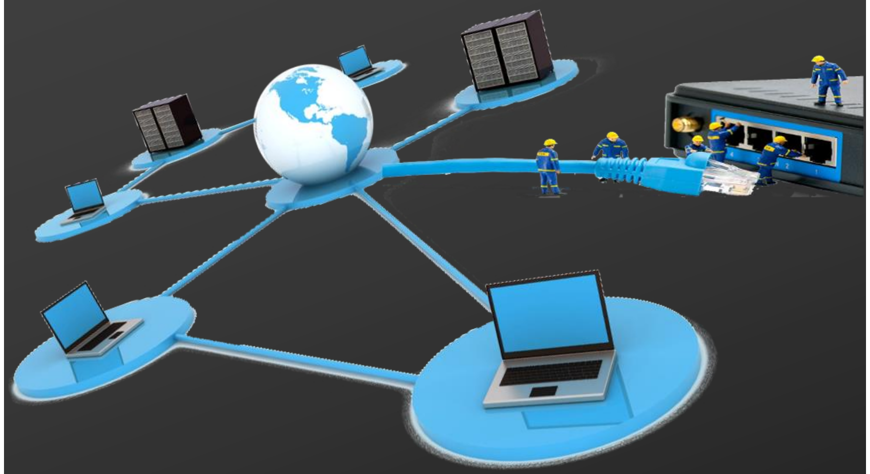
TRƯỜNG ĐẠI HỌC CÔNG NGHỆ THÔNG TIN – ĐHQG-HCM
Khoa Mạng máy tính & Truyền thông

Switching và VLAN

NT132 – Quản trị mạng và hệ thống

GV: Đỗ Hoàng Hiển

hiendh@uit.edu.vn



Nội dung

Cơ sở hạ tầng mạng

Hôm nay học gì?

1. Frame Forwarding
2. VLANs and Trunking
3. Inter-VLAN Routing

Frame Forwarding

Frame Forwarding

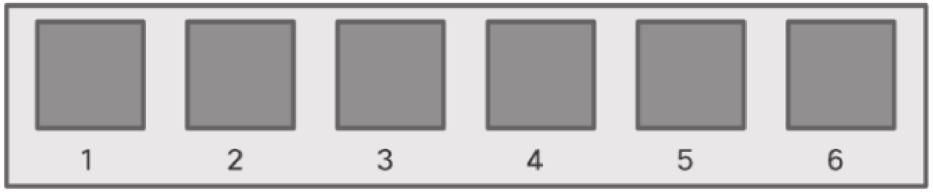
Switching in Networking

Two terms are associated with frames entering or leaving an interface:

- **Ingress** – entering the interface
- **Egress** – exiting the interface

A switch forwards based on the ingress interface and the destination MAC address.

A switch uses its MAC address table to make forwarding decisions.



Port Table

Destination Addresses	Port
EE	1
AA	2
BA	3
EA	4
AC	5
AB	6

Note: A switch will never allow traffic to be forwarded out the interface it received the traffic.

The Switch MAC Address Table

A switch will use the destination MAC address to determine the egress interface.

Before a switch can make this decision it must learn what interface the destination is located.

A switch builds a MAC address table, also known as a Content Addressable Memory (CAM) table, by recording the source MAC address into the table along with the port it was received.

The Switch Learn and Forward Method

The switch uses a two step process:

Step 1. Learn – Examines Source Address

- Adds the source MAC if not in table
- Resets the time out setting back to 5 minutes if source is in the table

Step 2. Forward – Examines Destination Address

- If the destination MAC is in the MAC address table it is forwarded out the specified port
- If a destination MAC is not in the table, it is flooded out all interfaces except the one it was received

Frame Forwarding

Switch Forwarding Methods

Switches use software on application-specific-integrated circuits (ASICs) to make very quick decisions.

A switch will use one of two methods to make forwarding decisions after it receives a frame:

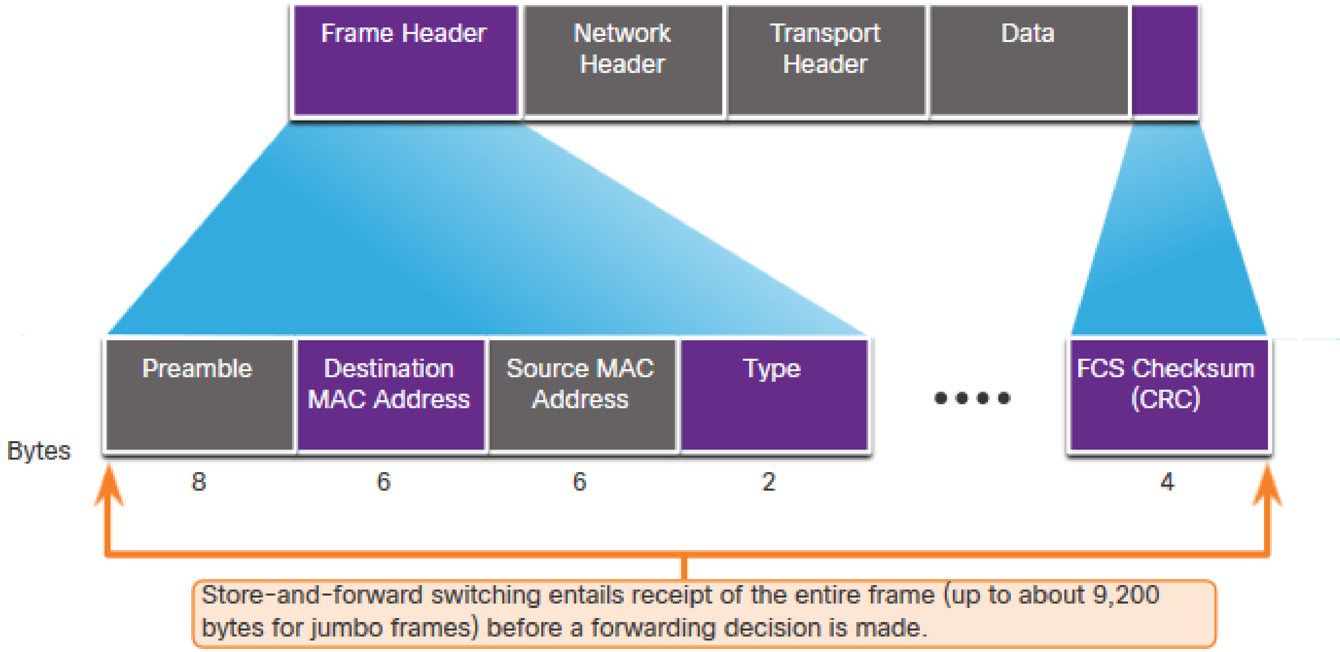
- **Store-and-forward switching** - Receives the entire frame and ensures the frame is valid. Store-and-forward switching is Cisco's preferred switching method.
- **Cut-through switching** – Forwards the frame immediately after determining the destination MAC address of an incoming frame and the egress port.

Frame Forwarding

Store-and-Forward Switching

Store-and-forward has two primary characteristics:

- **Error Checking** – The switch will check the Frame Check Sequence (FCS) for CRC errors. Bad frames will be discarded.
- **Buffering** – The ingress interface will buffer the frame while it checks the FCS. This also allows the switch to adjust to a potential difference in speeds between the ingress and egress ports.

