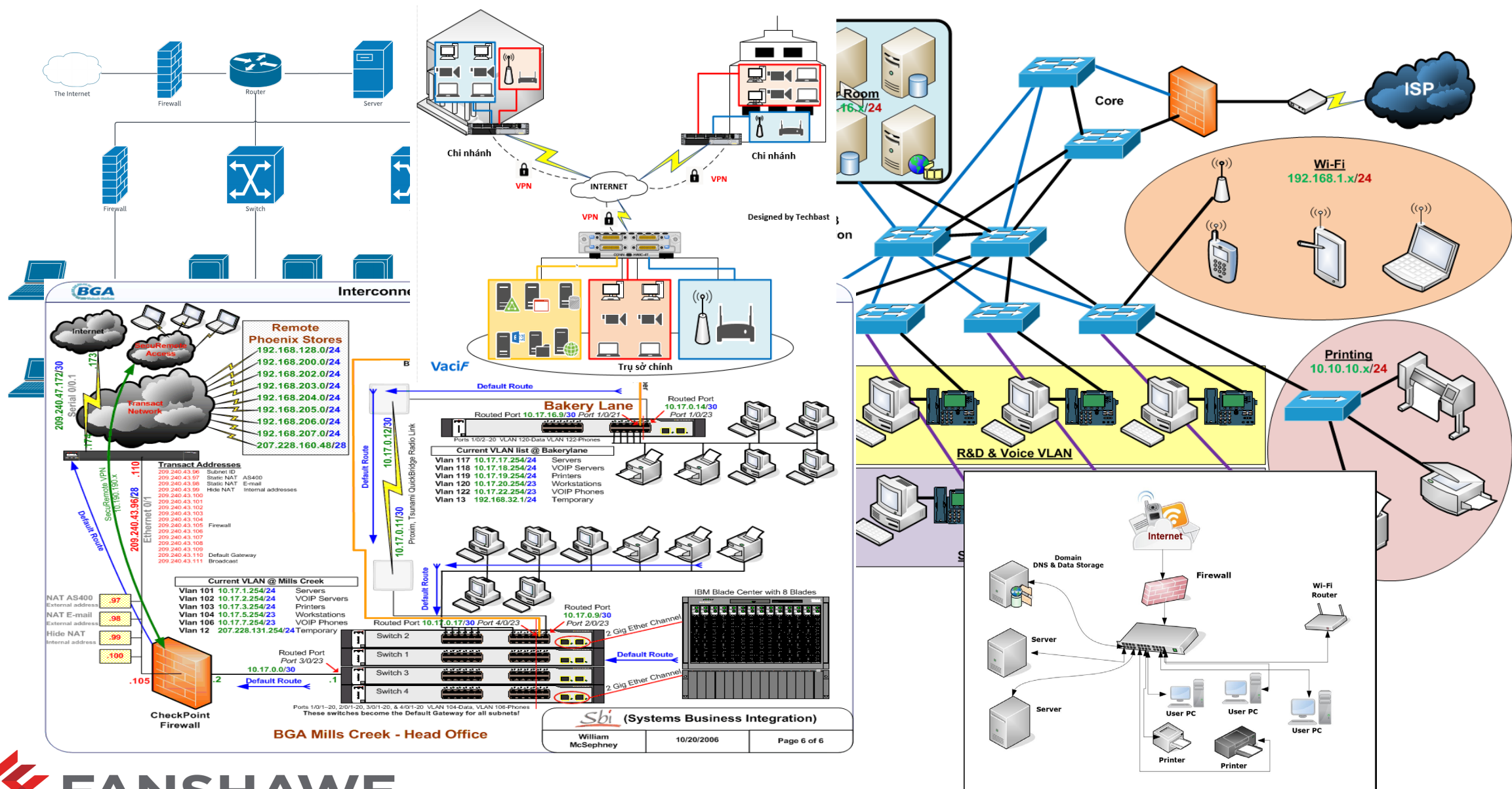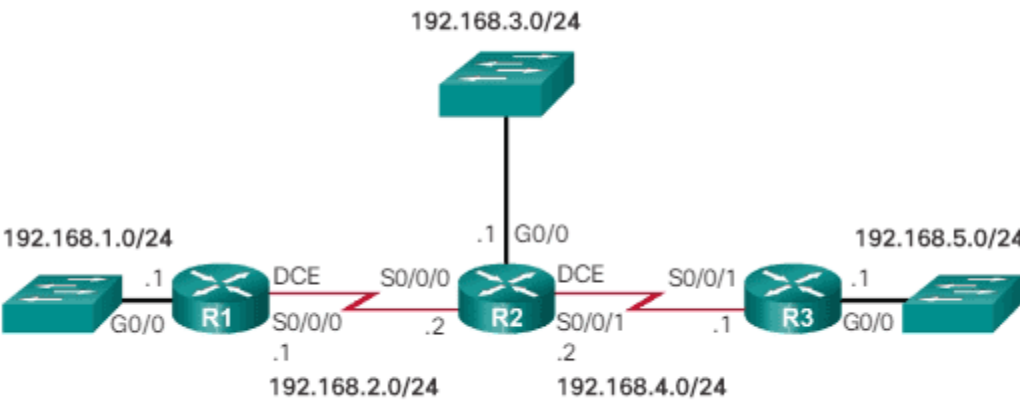# Inter VLAN routing

INFO-6047 Switching and Routing

ISM1 - Information Security Management (ISM1-ITY-20189)   Detailed Weekly Content

| Week	Date of Lecture or Tests, 7:00 – 9:00 PM EST	Lecture/Test	Reading	Lab Time INFO-6047-01 Wednesday 5:00 – 8:00 PM EST INFO-6047-02 Tuesday 5:00 – 8:00 PM EST	Grade
Week 01	Monday, January 02, 2023		College-Wide Orientation		
Week 02	Monday, January 09, 2023	Introduction	N/A	Lab 01 - Basics of PT	3.0%
Week 03	Monday, January 16, 2023	Basics of Routing	Chapter 01 & 02 *(Introduction to Networking, Network Media Copper)*	Lab 02 - Intro to Routing	3.0%
Week 04	Monday, January 23, 2023	Basics of Switching	Chapter 03 & 04 *(Network Media Fiber Network Media Wireless)*	Lab 03 - Intro to Switching	3.0%
Week 05	Monday, January 30, 2023	VLANs	Chapter 05 *(Data Encoding & Transmission)*	Lab 04 - VLANs	3.0%
Week 06	Monday, February 06, 2023	Routing	Chapter 06 *(Network OS & Communications)*	Lab 05 - Routing	3.0%
Week 07	Monday, February 13, 2023	Mid-Term Test		Mid-Term (Test 1)	32.0%
Study Break	Monday, February 20, 2023		Study Break - No Class This Week		
Week 08	Monday, February 27, 2023	Inter-VLAN Routing	Chapter 10 *(TCP/IP Fundamentals)*	Lab 06 - Inter VLAN Routing	3.0%
Week 09	Monday, March 06, 2023	Static Routing	Chapter 11 *(Subnetting)*	Lab 07 - Static & Default Routs	3.0%
Week 10	Monday, March 13, 2023	Dynamic Routing - RIP	Chapter 12 *(Additional Transmission Modalities)*	Lab 08 - RIP Protocol	3.0%
Week 11	Monday, March 20, 2023	Dynamic Routing - OSPF	Chapter 14 *(RA & LD Communications)*	Lab 09 - OSPF Protocol	3.0%
Week 12	Monday, March 27, 2023	Access Control Lists	Chapter 15 *(Network Security)*	Lab 10 - ACLs	3.0%
Week 13	Monday, April 03, 2023	DHCP	Chapter 16 *Maintaining the Network)*	Lab 11 - DHCP	3.0%
Week 14	Monday, April 10, 2023	NAT	Chapter 17 *(Troubleshooting Fundamentals of a Network)*	Lab 12 - NAT	3.0%
Week 15	Monday, April 17, 2023	Final Test		Final Test (Test 2)	32%

