



# Chapter 5: Inter-VLAN Routing



## Routing & Switching

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# Chapter 5

5.1 Inter-VLAN Routing Configuration

5.2 Troubleshooting Inter-VLAN Routing

5.3 Layer 3 Switching

5.4 Summary



# Chapter 5: Objectives

- Describe the three primary options for enabling inter-VLAN routing.
- Configure legacy inter-VLAN routing.
- Configure router-on-a-stick inter-VLAN routing.
- Troubleshoot common inter-VLAN configuration issues.
- Troubleshoot common IP addressing issues in an inter-VLAN-routed environment.
- Configure inter-VLAN routing using Layer 3 switching.
- Troubleshoot inter-VLAN routing in a Layer 3-switched environment.



## 5.1 Inter-VLAN Routing Configuration



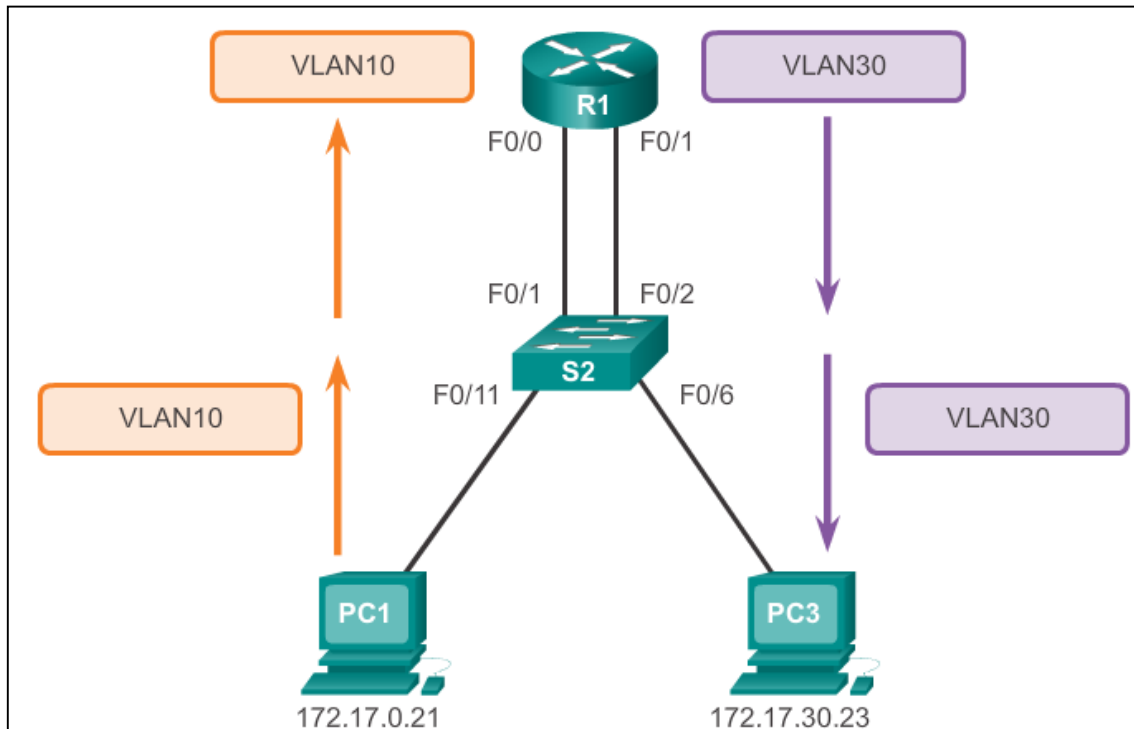
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## Inter-VLAN Routing Operation

# What is Inter-VLAN routing?

- Layer 2 switches cannot forward traffic between VLANs without the assistance of a router.
- Inter-VLAN routing is a process for forwarding network traffic from one VLAN to another, using a router.





## Inter-VLAN Routing Operation

# Legacy Inter-VLAN Routing

In the past:

- Actual routers were used to route between VLANs.
- Each VLAN was connected to a different physical router interface.
- Packets would arrive on the router through one through interface, be routed and leave through another.
- Because the router interfaces were connected to VLANs and had IP addresses from that specific VLAN, routing between VLANs was achieved.
- Large networks with large number of VLANs required many router interfaces.