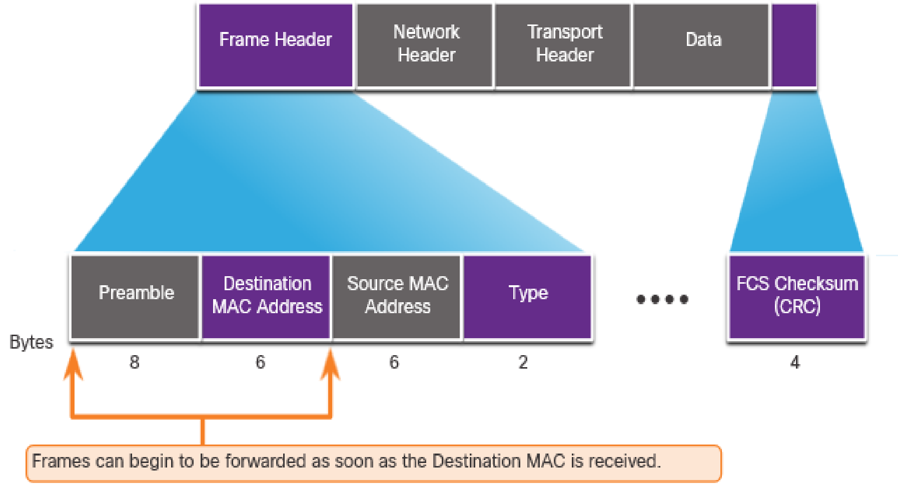


Cut-Through Switching

- Cut-through forwards the frame immediately after determining the destination MAC.
- Fragment (Frag) Free method will check the destination and ensure that the frame is at least 64 Bytes. This will eliminate runts.

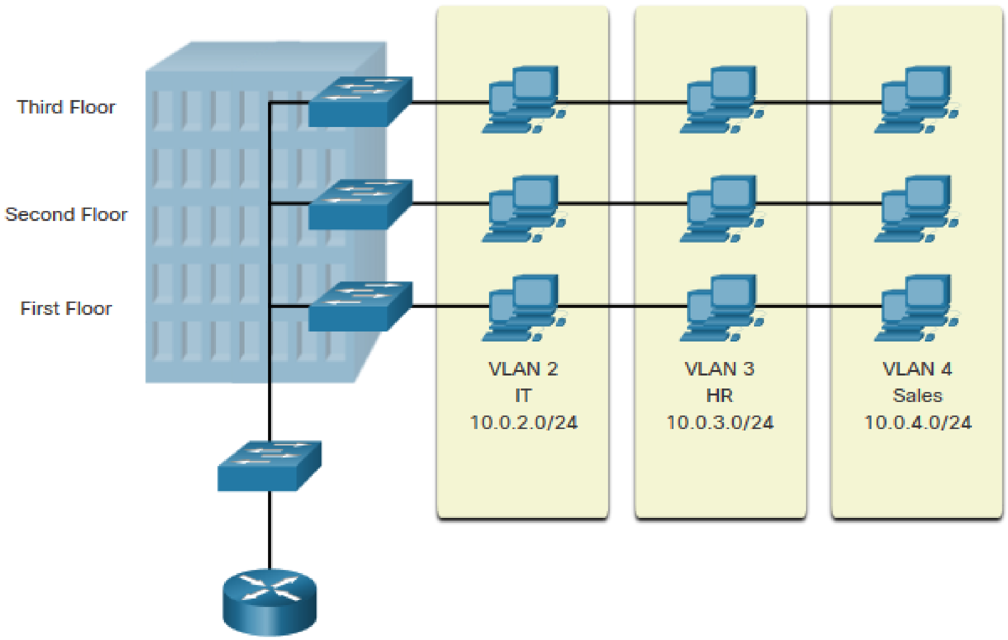
Concepts of Cut-Through switching:

- Is appropriate for switches needing latency to be under 10 microseconds
- Does not check the FCS, so it can propagate errors
- May lead to bandwidth issues if the switch propagates too many errors
- Cannot support ports with differing speeds going from ingress to egress



VLANs and Trunking

VLAN Definitions

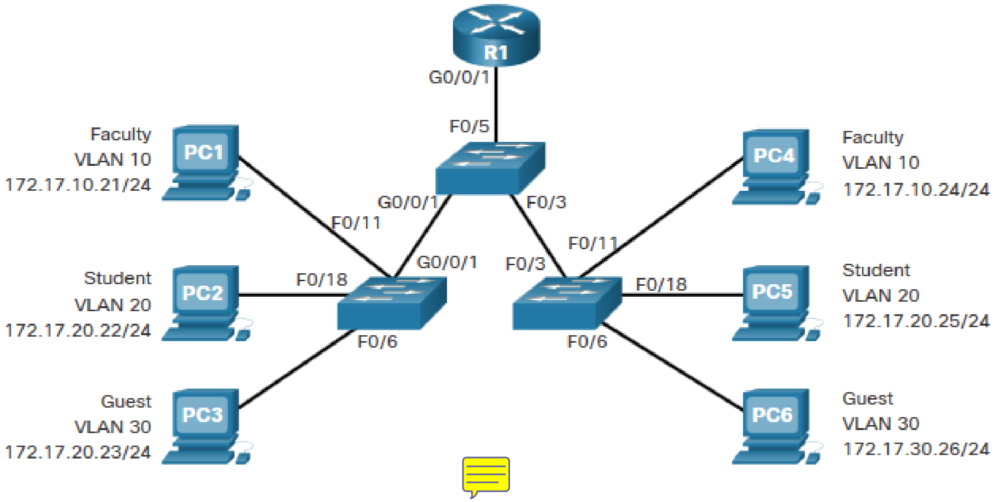


VLANs are logical connections with other similar devices.

Placing devices into various VLANs have the following characteristics:

- Provides segmentation of the various groups of devices on the same switches
- Provide organization that is more manageable
  - Broadcasts, multicasts and unicasts are isolated in the individual VLAN
  - Each VLAN will have its own unique range of IP addressing
  - Smaller broadcast domains

Benefits of a VLAN Design



Benefits of using VLANs are as follows:

Benefits	Description
Smaller Broadcast Domains	Dividing the LAN reduces the number of broadcast domains
Improved Security	Only users in the same VLAN can communicate together
Improved IT Efficiency	VLANs can group devices with similar requirements, e.g. faculty vs. students
Reduced Cost	One switch can support multiple groups or VLANs
Better Performance	Small broadcast domains reduce traffic, improving bandwidth
Simpler Management	Similar groups will need similar applications and other network resources

Types of VLANs

Default VLAN

VLAN 1 is the following:

- The default VLAN
- The default Native VLAN
- The default Management VLAN
- Cannot be deleted or renamed

Note: While we cannot delete VLAN1 Cisco will recommend that we assign these default features to other VLANs

```
Switch# show vlan brief
VLAN Name                 Status    Ports
---- -------------------- --------- ---------------------
1    default              active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                    Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                    Fa0/9, Fa0/10, Fa0/11, Fa0/12
                                    Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                    Fa0/17, Fa0/18, Fa0/19, Fa0/20
                                    Fa0/21, Fa0/22, Fa0/23, Fa0/24
                                    Gi0/1, Gi0/2
1002 fddi-default                         act/unsup
1003 token-ring-default                   act/unsup
1004 fddinet-default                      act/unsup
1005 trnet-default                        act/unsup
```

Types of VLANs (Cont.)

