



Module 3: VLANs

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



Module Objectives

Module Title: Protocols and Models

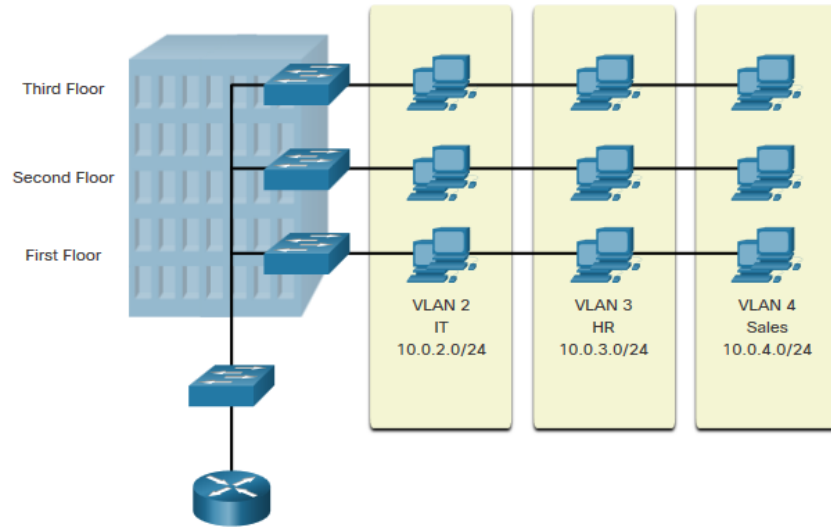
Module Objective: Explain how network protocols enable devices to access local and remote network resources.

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

Overview of VLANs

VLAN Definitions



VLANs are logical connections with other similar devices.

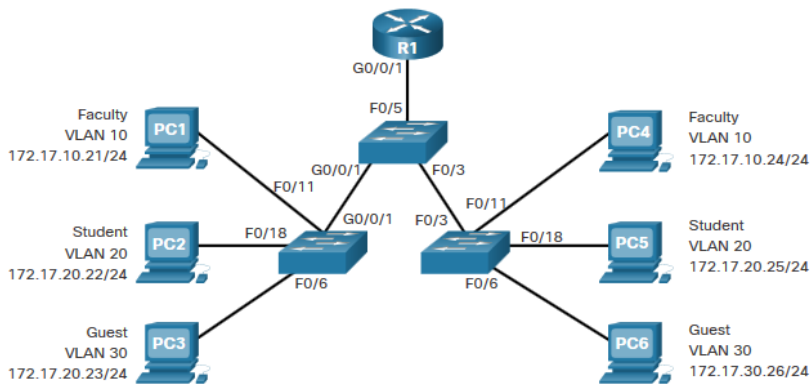
Placing devices into various VLANs have the following characteristics:

- 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

Overview of VLANs

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.

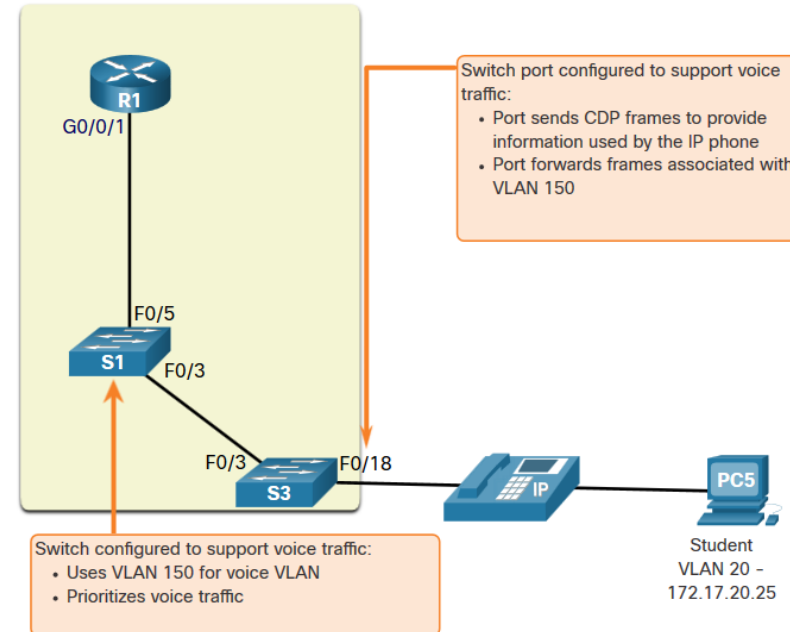
Management VLAN

- 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 than 150 ms from source to destination
- The entire network must be designed to support voice.