## Inter-VLAN Routing Operation

# Router-on-a-Stick Inter-VLAN Routing

- The router-on-a-stick approach uses a different path to route between VLANs.
- One of the router's physical interfaces is configured as a 802.1Q trunk port so it can understand VLAN tags.
- Logical subinterfaces are created; one subinterface per VLAN.
- Each subinterface is configured with an IP address from the VLAN it represents.
- VLAN members (hosts) are configured to use the subinterface address as a default gateway.
- Only one of the router's physical interface is used.



## Inter-VLAN Routing Operation

# Multilayer Switch Inter-VLAN Routing

- Multilayer switches can perform Layer 2 and Layer 3 functions, replacing the need for dedicated routers.
- Multilayer switches support dynamic routing and inter-VLAN routing.
- The multilayer switch must have IP routing enabled.
- A switch virtual interface (SVI) exists for VLAN 1 by default. On a multilayer switch, a logical (layer 3) interface can be configured for any VLAN.
- The switch understands network-layer PDUs; therefore, can route between its SVIs, just as a router routes between its interfaces.
- With a multilayer switch, traffic is routed internal to the switch device.
- This routing process is a suitable and scalable solution.



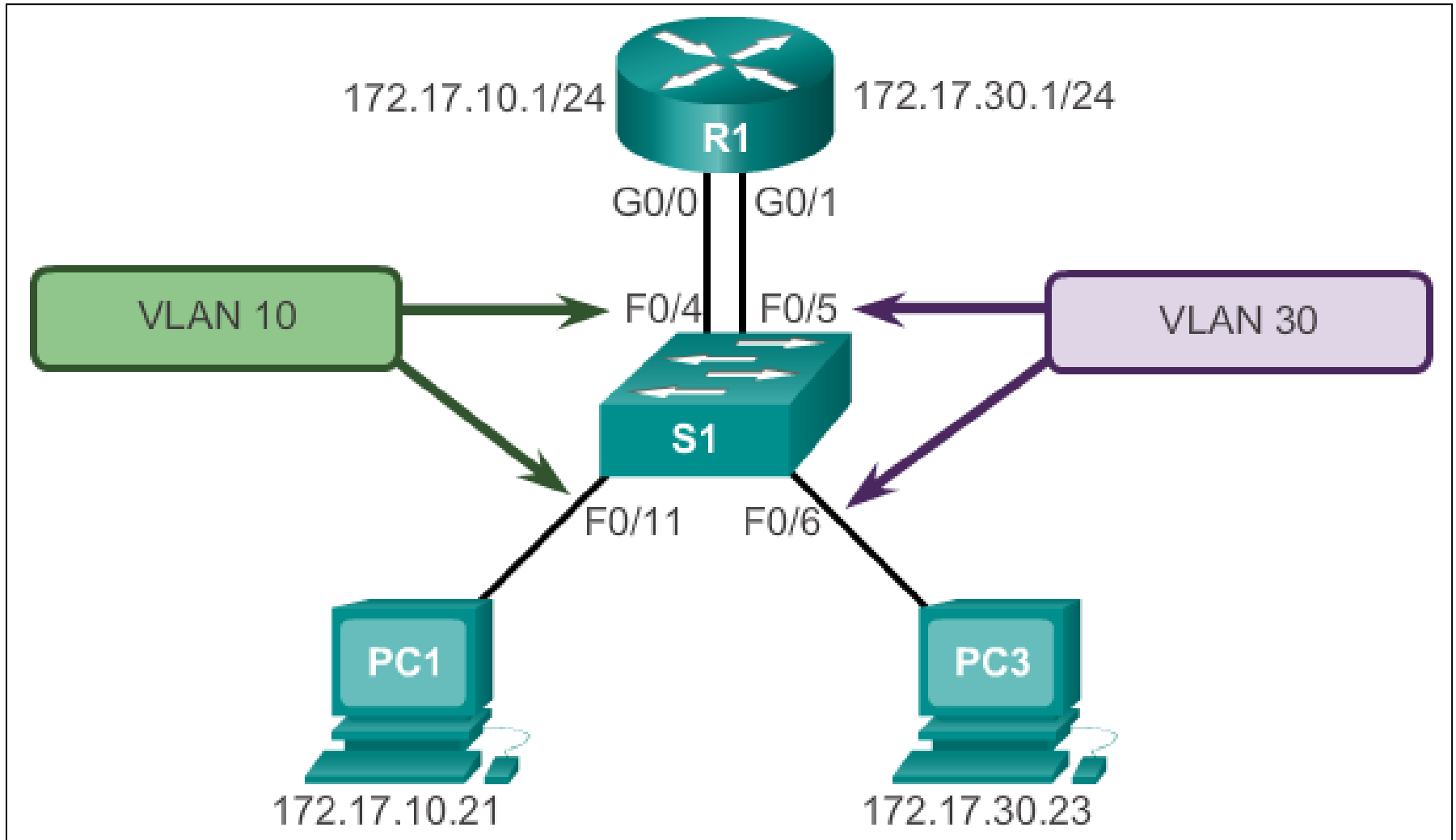


## Configure Legacy Inter-VLAN Routing Preparation

- Legacy inter-VLAN routing requires routers to have multiple physical interfaces.
- Each one of the router's physical interfaces is connected to a unique VLAN.
