



Module 4: Inter-VLAN Routing

Switching, Routing and Wireless
Essentials v7.0 (SRWE)



Module Objectives

Module Title: Inter-VLAN Routing

Module Objective: Troubleshoot inter-VLAN routing on Layer 3 devices

Topic Title	Topic Objective
Inter-VLAN Routing Operation	Describe options for configuring inter-VLAN routing.
Router-on-a-Stick Inter-VLAN Routing	Configure router-on-a-stick inter-VLAN routing.
Inter-VLAN Routing using Layer 3 Switches	Configure inter-VLAN routing using Layer 3 switching.
Troubleshoot Inter-VLAN Routing	Troubleshoot common inter-VLAN configuration issues.

4.1 Inter-VLAN Routing Operation

Inter-VLAN Routing Operation

What is Inter-VLAN Routing?

VLANs are used to segment switched Layer 2 networks for a variety of reasons. Regardless of the reason, hosts in one VLAN cannot communicate with hosts in another VLAN unless there is a router or a Layer 3 switch to provide routing services.

Inter-VLAN routing is the process of forwarding network traffic from one VLAN to another VLAN.

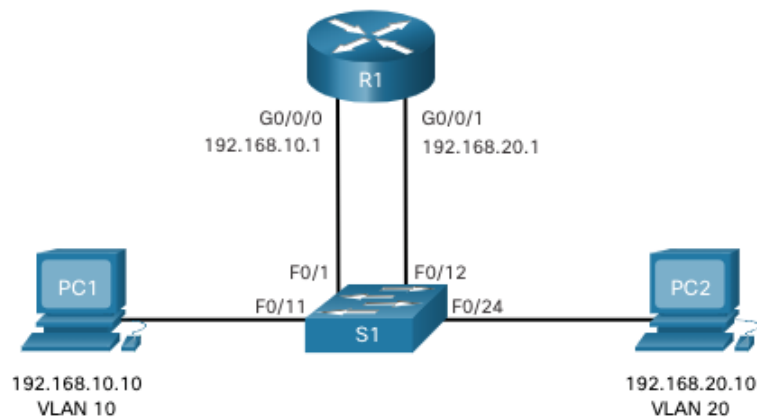
There are three inter-VLAN routing options:

- **Legacy Inter-VLAN routing** - This is a legacy solution. It does not scale well.
- **Router-on-a-Stick** - This is an acceptable solution for a small to medium-sized network.
- **Layer 3 switch using switched virtual interfaces (SVIs)** - This is the most scalable solution for medium to large organizations.

Inter-VLAN Routing Operation

Legacy Inter-VLAN Routing

- The first inter-VLAN routing solution relied on using a router with multiple Ethernet interfaces. Each router interface was connected to a switch port in different VLANs. The router interfaces served as the default gateways to the local hosts on the VLAN subnet.
- Legacy inter-VLAN routing using physical interfaces works, but it has a significant limitation. It is not reasonably scalable because routers have a limited number of physical interfaces. Requiring one physical router interface per VLAN quickly exhausts the physical interface capacity of a router.
- **Note:** This method of inter-VLAN routing is no longer implemented in switched networks and is included for explanation purposes only.



Inter-VLAN Routing Operation

Router-on-a-Stick Inter-VLAN Routing

The 'router-on-a-stick' inter-VLAN routing method overcomes the limitation of the legacy inter-VLAN routing method. It only requires one physical Ethernet interface to route traffic between multiple VLANs on a network.

