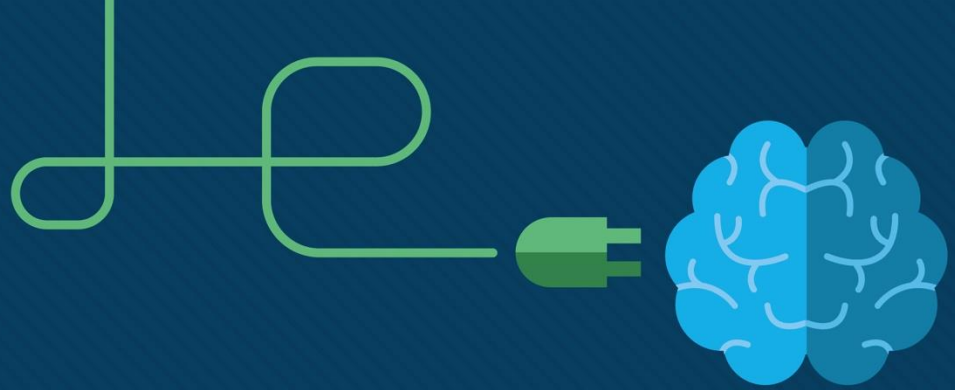


Module 3: VLANs

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

Module Objectives

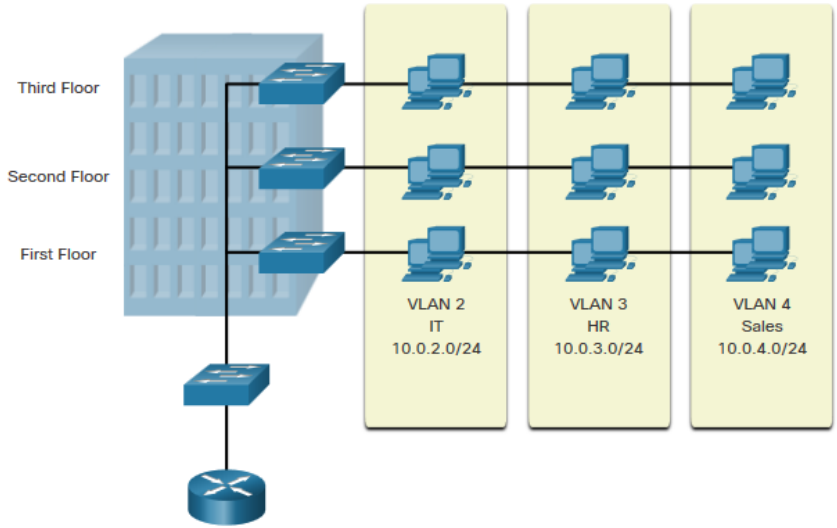
Module Title: Protocols and Models

Module Objective: Explain how network protocols enable devices to access local and remote network resources.

Topic Title	Topic Objective
Overview of VLANs	Explain the purpose of VLANs in a switched network.
VLANs in a Multi-Switched Environment	Explain how a switch forwards frames based on VLAN configuration in a multi-switch environment.
VLAN Configuration	Configure a switch port to be assigned to a VLAN based on requirements.
VLAN Trunks	Configure a trunk port on a LAN switch.
Dynamic Trunking Protocol	Configure Dynamic Trunking Protocol (DTP).

3.1 Overview of VLANs

VLAN Definitions

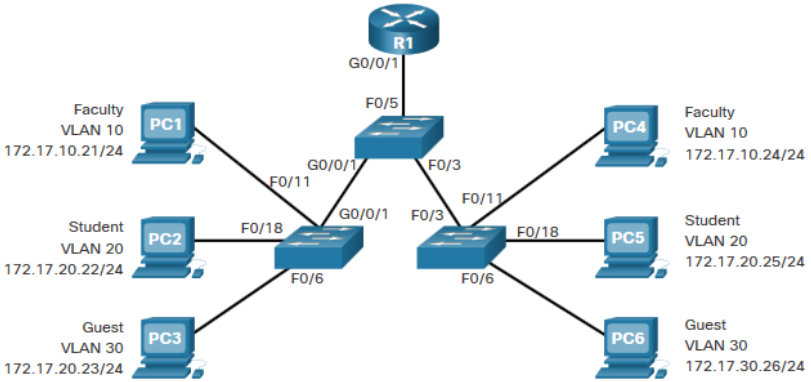


VLANs are logical connections with other similar devices.

