Chapter 6: VLANs

Routing and Switching Essentials v6.0

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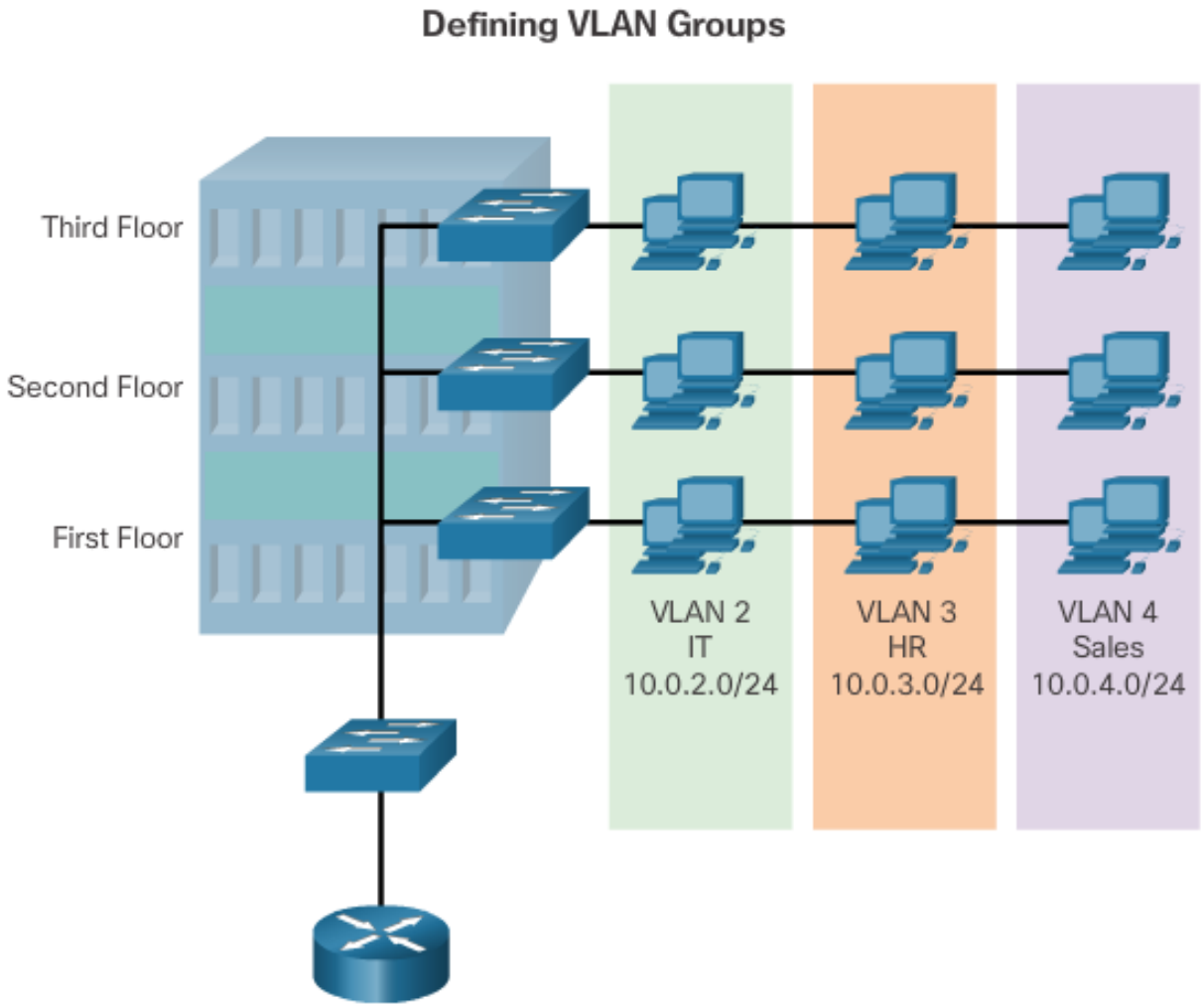
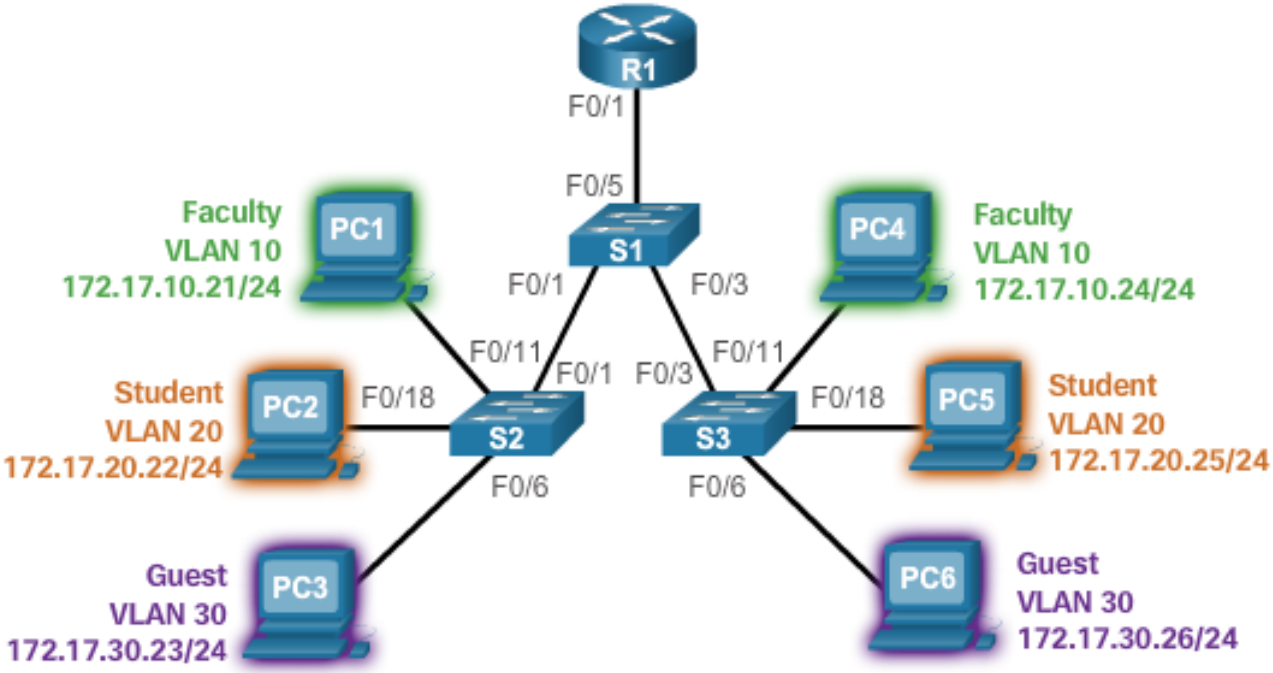
VLAN Definitions