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Review - Lecture 05 – Routing

- Layer 3 / Routing
- Interface Addressing
- Default Gateway
- IP Addressing
- Routers
- Router Configuration
- Lab

Summary   -   Inter VLAN Routing

- Inter-VLAN Routing
  - What is inter-VLAN routing
    - Legacy Inter-VLAN Routing
    - Router on a Stick
    - Layer 3 Switches
  - Troubleshoot Inter-VLAN Routing
    - legacy inter-VLAN routing
    - Router on a Stick
    - Layer 3 Switch Configuration Issues
  - Troubleshooting general tools
- Lab

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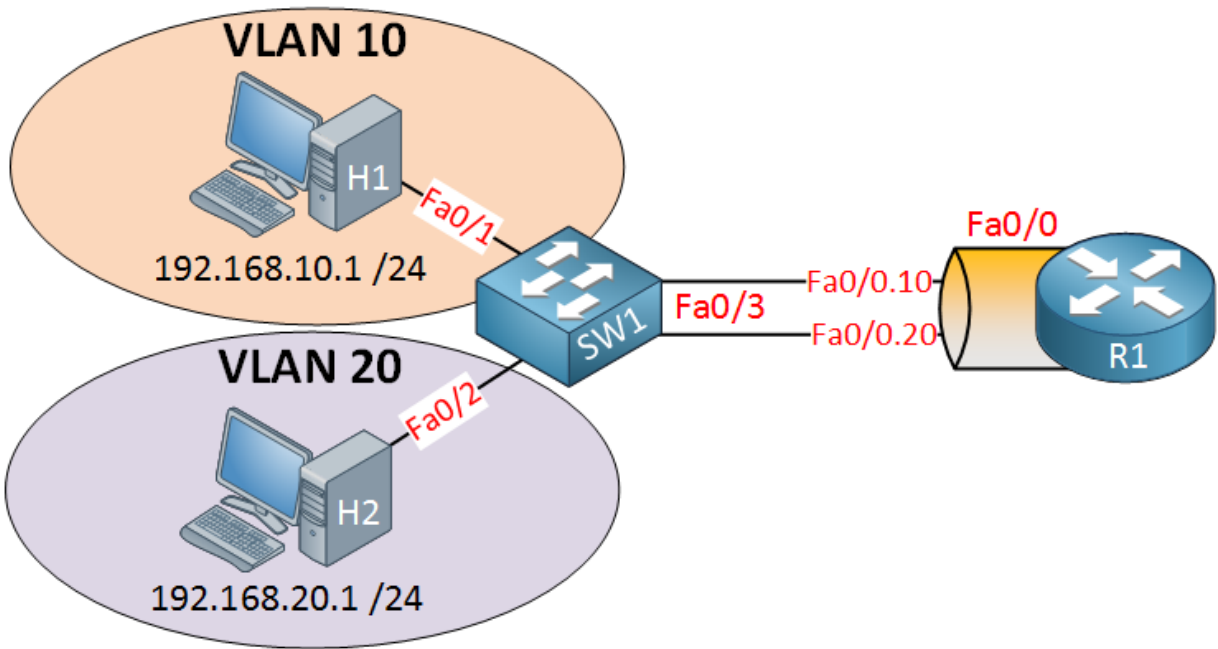
Inter-VLAN Routing

- ## 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
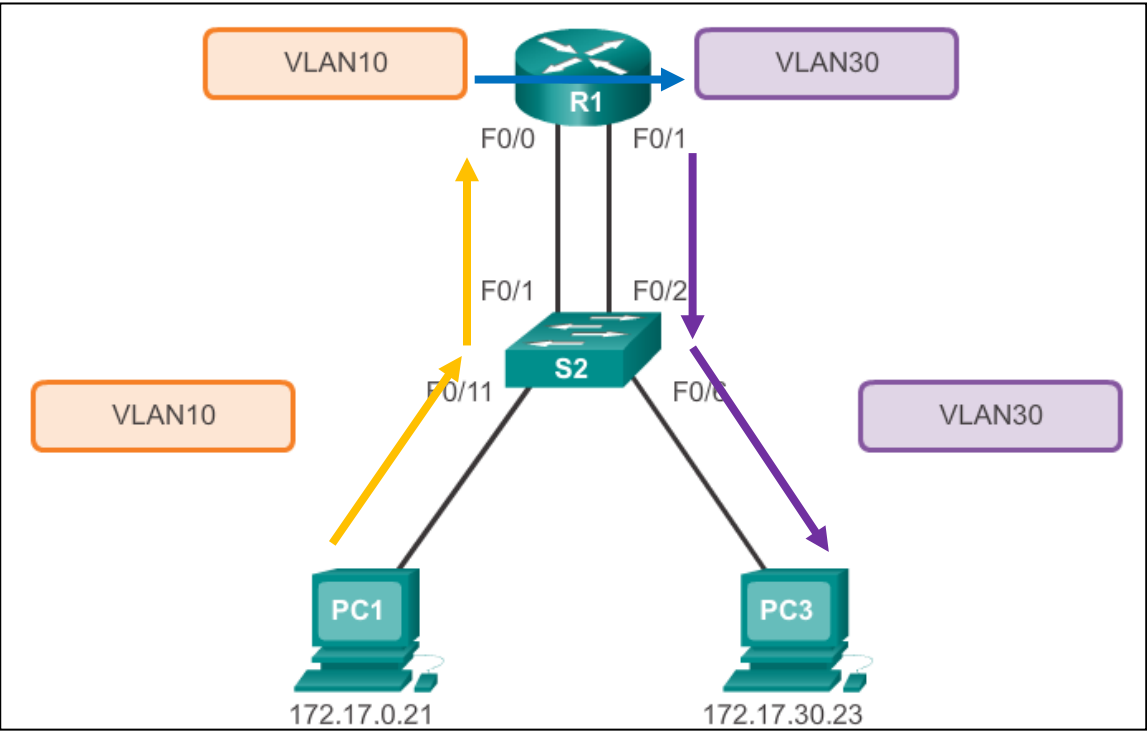
Routing
**MAC addresses striped**

