# Chapter 3: VLANs

## Routing & Switching

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# Chapter 3

3.1 VLAN Segmentation

3.2 VLAN Implementation

3.3 VLAN Security and Design

3.4 Summary

# Chapter 3: Objectives

- Explain the purpose of  VLANs in a switched network.
- Analyze how a switch forwards frames based on VLAN configuration in a multi-switched environment.
- Configure a switch port to be assigned to a VLAN based on requirements.
- Configure a trunk port on a LAN switch.
- Configure Dynamic Trunk Protocol (DTP).
- Troubleshoot VLAN and trunk configurations in a switched network.
- Configure security features to mitigate attacks in a VLAN-segmented environment.
- Explain security best practices for a VLAN-segmented environment.

# 3.1 VLAN Segmentation

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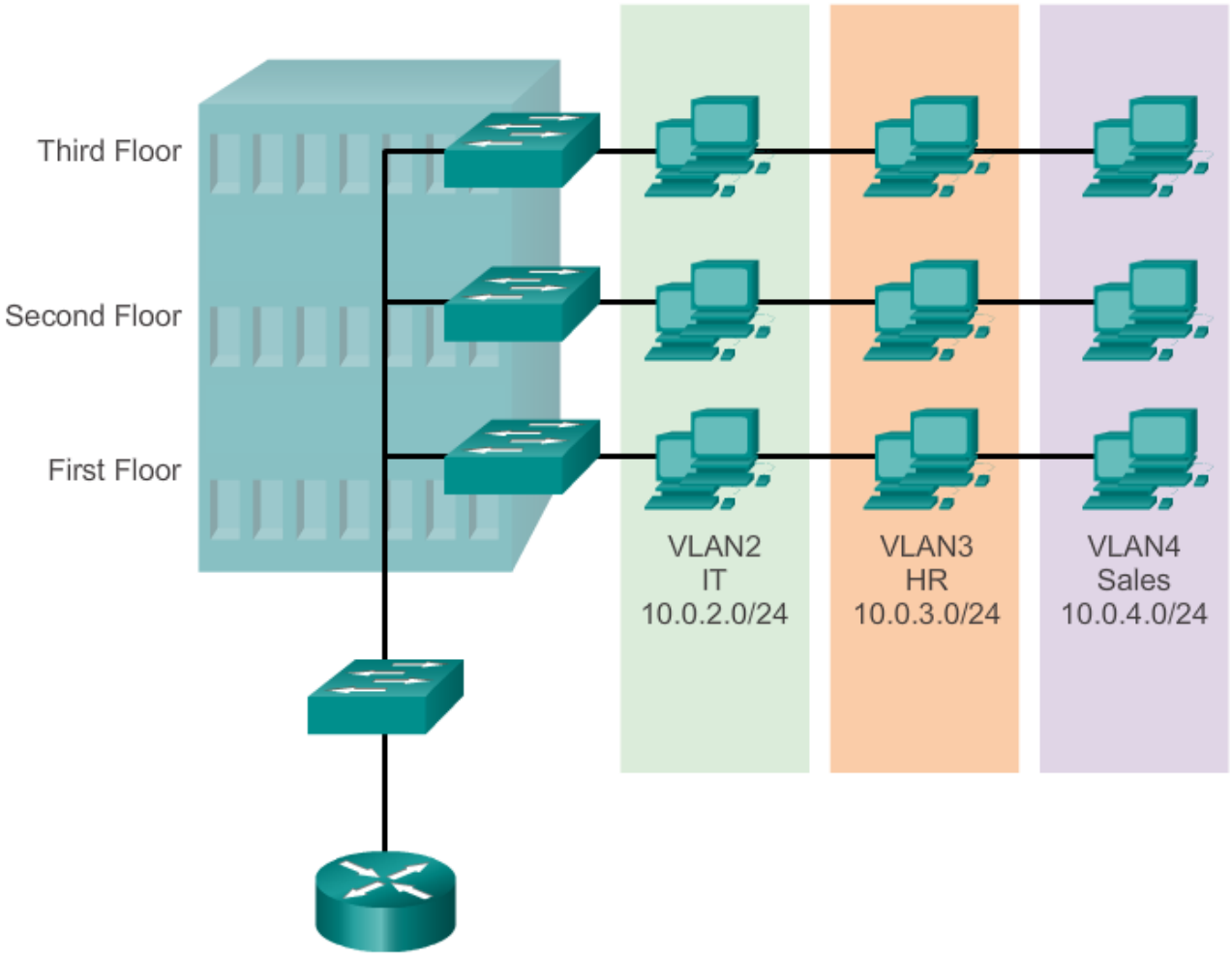
# VLAN Definitions

- A VLAN is a logical partition of a Layer 2 network.
- Multiple partitions can be created, allowing for multiple VLANs to co-exist.
- Each VLAN is a broadcast domain, usually with its own IP network.
- VLANs are mutually isolated and packets can only pass between them via a router.
- The partitioning of the Layer 2 network takes place inside a Layer 2 device, usually via a switch.
- The hosts grouped within a VLAN are unaware of the VLAN's existence.

# VLAN Definitions (cont.)



# Benefits of VLANs

- Security
- Cost reduction
- Better performance
- Shrink broadcast domains
- Improved IT staff efficiency
- Simpler project and application management

# Types of VLANs

- Data VLAN
- Default VLAN
- Native VLAN
- Management VLAN

# Types of VLANs (cont.)

**VLAN 1**

```
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
```

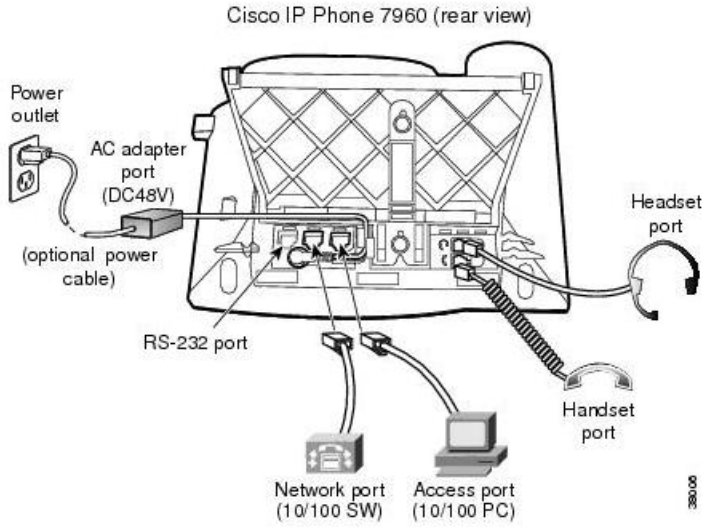
- All ports assigned to VLAN 1 to forward data by default.
- Native VLAN is VLAN 1 by default.
- Management VLAN is VLAN 1 by default.
- VLAN 1 cannot be renamed or deleted.