Data VLAN

- Dedicated to user-generated traffic (email and web traffic).
- VLAN 1 is the default data VLAN because all interfaces are assigned to this VLAN.

Native VLAN

- This is used for trunk links only.
- All frames are tagged on an 802.1Q trunk link except for those on the native VLAN.

Management VLAN

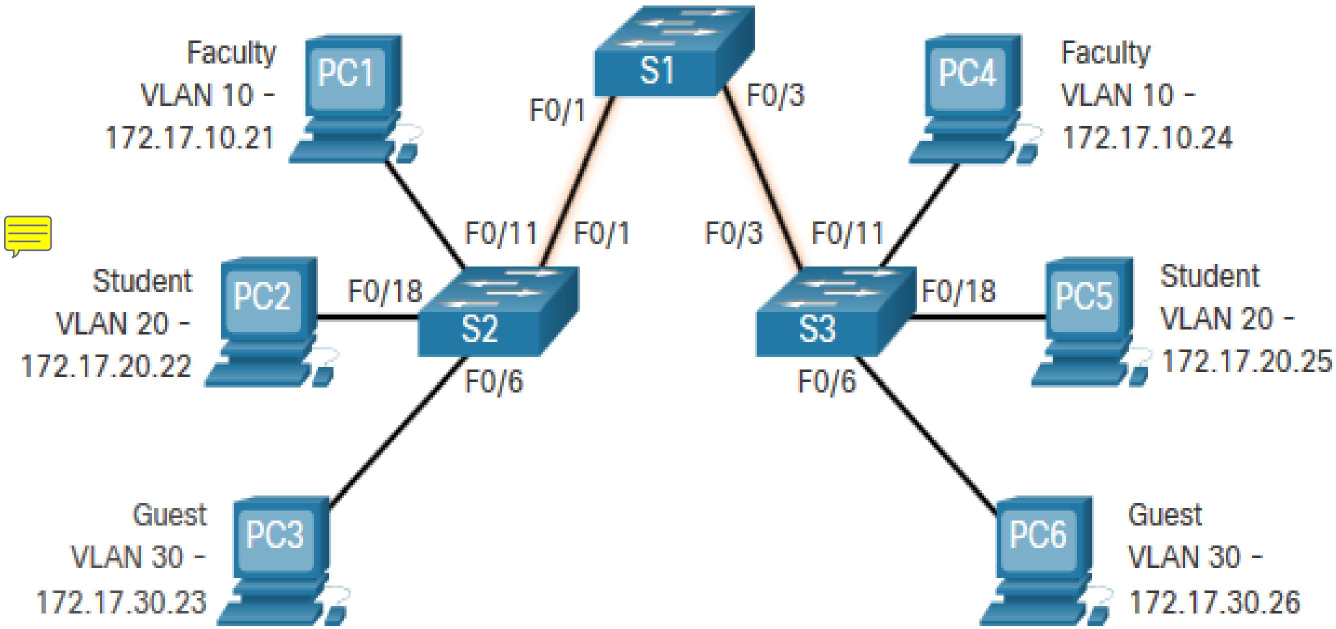
- This is used for SSH/Telnet VTY traffic and should not be carried with end user traffic.
- Typically, the VLAN that is the SVI for the Layer 2 switch.

Defining VLAN Trunks

A trunk is a point-to-point link between two network devices.

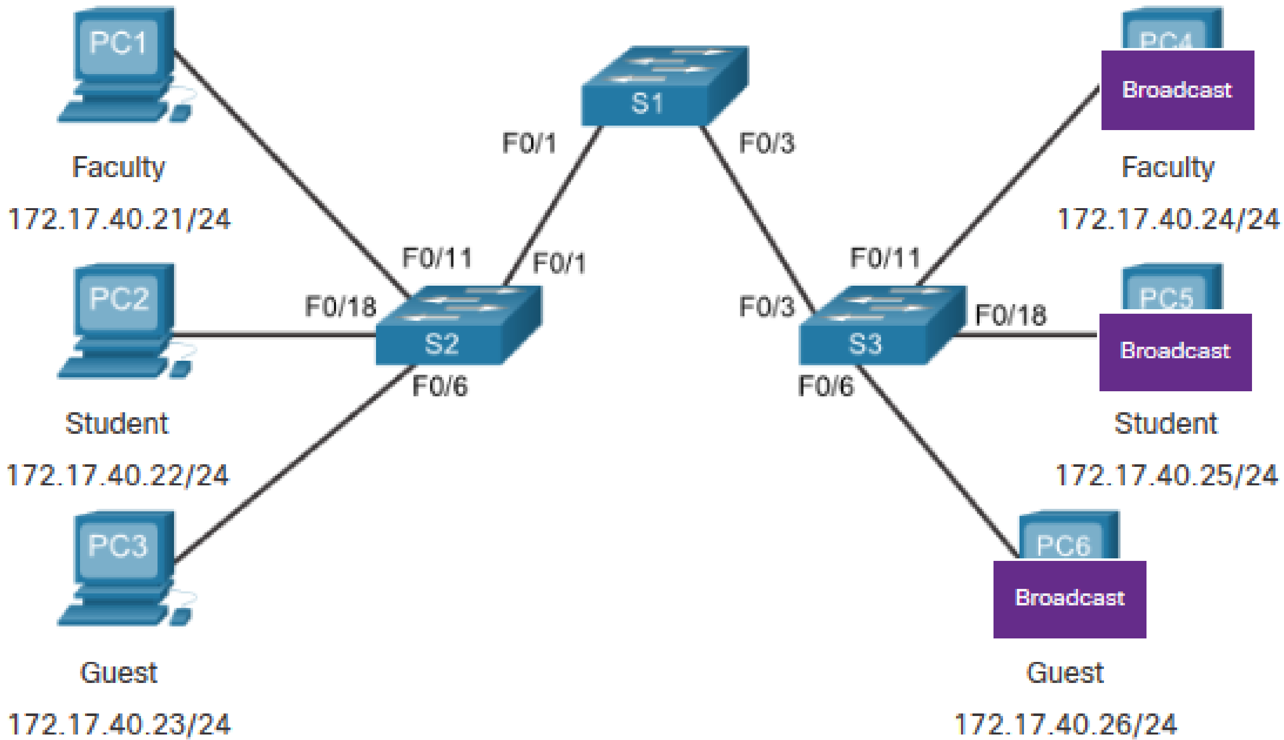
Cisco trunk functions:

- Allow more than one VLAN
- Extend the VLAN across the entire network
- By default, supports all VLANs
- Supports 802.1Q trunking



Networks without VLANs

Without VLANs, all devices connected to the switches will receive all unicast, multicast, and broadcast traffic.