Passed to the IP, layer 3

IP addresses looked up in the routing table

Passed back to layer 2

New source and destination MAC addresses assigned

Inter-VLAN Routing (continued)

- There are **three** methods of routing between VLANs
  - One router port is connected to a port in each VLAN (**legacy**)

  - **Router on a stick** (trunk between a switch and a router)

  - Switch **Layer 3 Routing**

4 separate Ethernet ports/cables one for each Vlan
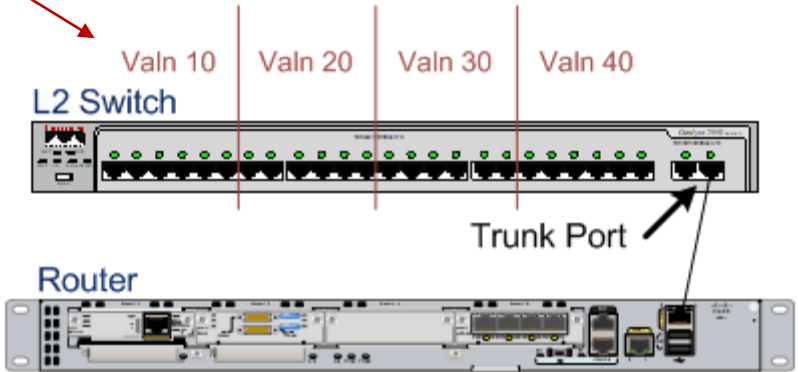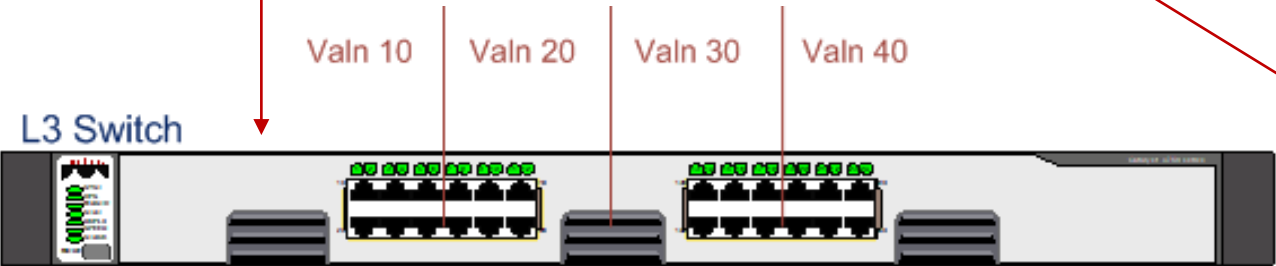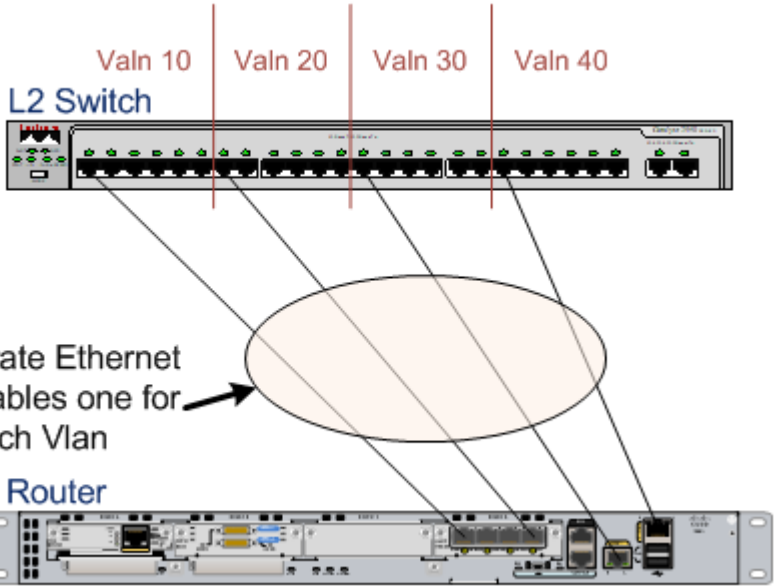
Inter-VLAN Routing (continued)

- Legacy Inter-VLAN Routing
  - The router has one physical port for each VLAN
  - Each router port has an IP address for the VLAN
    - Router is default gateway for the each of the VLAN

Inter-VLAN Routing (continued)

- ## Legacy Inter-VLAN Routing (continued)

Router looks up 172.17.30.0 network – port F0/1

Router sends out packet through F0/1 to switchport F0/2
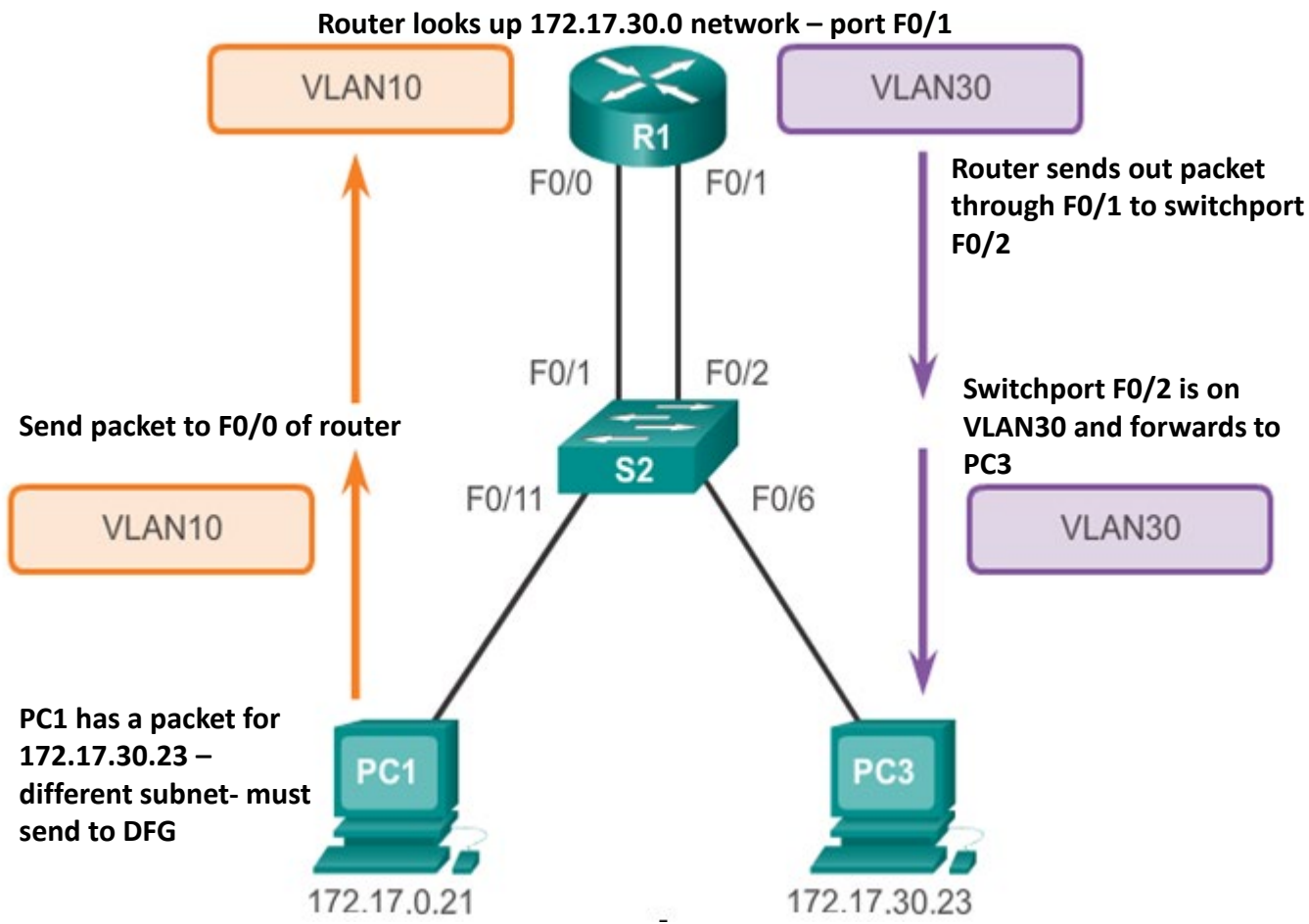
Send packet to F0/0 of router