# Voice VLANs

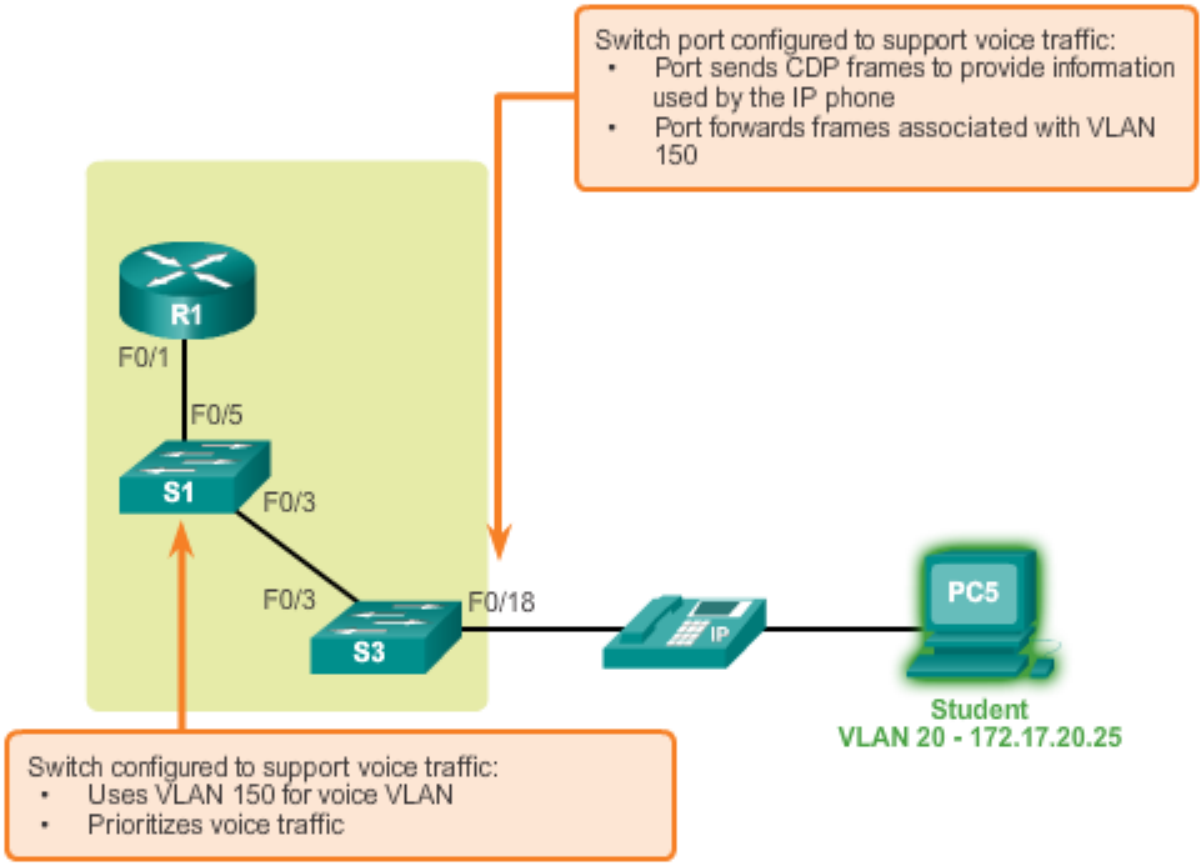
- VoIP traffic is time-sensitive and requires:
  - Assured bandwidth to ensure voice quality.
  - Transmission priority over other types of network traffic.
  - Ability to be routed around congested areas on the network.
  - Delay of less than 150 ms across the network.
- The voice VLAN feature enables access ports to carry IP voice traffic from an IP phone.
- The switch can connect to a Cisco 7960 IP phone and carry IP voice traffic.
- The sound quality of an IP phone call can deteriorate if the data is unevenly sent; the switch supports quality of service (QoS).

# Voice VLANs (cont.)

- The Cisco 7960 IP phone has two RJ-45 ports that each support connections to external devices.
  - **Network Port (10/100 SW) -** Use this port to connect the phone to the network. The phone can also obtain inline power from the Cisco Catalyst switch over this connection.
  - **Access Port (10/100 PC) -** Use this port to connect a network device, such as a computer, to the phone.