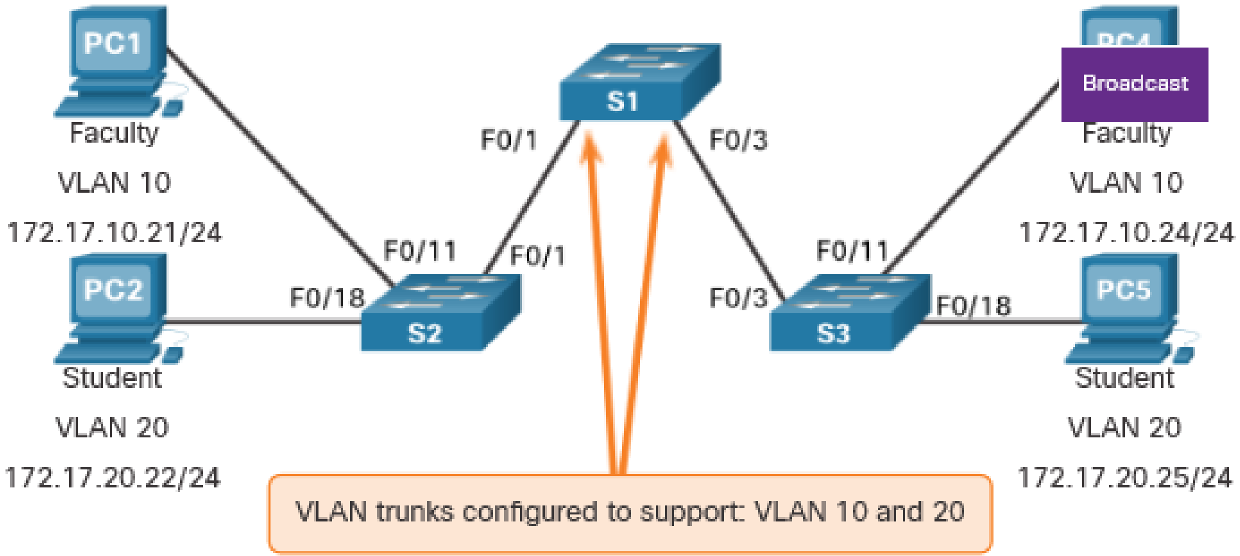


PC1 sends out a local Layer 2 broadcast. The switches forward the broadcast frame out all available ports.

VLANs in a Multi-Switched Environment

Networks with VLANs

With VLANs, unicast, multicast, and broadcast traffic is confined to a VLAN. Without a Layer 3 device to connect the VLANs, devices in different VLANs cannot communicate.

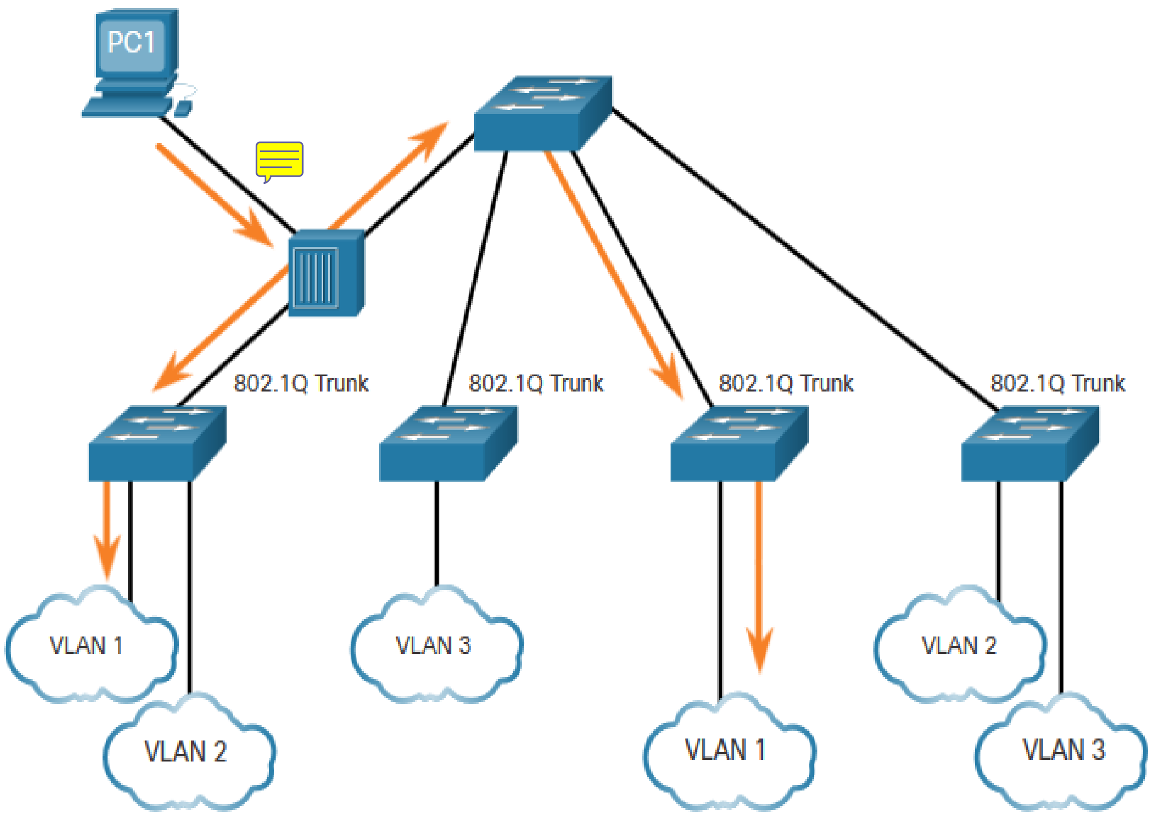


PC1 sends out a local Layer 2 broadcast. The switches forward the broadcast frame only out ports configured for VLAN10.

Native VLANs and 802.1Q Tagging

802.1Q trunk basics:

- Tagging is typically done on all VLANs.
- The use of a native VLAN was designed for legacy use, like the hub in the example.
- Unless changed, VLAN1 is the native VLAN.
- Both ends of a trunk link must be configured with the same native VLAN.
- Each trunk is configured separately, so it is possible to have a different native VLANs on separate trunks.



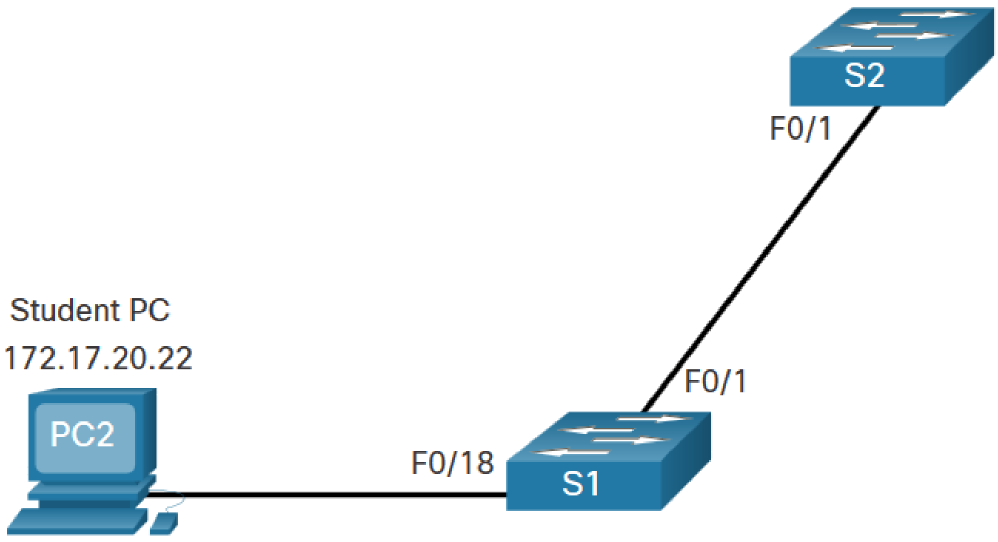
VLAN Creation Commands

VLAN details are stored in the **vlan.dat** file. You create VLANs in the global configuration mode.