VLAN Definitions

- VLANs allow an administrator to segment networks based on factors such as function, project team, or application, without regard for the physical location of the user or device.
- VLANs enable the implementation of access and security policies according to specific groupings of users.
- A VLAN is a logical partition of a Layer 2 network.
- Each VLAN is a broadcast domain
- VLANs are isolated, and packets can only pass between them via a router.

Benefits of VLANs



- Improved Security
- Reduced Cost
- Better Performance
- Smaller Broadcast Domains
- IT Efficiency
- Management Efficiency
- Simpler Project and Application Management

Types of VLANs

- Data VLAN – user generated traffic
- Default VLAN – all switch ports become part of this VLAN until switch is configured, **`show vlan brief`**
- Native VLAN – used for untagged traffic
- Management VLAN – used to access management capabilities

Types of VLANs (cont.)

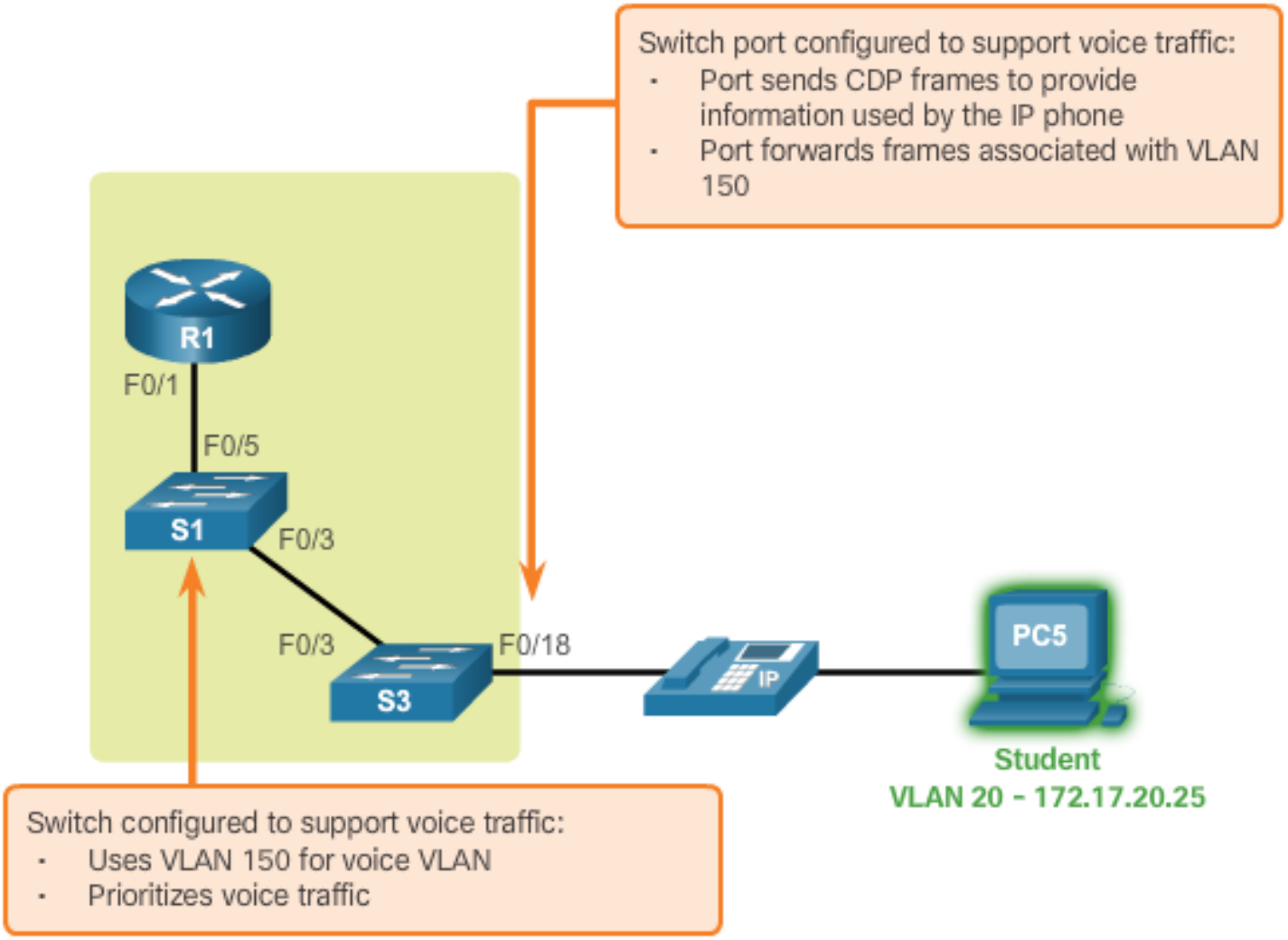
VLAN 1

```
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 by default.
- Native VLAN is VLAN 1 by default.
- Management VLAN is VLAN 1 by default.

Voice VLANs



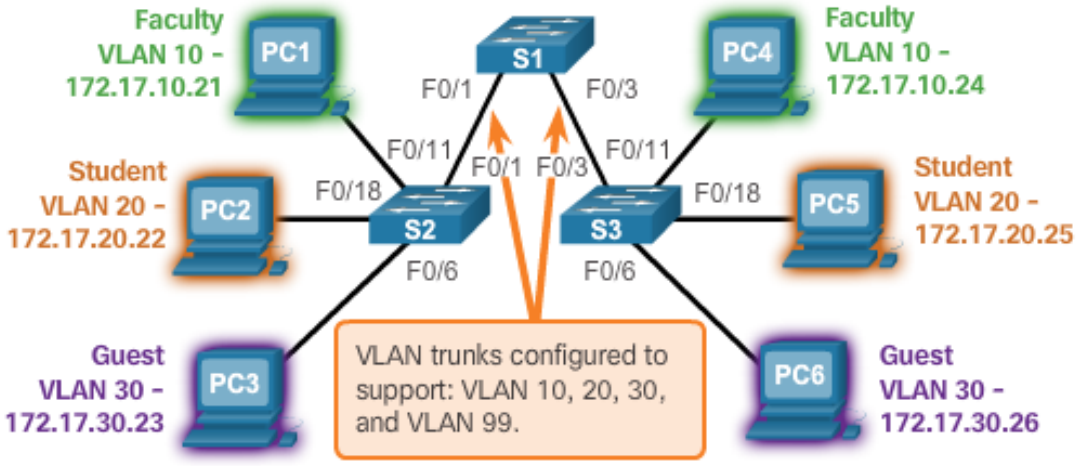
Voice VLANs

- 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.

VLAN Trunks

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.

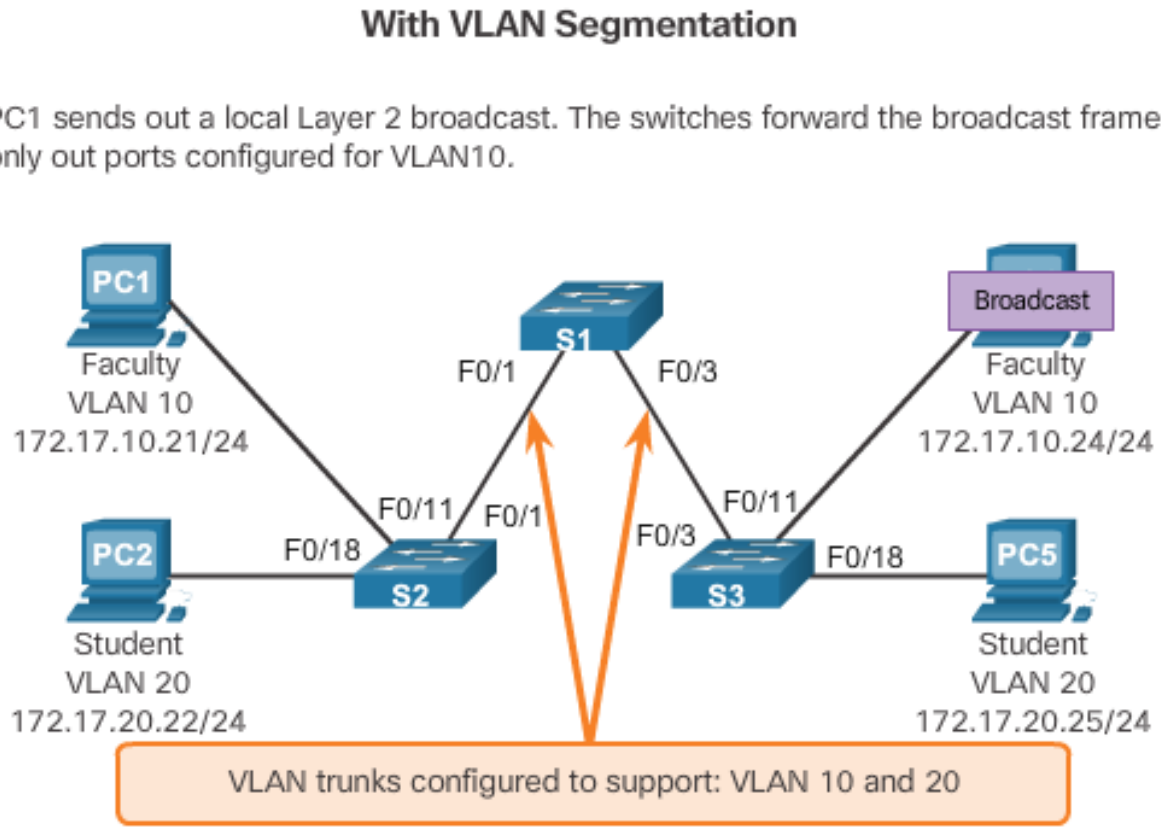