Switchport F0/2 is on VLAN30 and forwards to PC3

PC1 has a packet for 172.17.30.23 – different subnet- must send to DFG
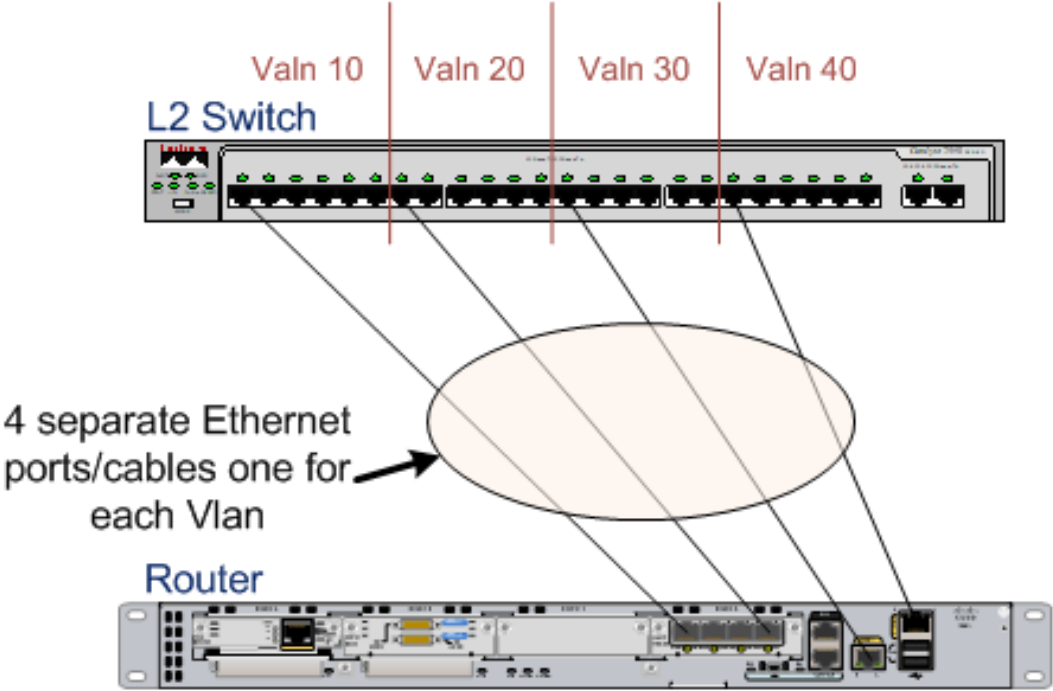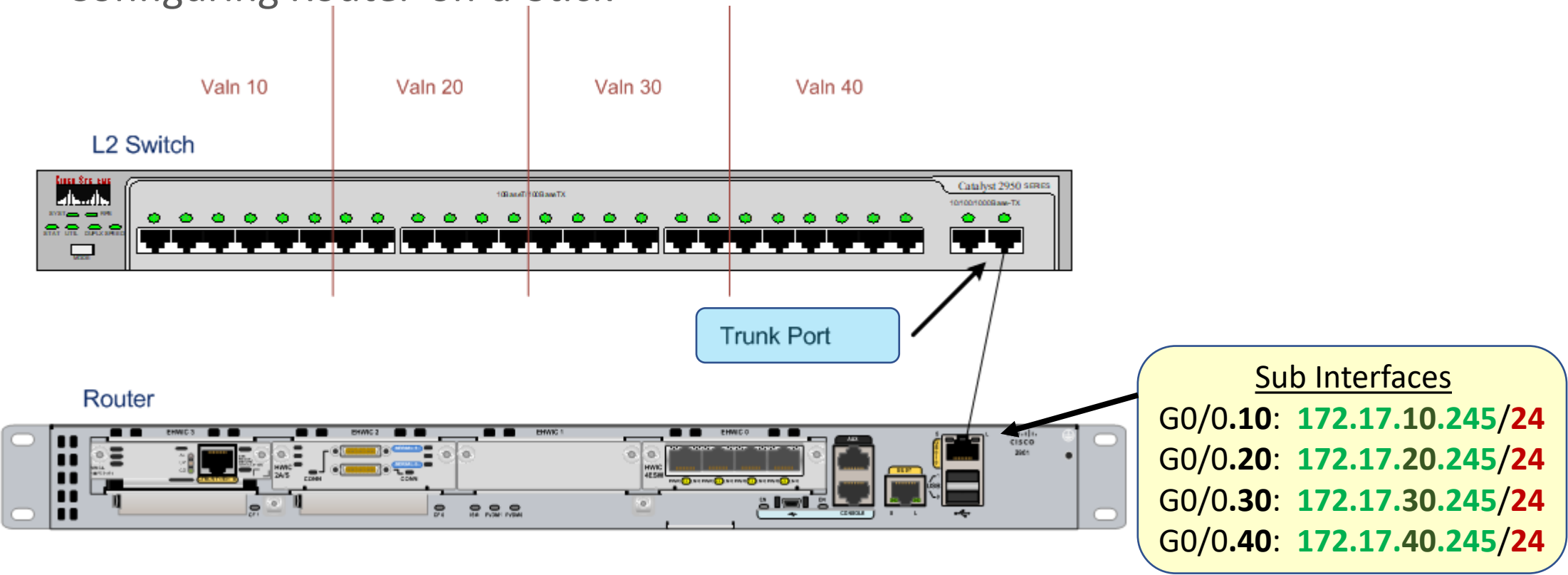
```
R1(config)# interface g0/0
R1(config-if)# ip address 172.17.10.1 255.255.255.0
R1(config-if)# no shutdown
*Mar 20 01:42:12.951: %LINK-3-UPDOWN: Interface GigabitEthernet0/0,
changed state to up
*Mar 20 01:42:13.951: %LINEPROTO-5-UPDOWN: Line protocol on Interface
GigabitEthernet0/0, changed state 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
R1#show ip route        changed state to up
        172.17.0.0/24 is subnetted, 2 subnets
C       172.17.30.0 is directly connected, FastEthernet0/1
C       172.17.10.0 is directly connected, FastEthernet0/0
```

```
S1(config)# vlan 10
S1(config-vlan)# vlan 30
S1(config-vlan)# interface f0/11
S1(config-if)# switchport access vlan 10
S1(config-if)# interface f0/4
S1(config-if)# switchport access vlan 10
S1(config-if)# interface f0/6
S1(config-if)# switchport access vlan 30
S1(config-if)# interface f0/5
S1(config-if)# switchport access vlan 30
S1(config-if)# end
*Mar 20 01:22:56.751: %SYS-5-CONFIG_I: Configured from console by
console
S1# copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
```