- A Cisco IOS router Ethernet interface is configured as an 802.1Q trunk and connected to a trunk port on a Layer 2 switch. Specifically, the router interface is configured using subinterfaces to identify routable VLANs.
- The configured subinterfaces are software-based virtual interfaces. Each is associated with a single physical Ethernet interface. Subinterfaces are configured in software on a router. Each subinterface is independently configured with an IP address and VLAN assignment. Subinterfaces are configured for different subnets that correspond to their VLAN assignment. This facilitates logical routing.
- When VLAN-tagged traffic enters the router interface, it is forwarded to the VLAN subinterface. After a routing decision is made based on the destination IP network address, the router determines the exit interface for the traffic. If the exit interface is configured as an 802.1q subinterface, the data frames are VLAN-tagged with the new VLAN and sent back out the physical interface

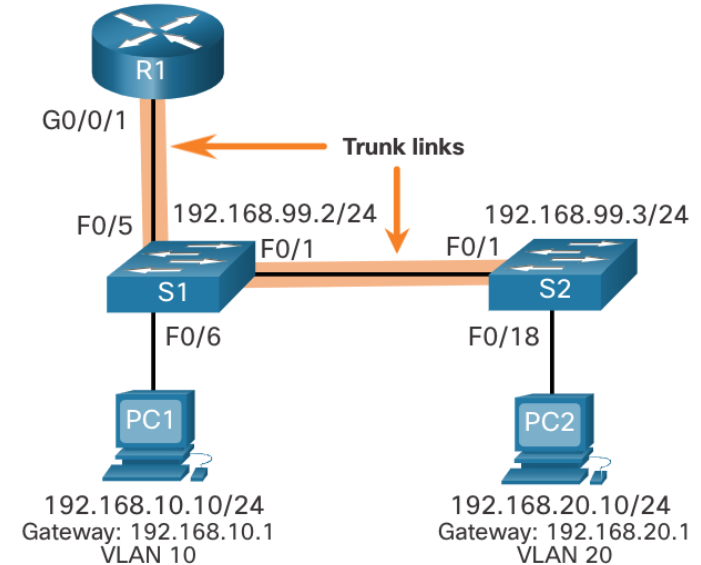
Note: The router-on-a-stick method of inter-VLAN routing does not scale beyond 50 VLANs.

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

Router-on-a-Stick Inter-VLAN Routing

Router-on-a-Stick Scenario

- In the figure, the R1 GigabitEthernet 0/0/1 interface is connected to the S1 FastEthernet 0/5 port. The S1 FastEthernet 0/1 port is connected to the S2 FastEthernet 0/1 port. These are trunk links that are required to forward traffic within and between VLANs.
- To route between VLANs, the R1 GigabitEthernet 0/0/1 interface is logically divided into three subinterfaces, as shown in the table. The table also shows the three VLANs that will be configured on the switches.
- Assume that R1, S1, and S2 have initial basic configurations. Currently, PC1 and PC2 cannot **ping** each other because they are on separate networks. Only S1 and S2 can **ping** each other, but they but are unreachable by PC1 or PC2 because they are also on different networks.
- To enable devices to ping each other, the switches must be configured with VLANs and trunking, and the router must be configured for inter-VLAN routing.



Subinterface	VLAN	IP Address
G0/0/1.10	10	192.168.10.1/24
G0/0/1.20	20	192.168.20.1/24
G0/0/1.30	99	192.168.99.1/24

S1 VLAN and Trunking Configuration

Complete the following steps to configure S1 with VLANs and trunking:

- **Step 1.** Create and name the VLANs.
- **Step 2.** Create the management interface.
- **Step 3.** Configure access ports.
- **Step 4.** Configure trunking ports.

Router-on-a-Stick Inter-VLAN Routing

S2 VLAN and Trunking Configuration

The configuration for S2 is similar to S1.

```
S2(config)# vlan 10
S2(config-vlan)# name LAN10
S2(config-vlan)# exit
S2(config)# vlan 20
S2(config-vlan)# name LAN20
S2(config-vlan)# exit
S2(config)# vlan 99
S2(config-vlan)# name Management
S2(config-vlan)# exit
S2(config)#
S2(config)# interface vlan 99
S2(config-if)# ip add 192.168.99.3 255.255.255.0
S2(config-if)# no shut
S2(config-if)# exit
S2(config)# ip default-gateway 192.168.99.1
S2(config)# interface fa0/18
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
S2(config-if)# no shut
S2(config-if)# exit
S2(config)# interface fa0/1
S2(config-if)# switchport mode trunk
S2(config-if)# no shut
S2(config-if)# exit
S2(config-if)# end
*Mar 1 00:23:52.137: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
```