# Voice VLANs (cont.)



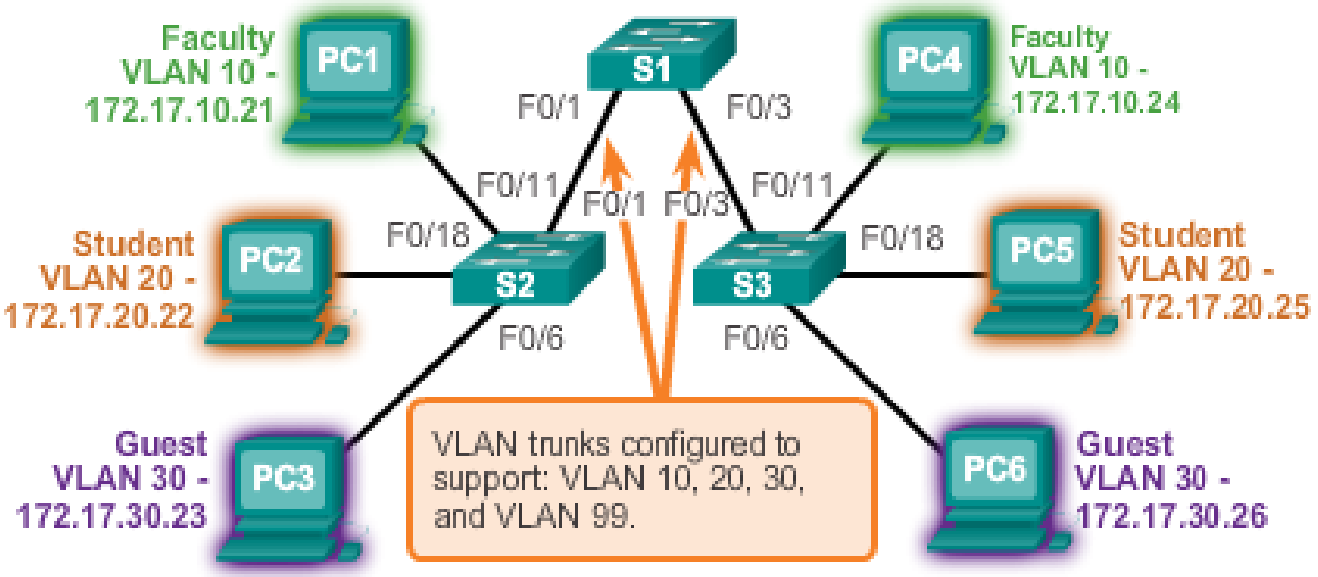
# VLAN Trunks

- A VLAN trunk carries more than one VLAN.
- A VLAN trunk is usually established between switches so same-VLAN devices can communicate, even if physically connected to different switches.
- A VLAN trunk is not associated to any VLANs; neither is the trunk ports used to establish the trunk link.
- Cisco IOS supports IEEE802.1q, a popular VLAN trunk protocol.

# VLAN Trunks (cont.)

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

F0/1-5 are 802.1Q trunk interfaces with native VLAN 99.
F0/11-17 are in VLAN 10.
F0/18-24 are in VLAN 20.
F0/6-10 are in VLAN 30.



# Controlling Broadcast Domains with VLANs

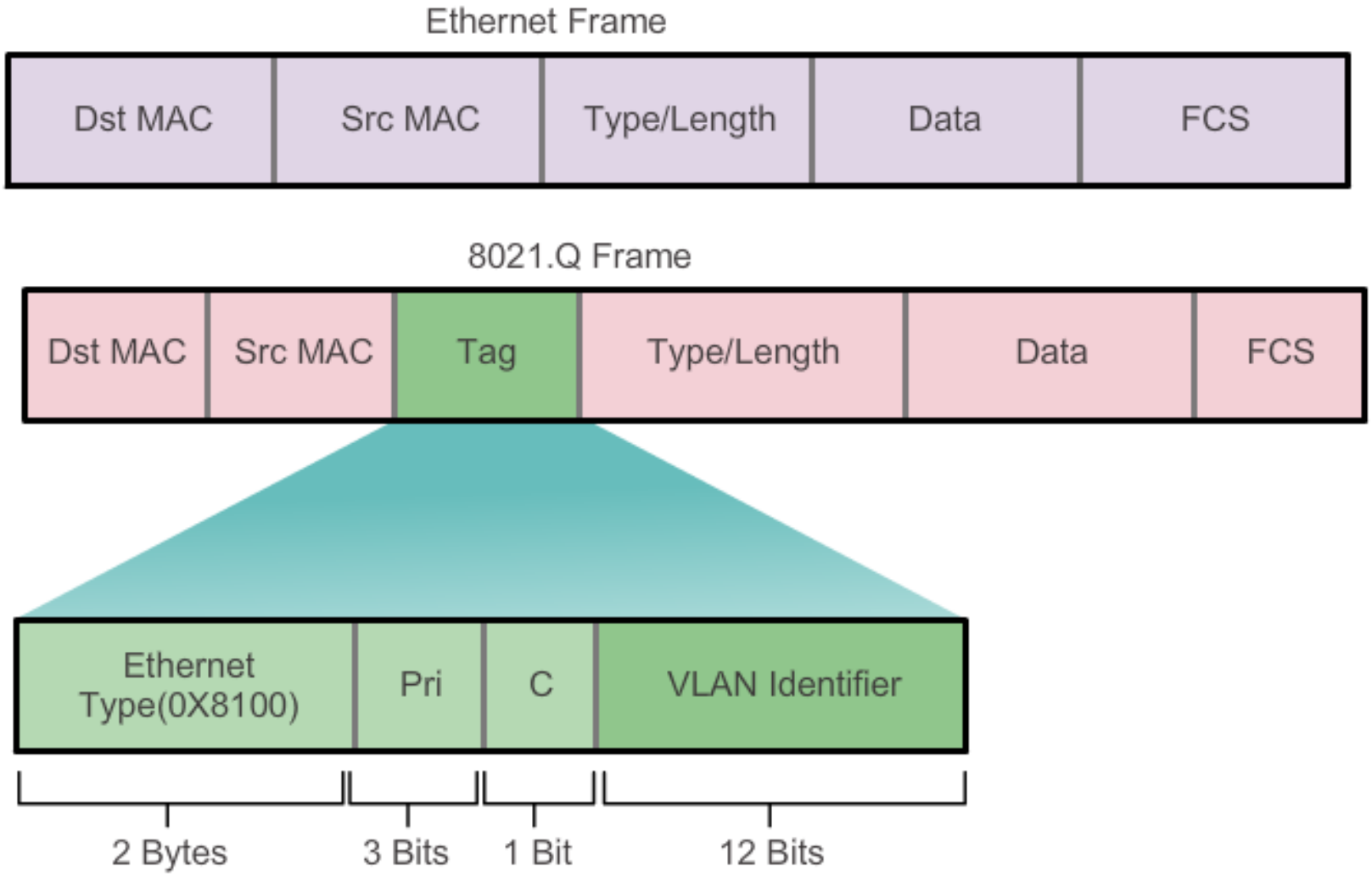
- VLANs can be used to limit the reach of broadcast frames.
- A VLAN is a broadcast domain of its own.
- A broadcast frame sent by a device in a specific VLAN is forwarded within that VLAN only.
- VLANs help control the reach of broadcast frames and their impact in the network.
- Unicast and multicast frames are forwarded within the originating VLAN.