Inter-VLAN Routing (continued)

- Router on a Stick
  - Configuring Router-on-a-Stick

Sub Interfaces
G0/0.**10**: 172.17.10.245/24
G0/0.**20**: 172.17.20.245/24
G0/0.**30**: 172.17.30.245/24
G0/0.**40**: 172.17.40.245/24

Inter-VLAN Routing (continued)

- Router on a Stick (continued)
  - A trunk link can be connected to a router interface
    - trunk link can be used to carry data from several VLANs to the same router interface
    - Routers do not know what a "TRUNK" is....!
      - logical sub-interfaces are created on the router interface
      - each sub-interface is given an IP address
      - These sub-interfaces are linked back to the VLANs with the command
        - **encapsulation dot1q X** (where "**X**" is the VLAN number in the trunk)
  - One sub-interface is assigned to each VLAN
    - each with its own IP address and is the default gateway for the VLAN
  - All frames sent across the trunk link to the router are **tagged** to identify the VLAN
    - 802.1q tag link back to

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Inter-VLAN Routing (continued)

- Router on a Stick (continued)
  - Sub interfaces
    - Think of a "Sub-Interfaces" as a virtual interface
    - Sub-interfaces take the interface name followed by a dot and a number
    - It is normal to use the VLAN number after the dot
      - E.g. interface fa0/0.**10**
    - The sub-interfaces each have an IP address within the network range and becomes the default gateway for the VLAN
    - The physical interface has no IP address
    - The physical interfaces needs a **no shutdown** command to bring it up or else nothing will work!

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Inter-VLAN Routing (continued)

- ## Router on a Stick (continued)

 - ### Configuring Router-on-a-Stick (continued)

```
Router>en
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface f0/0.10
Router(config-subif)#encapsulation dot1q 10
Router(config-subif)#ip address 172.16.10.254 255.255.255.0
Router(config-subif)#interface f0/0.20
Router(config-subif)#encapsulation dot1q 20
Router(config-subif)#ip address 172.16.20.254 255.255.255.0
Router(config-subif)#interface f0/0.30
Router(config-subif)#encapsulation dot1q 30
Router(config-subif)#ip address 172.16.30.254 255.255.255.0
Router(config-subif)#interface f0/0.40
Router(config-subif)#encapsulation dot1q 40
Router(config-subif)#ip address 172.16.40.254 255.255.255.0
Router(config-subif)#interface f0/0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

%LINK-5-CHANGED: Interface FastEthernet0/0.10, changed state to up

%LINK-5-CHANGED: Interface FastEthernet0/0.20, changed state to up

%LINK-5-CHANGED: Interface FastEthernet0/0.30, changed state to up

%LINK-5-CHANGED: Interface FastEthernet0/0.40, changed state to up
```
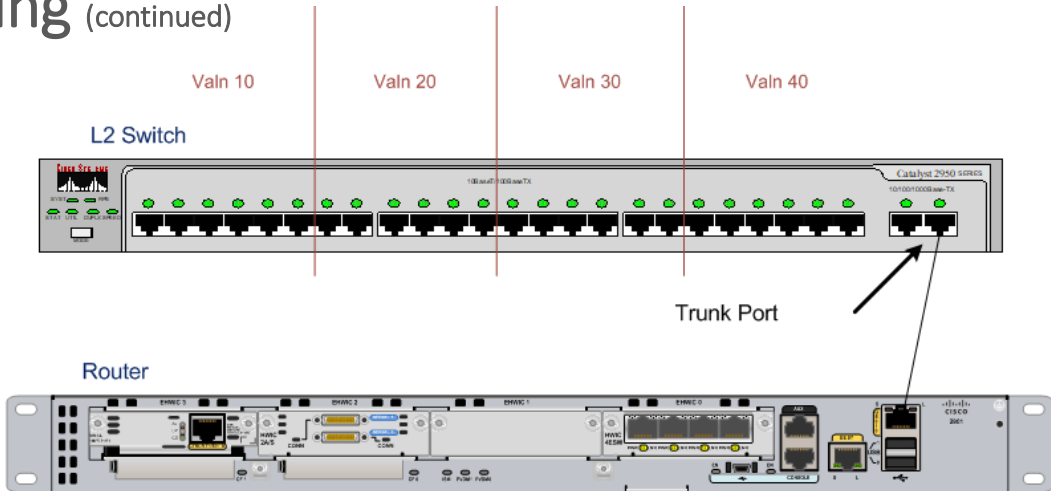
Valn 10   Valn 20   Valn 30   Valn 40