3.2 VLANs in a Multi-Switched Environment

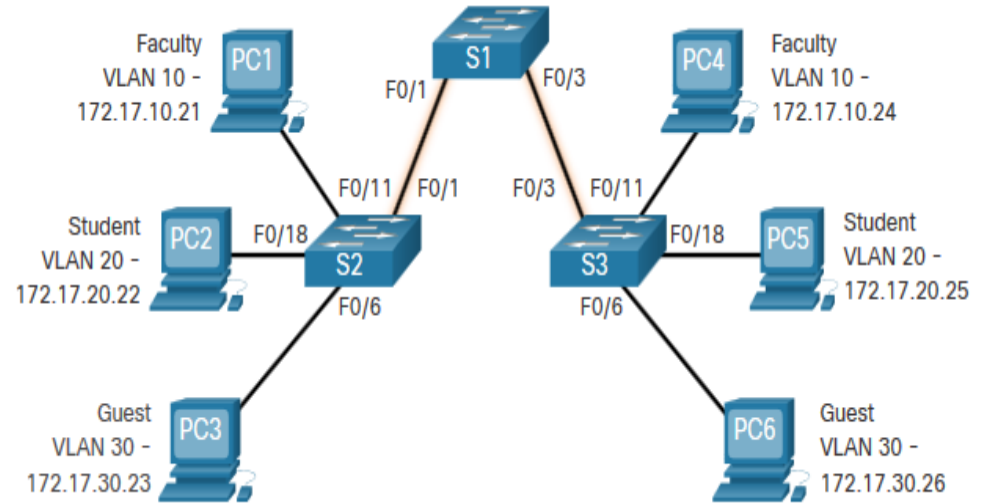
VLANs in a Multi-Switched Environment

Defining VLAN Trunks

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

Cisco trunk functions:

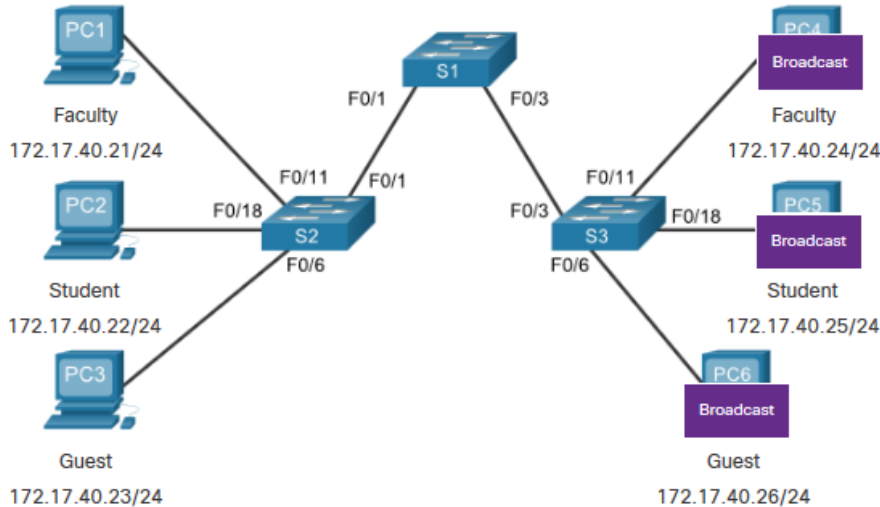
- Allow more than one VLAN
- Extend the VLAN across the entire network
- By default, supports all VLANs
- Supports 802.1Q trunking