# Tagging Ethernet Frames for VLAN Identification

- Frame tagging is the process of adding a VLAN identification header to the frame.
- It is used to properly transmit multiple VLAN frames through a trunk link.
- Switches tag frames to identify the VLAN to that they belong. Different tagging protocols exist; IEEE 802.1Q is a vey popular example.
- The protocol defines the structure of the tagging header added to the frame.
- Switches add VLAN tags to the frames before placing them into trunk links and remove the tags before forwarding frames through nontrunk ports.
- When properly tagged, the frames can transverse any number of switches via trunk links and still be forwarded within the correct VLAN at the destination.

## VLANs in a Multi-Switched Environment

# Tagging Ethernet Frames for VLAN Identification

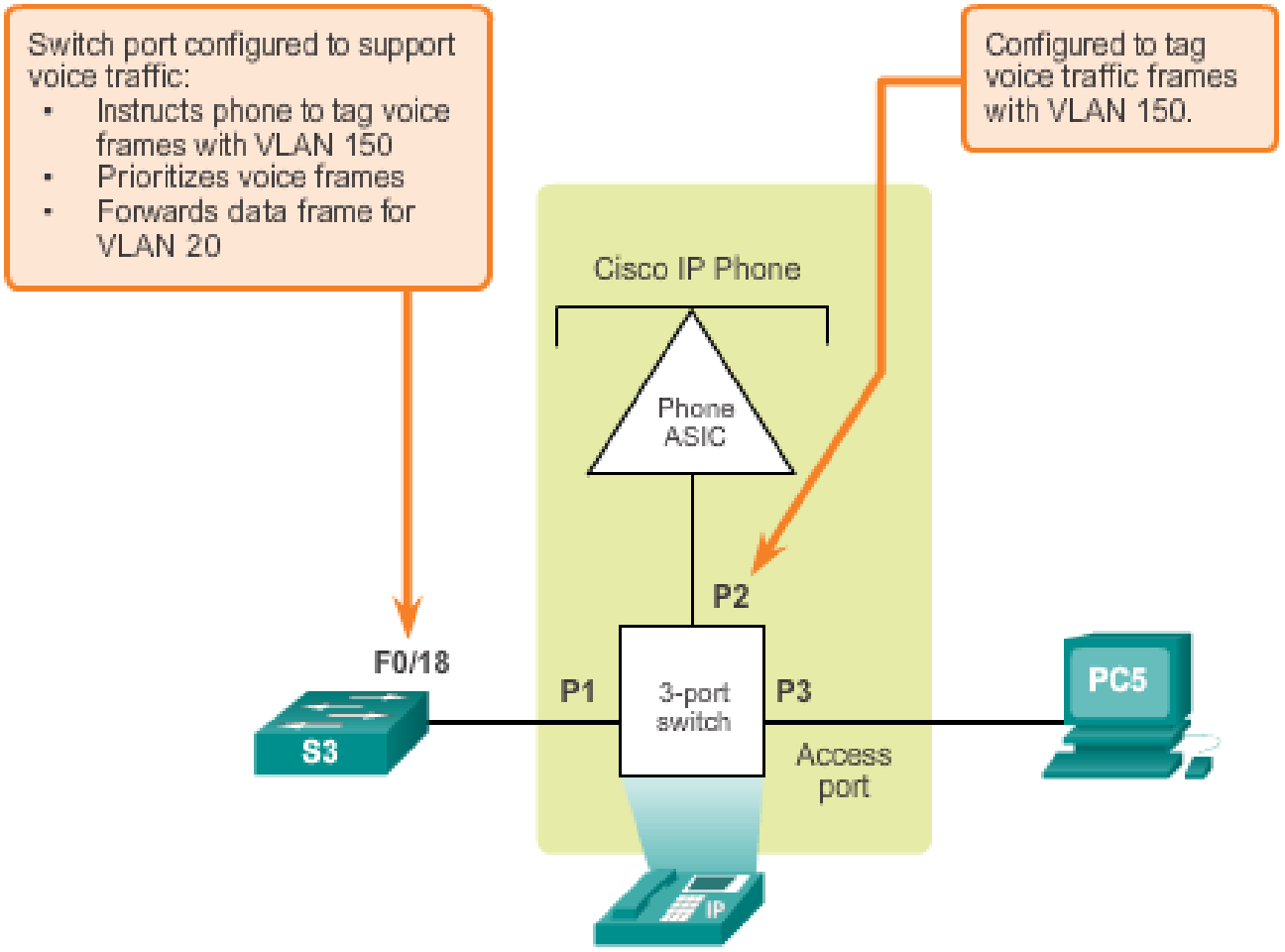


# Native VLANs and 802.1Q Tagging

- Frames that belong to the native VLAN are not tagged.
- Frames received untagged remain untagged and are placed in the native VLAN when forwarded.
- If there are no ports associated to the native VLAN and no other trunk links, an untagged frame is dropped.
- In Cisco switches, the native VLAN is VLAN 1, by default.

## VLANs in a Multi-Switched Environment

# Voice VLAN Tagging



# 3.2 VLAN Implementations

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# VLAN Ranges on Catalyst Switches

- Cisco Catalyst 2960 and 3560 Series switches support over 4,000 VLANs.
- VLANs are split into two categories:
  - Normal range VLANs
    - VLAN numbers from 1 to 1,005
    - Configurations stored in the vlan.dat (in the flash memory)
    - VTP can only learn and store normal range VLANs
  - Extended Range VLANs
    - VLAN numbers from 1,006 to 4,096
    - Configurations stored in the running configuration (NVRAM)
    - VTP does not learn extended range VLANs

# Creating a VLAN

| Cisco Switch IOS Commands | |
|---|---|
| Enter global configuration mode. | `S1# configure terminal` |
| Create a VLAN with a valid id number. | `S1(config)# vlan vlan_id` |
| Specify a unique name to identify the VLAN. | `S1(config)# name vlan_name` |
| Return to the privileged EXEC mode. | `S1(config)# end` |