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

```
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
```

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

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.

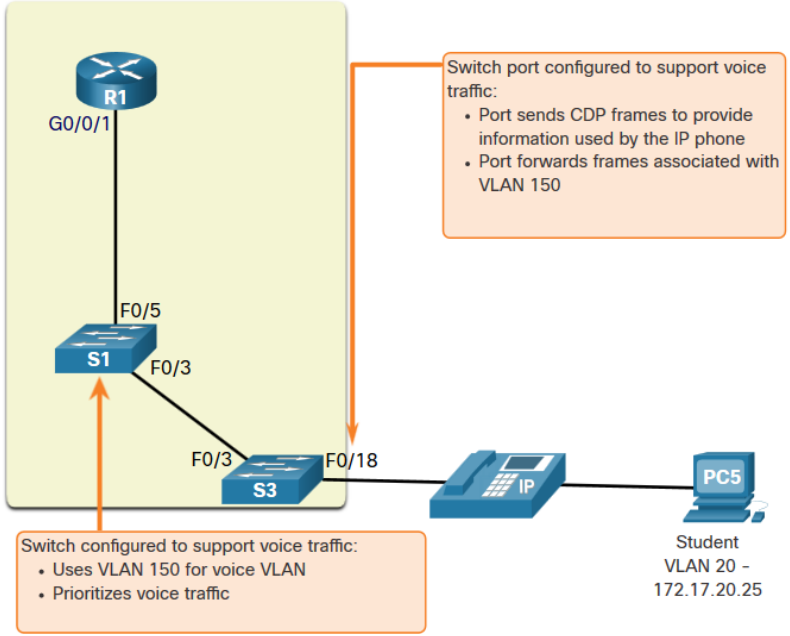
Management VLAN

- 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.

Types of VLANs (Cont.)

Voice VLAN

- A separate VLAN is required because Voice traffic requires:
  - Assured bandwidth
  - High QoS priority
  - Ability to avoid congestion
  - Delay less that 150 ms from source to destination
- The entire network must be designed to support voice.



Packet Tracer – Who Hears the Broadcast?

In this Packet Tracer activity, you will do the following:

- Observe Broadcast Traffic in a VLAN Implementation
- Complete Review Questions

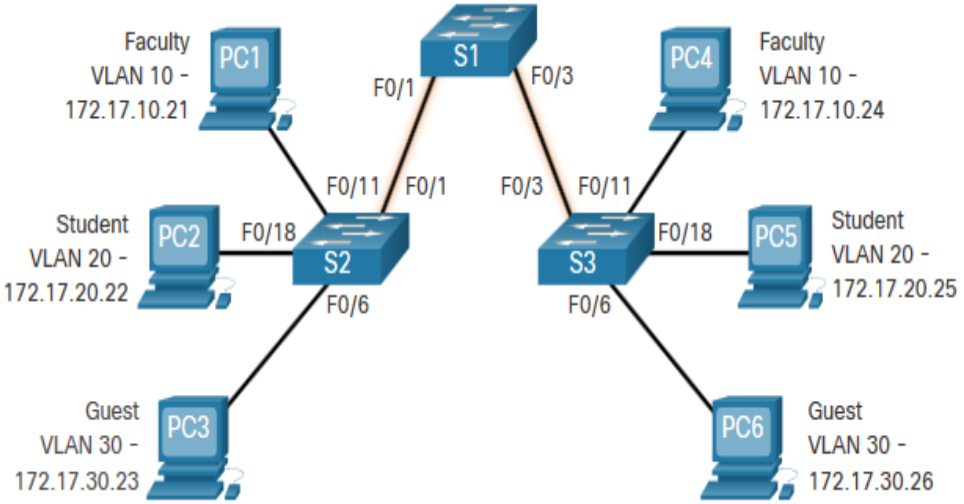
3.2 VLANs in a Multi-Switched Environment