- Each interface is also configured with an IP address for the subnet associated with the particular VLAN.
- Network devices use the router as a gateway to access the devices connected to the other VLANs.



# Configure Legacy Inter-VLAN Routing Preparation (cont.)





# Configure Legacy Inter-VLAN Routing

## Switch Configuration

```

S1(config)# vlan 10
S1(config-vlan)# vlan 30
S1(config-vlan)# interface f0/11
S1(config-if)# switchport access vlan 10
S1(config-if)# interface f0/4
S1(config-if)# switchport access vlan 10
S1(config-if)# interface f0/6
S1(config-if)# switchport access vlan 30
S1(config-if)# interface f0/5
S1(config-if)# switchport access vlan 30
S1(config-if)# end
*Mar 20 01:22:56.751: %SYS-5-CONFIG_I: Configured from console by
console
S1# copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]

```



# Configure Legacy Inter-VLAN Routing

## Router Interface Configuration

```

R1(config)# interface g0/0
R1(config-if)# ip address 172.17.10.1 255.255.255.0
R1(config-if)# no shutdown
*Mar 20 01:42:12.951: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
changed state to up
*Mar 20 01:42:13.951: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0, changed state to up
R1(config-if)# interface g0/1
R1(config-if)# ip address 172.17.30.1 255.255.255.0
R1(config-if)# no shutdown
*Mar 20 01:42:54.951: %LINK-3-UPDOWN: Interface GigabitEthernet0/1,
changed state to up
*Mar 20 01:42:55.951: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/1, changed state to up
R1(config-if)# end
R1# copy running-config startup-config