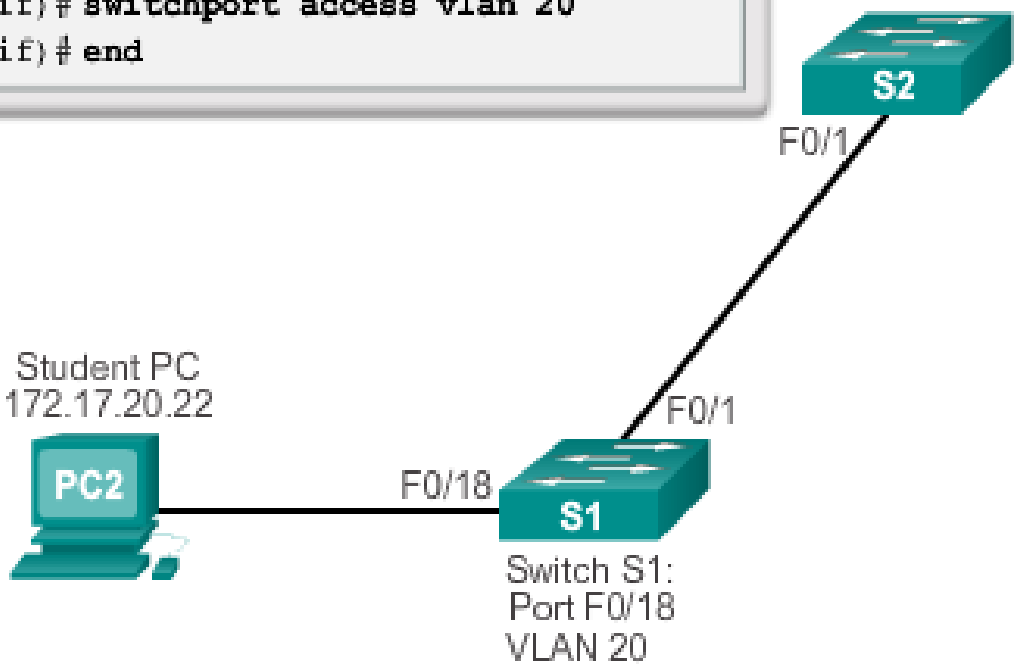
# Assigning Ports to VLANs

| Cisco Switch IOS Commands | |
|---|---|
| Enter global configuration mode. | S1 # **configure terminal** |
| Enter interface configuration mode for the SVI. | S1(config) # **interface** *interface_id* |
| Configure the management interface IP address. | S1(config) # **ip address 172.17.99.11** |
| Set the port to access mode. | S1(config-if) # **switchport mode access** |
| Assign the port to a VLAN. | S1(config-if) # **switchport access vlan** *vlan_id* |
| Return to the privileged EXEC mode. | S1(config-if) # **end** |

## VLAN Assignment

# Assigning Ports to VLANs (cont.)

```
s1# configure terminal
s1(config)# interface F0/18
s1(config-if)# switchport mode access
s1(config-if)# switchport access vlan 20
s1(config-if)# end
```



## VLAN Assignment

# Changing VLAN Port Membership

```
S1(config)# int fa0/18
S1(config-if)# no switchport access vlan
S1(config-if)# end
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#
```

# Changing VLAN Port Membership (cont.)

```
S1# config t
S1(config)# int fa0/11
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 20
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, Fa0/12, Fa0/1
                                     Fa0/14, Fa0/15, Fa0/16, Fa0/
                                     Fa0/18, Fa0/19, Fa0/20, Fa0/
                                     Fa0/22, Fa0/23, Fa0/24, Gi0/
                                     Gi0/2
20   student              active     Fa0/11
1002 fddi-default         act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default      act/unsup
1005 trnet-default        act/unsup
S1#
```

## VLAN Assignment

# Deleting VLANs

```
S1# conf t
S1(config)# no vlan 20
S1(config)# end
S1#
S1# sh 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, Fa0/12, 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
S1#
```

## VLAN Assignment

# Verifying VLAN Information

```
S1# show vlan name student

VLAN Name                              Status    Ports
---- --------------------------------- --------- -------------
20   student                           active    Fa0/11, Fa0/18

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
20   enet  100020     1500  -      -      -        -    -        0      0

Remote SPAN VLAN
----------------
Disabled

Primary Secondary Type              Ports
------- --------- ----------------- ------------------------

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

S1#
```

## VLAN Assignment

# Verifying VLAN Information (cont.)

```
S1# show interfaces vlan 20
Vlan20 is up, line protocol is down
  Hardware is EtherSVI, address is 001c.57ec.0641 (bia
001c.57ec.0641)
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output
drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicast)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

## VLAN Assignment

# Configuring IEEE 802.1q Trunk Links

| Cisco Switch IOS Commands | |
|---|---|
| Enter global configuration mode. | `S1# configure terminal` |
| Enter interface configuration mode. | `S1(config)# interface interface_id` |
| Force the link to be a trunk link. | `S1(config-if)# switchport mode trunk` |
| Specify a native VLAN for untagged 802.1Q trunks. | `S1(config-if)# switchport trunk native vlan vlan_id` |
| Specify the list of VLANs to be allowed on the trunk link. | `S1(config-if)# switchport trunk allowed vlan vlan-list` |
| Return to the privileged EXEC mode. | `S1(config-if)# end` |

```
S1(config)# interface FastEthernet0/1
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99
S1(config-if)# switchport trunk allowed vlan 10,20,30
S1(config-if)# end
```

## VLAN Assignment

# Resetting the Trunk To Default State

```
S1(config)# interface f0/1
S1(config-if)# no switchport trunk allowed vlan
S1(config-if)# no switchport trunk native vlan
S1(config-if)# end
S1# show interfaces f0/1 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
<output omitted>
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
<output omitted>
```

# Resetting the Trunk To Default State (cont.)

## Return Port to Access Mode

```
S1(config)# interface f0/1
S1(config-if)# switchport mode access
S1(config-if)# end
S1# show interfaces f0/1 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>
```

## VLAN Assignment

# Verifying Trunk Configuration