Defining VLAN Trunks

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

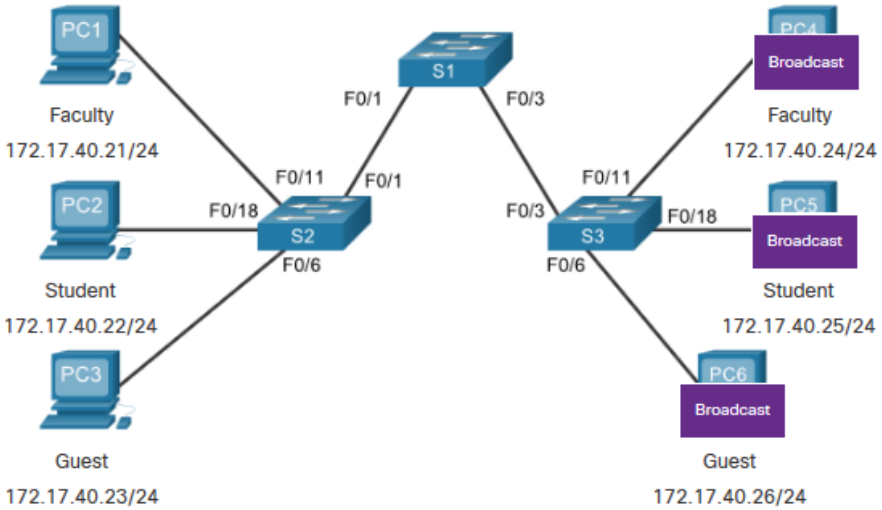
Cisco trunk functions:

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



Networks without VLANs

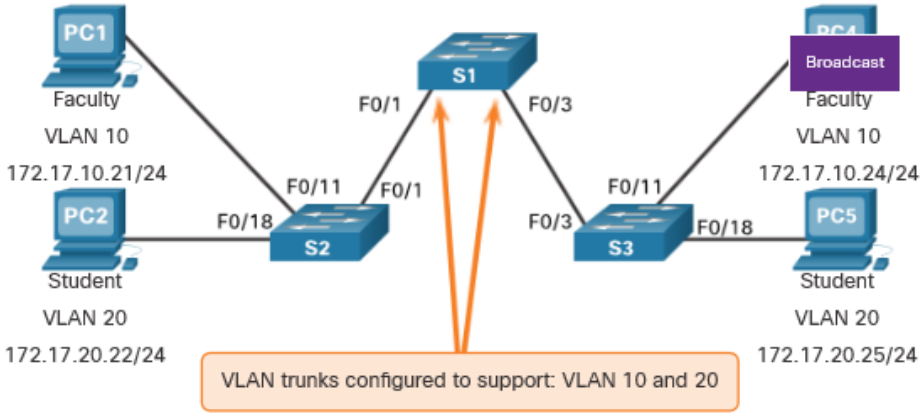
Without VLANs, all devices connected to the switches will receive all unicast, multicast, and broadcast traffic.



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

Networks with VLANs

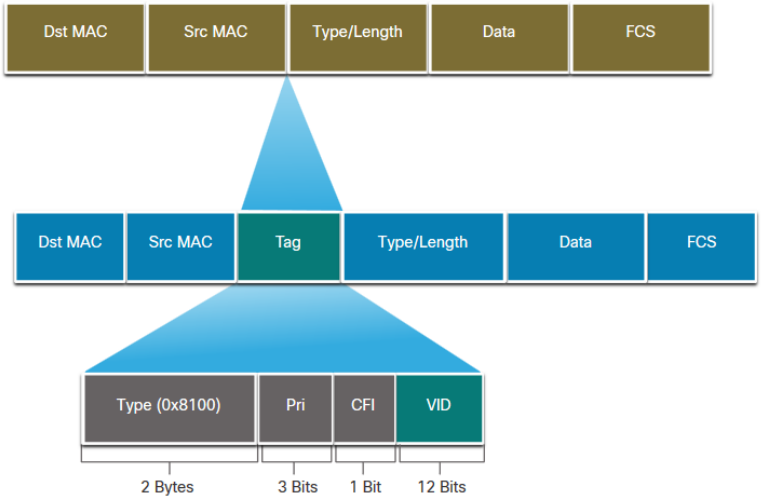
With VLANs, unicast, multicast, and broadcast traffic is confined to a VLAN. Without a Layer 3 device to connect the VLANs, devices in different VLANs cannot communicate.



