Chapter 5: Inter-VLAN Routing

Routing And Switching

5.0

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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

5.0

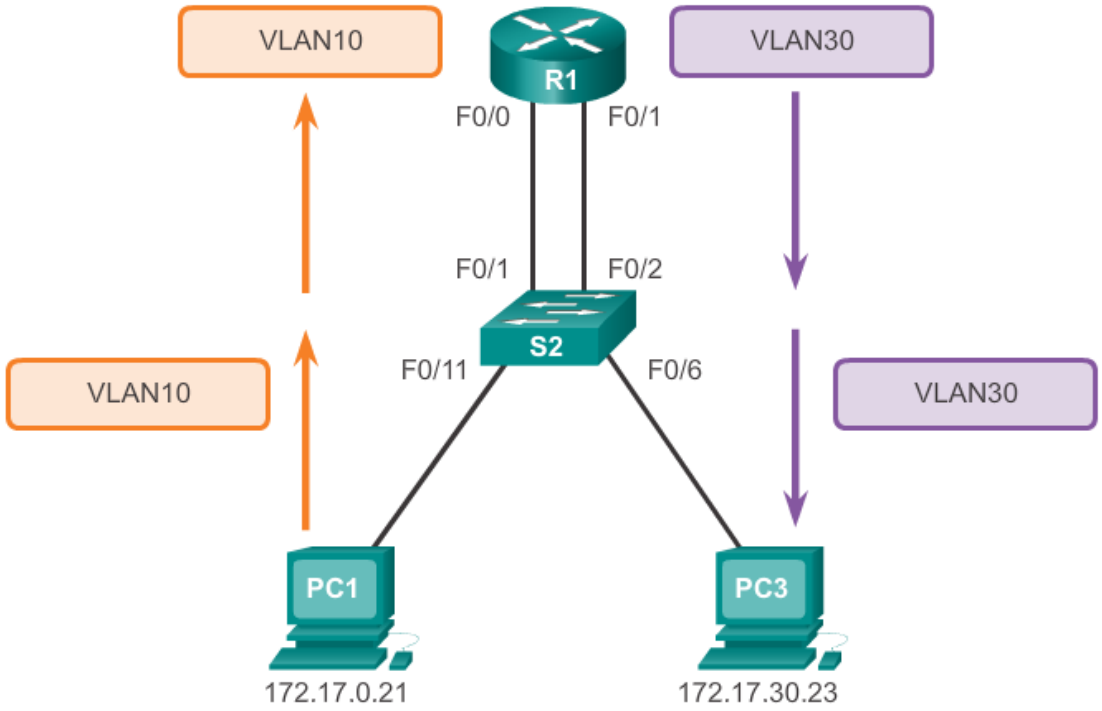
Chapter 5: Objectives

- 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

5.0.1.1

What is Inter-VLAN Routing?

- Layer 2 switches can't 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



5.1.1.1

Legacy Inter-VLAN Routing

- In the past, actual routers were used to route between VLAN
- 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
- Since the router interfaces were connected to VLANs and had IP addresses from that specific VLAN, routing between VLANs was achieved.
- Simple solution but not scalable. Large networks with large number of VLANs would require lots of router interfaces

5.1.1.2

Do animation on 5.1.1.2

Router-On-A-Stick Inter-VLAN Routing

- The so called 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. Now that interface can understand VLAN tags
- Logical subinterfaces are then 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