```

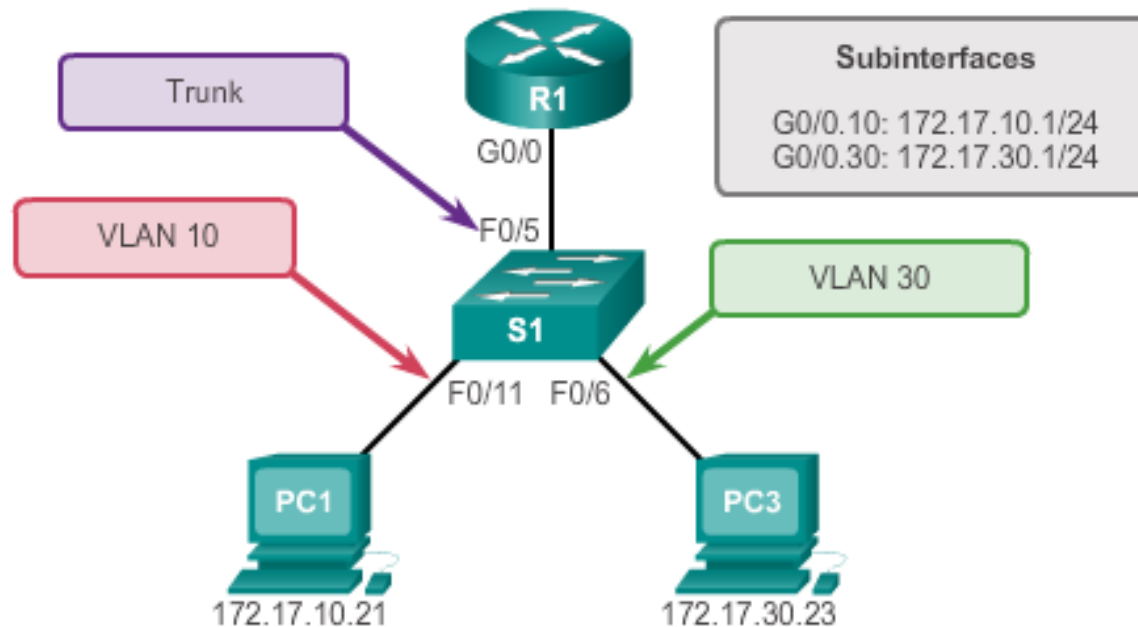


## Configure Router-on-a-Stick Preparation

- An alternative to legacy inter-VLAN routing is to use VLAN trunking and subinterfaces.
- VLAN trunking allows a single physical router interface to route traffic for multiple VLANs.
- The physical interface of the router must be connected to a trunk link on the adjacent switch.
- On the router, subinterfaces are created for each unique VLAN.
- Each subinterface is assigned an IP address specific to its subnet or VLAN and is also configured to tag frames for that VLAN.



# Configure Router-on-a-Stick Switch Configuration



```
S1(config)# vlan 10
S1(config-vlan)# vlan 30
S1(config-vlan)# interface f0/5
S1(config-if)# switchport mode trunk
S1(config-if)# end
S1#
```



## Configure Router-on-a-Stick

# Router Subinterface Configuration

```
R1(config)# interface g0/0.10
R1(config-subif)# encapsulation dot1q 10
R1(config-subif)# ip address 172.17.10.1 255.255.255.0
R1(config-subif)# interface g0/0.30
R1(config-subif)# encapsulation dot1q 30
R1(config-subif)# ip address 172.17.30.1 255.255.255.0
R1(config)# interface g0/0
R1(config-if)# no shutdown
*Mar 20 00:20:59.299: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
changed state to down
*Mar 20 00:21:02.919: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
changed state to up
*Mar 20 00:21:03.919: %LINEPROTO-5-UPDOWN: Line protocol on
changed state to down
*Mar 20 00:21:02.919: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
changed state to up
*Mar 20 00:21:03.919: %LINEPROTO-5-UPDOWN: Line protocol on
Interface GigabitEthernet0/0, changed state to up
```



# Configure Router-on-a-Stick

## Verifying Subinterfaces

```
R1# show vlans
```

```
<output omitted>
```

```
Virtual LAN ID: 10 (IEEE 802.1Q Encapsulation)
```

```
vLAN Trunk Interface: GigabitEthernet0/0.10
```

Protocols Configured:	Address:	Received:	Transmitted:
IP	172.17.10.1	11	18

```
<output omitted>
```

```
Virtual LAN ID: 30 (IEEE 802.1Q Encapsulation)
```

```
vLAN Trunk Interface: GigabitEthernet0/0.30
```

Protocols Configured:	Address:	Received:	Transmitted:
IP	172.17.30.1	11	8

```
<output omitted>
```





# Configure Router-on-a-Stick

## Verifying Subinterfaces (cont.)

```
R1# show ip route
```

```
Codes: L - local, 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, H - NHRP,
       l - LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is not set
```

```
172.17.0.0/16 is variably subnetted, 4 subnets, 2 masks
```

```
C    172.17.10.0/24 is directly connected, GigabitEthernet0/0.10
L    172.17.10.1/32 is directly connected, GigabitEthernet0/0.10
C    172.17.30.0/24 is directly connected, GigabitEthernet0/0.30
L    172.17.30.1/32 is directly connected, GigabitEthernet0/0.30
```



## Configure Router-on-a-Stick

# Verifying Routing

- Access to devices on remote VLANs can be tested using the **ping** command.
- The **ping** command sends an ICMP echo request to the destination address.
- When a host receives an ICMP echo request, it responds with an ICMP echo reply.
- Tracert is a useful utility for confirming the routed path taken between two devices.