VLANs in a Multi-Switched Environment

Networks without VLANs

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

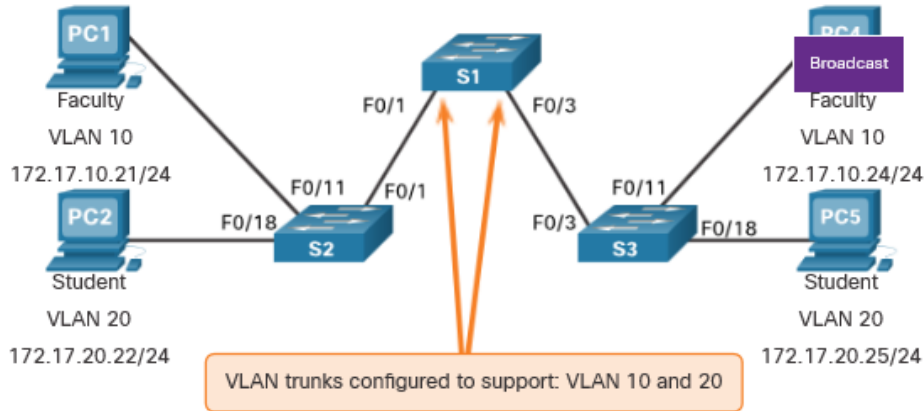


PC1 sends out a local Layer 2 broadcast. The switches forward the broadcast frame out all available ports.

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.

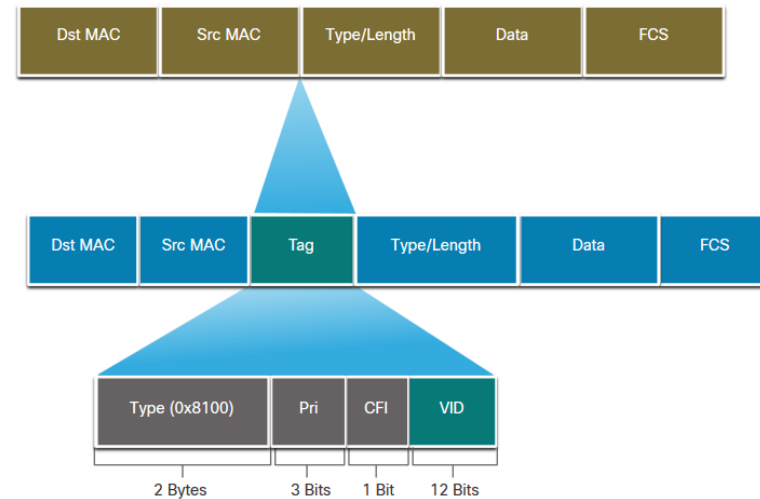


PC1 sends out a local Layer 2 broadcast. The switches forward the broadcast frame only out ports configured for VLAN10.

VLANs in a Multi-Switched Environment

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.



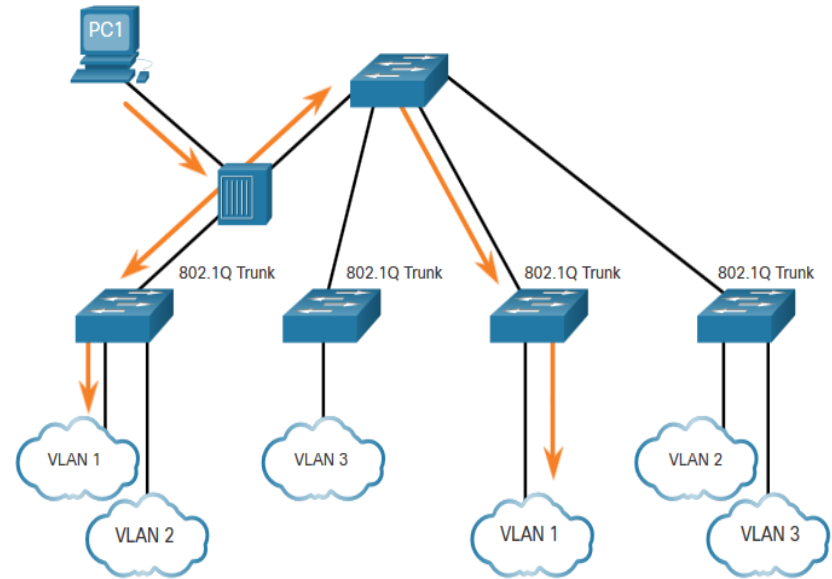
802.1Q VLAN Tag Field	Function
Type	<ul style="list-style-type: none">• 2-Byte field with hexadecimal 0x8100• This is referred to as Tag Protocol ID (TPID)
User Priority	<ul style="list-style-type: none">• 3-bit value that supports
Canonical Format Identifier (CFI)	<ul style="list-style-type: none">• 1-bit value that can support token ring frames on Ethernet
VLAN ID (VID)	<ul style="list-style-type: none">• 12-bit VLAN identifier that can support up to 4096 VLANs

VLANs in a Multi-Switched Environment

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.