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

VLAN Identification with a Tag

- The IEEE 802.1Q header is 4 Bytes
- When the tag is created the FCS must be recalculated.
- When sent to end devices, this tag must be removed and the FCS recalculated back to its original number.

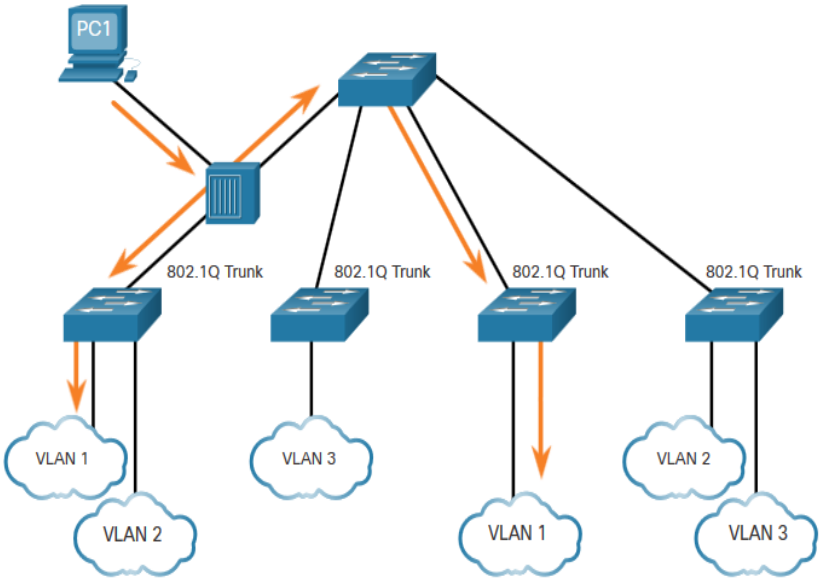


802.1Q VLAN Tag Field	Function
Type	• 2-Byte field with hexadecimal 0x8100 • This is referred to as Tag Protocol ID (TPID)
User Priority	• 3-bit value that supports
Canonical Format Identifier (CFI)	• 1-bit value that can support token ring frames on Ethernet
VLAN ID (VID)	• 12-bit VLAN identifier that can support up to 4096 VLANs

Native VLANs and 802.1Q Tagging

802.1Q trunk basics:

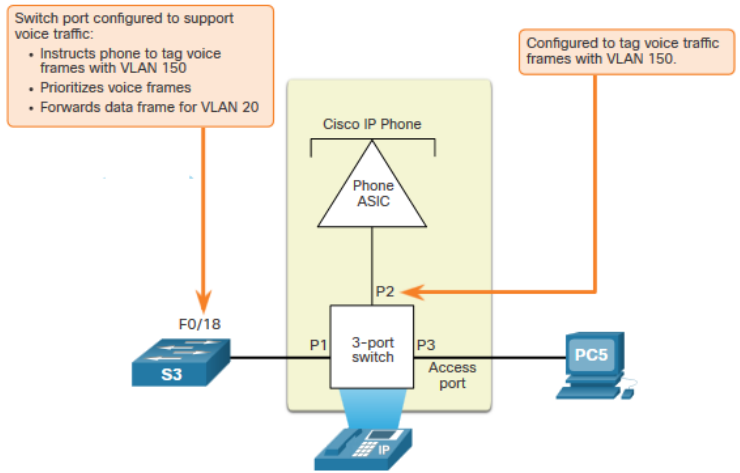
- Tagging is typically done on all VLANs.
- The use of a native VLAN was designed for legacy use, like the hub in the example.
- Unless changed, VLAN1 is the native VLAN.
- Both ends of a trunk link must be configured with the same native VLAN.
- Each trunk is configured separately, so it is possible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



Voice VLAN Tagging

The VoIP phone is a three port switch:

- The switch will use CDP to inform the phone of the Voice VLAN.
- The phone will tag its own traffic (Voice) and can set Cost of Service (CoS). CoS is QoS for layer 2.
- The phone may or may not tag frames from the PC.