5.1.1.3

Do animation on 5.1.1.3

Multilayer Switch Inter-VLAN Routing

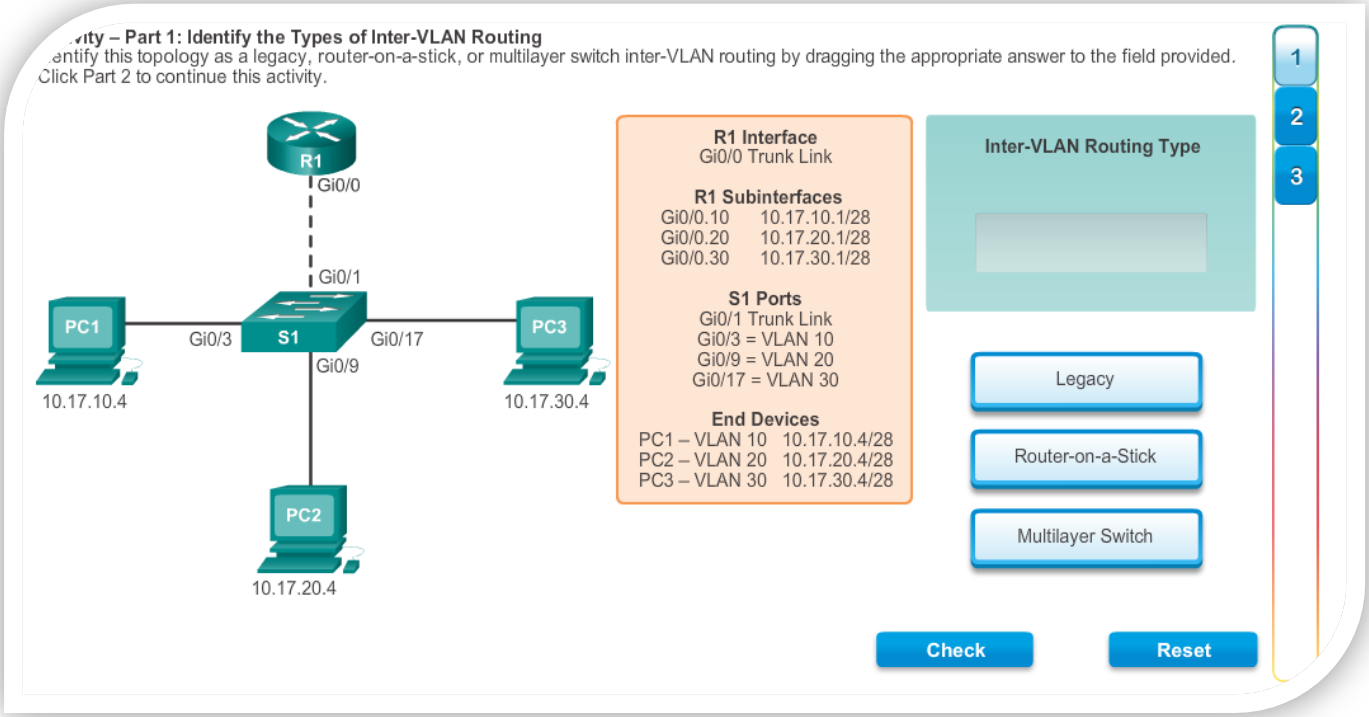
- Multilayer switches can perform Layer 2 and Layer 3 functions. Routers are not required anymore
- Each VLAN existent in the switch is a SVI
- SVI are seen as layer 3 interfaces
- The switch understands network layer PDUs and therefore, it can route between its SVIs just as a router routes between its interfaces
- With a multilayer switch, traffic is routed internal to the switch device
- Very scalable solution