The links between switches S1 and S2, and S1 and S3 are configured to transmit traffic coming from VLANs 10, 20, 30, and 99 across the network. This network could not function without VLAN trunks.

VLAN Trunks

- A VLAN trunk is a point-to-point link that 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.
- (Ilman Trunk-määrittelyä, useamman kytkimen verkossa, on kaikki VLAN:t liitettävä toisiinsa omalla “johdollaan”)

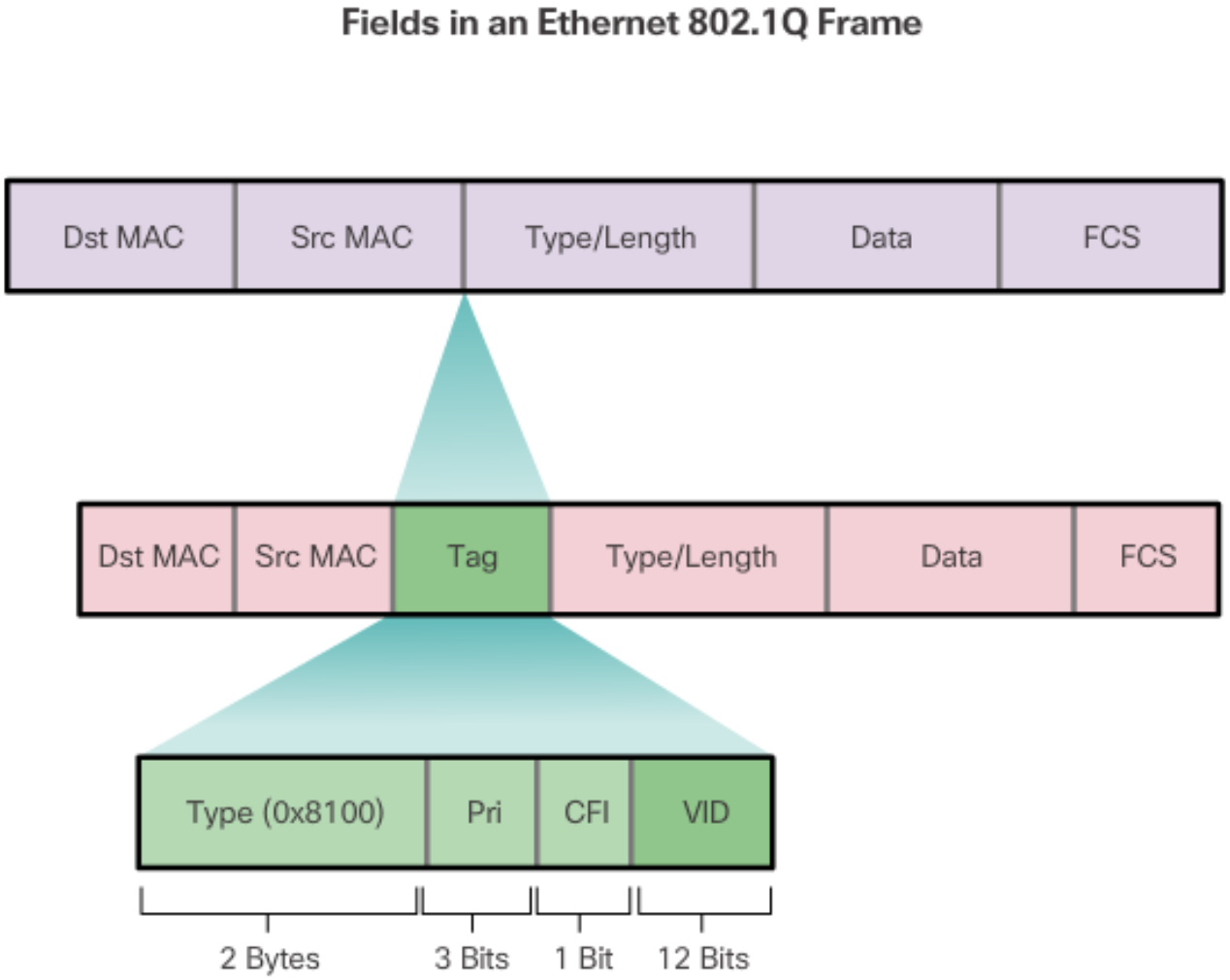
Controlling Broadcast Domains with VLANs



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 which 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 non-trunk 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.

Tagging Ethernet Frames for VLAN Identification



Native VLANs and 802.1Q Tagging

- traffic sent on the native VLAN should not be 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.
- When configuring a switch port on a Cisco switch, configure devices so that they do not send tagged frames on the native VLAN.
- In Cisco switches, the native VLAN is VLAN 1, by default.

6.2 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)
  - Extended Range VLANs
    - VLAN numbers from 1,006 to 4,096
    - Configurations stored in the running configuration (NVRAM)

VLAN Ranges on Catalyst Switches (cont.)

- Normal Range 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
```