Router-on-a-Stick Inter-VLAN Routing

R1 Subinterface Configuration

The router-on-a-stick method requires you to create a subinterface for each VLAN to be routed. A subinterface is created using the **interface** *interface_id subinterface_id* global configuration mode command. The subinterface syntax is the physical interface followed by a period and a subinterface number. Although not required, it is customary to match the subinterface number with the VLAN number.

Each subinterface is then configured with the following two commands:

- **encapsulation dot1q** *vlan_id* [**native**] - This command configures the subinterface to respond to 802.1Q encapsulated traffic from the specified *vlan-id*. The **native** keyword option is only appended to set the native VLAN to something other than VLAN 1.
- **ip address** *ip-address subnet-mask* - This command configures the IPv4 address of the subinterface. This address typically serves as the default gateway for the identified VLAN.

Repeat the process for each VLAN to be routed. Each router subinterface must be assigned an IP address on a unique subnet for routing to occur. When all subinterfaces have been created, enable the physical interface using the **no shutdown** interface configuration command. If the physical interface is disabled, all subinterfaces are disabled.

Router-on-a-Stick Inter-VLAN Routing

R1 Subinterface Configuration (Cont.)

In the configuration, the R1 G0/0/1 subinterfaces are configured for VLANs 10, 20, and 99.

```
R1(config)# interface G0/0/1.10
R1(config-subif)# Description Default Gateway for VLAN 10
R1(config-subif)# encapsulation dot1Q 10
R1(config-subif)# ip add 192.168.10.1 255.255.255.0
R1(config-subif)# exit
R1(config)#
R1(config)# interface G0/0/1.20
R1(config-subif)# Description Default Gateway for VLAN 20
R1(config-subif)# encapsulation dot1Q 20
R1(config-subif)# ip add 192.168.20.1 255.255.255.0
R1(config-subif)# exit
R1(config)#
R1(config)# interface G0/0/1.99
R1(config-subif)# Description Default Gateway for VLAN 99
R1(config-subif)# encapsulation dot1Q 99
R1(config-subif)# ip add 192.168.99.1 255.255.255.0
R1(config-subif)# exit
R1(config)#
R1(config)# interface G0/0/1
R1(config-if)# Description Trunk link to S1
R1(config-if)# no shut
R1(config-if)# end
R1#
*Sep 15 19:08:47.015: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/1, changed state to down
*Sep 15 19:08:50.071: %LINK-3-UPDOWN: Interface GigabitEthernet0/0/1, changed state to up
*Sep 15 19:08:51.071: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0/1,
changed state to up
R1#
```

Router-on-a-Stick Inter-VLAN Routing

Verify Connectivity Between PC1 and PC2

The router-on-a-stick configuration is complete after the switch trunk and the router subinterfaces have been configured. The configuration can be verified from the hosts, router, and switch.

From a host, verify connectivity to a host in another VLAN using the **ping** command. It is a good idea to first verify the current host IP configuration using the **ipconfig** Windows host command.

Next, use **ping** to verify connectivity with PC2 and S1, as shown in the figure. The **ping** output successfully confirms inter-VLAN routing is operating.

```
C:\Users\PC1> ping 192.168.20.10
Pinging 192.168.20.10 with 32 bytes of data:
Reply from 192.168.20.10: bytes=32 time<1ms TTL=127
Reply from 192.168.20.10: bytes=32 time<1ms TTL=127
Reply from 192.168.20.10: bytes=32 time<1ms TTL=127
Reply from 192.168.20.10: bytes=32 time<1ms TTL=127
Ping statistics for 192.168.20.10:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss).
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
C:\Users\PC1>
C:\Users\PC1> ping 192.168.99.2
Pinging 192.168.99.2 with 32 bytes of data:
Request timed out.
Request timed out.
Reply from 192.168.99.2: bytes=32 time=2ms TTL=254
Reply from 192.168.99.2: bytes=32 time=1ms TTL=254
Ping statistics for 192.168.99.2:
    Packets: Sent = 4, Received = 2, Lost = 2 (50% loss).
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 2ms, Average = 1ms
C:\Users\PC1>
```