5.1.1.4

Do animation on 5.1.1.4

Inter-VLAN Routing Operation

5.1.1.5 Activity - Identify the Types of Inter-VLAN Routing



Students do buttons 1-3 on Activity 5.1.1.5

5.1.1.5

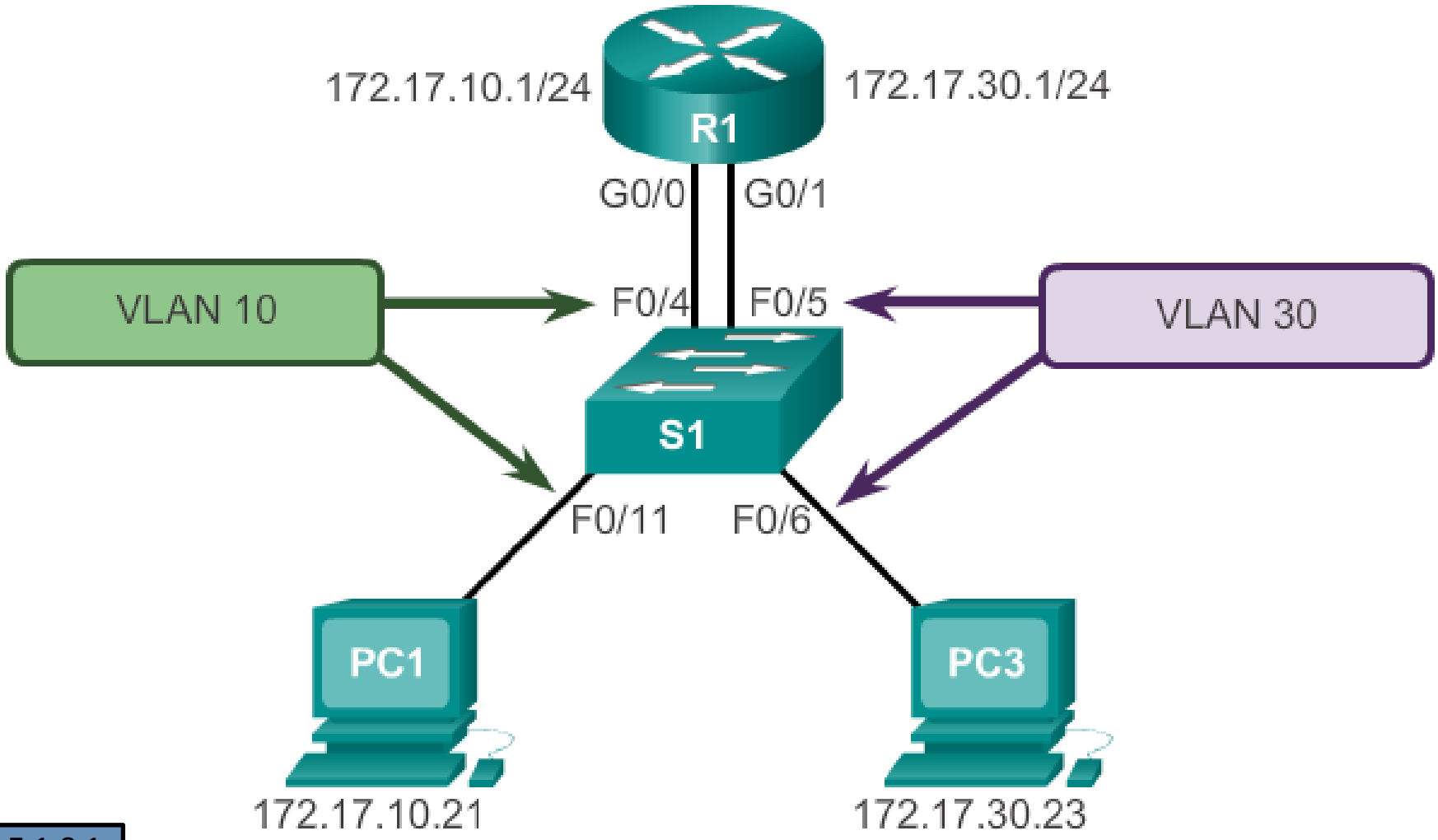
Preparation

- 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

5.1.2.1

Do animation on 5.1.2.1

Preparation



5.1.2.1

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]
```

5.1.2.2

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
```