L2 Switch

Trunk Port

Router

```
Switch>en
Switch#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#interface range f0/1 - 6
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#interface range f0/7 - 12
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#interface range f0/13 - 18
Switch(config-if-range)#switchport access vlan 30
Switch(config-if-range)#interface range f0/19 - 24
Switch(config-if-range)#switchport access vlan 40
Switch(config-if-range)#
Switch(config-if-range)#interface g0/1
Switch(config-if)#switchport mode trunk
```

```
Router#sh ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 4 subnets
C       172.16.10.0 is directly connected, FastEthernet0/0.10
C       172.16.20.0 is directly connected, FastEthernet0/0.20
C       172.16.30.0 is directly connected, FastEthernet0/0.30
C       172.16.40.0 is directly connected, FastEthernet0/0.40
```
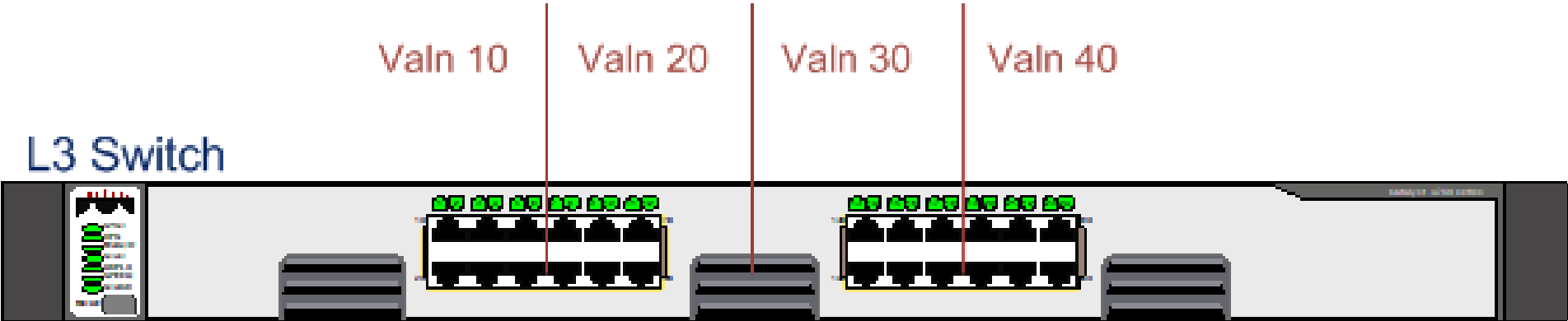
Inter-VLAN Routing (continued)

- Router on a Stick (continued)
  - Configuring Router-on-a-Stick (continued)
    - Sub interface Considerations
      - Routers have a limited number of interfaces, so sub-interfaces help where there are many VLANs
      - Sub-interfaces share the bandwidth on a physical interface so can cause bottlenecks
      - Cheaper to use sub-interfaces
      - Simpler physical layout but more complex configuration with sub-interfaces

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Inter-VLAN Routing (continued)

- Layer 3 Switching or Multilayer Switching

- Routing is built in
- Routing is faster
- No keeping track of interfaces or sub-interfaces on a router

Inter-VLAN Routing (continued)

- Layer 3 Switching or Multilayer Switching (continued)
  - Layer 3 switches usually have packet-switching through-puts in the millions of packets per second (pps)
  - All Catalyst multilayer switches support the following types of Layer 3 interfaces:
    - Routed port
    - Switch Virtual Interface (SVI)
  - High-performance switches, such as the Catalyst 6500 and Catalyst 4500, are able to perform most routing functions
  - Several models of Catalyst switches require enhanced software for specific routing protocol features
  - Today's routing has become faster and cheaper and can be performed at hardware speed
  - Routing can be transferred to core and distribution devices with little to no impact on network performance
  - Many users are in separate VLANs, and each VLAN is usually a separate subnet. This implies that each distribution switch must have IP addresses matching each access switch VLAN.
  - Layer 3 (routed) ports are normally implemented between the distribution and the core layer. This model is less dependent on spanning tree, because there are no loops in the Layer 2 portion of the topology.

Inter-VLAN Routing (continued)

- ## Layer 3 Switching or Multilayer Switching (continued)

```
Switch>en
Switch#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 10
Switch(config-vlan)#name students
Switch(config-vlan)#vlan 20
Switch(config-vlan)#name faculty
Switch(config-vlan)#vlan 30
Switch(config-vlan)#name RandD
Switch(config-vlan)#vlan 40
Switch(config-vlan)#name acounting
Switch(config-vlan)#inter range f0/1 - 6
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#inter range f0/7 - 12
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#inter range f0/13 - 18
Switch(config-if-range)#switchport access vlan 30
Switch(config-if-range)#inter range f0/19 - 24
Switch(config-if-range)#switchport access vlan 40
Switch(config-if-range)#interface vlan 10
Switch(config-if)#no shutdown
Switch(config-if)#interface vlan 20
Switch(config-if)#no shutdown
Switch(config-if)#interface vlan 30
Switch(config-if)#no shutdown
Switch(config-if)#interface vlan 40
Switch(config-if)#no shutdown
Switch(config-if)#interface g0/1
Switch(config-if)#switchport mode trunk

Switch(config-if)#
%LINK-5-CHANGED: Interface Vlan10, changed state to up

%LINK-5-CHANGED: Interface Vlan20, changed state to up

%LINK-5-CHANGED: Interface Vlan30, changed state to up

%LINK-5-CHANGED: Interface Vlan40, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to down

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan10, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan20, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan30, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan40, changed state to up
```
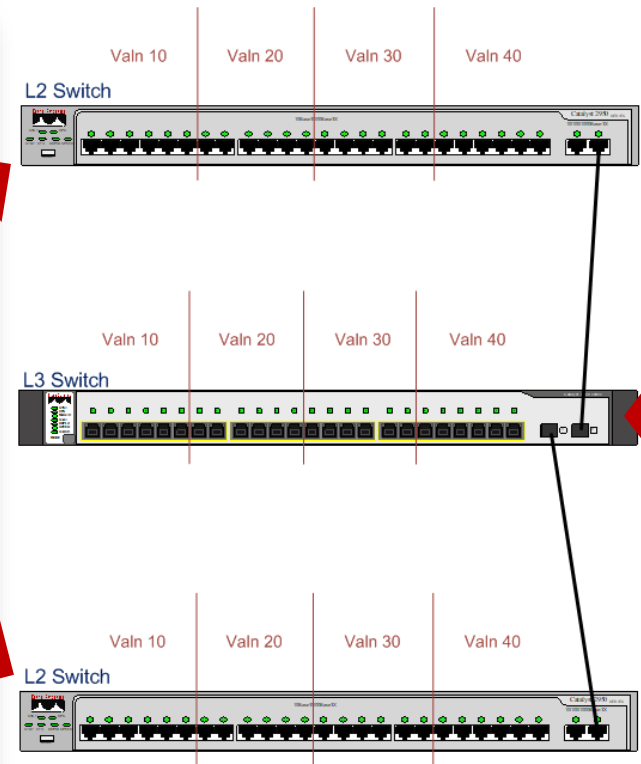
L2 Switch