## 6.2 Troubleshoot Inter-VLAN Routing



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## Inter-VLAN Configuration Issues

# Switch Port Issues

- When using the legacy routing model, ensure that the switch ports connect to the router interfaces and are configured with the correct VLANs.
- Use the **switchport access vlan** [*appropriate vlan#*] command to correct any erroneous VLAN port assignment.
- Ensure that the router is connected to the correct switch port.
- When using router-on-a-stick, ensure that the switch port connected to the router is configured as a trunk link.
- Use the **switchport mode trunk** command to make the switch port a trunk.



## Inter-VLAN Configuration Issues

# Verify Switch Configuration

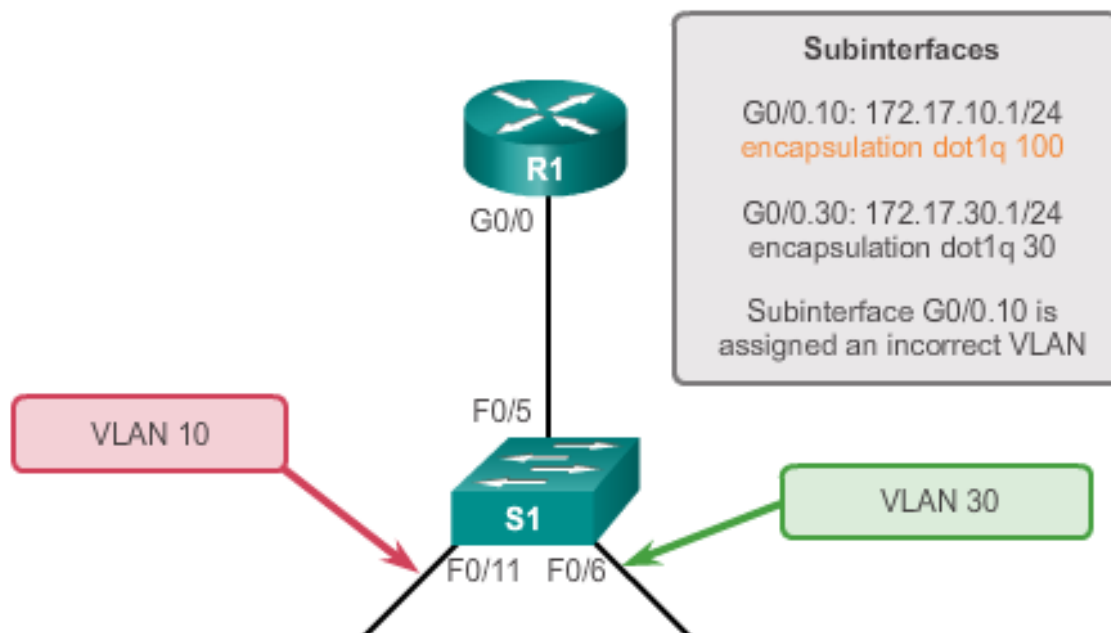
```
S1# show interfaces fastEthernet 0/4 switchport
Name: Fa0/4
Switchport: Enabled
Administrative Mode: static access
Operational Mode: up
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
<output omitted>
S1#
```



## Inter-VLAN Configuration Issues

# Verify Router Configuration

- With router-on-a-stick configurations, a common problem is assigning the wrong VLAN ID to the subinterface.
- The **show interface** command can help detect this problem.
- If this is the case, use the **encapsulation dot1q <vlan\_id> interface** command to fix the problem.