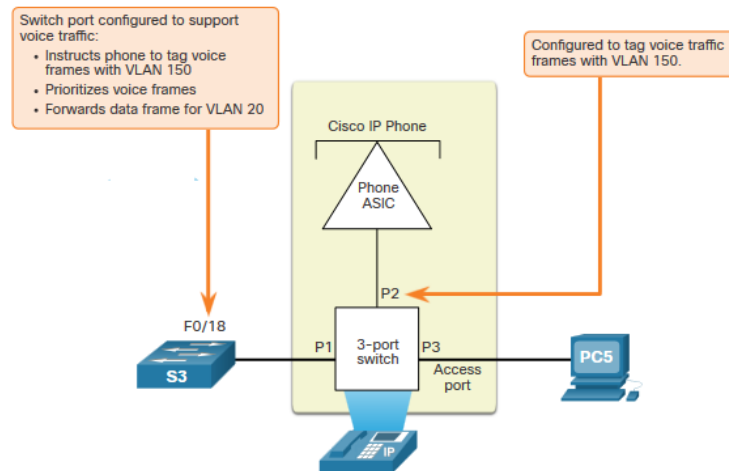


VLANs in a Multi-Switched Environment

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)
```


3.3 VLAN Configuration

VLAN Ranges on Catalyst Switches

Catalyst switches 2960 and 3650 support over 4000 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

Normal Range VLAN 1 – 1005

Used in Small to Medium sized businesses

1002 – 1005 are reserved for legacy VLANs

1, 1002 – 1005 are auto created and cannot be deleted

Stored in the vlan.dat file in flash

VTP can synchronize between switches

Extended Range VLAN 1006 - 4095

Used by Service Providers

Are in Running-Config

Supports fewer VLAN features

Requires VTP configurations

VLAN Creation Commands

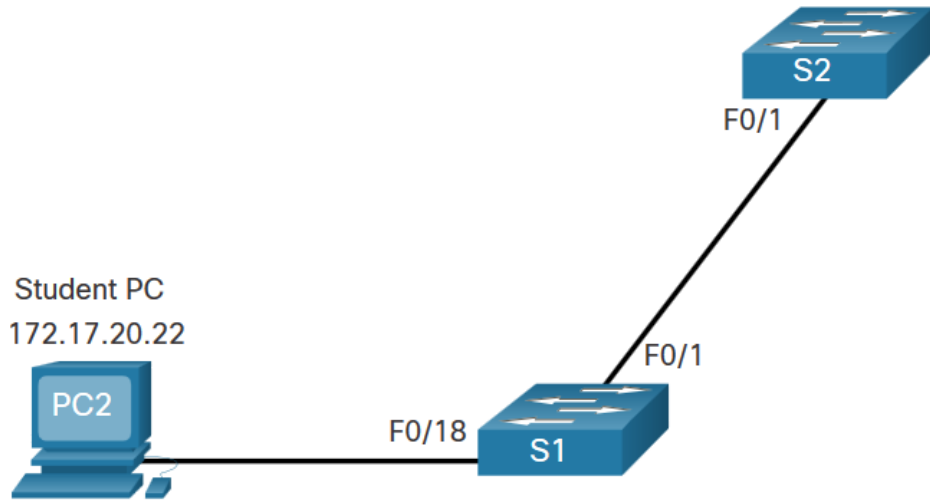
VLAN details are stored in the `vlan.dat` file. You create VLANs in the global configuration mode.

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

VLAN Configuration

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

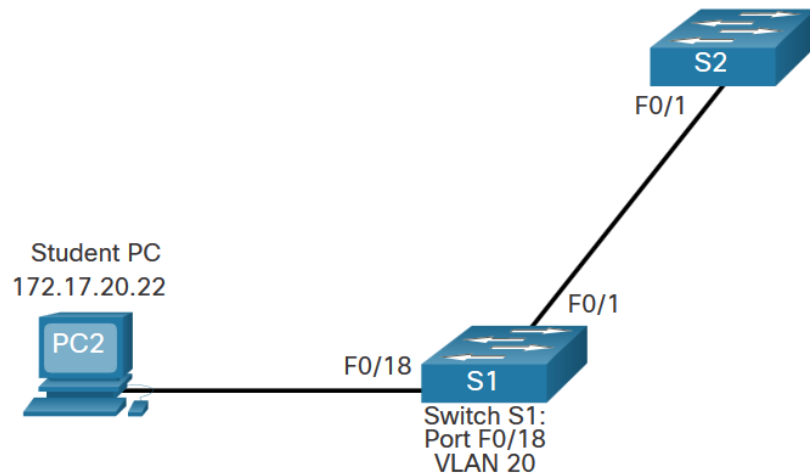
Once the VLAN is created, we can then assign it to the correct interfaces.

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

VLAN Port Assignment Example

We can assign the VLAN to the port interface.

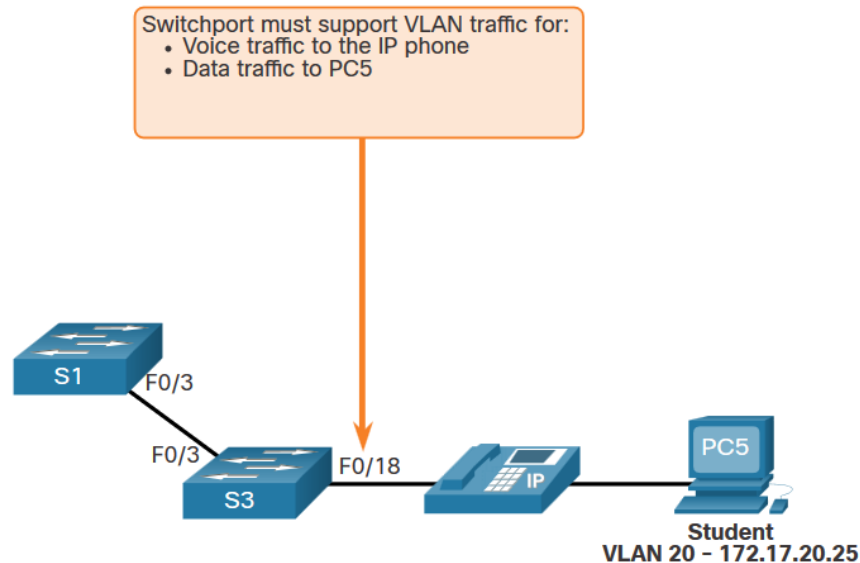
- Once the device is assigned the VLAN, then the end device will need the IP address information for that VLAN
- Here, Student PC receives 172.17.20.22



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
```