Task	IOS Command
Enter global configuration mode.	Switch# **configure terminal**
Create a VLAN with a valid ID number.	Switch(config)# **vlan** *vlan-id*
Specify a unique name to identify the VLAN.	Switch(config-vlan)# **name** *vlan-name*
Return to the privileged EXEC mode.	Switch(config-vlan)# **end**
Enter global configuration mode.	Switch# **configure terminal**

VLAN Creation Example

- If the Student PC is going to be in VLAN 20, we will create the VLAN first and then name it.
- If you do not name it, the Cisco IOS will give it a default name of vlan and the four digit number of the VLAN. E.g. vlan0020 for VLAN 20.



Prompt	Command
S1#	**configure terminal**
S1(config)#	**vlan** 20
S1(config-vlan)#	**name** student
S1(config-vlan)#	**end**

VLAN Port Assignment Commands

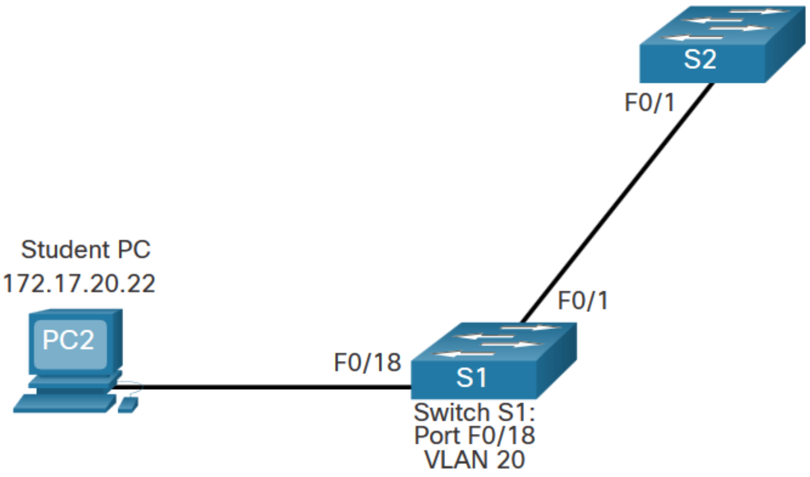
Once the VLAN is created, we can then assign it to the correct interfaces.

Task	Command
Enter global configuration mode.	Switch# **configure terminal**
Enter interface configuration mode.	Switch(config)# **interface** *interface-id*
Set the port to access mode.	Switch(config-if)# **switchport mode access**
Assign the port to a VLAN.	Switch(config-if)# **switchport access vlan** *vlan-id*
Return to the privileged EXEC mode.	Switch(config-if)# **end**

VLAN Port Assignment Example

We can assign the VLAN to the port interface.

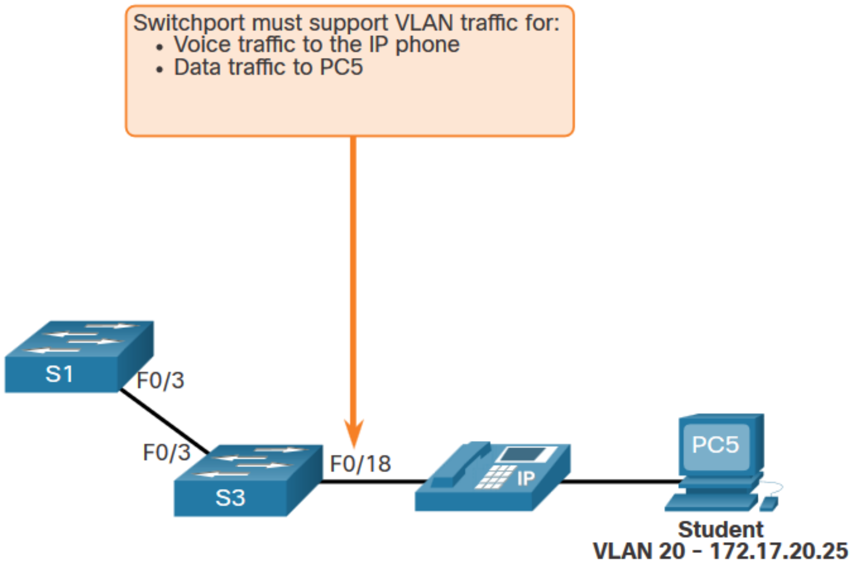
- Once the device is assigned the VLAN, then the end device will need the IP address information for that VLAN
- Here, Student PC receives 172.17.20.22



Prompt	Command
S1#	**configure terminal**
S1(config)#	**interface** fa0/18
S1(config-if)#	**switchport mode access**
S1(config-if)#	**switchport access vlan** 20
S1(config-if)#	**end**

Data and Voice VLANs

An access port may only be assigned to one data VLAN. However it may also be assigned to one Voice VLAN for when a phone and an end device are off of the same switchport.



Verify VLAN Information

Use the **show vlan** command. The complete syntax is:

show vlan [brief | **id** *vlan-id* | **name** *vlan-name* | **summary**]

```
S1# show vlan summary
Number of existing VLANs                 : 7
 Number of existing VTP VLANs            : 7
 Number of existing extended VLANS       : 0
```

```
S1# show interface vlan 20
Vlan20 is up, line protocol is up
  Hardware is EtherSVI, address is 001f.6ddb.3ec1 (bia 001f.6ddb.3ec1)
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set

 (Output omitted)
```

Task	Command Option
Display VLAN name, status, and its ports one VLAN per line.	**brief**
Display information about the identified VLAN ID number.	**id** *vlan-id*
Display information about the identified VLAN name. The *vlan-name* is an ASCII string from 1 to 32 characters.	**name** *vlan-name*
Display VLAN summary information.	**summary**

Change VLAN Port Membership

There are a number of ways to change VLAN membership:

- re-enter **switchport access vlan** *vlan-id* command
- use the **no switchport access vlan** to place interface back in VLAN 1

Use the **show vlan brief** or the **show interface fa0/18 switchport** commands to verify the correct VLAN association.

```
S1(config)# interface fa0/18
S1(config-if)# no switchport access vlan
S1(config-if)# end
S1#
S1# show vlan brief
VLAN Name                 Status    Ports
---- ------------------ --------- -------------------------------
1    default              active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                    Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                    Fa0/9, Fa0/10, Fa0/11, Fa0/12
                                    Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                    Fa0/17, Fa0/18, Fa0/19, Fa0/20
                                    Fa0/21, Fa0/22, Fa0/23, Fa0/24
                                    Gi0/1, Gi0/2
20   student              active
1002 fddi-default         act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default      act/unsup
1005 trnet-default        act/unsup
```

```
S1# show interfaces fa0/18 switchport
Name: Fa0/18
Switchport: Enabled
Administrative Mode: static access
Operational Mode: static access
Administrative Trunking Encapsulation: negotiate
Operational Trunking Encapsulation: native
Negotiation of Trunking: Off
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
```

Delete VLANs

Delete VLANs with the **no vlan** *vlan-id* command.