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

In addition to using **ping** between devices, the following **show** commands can be used to verify and troubleshoot the router-on-a-stick configuration.

- **show ip route**
- **show ip interface brief**
- **show interfaces**
- **show interfaces trunk**

4.4 Troubleshoot Inter-VLAN Routing

Troubleshoot Inter-VLAN Routing

Common Inter-VLAN Issues

There are a number of reasons why an inter-VLAN configuration may not work. All are related to connectivity issues. First, check the physical layer to resolve any issues where a cable might be connected to the wrong port. If the connections are correct, then use the list in the table for other common reasons why inter-VLAN connectivity may fail.

Issue Type	How to Fix	How to Verify
Missing VLANs	<ul style="list-style-type: none">•Create (or re-create) the VLAN if it does not exist.•Ensure host port is assigned to the correct VLAN.	show vlan [brief] show interfaces switchport ping
Switch Trunk Port Issues	<ul style="list-style-type: none">•Ensure trunks are configured correctly.•Ensure port is a trunk port and enabled.	show interface trunk show running-config
Switch Access Port Issues	<ul style="list-style-type: none">•Assign correct VLAN to access port.•Ensure port is an access port and enabled.•Host is incorrectly configured in the wrong subnet.	show interfaces switchport show running-config interface ipconfig
Router Configuration Issues	<ul style="list-style-type: none">•Router subinterface IPv4 address is incorrectly configured.•Router subinterface is assigned to the VLAN ID.	show ip interface brief show interfaces

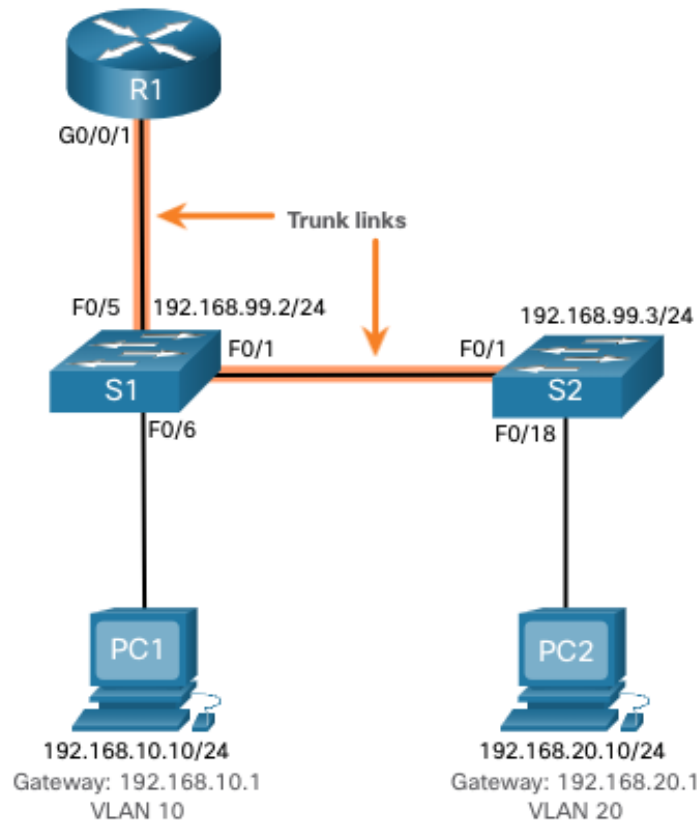
Troubleshoot Inter-VLAN Routing

Troubleshoot Inter-VLAN Routing Scenario

Examples of some of these inter-VLAN routing problems will now be covered in more detail. This topology will be used for all of these issues.