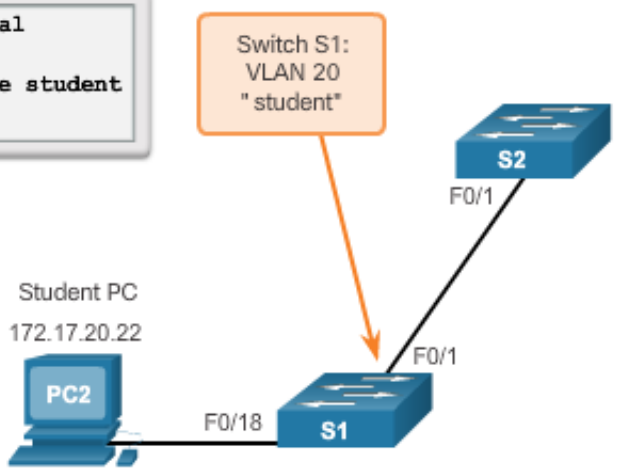
VLAN Assignment

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-vlan)# name vlan-name`
Return to the privileged EXEC mode.	`S1(config-vlan)# end`

Sample Configuration

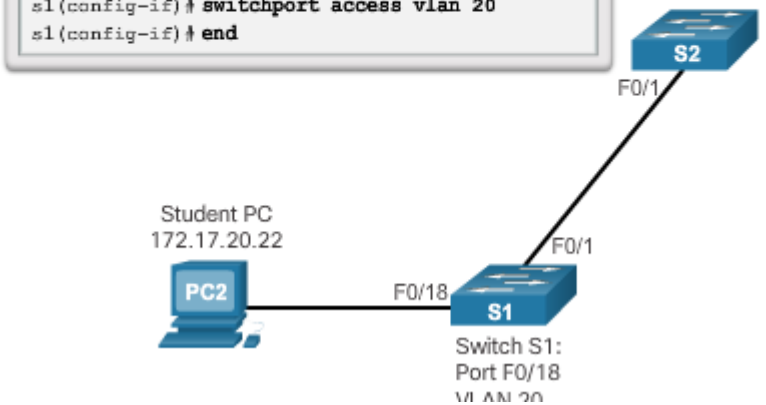
```
S1# configure terminal
S1(config)# vlan 20
S1(config-vlan)# name student
S1(config-vlan)# end
```