Valn 10   Valn 20   Valn 30   Valn 40

L3 Switch

Valn 10   Valn 20   Valn 30   Valn 40

L2 Switch

Valn 10   Valn 20   Valn 30   Valn 40

```
Switch#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 4 subnets
C       172.16.10.0 is directly connected, Vlan10
C       172.16.20.0 is directly connected, Vlan20
C       172.16.30.0 is directly connected, Vlan30
C       172.16.40.0 is directly connected, Vlan40
```

```
Switch>en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#ip routing
Switch(config)#vlan 10
Switch(config-vlan)#name students
Switch(config-vlan)#vlan 20
Switch(config-vlan)#name faculty
Switch(config-vlan)#vlan 30
Switch(config-vlan)#name RandD
Switch(config-vlan)#vlan 40
Switch(config-vlan)#name acounting
Switch(config-vlan)#inter range f0/1 - 6
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#inter range f0/7 - 12
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#inter range f0/13 - 18
Switch(config-if-range)#switchport access vlan 30
Switch(config-if-range)#inter range f0/19 - 24
Switch(config-if-range)#switchport access vlan 40
Switch(config-if-range)#interface vlan 10
Switch(config-if)#ip address 172.16.10.254 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#interface vlan 20
Switch(config-if)#ip address 172.16.20.254 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#interface vlan 30
Switch(config-if)#ip address 172.16.30.254 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#interface vlan 40
Switch(config-if)#ip address 172.16.40.254 255.255.255.0
Switch(config-if)#no shutdown
Switch(config-if)#interface g0/1
Switch(config-if)#switchport trunk encapsulation dot1q
Switch(config-if)#switchport mode trunk
Switch(config-if)#interface g0/2
Switch(config-if)#switchport trunk encapsulation dot1q
Switch(config-if)#switchport mode trunk

%LINK-5-CHANGED: Interface Vlan10, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan10, changed state to up

%LINK-5-CHANGED: Interface Vlan20, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan20, changed state to up

%LINK-5-CHANGED: Interface Vlan30, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan30, changed state to up

%LINK-5-CHANGED: Interface Vlan40, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan40, changed state to up
```

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Inter-VLAN Routing (continued)

- ## Layer 3 Switching or Multilayer Switching (continued)

  - A layer 3 switch has a routing function built into the switch software
    - Both switching and a routing software in one device. (enterprise software)
  - The multilayer switch must have ip routing enabled
  - On a L3 switch each VLAN can have a virtual IP address assigned which can connect it to the router logic

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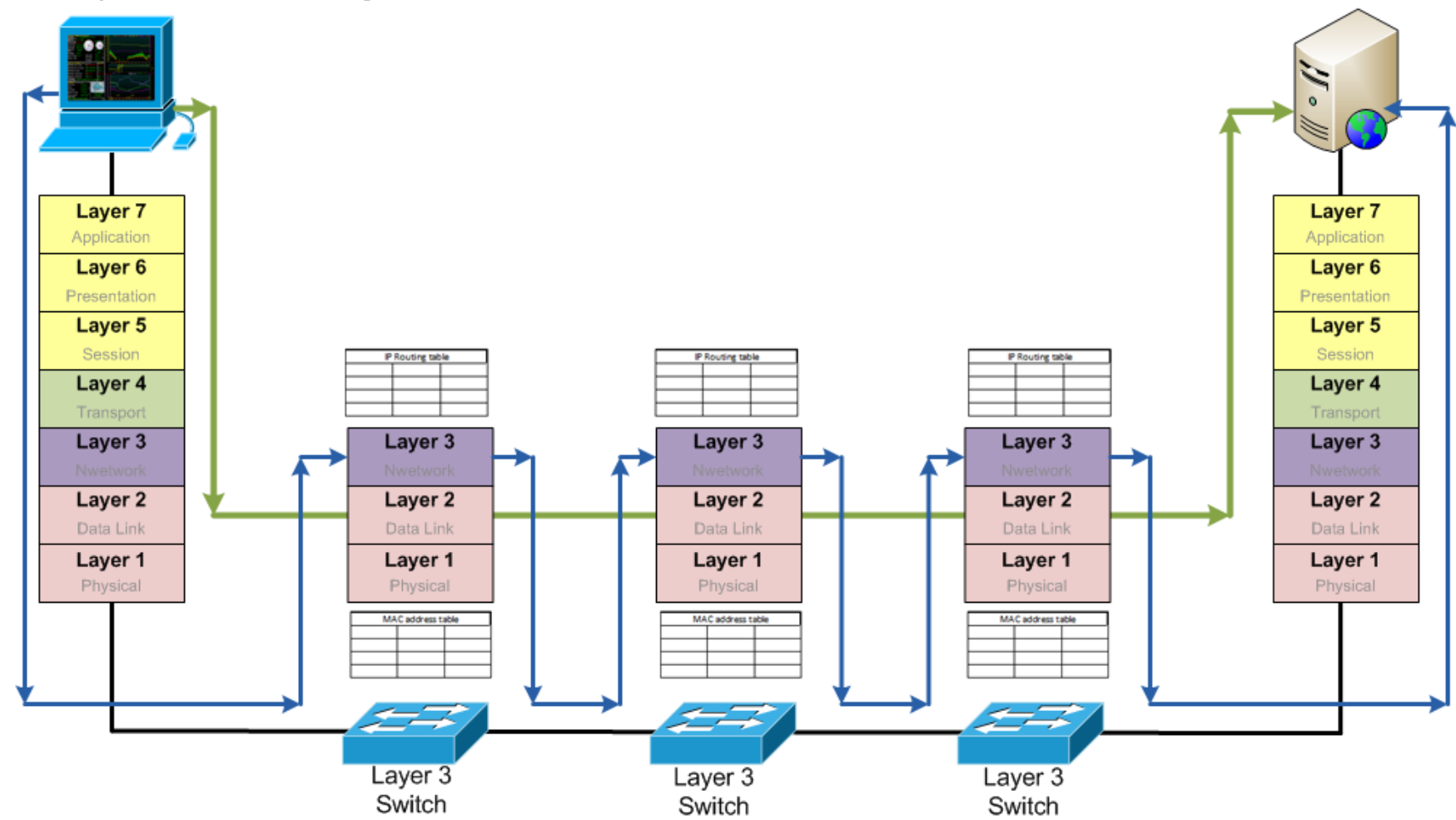
Inter-VLAN Routing (continued)