```
S1(config)# interface f0/1
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99
S1(config-if)# end
S1# show interfaces f0/1 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>
```

# Introduction to DTP

- Switch ports can be manually configured to form trunks.
- Switch ports can also be configured to negotiate and establish a trunk link with a connected peer.
- The Dynamic Trunking Protocol (DTP) manages trunk negotiation.
- DTP is a Cisco proprietary protocol and is enabled, by default, in Cisco Catalyst 2960 and 3560 switches.
- If the port on the neighbor switch is configured in a trunk mode that supports DTP, it manages the negotiation.
- The default DTP configuration for Cisco Catalyst 2960 and 3560 switches is dynamic auto.

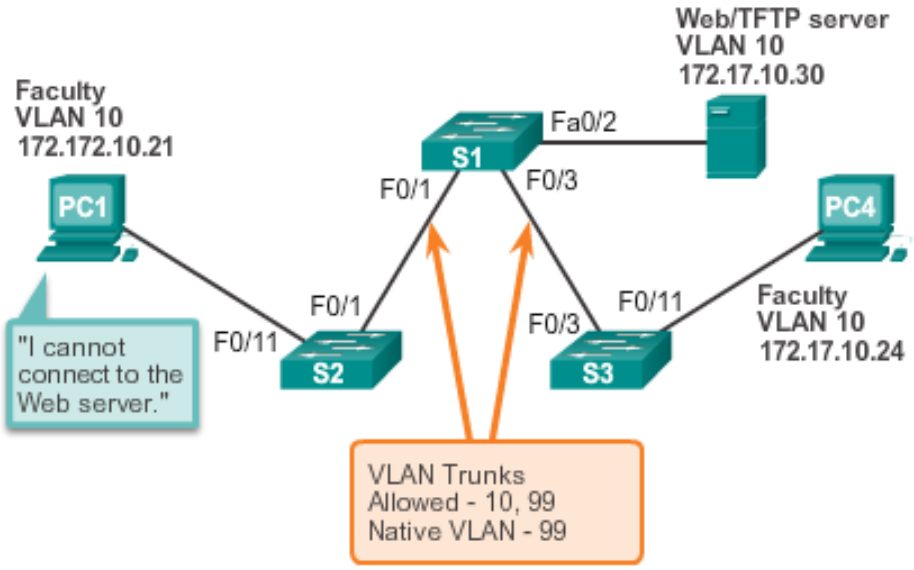
# Negotiated Interface Modes

- Cisco Catalyst 2960 and 3560 support the following trunk modes:
  - Switchport mode dynamic auto
  - Switchport mode dynamic desirable
  - Switchport mode trunk
  - Switchport nonegotiate

| | 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** |

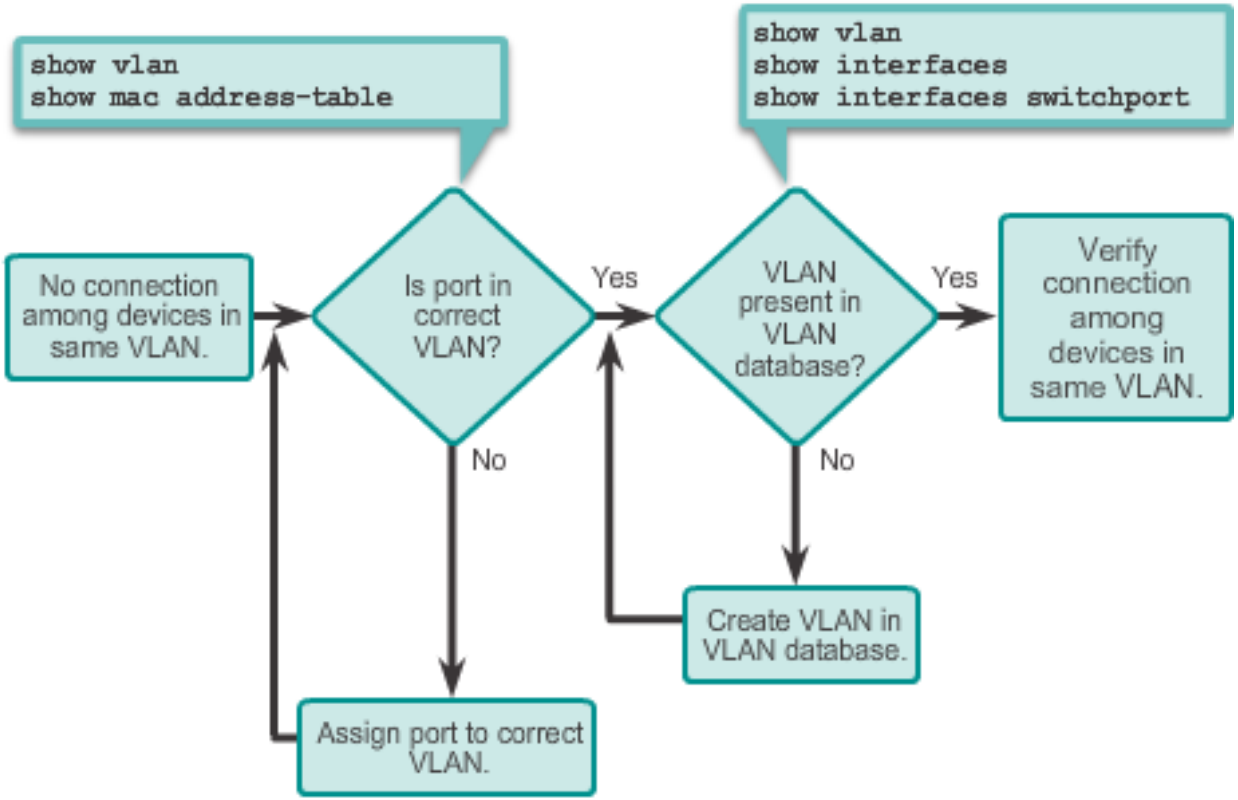
# IP Addressing Issues with VLAN

- It is a common practice to associate a VLAN with an IP network.
- Because different IP networks only communicate through a router, all devices within a VLAN must be part of the same IP network to communicate.
- The figure displays that PC1 cannot communicate to the server because it has a wrong IP address configured.

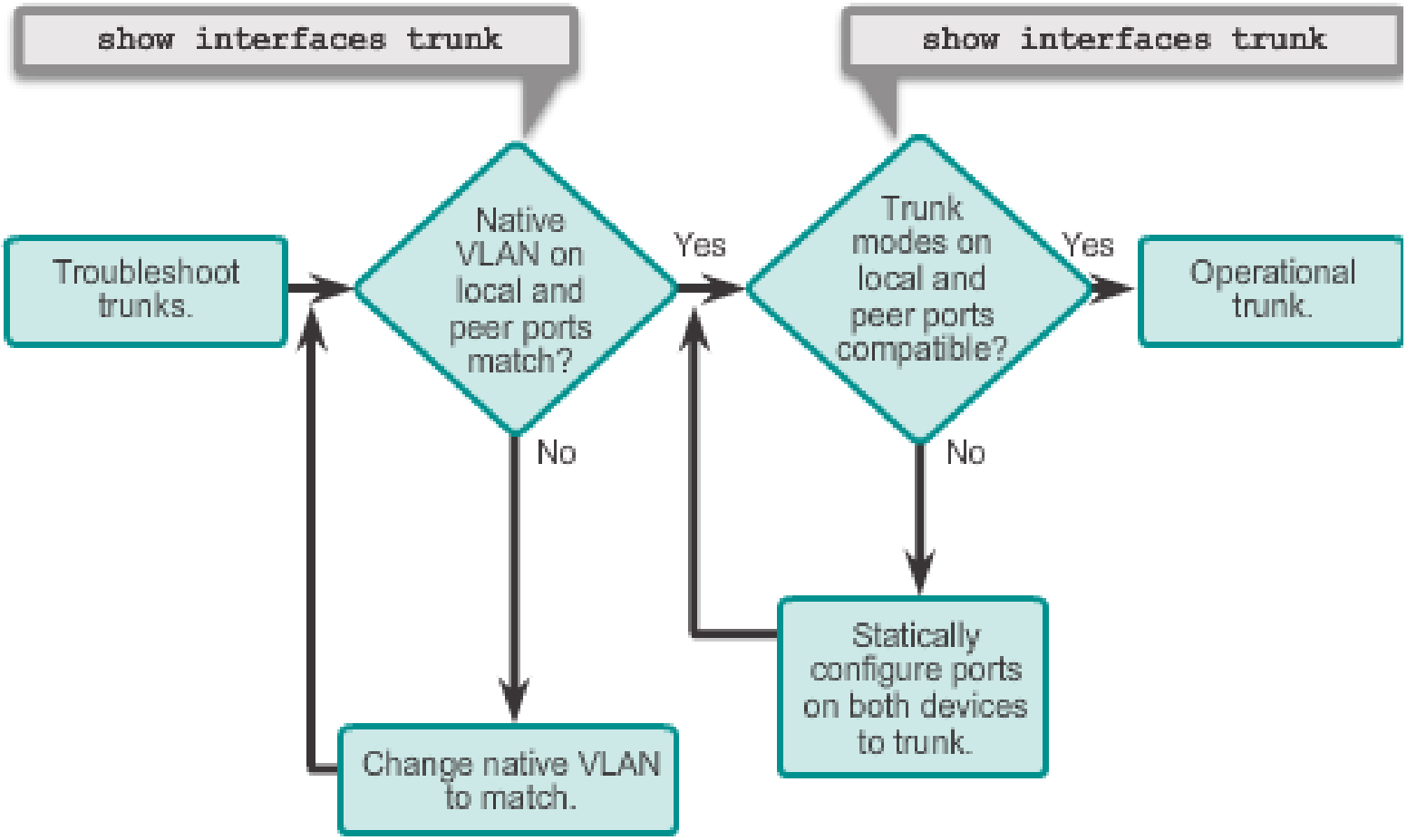


# Missing VLANs

- If all the IP addresses mismatches have been solved, but the device still cannot connect, check if the VLAN exists in the switch.



# Introduction to Troubleshooting Trunks



# Common Problems with Trunks

- Trunking issues are usually associated with incorrect configurations.