Assigning Ports to VLANs

Cisco Switch IOS Commands	
Enter global configuration mode.	`S1# configure terminal`
Enter interface configuration mode.	`S1(config)# interface interface_id`
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`

```
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

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#
```

- The entire vlan.dat file can be deleted using the **delete flash:vlan.dat** privileged EXEC mode command
- Abbreviated command version (**delete vlan.dat**) can be used if the vlan.dat file has not been moved from its default location

VLAN Assignment

Verifying VLAN Information

`show vlan` Command

Cisco IOS CLI Command Syntax	
show vlan [**brief** | **id** *vlan-id* | **name** *vlan-name* | **summary**]	
Display one line for each VLAN with the VLAN name, status, and its ports.	**brief**
Display information about a single VLAN identified by VLAN ID number. For vlan-id, the range is 1 to 4094.	**id** *vlan-id*
Display information about a single VLAN identified by VLAN name. The VLAN name is an ASCII string from 1 to 32 characters.	**name** *vlan-name*
Display VLAN summary information.	**summary**

`show interfaces` Command

Cisco IOS CLI Command Syntax	
show interfaces [*interface-id* | **vlan** *vlan-id*] | **switchport**	
Valid interfaces include physical ports (including type, module, and port number) and port channels. The port-channel range is 1 to 6.	*interface-id*
VLAN identification. The range is 1 to 4094.	**vlan** *vlan-id*
Display the administrative and operational status of a switching port, including port blocking and port protection settings.	**switchport**

Configuring IEEE 802.1q Trunk Links

Trunk Configuration

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 frames.	`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`

optional

```
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 10,20,30,99
S1(config-if)# end
```