## Inter-VLAN Configuration Issues

# Verify Router Configuration (cont.)

```
R1# show interface
```

```
<output omitted>
```

```
GigabitEthernet0/0.10 is up, line protocol is down (disabled)
```

```
Encapsulation 802.1Q Virtual Lan, Vlan ID 100
```

```
ARP type :ARPA, ARP Timeout 04:00:00,
```

```
Last clearing of "show interface" counters never
```

```
<output omitted>
```

```
R1#
```

```
R1# show run
```

```
Building configuration...
```

```
Current configuration : 505 bytes
```

```
<output omitted>
```

```
!
```

```
interface GigabitEthernet0/0.10
```

```
encapsulation dot1q 100
```

```
ip address 172.17.10.1 255.255.255.0
```

```
!
```

```
interface GigabitEthernet0/0.30
```



## IP Addressing Issues

# Errors with IP Address and Subnet Masks

- When using legacy inter-VLAN routing, ensure that the router has the correct IP address and mask on the interfaces connecting to the switch.
- Ensure that the network devices are configured with the correct IP address and mask.
- In the router, use the **ip address** command to fix any erroneous IP assignments.
- In the PCs, refer to the installed operating system documentation to properly change IP information.





## IP Addressing Issues

# Verifying IP Address and Subnet Mask Configuration Issues

- Use the **show ip interface** command to verify if the correct IP address is configured in the router.
- Use the **show running-config** when troubleshooting router-related problems.
- When troubleshooting addressing issues, ensure that the subinterface is configured with the correct address for that VLAN.
- Subinterface IDs are often configured to match the VLAN number, which makes it easier to manage inter-VLAN configuration, but this is not a requirement.



## 5.3 Layer 3 Switching



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## Layer 3 Switching Operation and Configuration

# Introduction to Layer 3 Switching

- Layer 3 switches usually have packet-switching throughputs in the millions of packets per second (pps).
- All Catalyst multilayer switches support the following types of Layer 3 interfaces:
  - Routed port
  - Switch virtual interface (SVI)
- High-performance switches, such as the Catalyst 6500 and Catalyst 4500, are able to perform most of the router's functions.
- Several models of Catalyst switches require enhanced software for specific routing protocol features.



## Layer 3 Switching Operation and Configuration

# Inter-VLAN Routing with Switch Virtual Interfaces

- Today's routing has become faster and cheaper and can be performed at hardware speed.
- Routing can be transferred to core and distribution devices with little to no impact on network performance.
- Many users are in separate VLANs, and each VLAN is usually a separate subnet. This implies that each distribution switch must have IP addresses matching each access switch VLAN.
- Layer 3 (routed) ports are normally implemented between the distribution and the core layer. This model is less dependent on spanning tree, because there are no loops in the Layer 2 portion of the topology.



## Layer 3 Switching Operation and Configuration

# Inter-VLAN Routing with SVIs (Cont.)

- By default, an SVI is created for the default VLAN (VLAN 1). This allows for remote switch administration.
- Any additional SVIs must be created by the administrator.
- SVIs are created the first time the VLAN interface configuration mode is entered for a particular VLAN SVI.
- Enter the **interface vlan 10** command to create an SVI named VLAN 10.
- The VLAN number used corresponds to the VLAN tag associated with data frames on an 802.1Q encapsulated trunk.
- When the SVI is created, ensure that the specific VLAN is present in the VLAN database.



## Layer 3 Switching Operation and Configuration

# Inter-VLAN Routing with SVIs (Cont.)

- SVIs advantages include:
  - Much faster than router-on-a-stick, because everything is hardware-switched and routed.
  - No need for external links from the switch to the router for routing.
  - Not limited to one link. Layer 2 EtherChannels can be used between the switches to get more bandwidth.
  - Latency is much lower, because it does not need to leave the switch.



## Layer 3 Switching Operation and Configuration

# Inter-VLAN Routing with Routed Ports

- A routed port is a physical port that acts similarly to an interface on a router.
- Routed ports are not associated with any VLANs.
- Layer 2 protocols, such as STP, do not function on a routed interface.
- Routed ports on a Cisco IOS switch do not support subinterfaces.
- To configure routed ports, use the **no switchport** interface configuration mode command.
- **Note:** Routed ports are not supported on Catalyst 2960 Series switches.



## Layer 3 Switching Operation and Configuration

# Configuring Static Routes on a Catalyst 2960

- The Cisco Switch Database Manager (SDM) provides multiple templates for the Cisco Catalyst 2960 switch.
- The SDM *lanbase-routing* template can be enabled to allow the switch to route between VLANs and to support static routing.
- Use the **show sdm prefer** command to verify which template is in use.
- The SDM template can be changed in global configuration mode with the **sdm prefer** command.