Traffic	Tagging Function
Voice VLAN	tagged with an appropriate Layer 2 class of service (CoS) priority value
Access VLAN	can also be tagged with a Layer 2 CoS priority value
Access VLAN	is not tagged (no Layer 2 CoS priority value)

Voice VLAN Verification Example

The **show interfaces fa0/18 switchport** command can show us both data and voice VLANs assigned to the interface.

```
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: 20 (student)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: 150 (voice)
```

Packet Tracer – Investigate a VLAN Implementation

In this Packet Tracer activity, you will:

- Part 1: Observe Broadcast Traffic in a VLAN Implementation
- Part 2: Observe Broadcast Traffic without VLANs

3.3 VLAN Configuration

VLAN Ranges on Catalyst Switches

```
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
```

Catalyst switches 2960 and 3650 support over 4000 VLANs.

Normal Range VLAN 1 – 1005	Extended Range VLAN 1006 - 4095
Used in Small to Medium sized businesses	Used by Service Providers
1002 – 1005 are reserved for legacy VLANs	Are in Running-Config
1, 1002 – 1005 are auto created and cannot be deleted	Supports fewer VLAN features
Stored in the vlan.dat file in flash	Requires VTP configurations
VTP can synchronize between switches	

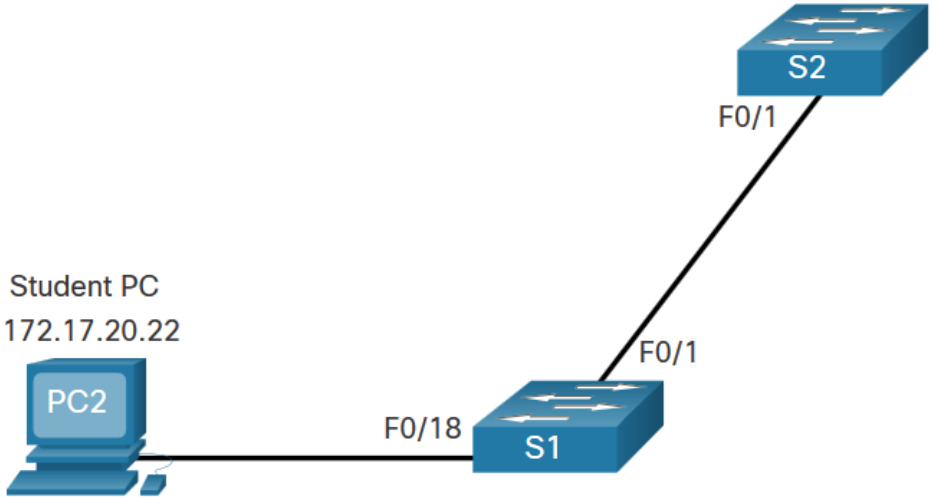
VLAN Creation Commands

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

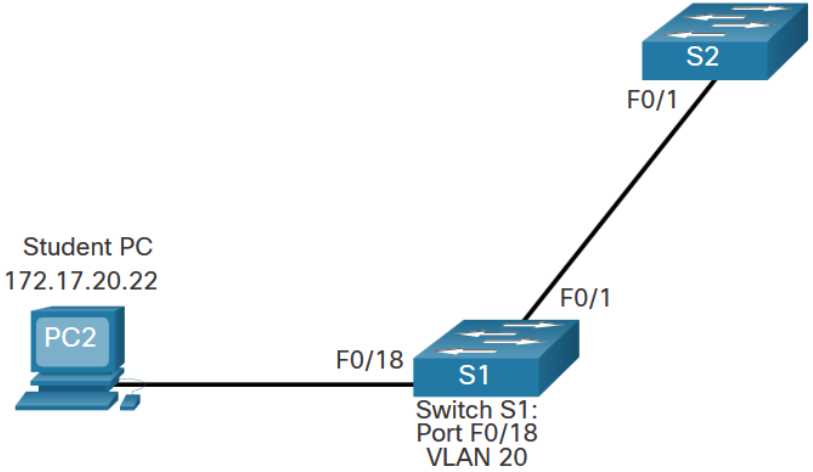
Once the VLAN is created, we can then assign it to the correct interfaces.

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.