Router R1 Subinterfaces

Subinterface	VLAN	IP Address
G0/0/0.10	10	192.168.10.1/24
G0/0/0.20	20	192.168.20.1/24
G0/0/0.30	99	192.168.99.1/24



Troubleshoot Inter-VLAN Routing

Missing VLANs

An inter-VLAN connectivity issue could be caused by a missing VLAN. The VLAN could be missing if it was not created, it was accidentally deleted, or it is not allowed on the trunk link.

When a VLAN is deleted, any ports assigned to that VLAN become inactive. They remain associated with the VLAN (and thus inactive) until you assign them to a new VLAN or recreate the missing VLAN. Recreating the missing VLAN would automatically reassign the hosts to it.

Use the **show interface *interface-id* switchport** command to verify the VLAN membership of the port.

```
S1(config)# do show interface fa0/6 switchport
Name: Fa0/6
Switchport: Enabled
Administrative Mode: static access
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: Off
Access Mode VLAN: 10 (Inactive)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
(Output omitted)
```

Troubleshoot Inter-VLAN Routing

Switch Trunk Port Issues

Another issue for inter-VLAN routing includes misconfigured switch ports. In a legacy inter-VLAN solution, this could be caused when the connecting router port is not assigned to the correct VLAN.

However, with a router-on-a-stick solution, the most common cause is a misconfigured trunk port.

- Verify that the port connecting to the router is correctly configured as a trunk link using the **show interface trunk** command.
- If that port is missing from the output, examine the configuration of the port with the **show running-config interface X** command to see how the port is configured.

```
S1# show interface trunk
Port      Mode           Encapsulation  Status        Native vlan
Fa0/1     on             802.1q         trunking      1
Port      Vlans allowed on trunk
Fa0/1     1-4094
Port      Vlans allowed and active in management domain
Fa0/1     1,10,20,99
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     1,10,20,99
S1#
```

Troubleshoot Inter-VLAN Routing

Switch Access Port Issues

When a problem is suspected with a switch access port configuration, use verification commands to examine the configuration and identify the problem.

A common indicator of this issue is the PC having the correct address configuration (IP Address, Subnet Mask, Default Gateway), but being unable to ping its default gateway.

- Use the **show vlan brief**, **show interface X switchport** or **show running-config interface X** command to verify the interface VLAN assignment.

```
Sl# show interface fa0/6 switchport
Name: Fa0/6
Switchport: Enabled
Administrative Mode: static access
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: Off
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
```

Troubleshoot Inter-VLAN Routing

Router Configuration Issues

Router-on-a-stick configuration problems are usually related to subinterface misconfigurations.

- Verify the subinterface status using the **show ip interface brief** command.
- Verify which VLANs each of the subinterfaces is on. To do so, the **show interfaces** command is useful but it generates a great deal of additional unrequired output. The command output can be reduced using IOS command filters. In this example, use the **include** keyword to identify that only lines containing the letters “Gig” or “802.1Q”

```
R1# show interfaces | include Gig|802.1Q
GigabitEthernet0/0/0 is administratively down, line protocol is down
GigabitEthernet0/0/1 is up, line protocol is up
  Encapsulation 802.1Q Virtual LAN, Vlan ID 1., loopback not set
GigabitEthernet0/0/1.10 is up, line protocol is up
  Encapsulation 802.1Q Virtual LAN, Vlan ID 100.
GigabitEthernet0/0/1.20 is up, line protocol is up
  Encapsulation 802.1Q Virtual LAN, Vlan ID 20.
GigabitEthernet0/0/1.99 is up, line protocol is up
  Encapsulation 802.1Q Virtual LAN, Vlan ID 99.
R1#
```