optional

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>
```

6.3 Inter-VLAN Routing Using Routers

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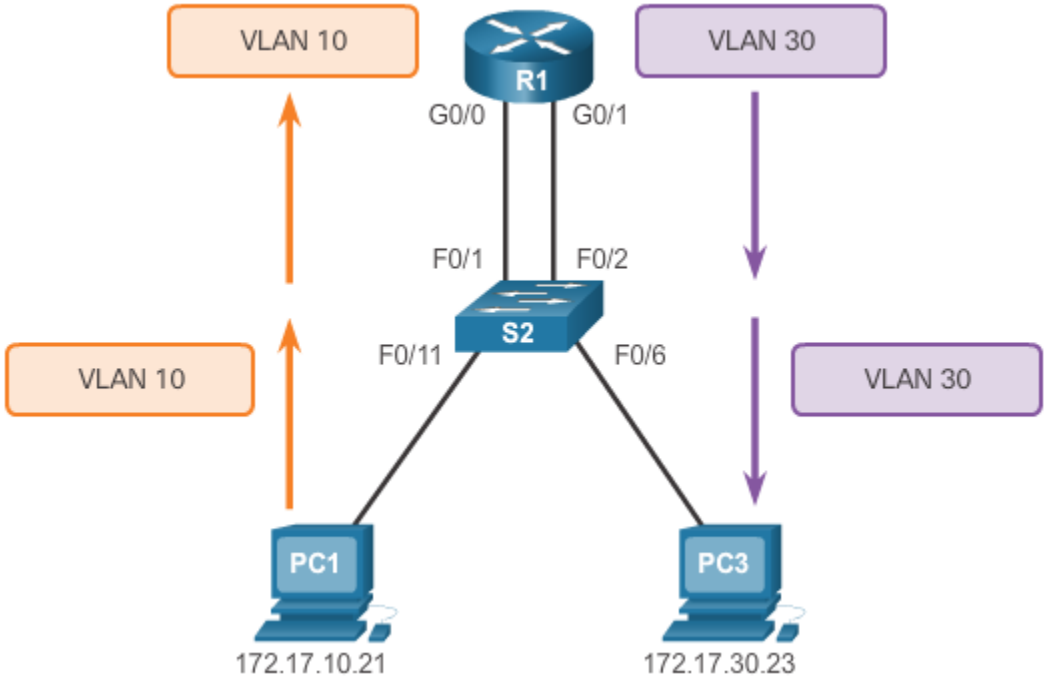
What is Inter-VLAN Routing?

- Layer 2 switches cannot forward traffic between VLANs without the assistance of a router.
- Inter-VLAN routing is a process for forwarding network traffic from one VLAN to another, using a router.
- All VLANs need IP-subnets on they own

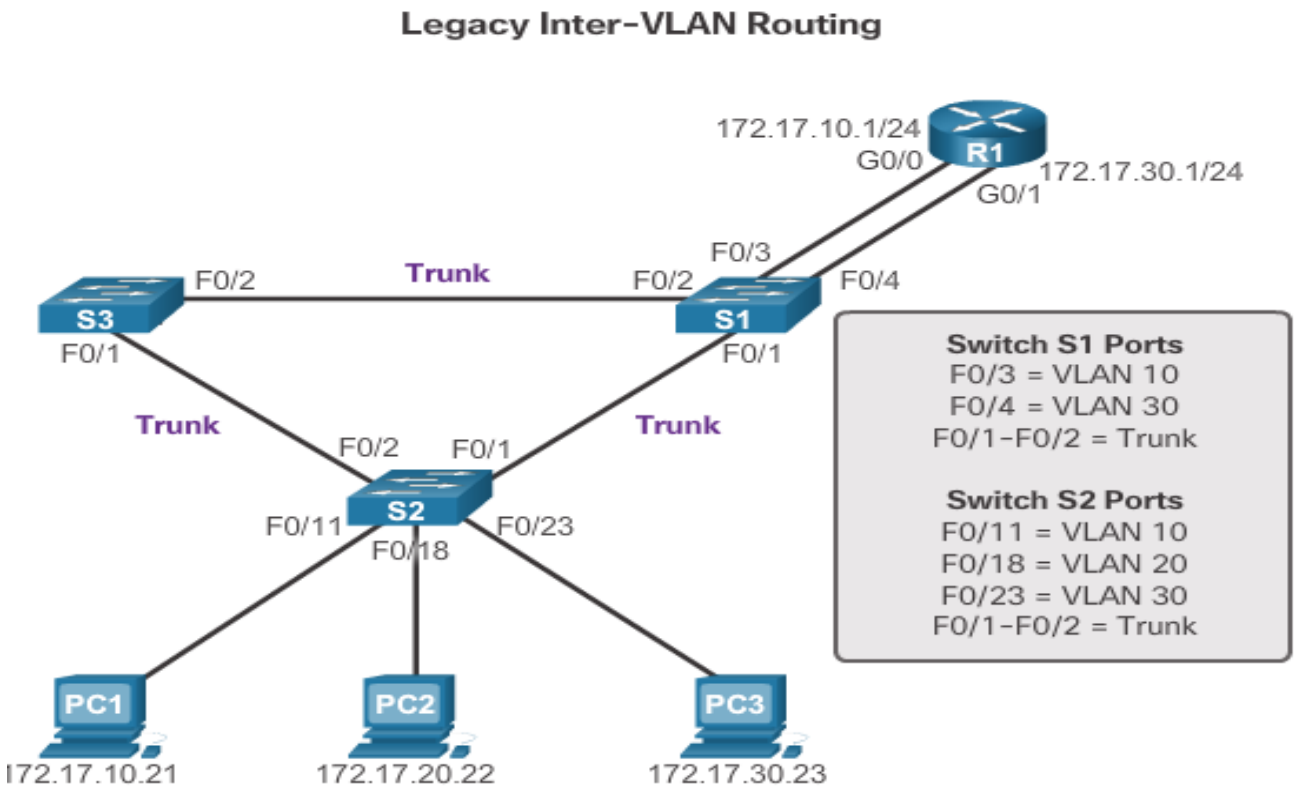


Legacy Inter-VLAN Routing

In the past:

- Actual routers were used to route between VLANs.
- Each VLAN was connected to a different physical router interface.
- Packets would arrive on the router through one interface, be routed and leave through another.
- Because the router interfaces were connected to VLANs and had IP addresses from that specific VLAN, routing between VLANs was achieved.
- Large networks with large number of VLANs required many router interfaces.

Legacy Inter-VLAN Routing



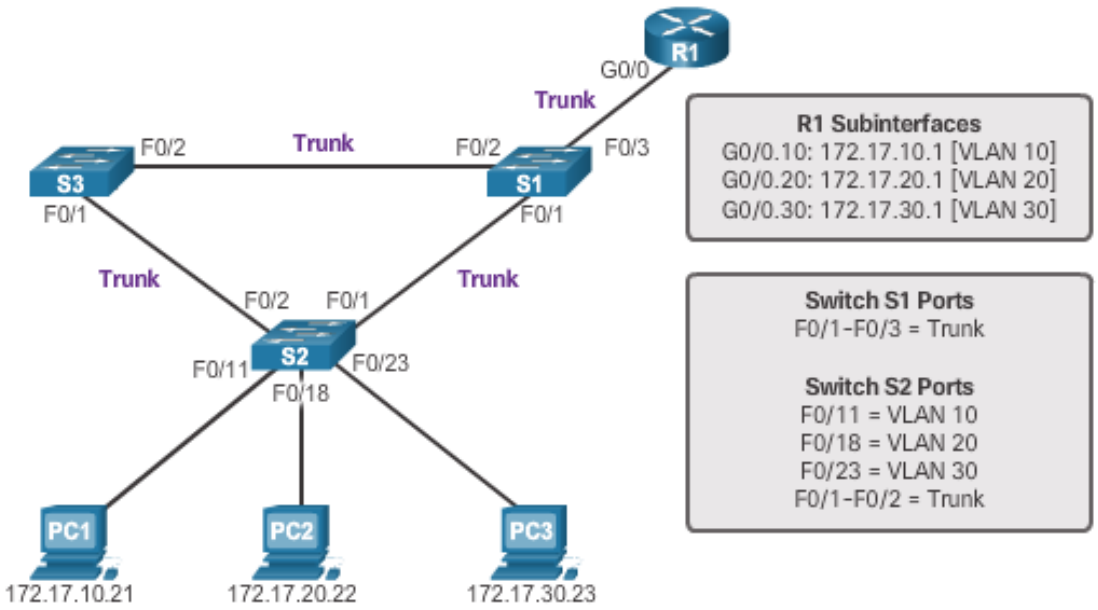
In this example, the router was configured with two separate physical interfaces to interact with the different VLANs and perform the routing.

Router-on-a-Stick Inter-VLAN Routing

- The router-on-a-stick approach uses only one of the router's physical interface.
- One of the router's physical interfaces is configured as a 802.1Q trunk port so it can understand VLAN tags.
- Logical subinterfaces are created; one subinterface per VLAN.
- Each subinterface is configured with an IP address from the VLAN it represents.
- VLAN members (hosts) are configured to use the subinterface address as a default gateway.

Inter-VLAN Routing Operation

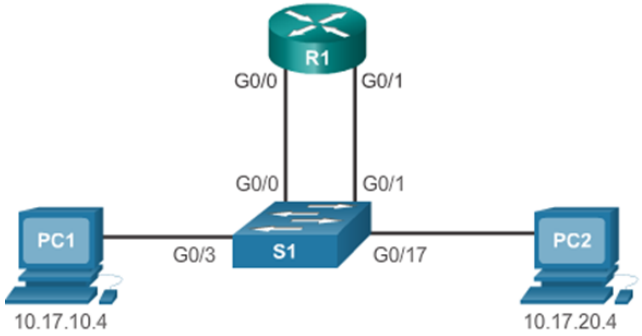
Router-on-a-Stick Inter-VLAN Routing



Router interface configured to operate as a trunk link and is connected to a trunked switch port. The router performs inter-VLAN routing by accepting VLAN-tagged traffic on the trunk interface coming from the adjacent switch, and then, internally routing between the VLANs using subinterfaces. The router then forwards the routed traffic, VLAN-tagged for the destination VLAN, out the same physical interface as it used to receive the traffic.

Identify the Types of Inter-VLAN Routing Activity

- Legacy or Router-on-a-Stick?