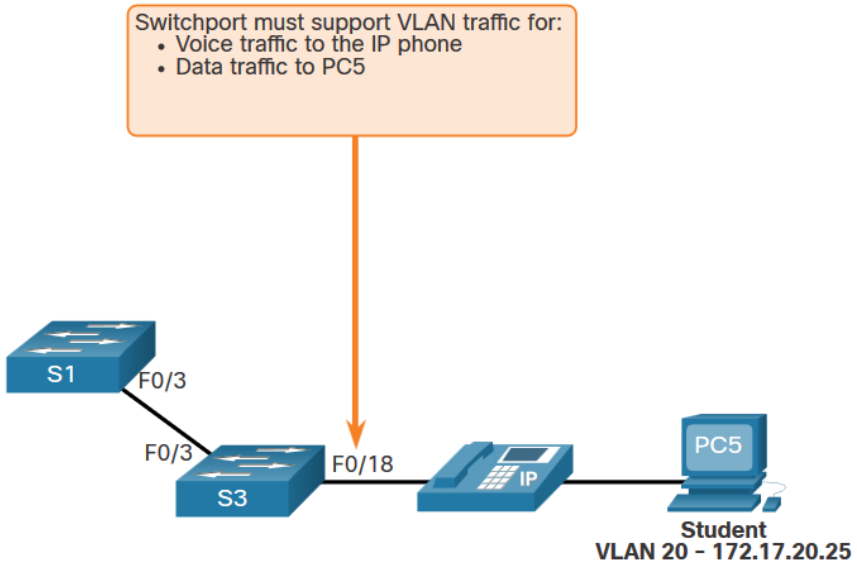
- Once the device is assigned the VLAN, then the end device will need the IP address information for that VLAN
- Here, Student PC receives 172.17.20.22



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.



Data and Voice VLAN Example

- We will want to create and name both Voice and Data VLANs.
- In addition to assigning the data VLAN, we will also assign the Voice VLAN and turn on QoS for the voice traffic to the interface.
- The newer catalyst switch will automatically create the VLAN, if it does not already exist, when it is assigned to an interface.

Note: QoS is beyond the scope of this course. Here we do show the use of the **mls qos trust [cos | device cisco-phone | dscp | ip-precedence]** command.

```
S1(config)# vlan 20
S1(config-vlan)# name student
S1(config-vlan)# vlan 150
S1(config-vlan)# name VOICE
S1(config-vlan)# exit
S1(config)# interface fa0/18
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 20
S1(config-if)# mls qos trust cos
S1(config-if)# switchport voice vlan 150
S1(config-if)# end
```

```
% Access VLAN does not exist. Creating vlan 30
```

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.

Packet Tracer – VLAN Configuration

In this Packet Tracer activity, you will perform the following:

- Verify the Default VLAN Configuration
- Configure VLANs
- Assign VLANs to Ports

3.4 VLAN Trunks

Trunk Configuration Commands

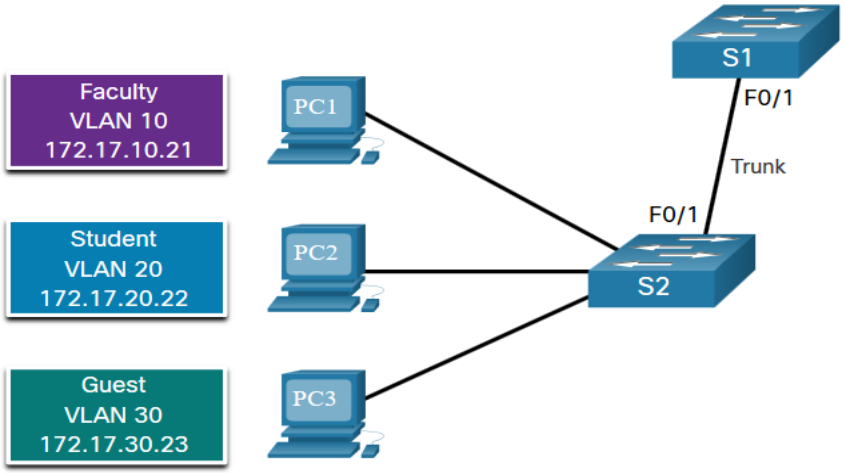
Configure and verify VLAN trunks. Trunks are layer 2 and carry traffic for all VLANs.