## Troubleshooting Layer 3 Switching

# Layer 3 Switch Configuration Issues

To troubleshoot Layer 3 switching issues, verify the following for accuracy:

### ■ VLANs

- VLANs must be defined across all the switches.
- VLANs must be enabled on the trunk ports.
- Ports must be in the right VLANs.

### ■ SVIs

- SVIs must have the correct IP address or subnet mask.
- SVIs must be up.
- SVIs must match with the VLAN number.



## Troubleshooting Layer 3 Switching

# Layer 3 Switching Configuration Issues (Cont.)

To troubleshoot Layer 3 switching issues, verify the following for accuracy:

### ■ Routing

- Routing must be enabled.
- Each interface or network should be added to the routing protocol.

### ■ Hosts

- Hosts must have the correct IP address or subnet mask.
- Hosts must have a default gateway associated with an SVI or routed port.



# Chapter 5: Summary

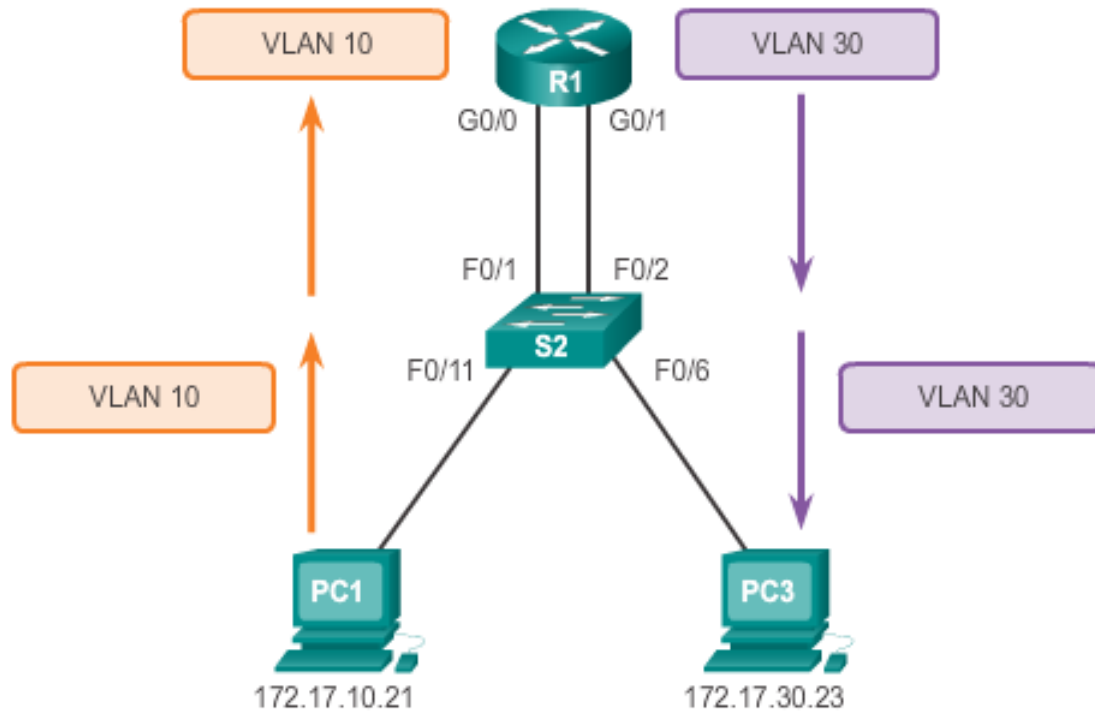
This chapter described and explained the following concepts:

- Inter-VLAN routing, the process of routing traffic between different VLANs, using either a dedicated router or a multilayer switch
- Legacy, router-on-a-stick, and multilayer switch inter-VLAN routing
- Layer 3 switching, SVIs, and routed ports
- Troubleshooting inter-VLAN routing with a router or a Layer 3 switch
- Common errors involving VLAN, trunk, Layer 3 interface, and IP address configurations



# Chapter 5: Summary

## What is Inter-VLAN Routing?



Router-based Inter-VLAN routing is a process for forwarding network traffic from one VLAN to another VLAN using a router.