Caution: Before deleting a VLAN, reassign all member ports to a different VLAN.

- Delete all VLANs with the **delete flash:vlan.dat** or **delete vlan.dat** commands.
- Reload the switch when deleting all VLANs.

Note: To restore to factory default – unplug all data cables, erase the startup-configuration and delete the vlan.dat file, then reload the device.

Trunk Configuration Commands

Configure and verify VLAN trunks. Trunks are layer 2 and carry traffic for all VLANs.

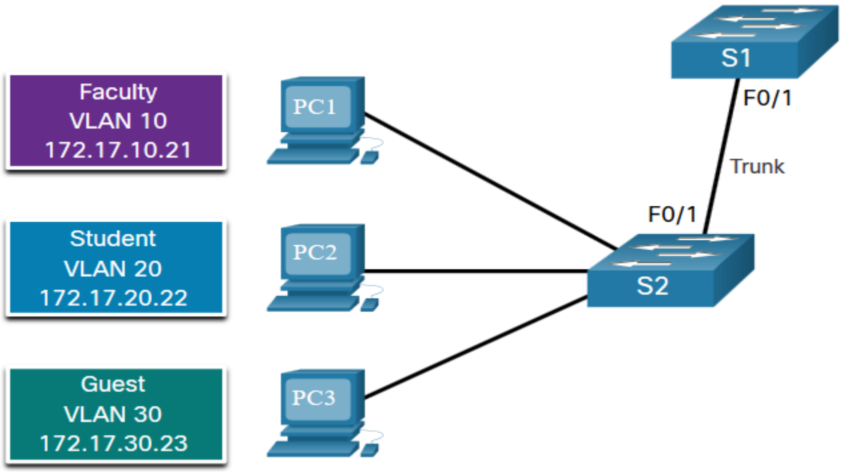
Task	IOS Command
Enter global configuration mode.	Switch# **configure terminal**
Enter interface configuration mode.	Switch(config)# **interface** *interface-id*
Set the port to permanent trunking mode.	Switch(config-if)# **switchport mode trunk**
Sets the native VLAN to something other than VLAN 1.	Switch(config-if)# **switchport trunk native vlan** *vlan-id*
Specify the list of VLANs to be allowed on the trunk link.	Switch(config-if)# **switchport trunk allowed vlan** *vlan-list*
Return to the privileged EXEC mode.	Switch(config-if)# **end**

VLAN Trunks

Trunk Configuration Example

The subnets associated with each VLAN are:

- VLAN 10 - Faculty/Staff - 172.17.10.0/24
- VLAN 20 - Students - 172.17.20.0/24
- VLAN 30 - Guests - 172.17.30.0/24
- VLAN 99 - Native - 172.17.99.0/24



F0/1 port on S1 is configured as a trunk port.

Note: This assumes a 2960 switch using 802.1q tagging. Layer 3 switches require the encapsulation to be configured before the trunk mode.

Prompt	Command
S1(config)#	**interface** fa0/1
S1(config-if)#	**switchport mode trunk**
S1(config-if)#	**switchport trunk native vlan** 99
S1(config-if)#	**switchport trunk allowed vlan** 10,20,30,99
S1(config-if)#	**end**

Verify Trunk Configuration

Set the trunk mode and native vlan.

Notice **sh int fa0/1 switchport** command:

- Is set to trunk administratively
- Is set as trunk operationally (functioning)
- Encapsulation is dot1q
- Native VLAN set to VLAN 99
- All VLANs created on the switch will pass traffic on this trunk

```
S1(config)# interface fa0/1
S1(config-if)# switchport mode trunk
S1(config-if)# no switchport trunk native vlan 99
S1(config-if)# end
S1# show interfaces fa0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 99 (VLAN0099)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
(output omitted)
```

Reset the Trunk to the Default State

- Reset the default trunk settings with the no command.
  - All VLANs allowed to pass traffic
  - Native VLAN = VLAN 1
- Verify the default settings with a **sh int fa0/1 switchport** command.

```
S1(config)# interface fa0/1
S1(config-if)# no switchport trunk allowed vlan
S1(config-if)# no switchport trunk native vlan
S1(config-if)# end
```

```
S1# show interfaces fa0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
(output omitted)
```

Reset the Trunk to the Default State (Cont.)

Reset the trunk to an access mode with the **switchport mode access** command:

- Is set to an access interface administratively
- Is set as an access interface operationally (functioning)

```
S1(config)# interface fa0/1
S1(config-if)# switchport mode access
S1(config-if)# end
S1# show interfaces fa0/1 switchport
Name: Fa0/1
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
(output omitted)
```

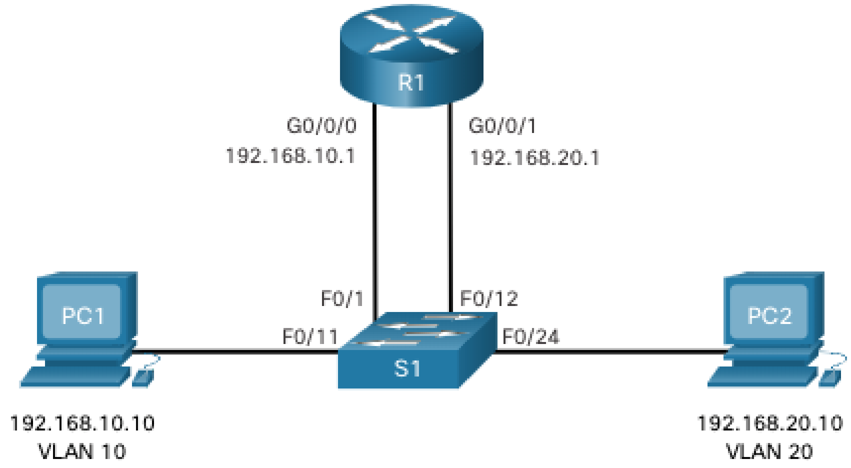
Inter-VLAN Routing

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.

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.