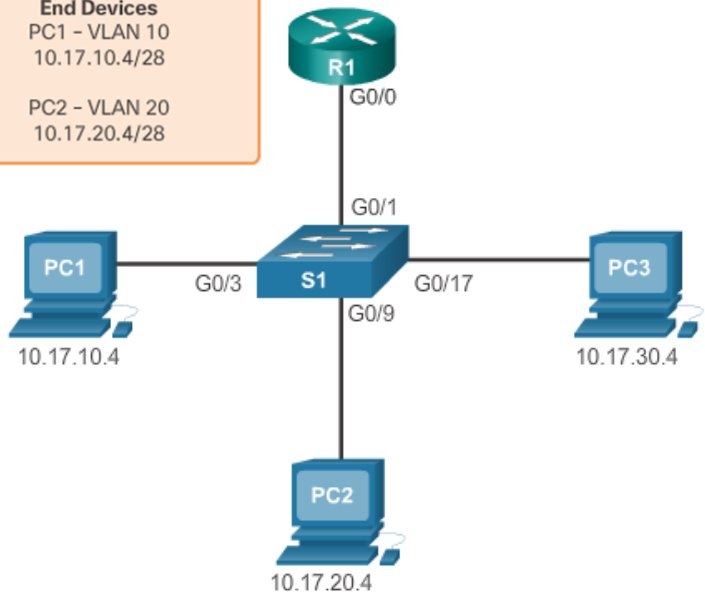


R1 Interface
G0/0 10.17.10.1/28
G0/1 10.17.20.1/28

S1 Ports
G0/3 = VLAN 10
G0/17 = VLAN 20

End Devices
PC1 – VLAN 10
10.17.10.4/28

PC2 – VLAN 20
10.17.20.4/28



R1 Interface
G0/0 Trunk Link

R1 Subinterfaces

G0/0.10	10.17.10.1/28
G0/0.20	10.17.20.1/28
G0/0.30	10.17.30.1/28

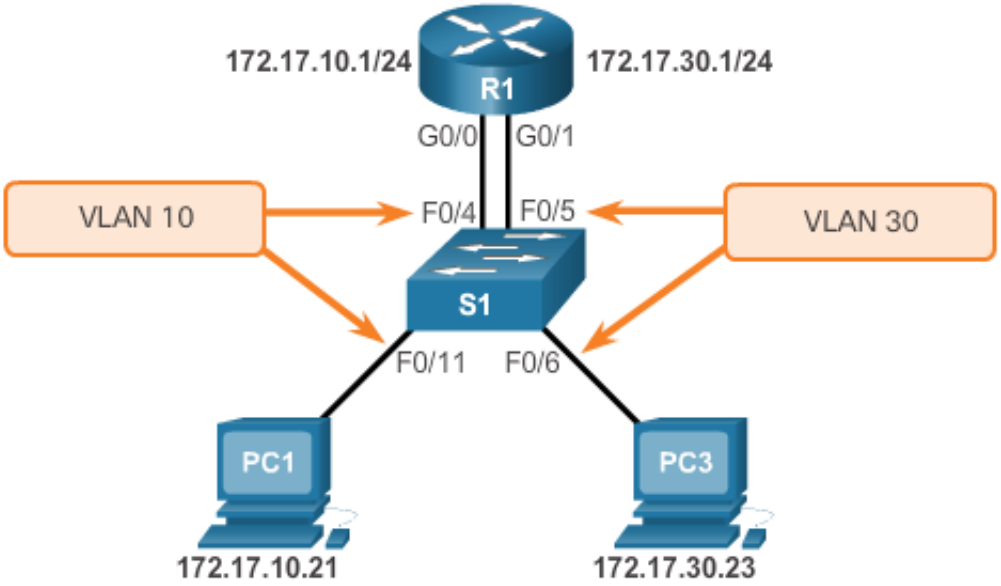
S1 Ports
G0/1 Trunk Link
G0/3 = VLAN 10
G0/9 = VLAN 20
G0/17 = VLAN 30

End Devices

PC1 – VLAN 10	10.17.10.4/28
PC2 – VLAN 20	10.17.20.4/28
PC3 – VLAN 30	10.17.30.4/28

Configure Legacy Inter-VLAN Routing: Preparation

- Legacy inter-VLAN routing requires routers to have multiple physical interfaces.
- Each one of the router's physical interfaces is connected to a unique VLAN.
- Each interface is also configured with an IP address for the subnet associated with the particular VLAN.
- Network devices use the router as a gateway to access the devices connected to the other VLANs.

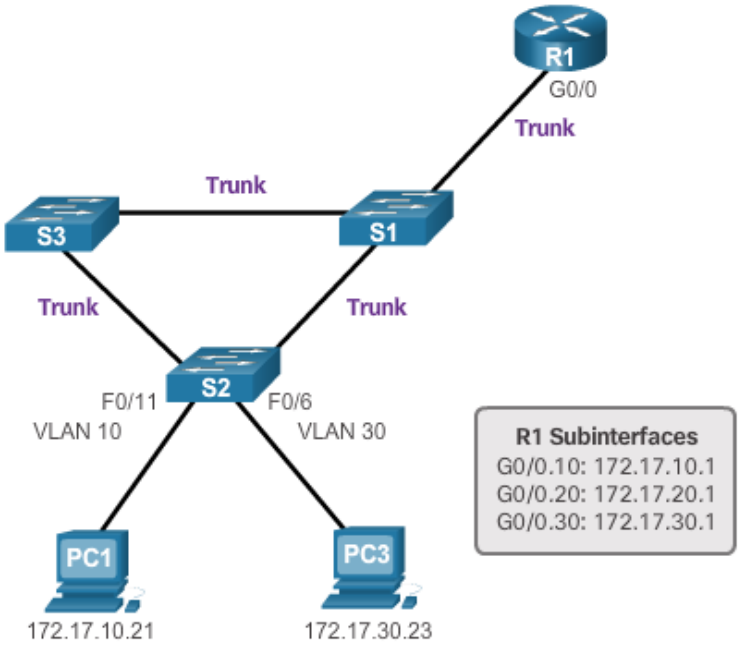


Configure Legacy Inter-VLAN Routing: Router Interface Configuration

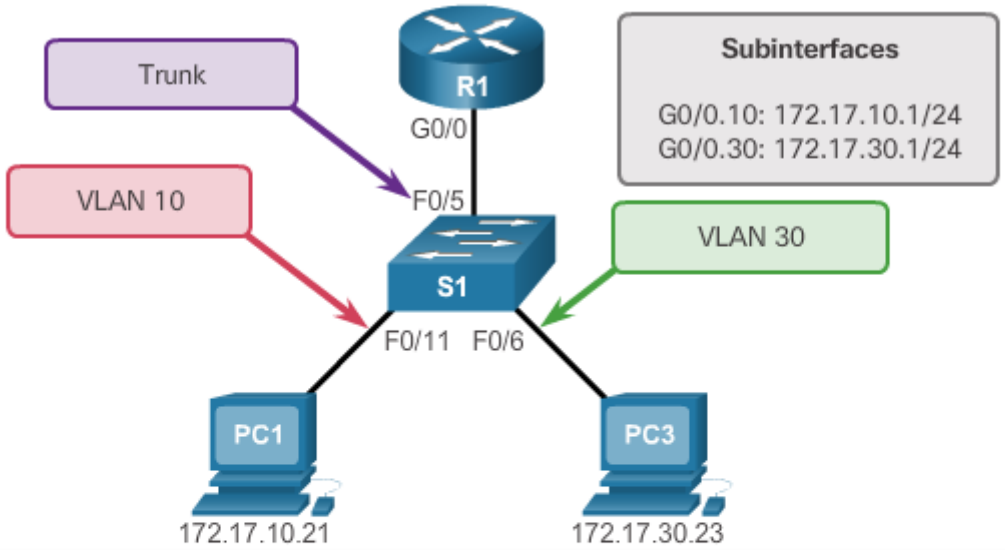
```
R1(config)# interface g0/0
R1(config-if)# ip address 172.17.10.1 255.255.255.0
R1(config-if)# no shutdown
*Mar 20 01:42:12.951: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
changed state to up
*Mar 20 01:42:13.951: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0, changed state to up
R1(config-if)# interface g0/1
R1(config-if)# ip address 172.17.30.1 255.255.255.0
R1(config-if)# no shutdown
*Mar 20 01:42:54.951: %LINK-3-UPDOWN: Interface GigabitEthernet0/1,
changed state to up
*Mar 20 01:42:55.951: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/1, changed state to up
R1(config-if)# end
R1# copy running-config startup-config
```

Configure Router-on-a Stick: Preparation

- An alternative to legacy inter-VLAN routing is to use VLAN trunking and subinterfaces.
- VLAN trunking allows a single physical router interface to route traffic for multiple VLANs.
- The physical interface of the router must be connected to a trunk link on the adjacent switch.
- On the router, subinterfaces are created for each unique VLAN.
- Each subinterface is assigned an IP address specific to its subnet or VLAN and is also configured to tag frames for that VLAN.



Configure Router-on-a Stick: Switch Configuration