- The most common type of trunk configuration errors are:
  1. Native VLAN mismatches
  2. Trunk mode mismatches
  3. Allowed VLANs on trunks
- If a trunk problem is detected, the best practice guidelines recommend to troubleshoot in the order shown above.

# Trunk Mode Mismatches

- If a port on a trunk link is configured with a trunk mode that is incompatible with the neighboring trunk port, a trunk link fails to form between the two switches.
- Use the **show interfaces trunk** command to check the status of the trunk ports on the switches.
- To fix the problem, configure the interfaces with proper trunk modes.

| | 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** |

# Incorrect VLAN List

- VLANs must be allowed in the trunk before their frames can be transmitted across the link.
- Use the **switchport trunk allowed vlan** command to specify which VLANs are allowed in a trunk link.
- Use the **show interfaces trunk** command to ensure the correct VLANs are permitted in a trunk.

# 3.3 VLAN Security and Design

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## Attacks on VLANs

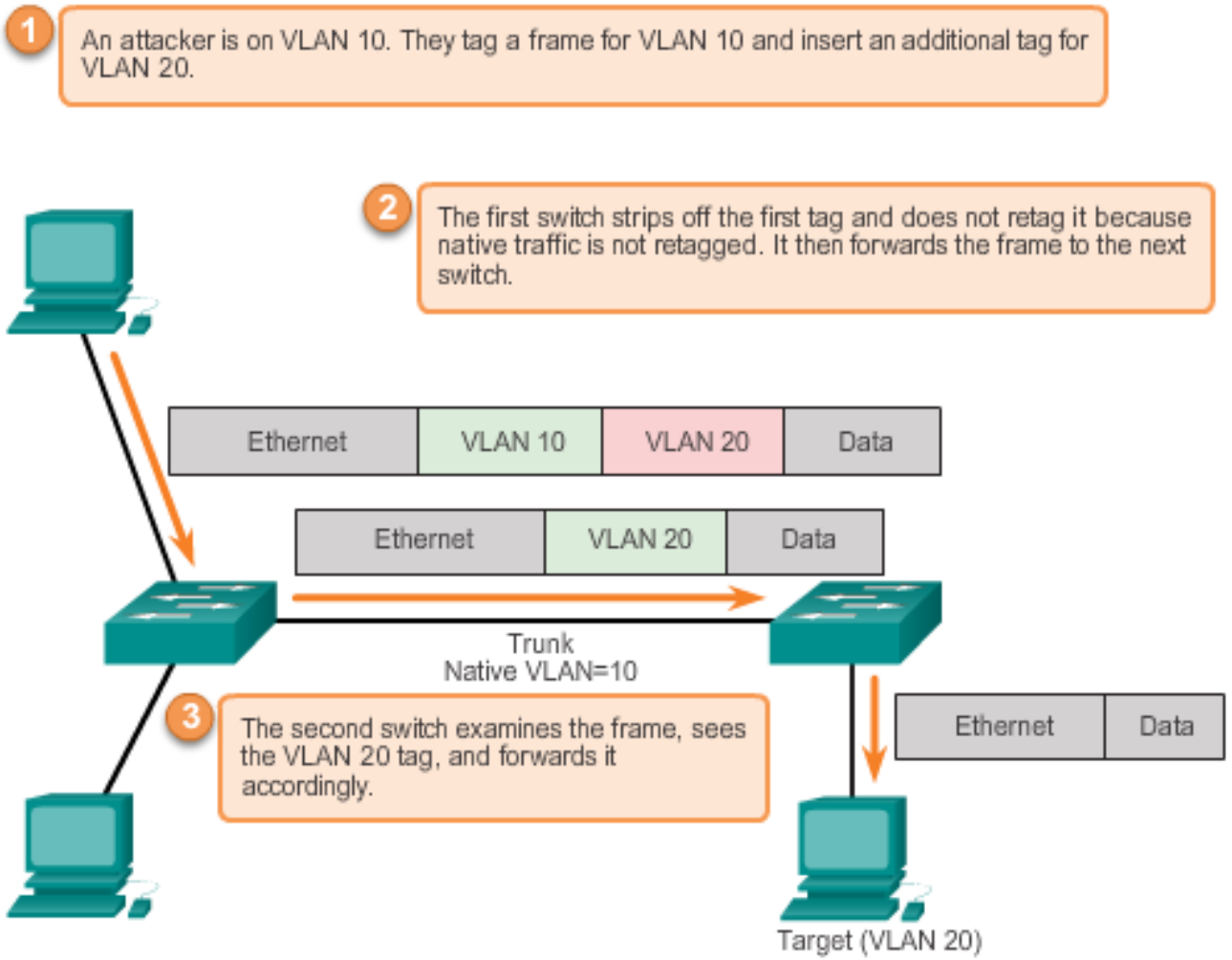
# Switch Spoofing Attack

- There are a number of different types of VLAN attacks in modern switched networks; VLAN hopping is one example.
- The default configuration of the switch port is dynamic auto.
- By configuring a host to act as a switch and form a trunk, an attacker could gain access to any VLAN in the network.
- Because the attacker is now able to access other VLANs, this is called a VLAN hopping attack.
- To prevent a basic switch spoofing attack, turn off trunking on all ports, except the ones that specifically require trunking.

# Double-Tagging Attack

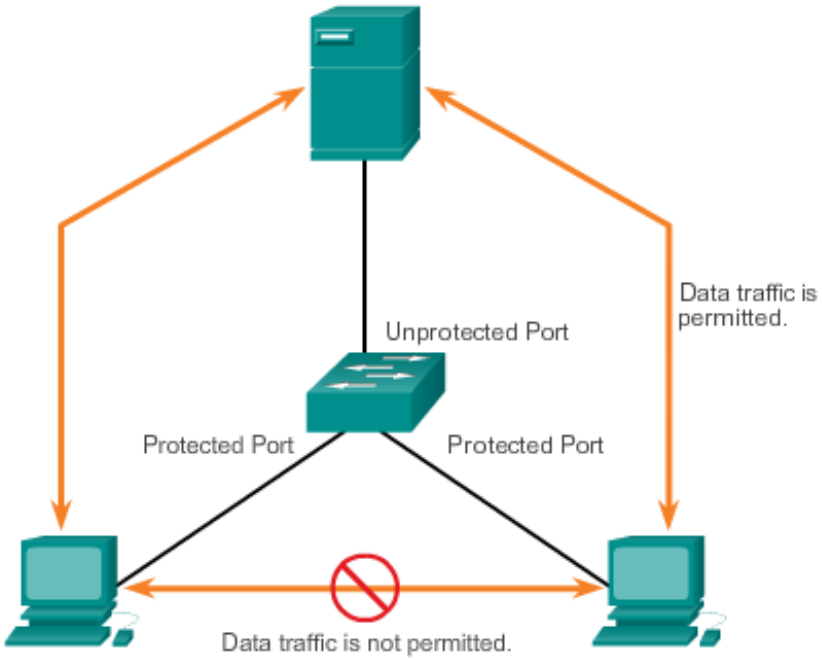
- Double-tagging attack takes advantage of the way that hardware on most switches de-encapsulate 802.1Q tags.