5.1.2.3

Preparation

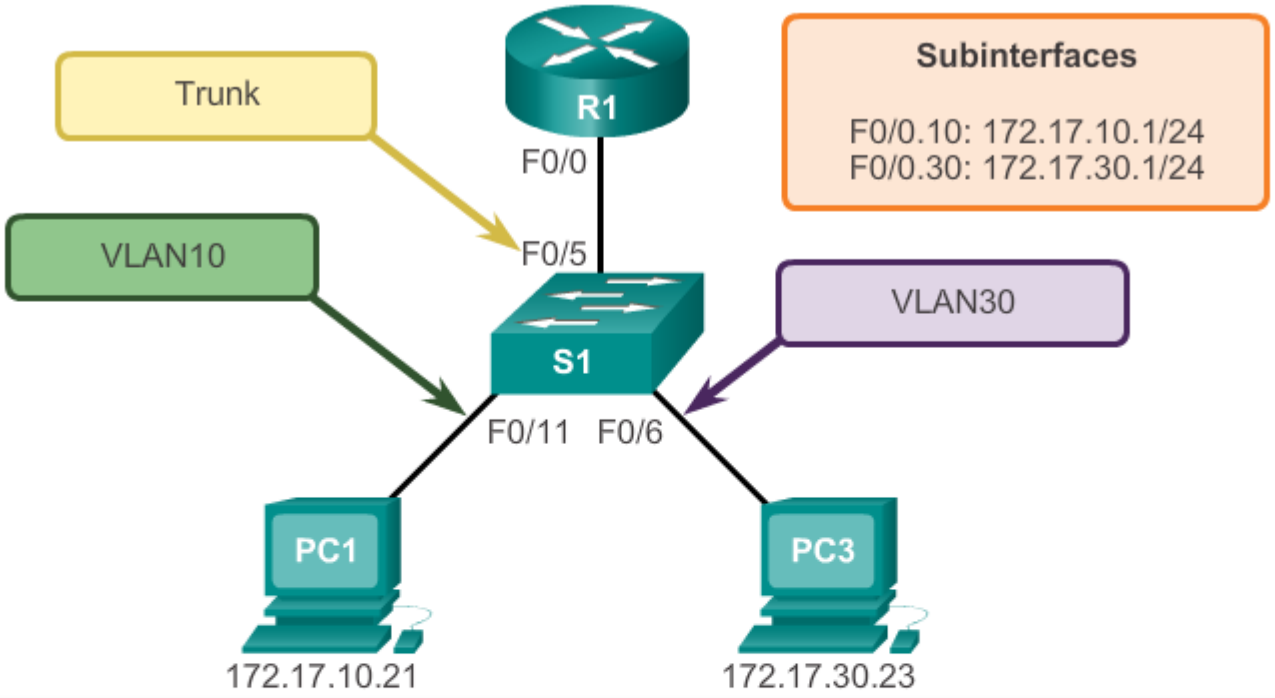
- An alternative to legacy inter-VLAN routing is to use VLAN trunking and subinterfaces
- VLAN trunking allows a single physical router interface to route traffic for multiple VLANs
- The physical interface of the router must be connected to a trunk link on the adjacent switch
- On the router, subinterfaces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

5.1.3.1

Do animation on 5.1.3.1

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#
```

5.1.3.2

Router Interface 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
```

5.1.3.3

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>
```

5.1.3.4

Verifying Subinterfaces

```
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
```

5.1.3.4

Do Buttons on 5.1.3.4
Students do practice on button 3

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

5.1.3.5

Switch Port Issues

- When using the legacy routing model, ensure that the switch ports that connect to the router interfaces are configured with the correct VLANs
- Use the **switchport access vlan 10** command to correct any errouneous VLAN port assignment
- Also ensure the router is connected to the correct switch port
- When using router-on-a-stick, ensure the switch port connected to the router is configured as a trunk link
- The **switchport mode trunk** command can be used to solve this problem

5.2.1.1

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#
```

5.2.1.2

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 detecting thi problem
- If this is the case, use the **encapsulation dot1q <vlan id>** interface command to fix the problem

5.2.1.4

Verify Router Configuration

```
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
```