```
S1(config)# vlan 10
S1(config-vlan)# vlan 30
S1(config-vlan)# interface f0/5
S1(config-if)# switchport mode trunk
S1(config-if)# end
S1#
```

Configure Router-on-a Stick: Router Subinterface Configuration

```
R1(config)# interface g0/0.10
R1(config-subif)# encapsulation dot1q 10
R1(config-subif)# ip address 172.17.10.1 255.255.255.0
R1(config-subif)# interface g0/0.30
R1(config-subif)# encapsulation dot1q 30
R1(config-subif)# ip address 172.17.30.1 255.255.255.0
R1(config)# interface g0/0
R1(config-if)# no shutdown
*Mar 20 00:20:59.299: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
 changed state to down
*Mar 20 00:21:02.919: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
 changed state to up
*Mar 20 00:21:03.919: %LINEPROTO-5-UPDOWN: Line protocol on
 changed state to down
*Mar 20 00:21:02.919: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
 changed state to up
*Mar 20 00:21:03.919: %LINEPROTO-5-UPDOWN: Line protocol on
 Interface GigabitEthernet0/0, changed state to up
```

Configure Router-on-a Stick: Verifying Subinterfaces

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP,M - mobile,
       B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF,
       IA - OSPF inter area
       N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1,
       L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default,
       U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP,
       l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

   172.17.0.0/16 is variably subnetted, 4 subnets, 2 masks
C      172.17.10.0/24 is directly connected, GigabitEthernet0/0.10
L      172.17.10.1/32 is directly connected, GigabitEthernet0/0.10
C      172.17.30.0/24 is directly connected, GigabitEthernet0/0.30
L      172.17.30.1/32 is directly connected, GigabitEthernet0/0.30
```