- Most switches perform only one level of 802.1Q de-encapsulation, allowing an attacker to embed a second, unauthorized attack header in the frame.
- After removing the first and legit 802.1Q header, the switch forwards the frame to the VLAN specified in the unauthorized 802.1Q header.
- The best approach to mitigating double-tagging attacks is to ensure that the native VLAN of the trunk ports is different from the VLAN of any user ports.

# Double-Tagging Attack (cont.)



# PVLAN Edge

- The Private VLAN (PVLAN) Edge feature, also known as protected ports, ensures that there is no exchange of unicast, broadcast, or multicast traffic between protected ports on the switch.
- Local relevancy only.
- A protected port only exchanges traffic with unprotected ports.
- A protected port does not exchange traffic with another protected port.



# VLAN Design Guidelines

- Move all ports from VLAN 1 and assign them to a not-in-use VLAN
- Shut down all unused switch ports.
- Separate management and user data traffic.
- Change the management VLAN to a VLAN other than VLAN 1. (The same goes to the native VLAN.)
- Ensure that only devices in the management VLAN can connect to the switches.
- The switch should only accept SSH connections.
- Disable autonegotiation on trunk ports.
- Do not use the auto or desirable switch port modes.

# Chapter 3: Summary

This chapter:

- Introduced VLANs and their types
- Described the connection between VLANs and broadcast domains
- Discussed IEEE 802.1Q frame tagging and how it enables differentiation between Ethernet frames associated with distinct VLANs as they traverse common trunk links.
- Examined the configuration, verification, and troubleshooting of VLANs and trunks using the Cisco IOS CLI and explored basic security and design considerations.