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**

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)
```

Packet Tracer – Configure Trunks

In this Packet Tracer activity, you will perform the following:

- Verify VLANs
- Configure Trunks

Lab – Configure VLANs and Trunks

In this lab, you will perform the following:

- Build the Network and Configure Basic Device Settings
- Create VLANs and Assign Switch Ports
- Maintain VLAN Port Assignments and the VLAN Database
- Configure an 802.1Q Trunk between the Switches
- Delete the VLAN Database

3.5 Dynamic Trunking Protocol

Introduction to DTP

Dynamic Trunking Protocol (DTP) is a proprietary Cisco protocol.

DTP characteristics are as follows:

- On by default on Catalyst 2960 and 2950 switches
- Dynamic-auto is default on the 2960 and 2950 switches
- May be turned off with the nonegotiate command
- May be turned back on by setting the interface to dynamic-auto
- Setting a switch to a static trunk or static access will avoid negotiation issues with the **switchport mode trunk** or the **switchport mode access** commands.

```
S1(config-if)# switchport mode trunk
S1(config-if)# switchport nonegotiate
```

```
S1(config-if)# switchport mode dynamic auto
```

Negotiated Interface Modes

The **switchport mode** command has additional options.

Use the **switchport nonegotiate** interface configuration command to stop DTP negotiation.

Option	Description
access	Permanent access mode and negotiates to convert the neighboring link into an access link
dynamic auto	Will becomes a trunk interface if the neighboring interface is set to trunk or desirable mode
dynamic desirable	Actively seeks to become a trunk by negotiating with other auto or desirable interfaces
trunk	Permanent trunking mode and negotiates to convert the neighboring link into a trunk link

Results of a DTP Configuration

DTP configuration options are as follows:

	Dynamic Auto	Dynamic Desirable	Trunk	Access
Dynamic Auto	Access	Trunk	Trunk	Access
Dynamic Desirable	Trunk	Trunk	Trunk	Access
Trunk	Trunk	Trunk	Trunk	Limited connectivity
Access	Access	Access	Limited connectivity	Access

Verify DTP Mode

The default DTP configuration is dependent on the Cisco IOS version and platform.

- Use the **show dtp interface** command to determine the current DTP mode.
- Best practice recommends that the interfaces be set to access or trunk and to turnoff DTP

```
S1# show dtp interface fa0/1
DTP information for FastEthernet0/1:
TOS/TAS/TNS: ACCESS/AUTO/ACCESS
TOT/TAT/TNT: NATIVE/NEGOTIATE/NATIVE
Neighbor address 1: C80084AEF101
Neighbor address 2: 000000000000
Hello timer expiration (sec/state): 11/RUNNING
Access timer expiration (sec/state): never/STOPPED
Negotiation timer expiration (sec/state): never/STOPPED
Multidrop timer expiration (sec/state): never/STOPPED
FSM state: S2:ACCESS
# times multi & trunk 0
Enabled: yes
In STP: no
```

Packet Tracer – Configure DTP

In this Packet Tracer activity, you will perform the following:

- Configure static trunking
- Configure and verify DTP

3.6 Module Practice and Quiz

Packet Tracer – Implement VLANs and Trunking

In this Packet Tracer activity, you will perform the following:

- Configure VLANs
- Assign Ports to VLANs
- Configure Static Trunking
- Configure Dynamic Trunking

Lab – Implement VLANs and Trunking

In this lab, you will perform the following:

- Build the Network and Configure Basic Device Settings
- Create VLANs and Assign Switch Ports
- Configure an 802.1Q Trunk between the Switches

What did I learn in this module?

- VLANs are based on logical instead of physical connections.
- VLANs can segment networks based on function, team, or application.
- Each VLAN is considered a separate logical network.
- A trunk is a point-to-point link that carries more than one VLAN.
- VLAN tag fields include the type, user priority, CFI and VID.
- A separate voice VLAN is required to support VoIP.
- Normal range VLAN configurations are stored in the vlan.dat file in flash.
- An access port can belong to one data VLAN at a time, but may also have a Voice VLAN.

What did I learn in this module? (Cont.)

- A trunk is a Layer 2 link between two switches that carries traffic for all VLANs.
- Trunks will need tagging for the various VLANs, typically 802.1q .
- IEEE 802.1q tagging makes provision for one native VLAN that will remain untagged.
- An interface can be set to trunking or nontrunking.
- Trunk negotiation is managed by the Dynamic Trunking Protocol (DTP).
- DTP is a Cisco proprietary protocol that manages trunk negotiations.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