VLAN Configuration

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 <i>vlan-id</i>
Display information about the identified VLAN name. The <i>vlan-name</i> is an ASCII string from 1 to 32 characters.	name <i>vlan-name</i>
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)
```

VLAN Configuration

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.

3.4 VLAN Trunks

Trunk Configuration Commands

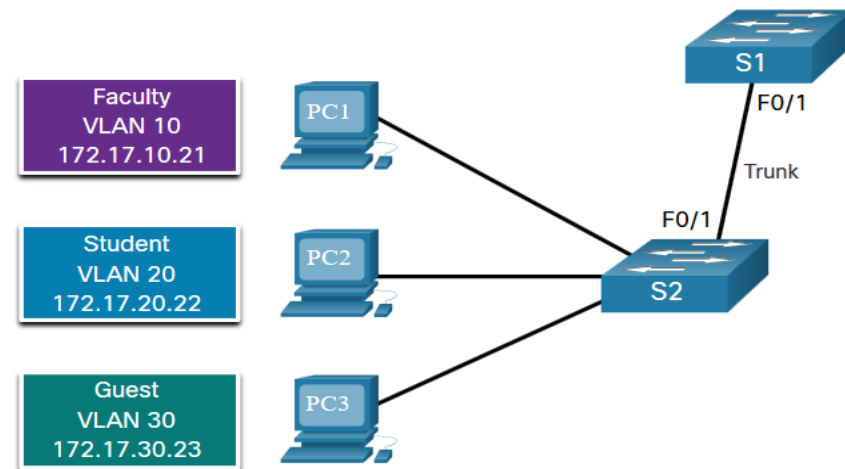
Configure and verify VLAN trunks. Trunks are layer 2 and carry traffic for all VLANs.

Task	IOS Command
Enter global configuration mode.	Switch# configure terminal
Enter interface configuration mode.	Switch(config)# interface <i>interface-id</i>
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 <i>vlan-id</i>
Specify the list of VLANs to be allowed on the trunk link.	Switch(config-if)# switchport trunk allowed vlan <i>vlan-list</i>
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)
```

3.5 Dynamic Trunking Protocol

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

Dynamic Trunking Protocol

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

Dynamic Trunking Protocol

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
```

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.