5.2.1.4

Errors With IP Address And Subnet Mask

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

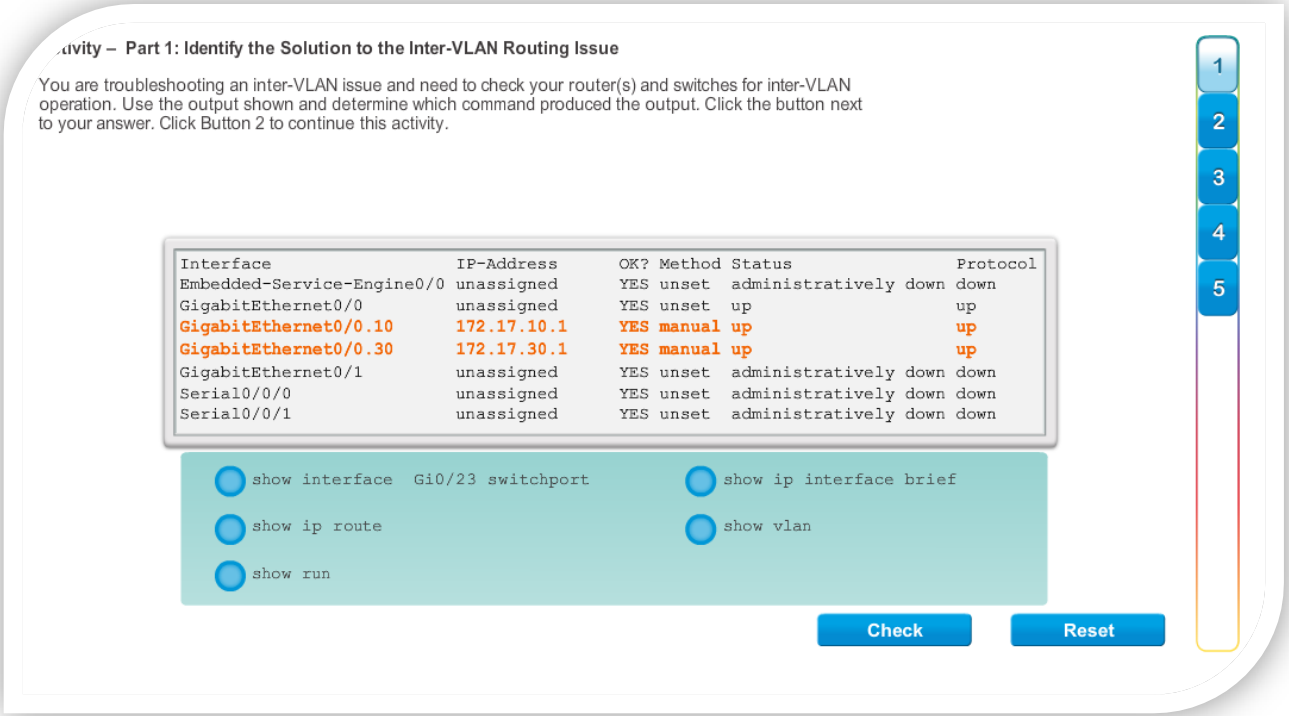
5.2.2.1

IP Addressing Issues
Verifying IP Address And Subnet Mask Configuration Issues

- To verify if the correct IP address is configured in the router, use the **show ip interface** command
- The **show running-config** can also be useful when troubleshooting router related problems
- Although configuring subinterface IDs to match the VLAN number makes it easier to manage inter-VLAN configuration, it is not a requirement. When troubleshooting addressing issues, ensure that the subinterface is configured with the correct address for that VLAN.

5.2.2.2

IP Addressing Issues
5.2.2.3 Activity - Identify the Solution to the Inter-VLAN Routing Issue



Students do buttons on Activity 5.2.2.3

5.2.2.3

Introduction To Layer 3 Switching

- Layer 3 switches usually have packet-switching throughputs in the millions of packets per second (pps)
- All Catalyst switches support two types of Layer 3 interfaces:
  - Routed Port
  - SVI
- High-performance switches, such as the Catalyst 6500 and Catalyst 4500, are able to perform most of the router's functions
- But several models of Catalyst switches require enhanced software for specific routing protocol feature

5.3.1.1

Inter-VLAN Routing with SVIs

- Today routing has become faster and cheaper and can performed at hardware speed
- It 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 as there are no loops in the Layer 2 portion of the topology

5.3.1.2

Inter-VLAN Routing with SVIs (cont)

- By default, an SVI is created for the default VLAN (VLAN1). This allows for remote switch administration
- Any additional SVIs must be created by the admin
- SVIs are created the first time the VLAN interface configuration mode is entered for a particular VLAN SVI
- The **interface vlan 10** entered by the first time creates an SVI named VLAN 10
- The VLAN number used corresponds to the VLAN tag associated with data frames on an 802.1Q encapsulated trunk
- Whenever the SVI is created, ensure that particular VLAN is present in the VLAN database

5.3.1.3

Inter-VLAN Routing with SVIs (cont)

- SVIs advantages include:
  - It is 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.

5.3.1.3

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.

5.3.1.4

Configuring Static Routes on a Cat2960

- The Cisco Switch Database Manager (SDM) provides multiple templates for the 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 verify which template is in use
- The SDM template can be changed in global configuration mode with the **sdm prefer** command

5.3.1.5

Do Buttons on 5.3.1.5

Layer 3 Switching Configuration Issues

- To troubleshoot Layer 3 switching issues, check the following items 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**
  - SVI must have the correct IP address or subnet mask
  - SVI must be up
  - SVI must match with the VLAN number

