Networks

## Inter VLAN routing - DHCP Configuration

- Configure DHCP pool with network, mask, and other parameters.
- Configure excluded addresses.
- Pool is selected when DHCP request is received from matching subnet.

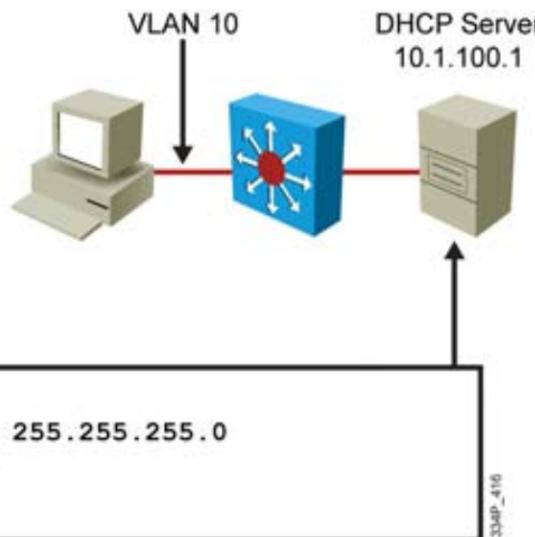


```
sudo nv set service dhcp-server default pool 10.8.2.0/24
sudo nv set service dhcp-server default pool 10.8.2.0/24 pool-name vlan2-pool
sudo nv set service dhcp-server default pool 10.8.2.0/24 range 10.8.2.10 to 10.8.2.200
sudo nv set service dhcp-server default pool 10.8.2.0/24 gateway 10.8.2.1
sudo nv set service dhcp-server default pool 10.8.2.0/24 domain-name-server 8.8.8.8
```

# Configuration and Management of Networks

## Inter VLAN routing - External DHCP

- Used if the DHCP server is not in the same broadcast domain as the client.
- Configure **ip helper** command on the incoming interface to forward DHCP requests via unicast to DHCP server.



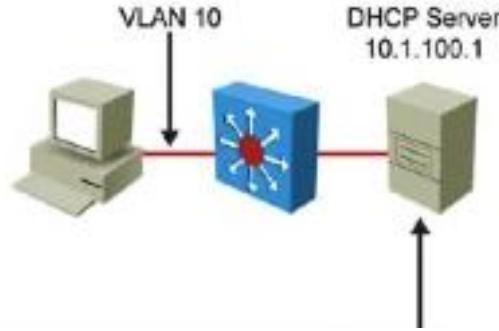
```
switch(config)# interface vlan10
switch(config-if)# ip address 10.1.10.1 255.255.255.0
switch(config-if)# ip helper 10.1.100.1
```

# Configuration and Management of Networks

## Inter VLAN routing - External DHCP

With SCI already configured:

```
sudo nv set interface vlan10 type svi  
sudo nv set interface vlan10 base-interface br_default  
sudo nv set interface vlan10 vlan 10  
sudo nv set interface vlan10 ip address 10.1.10.1/24
```



```
sudo nv set interface vlan10 service dhcp relay enable on  
sudo nv set interface vlan10 service dhcp relay server  
10.1.100.1
```

# Configuration and Management of Networks

## Inter VLAN routing - Summary

- Inter-VLAN communication requires a Layer 3 device; an external router can perform this function.
- SVI is a virtual interface providing Layer 3 processing for a particular VLAN, similar to what a router interface does.
- To be active, the SVI number must match an existing VLAN on the local switch.
- A routed interface has Layer 3 functionality.
- SVIs and routed interfaces are verified using the same commands.
- On multilayer switches, you can aggregate Layer 3 links using Layer 3 EtherChannels.
- Once you have configured a Layer 3 interface, you can enable routing.
- DHCP functions can be configured with Cisco IOS Software.

# Configuration and Management of Networks

## Network Layer - Routing

- **Static:** The router learns routes when an administrator manually configures the static route. The administrator must manually update this static route entry whenever an internetwork topology change requires an update.
- **Dynamic:** The router dynamically learns routes after an administrator configures a routing protocol that helps determine routes.



describe the following information:

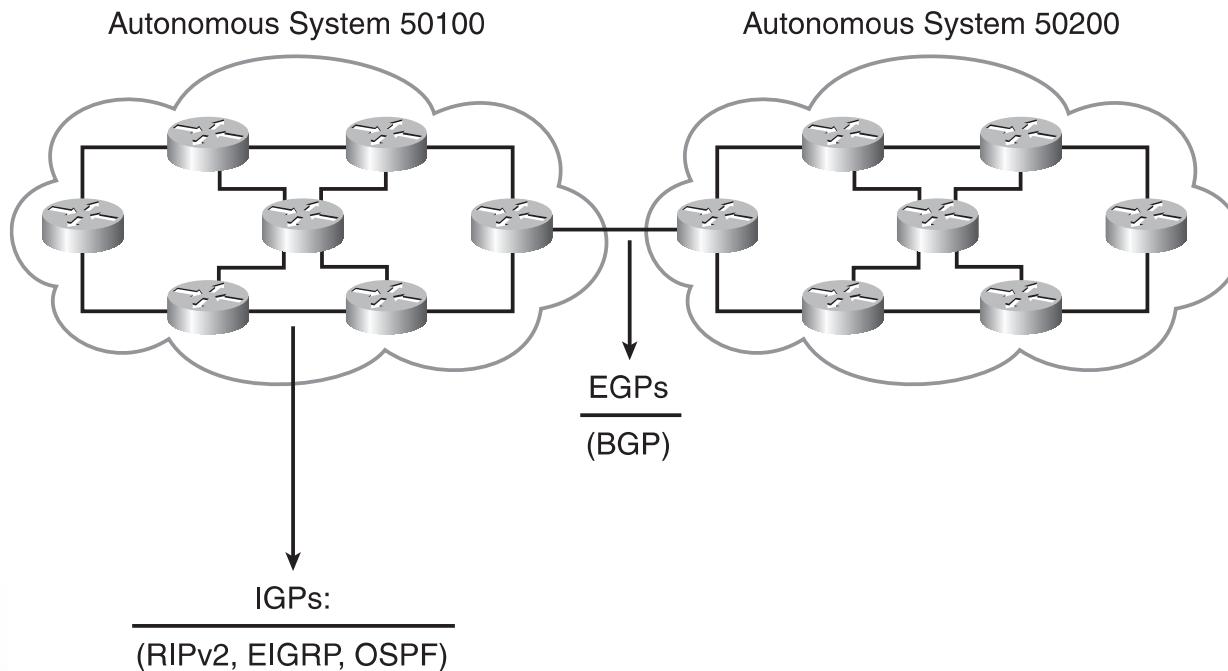
### Routing protocol

- How updates are conveyed
- What knowledge is conveyed
- When to convey the knowledge
- How to locate recipients of the updates

# Configuration and Management of Networks

## Network Layer – IGP and EGP

### *IGP Versus EGP*



# Configuration and Management of Networks

## Network Layer – IGP and EGP

- **Distance vector:** The distance vector routing approach determines the direction (vector) and distance (such as hops) to any link in the internetwork.
- **Link-state:** The link-state approach, which utilizes the shortest path first (SPF) algorithm, creates an abstraction of the exact topology of the entire internetwork, or at least of the partition in which the router is situated.
- **Advanced distance vector:** The advanced distance vector approach combines aspects of the link-state and distance vector algorithms. This is also sometimes referred to as a hybrid routing protocol.

# Configuration and Management of Networks

## Routing protocols in the Network