Router-on-a-Stick Inter-VLAN Routing

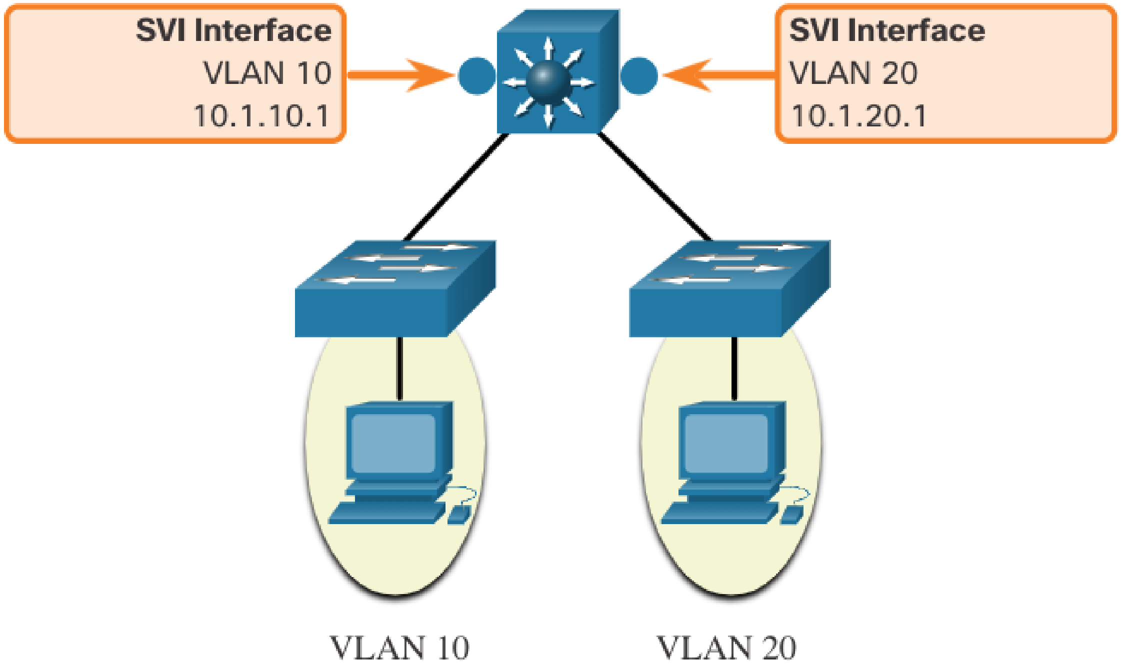
- The 'router-on-a-stick' inter-VLAN routing method overcomes the limitation of the legacy inter-VLAN routing method. It only requires one physical Ethernet interface to route traffic between multiple VLANs on a network.
  - A Cisco IOS router Ethernet interface is configured as an 802.1Q trunk and connected 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.

Inter-VLAN Routing on a Layer 3 Switch

- The modern method of performing inter-VLAN routing is to use Layer 3 switches and switched virtual interfaces (SVI). An SVI is a virtual interface that is configured on a Layer 3 switch, as shown in the figure.

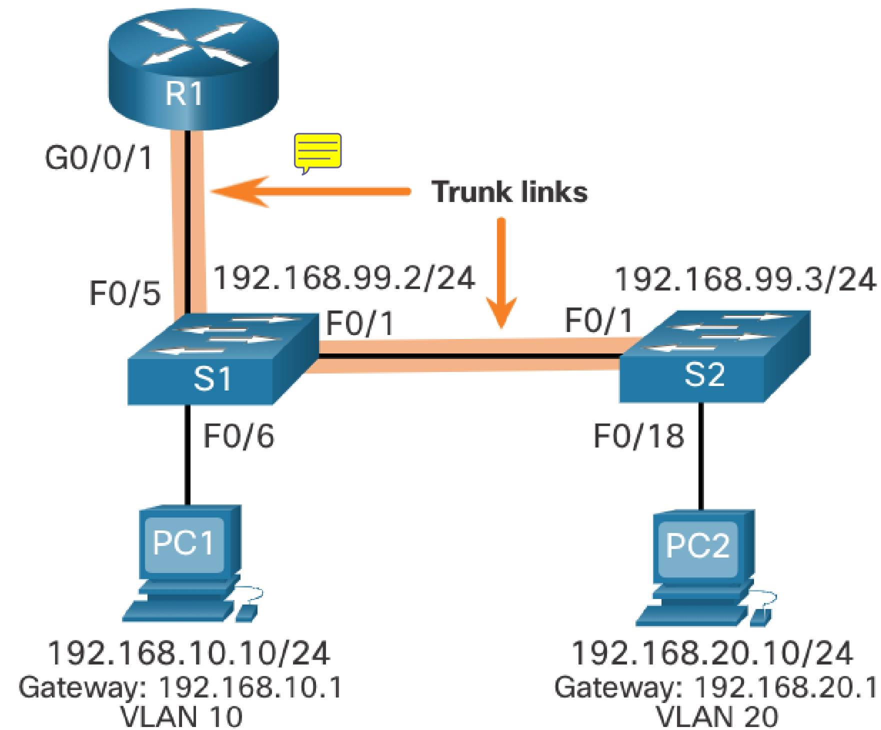
Note: A Layer 3 switch is also called a multilayer switch as it operates at Layer 2 and Layer 3. However, in this course we use the term Layer 3 switch.



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.

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
```

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#
```

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

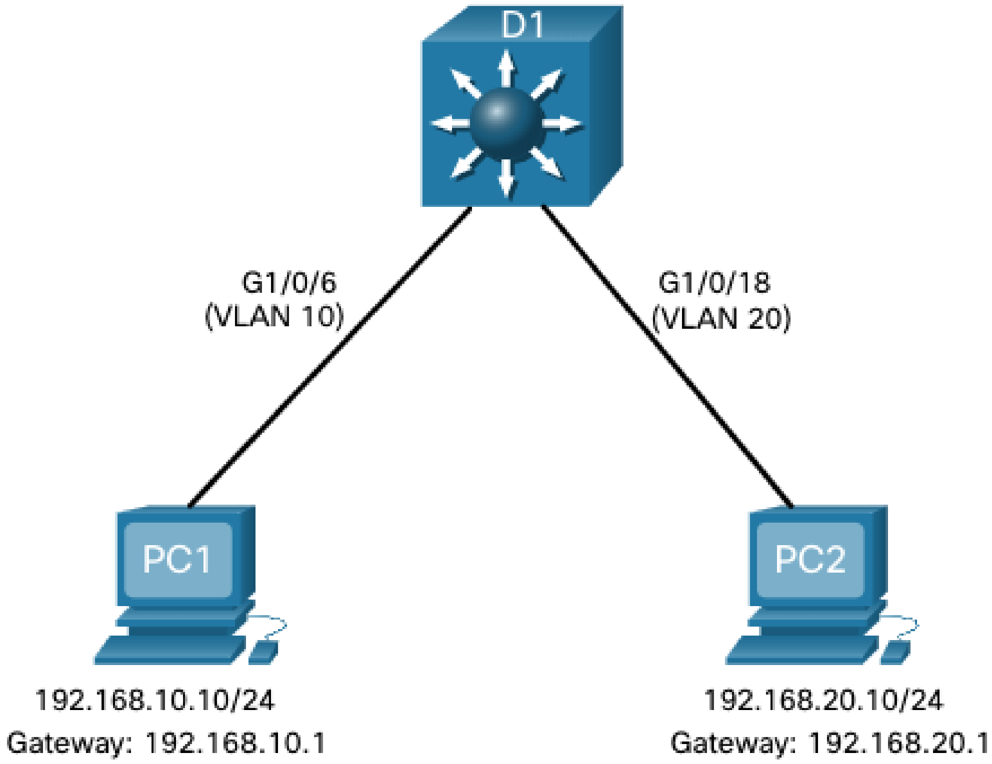
- In addition to using **ping** between devices, the following **show** commands can be used to verify and troubleshoot the router-on-a-stick configuration.
  - **show ip route**
  - **show ip interface brief**
  - **show interfaces**
  - **show interfaces trunk**

Layer 3 Switch Inter-VLAN Routing

- Inter-VLAN routing using the router-on-a-stick method is simple to implement for a small to medium-sized organization. However, a large enterprise requires a faster, much more scalable method to provide inter-VLAN routing.
- Enterprise campus LANs use Layer 3 switches to provide inter-VLAN routing. Layer 3 switches use hardware-based switching to achieve higher-packet processing rates than routers. Layer 3 switches are also commonly implemented in enterprise distribution layer wiring closets.
- Capabilities of a Layer 3 switch include the ability to do the following:
  - Route from one VLAN to another using multiple switched virtual interfaces (SVIs).
  - Convert a Layer 2 switchport to a Layer 3 interface (i.e., a routed port). A routed port is similar to a physical interface on a Cisco IOS router.
  - To provide inter-VLAN routing, Layer 3 switches use SVIs. SVIs are configured using the same **interface vlan** *vlan-id* command used to create the management SVI on a Layer 2 switch. A Layer 3 SVI must be created for each of the routable VLANs.