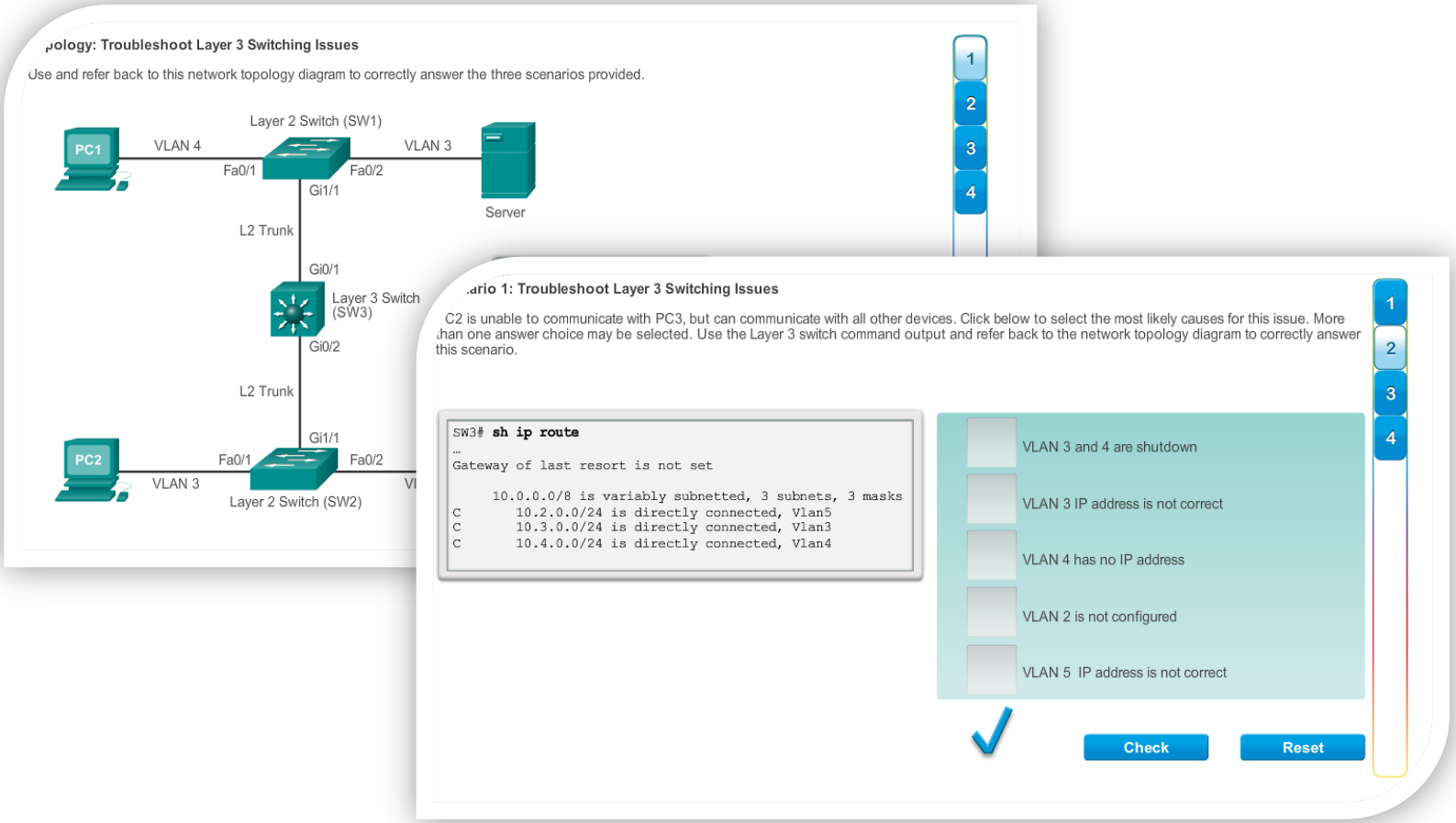
5.3.2.1

Layer 3 Switching Configuration Issues

- To troubleshoot Layer 3 switching issues, check the following items for accuracy (cont):
- **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

5.3.2.1

IP Addressing Issues
5.3.2.3 Activity - Troubleshoot Layer 3 Switching Issues



5.3.2.3

Students do buttons 1- 4 on Activity 5.3.2.3

Chapter 5: Summary

- This chapter covered Inter-VLAN routing, the process of routing traffic between different VLANs, using either a dedicated router or a multilayer switch.
- It discussed Legacy, router-on-a-stick and multilayer swtiching inter-VLAN routing.
- The chapter also covers Layer 3 switching, SVIs and routed ports.
- Lastly, troubleshooting inter-VLAN routing with a router or a Layer 3 switch were discussed. Common errors involve VLAN, trunk, Layer 3 interface, and IP address configurations.

5.4.1.2

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Ta da