Layer 3 Switch Scenario

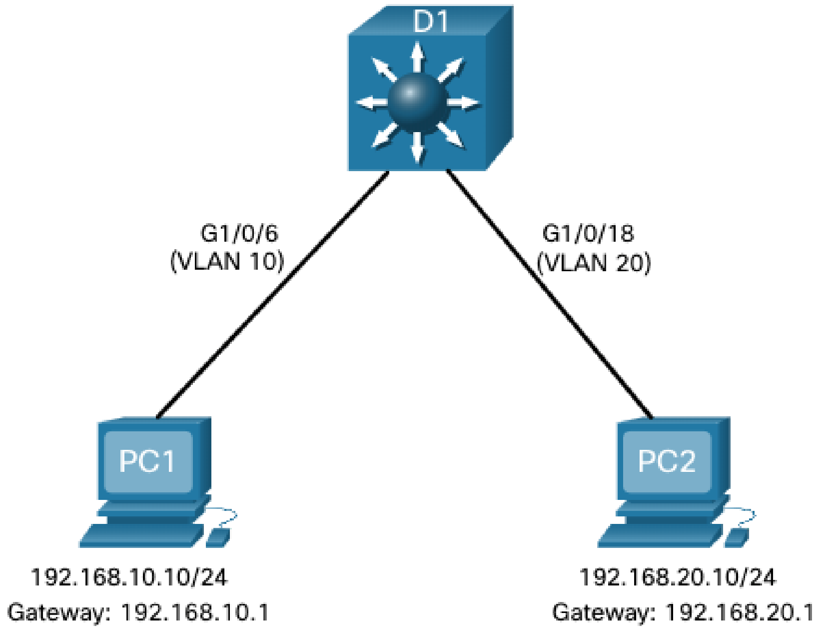
In the figure, the Layer 3 switch, D1, is connected to two hosts on different VLANs. PC1 is in VLAN 10 and PC2 is in VLAN 20, as shown. The Layer 3 switch will provide inter-VLAN routing services to the two hosts.



Layer 3 Switch Configuration

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

- **Step 1**. Create the VLANs. In the example, VLANs 10 and 20 are used.
- **Step 2**. Create the SVI VLAN interfaces. The IP address configured will serve as the default gateway for hosts in the respective VLAN.
- **Step 3**. Configure access ports. Assign the appropriate port to the required VLAN.
- **Step 4**. Enable IP routing. Issue the **ip routing** global configuration command to allow traffic to be exchanged between VLANs 10 and 20. This command must be configured to enable inter-VAN routing on a Layer 3 switch for IPv4.



Layer 3 Switch Inter-VLAN Routing Verification

Inter-VLAN routing using a Layer 3 switch is simpler to configure than the router-on-a-stick method. After the configuration is complete, the configuration can be verified by testing connectivity between the hosts.

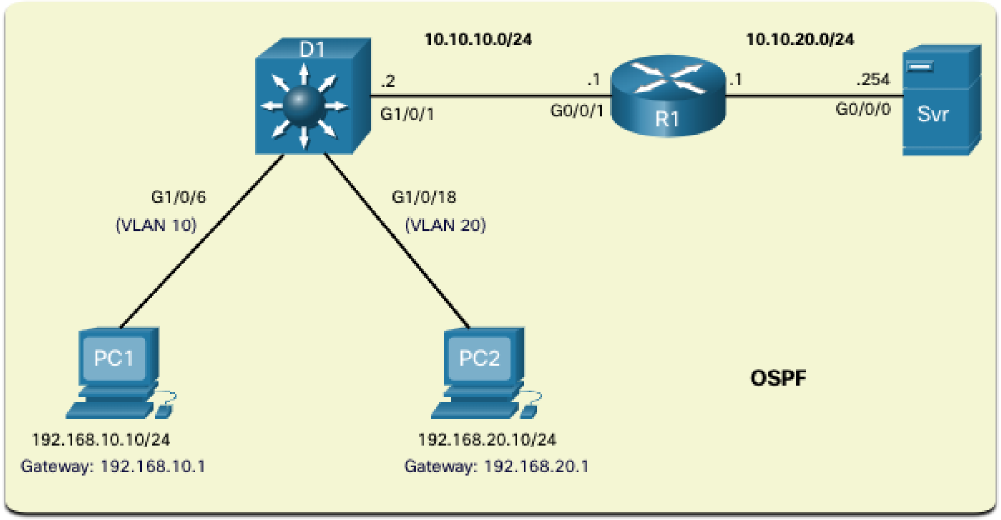
- From a host, verify connectivity to a host in another VLAN using the **ping** command. It is a good idea to first verify the current host IP configuration using the **ipconfig** Windows host command.
- Next, verify connectivity with PC2 using the **ping** Windows host command. The successful **ping** output confirms inter-VLAN routing is operating.

Routing on a Layer 3 Switch

- If VLANs are to be reachable by other Layer 3 devices, then they must be advertised using static or dynamic routing. To enable routing on a Layer 3 switch, a routed port must be configured.
- A routed port is created on a Layer 3 switch by disabling the switchport feature on a Layer 2 port that is connected to another Layer 3 device. Specifically, configuring the **no switchport** interface configuration command on a Layer 2 port converts it into a Layer 3 interface. Then the interface can be configured with an IPv4 configuration to connect to a router or another Layer 3 switch.

Routing Scenario on a Layer 3 Switch

In the figure, the previously configured D1 Layer 3 switch is now connected to R1. R1 and D1 are both in an Open Shortest Path First (OSPF) routing protocol domain. Assume inter-VLAN has been successfully implemented on D1. The G0/0/1 interface of R1 has also been configured and enabled. Additionally, R1 is using OSPF to advertise its two networks, 10.10.10.0/24 and 10.20.20.0/24.



Note: OSPF routing configuration is covered in another course. In this module, OSPF configuration commands will be given to you in all activities and assessments. It is not required that you understand the configuration in order to enable OSPF routing on the Layer 3 switch.

Routing Configuration on a Layer 3 Switch

Complete the following steps to configure D1 to route with R1:

- **Step 1**. Configure the routed port. Use the **no switchport** command to convert the port to a routed port, then assign an IP address and subnet mask. Enable the port.
- **Step 2**. Enable routing. Use the **ip routing** global configuration command to enable routing.
- **Step 3**. Configure routing. Use an appropriate routing method. In this example, Single-Area OSPFv2 is configured
- **Step 4**. Verify routing. Use the **show ip route** command.
- **Step 5**. Verify connectivity. Use the **ping** command to verify reachability.

Today end,

See you next week!