- Layer 3 Switching or Multilayer Switching (continued)
  - By default, an SVI is created for the default VLAN (VLAN 1). This allows for remote switch administration.
  - Any additional SVIs must be created by the administrator.
  - SVIs are created the first time the VLAN interface configuration mode is entered for a particular VLAN SVI.
  - Enter the **interface VLAN 10** command to create an SVI named VLAN 10.
  - The VLAN number used corresponds to the VLAN tag associated with data frames on an 802.1Q encapsulated trunk.
  - When the SVI is created, ensure that the specific VLAN is present in the VLAN database.
  - **SVIs advantages include:**
    - Much faster than router-on-a-stick, because everything is hardware-switched and routed.
    - No need for external links from the switch to the router for routing.
    - Not limited to one link. Layer 2 Ether Channels can be used between the switches to get more bandwidth.
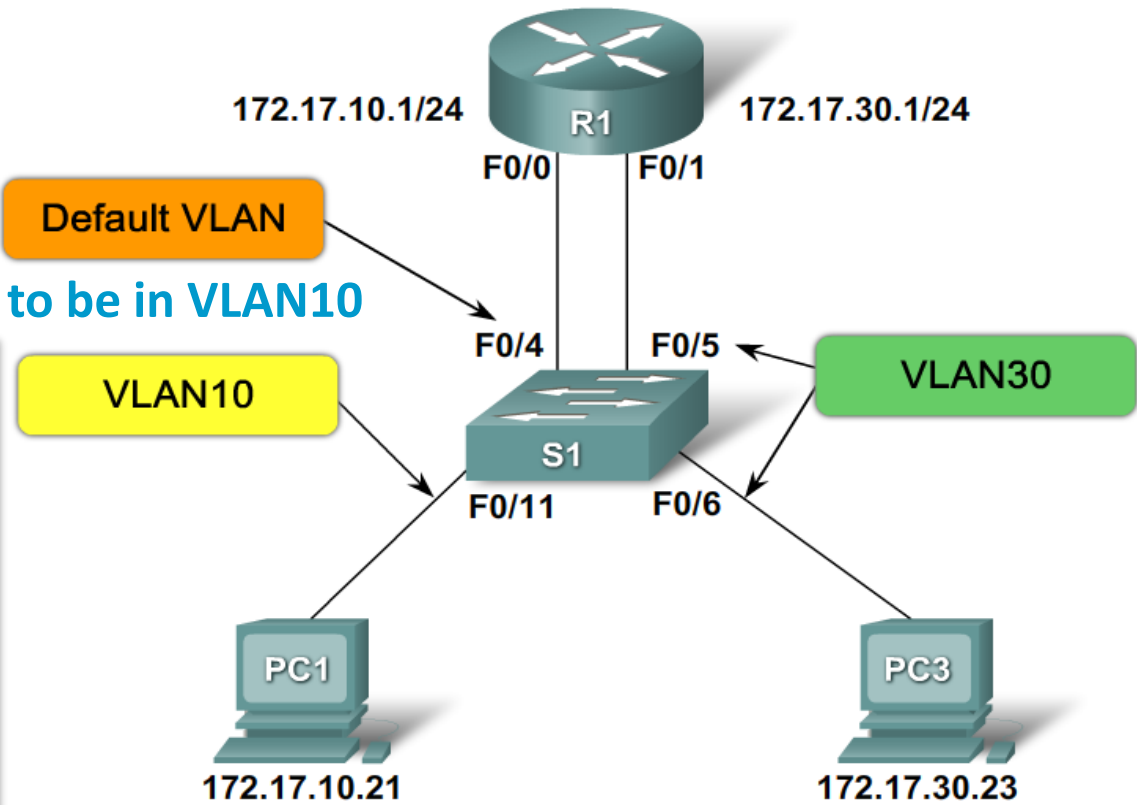   - Latency is much lower, because it does not need to leave the switch.

Inter-VLAN Routing (continued)

- Troubleshoot Inter-VLAN Routing
  - legacy
  - Common Issues

Switch Configuration Issues

Fa0/4 needs to be in VLAN10


```
S1#show interfaces fastEthernet 0/4 switchport
Name: Fa0/4
Switchport: Enabled
Administrative Mode: static access
Operational Mode: up
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
<Output omitted>
S1#
```

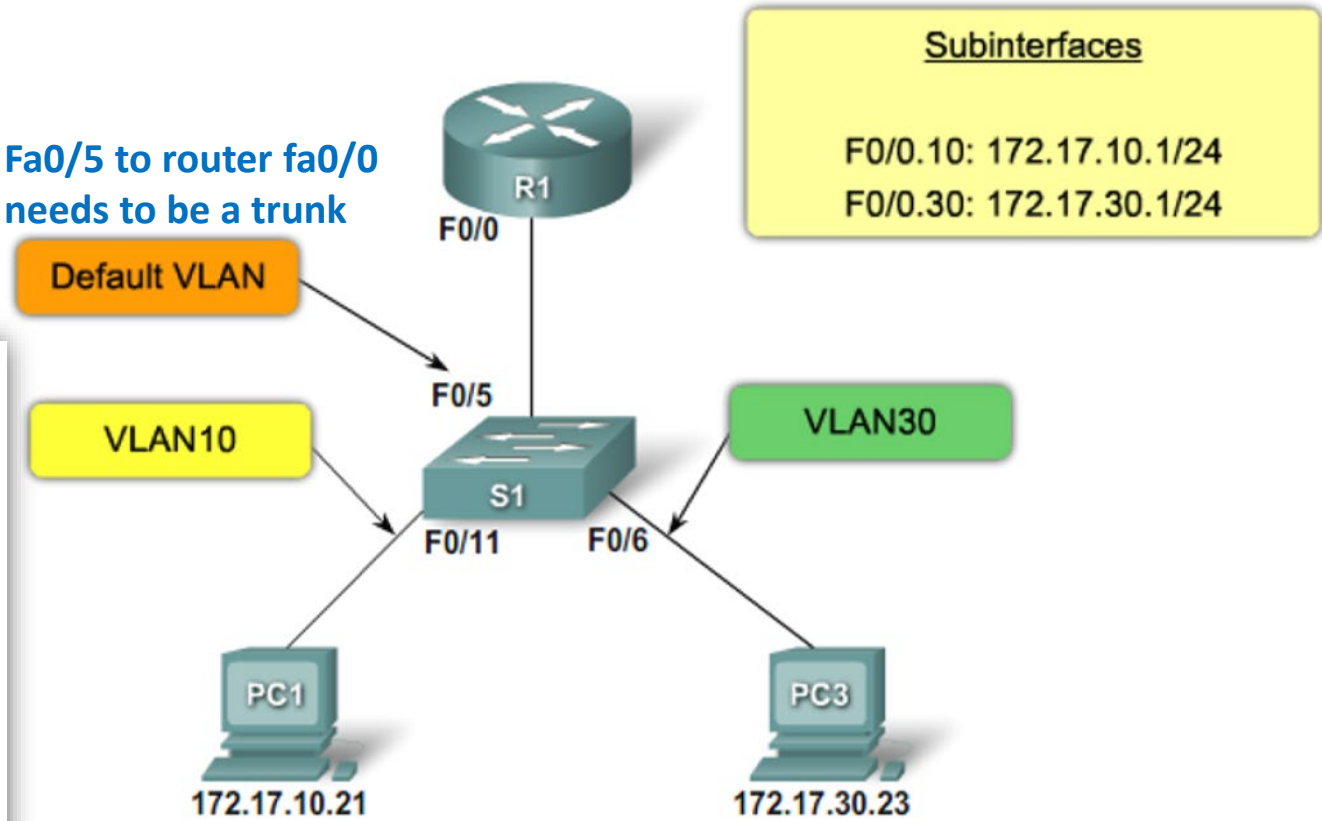**FANSHAWE**

Inter-VLAN Routing (continued)

- Troubleshoot Inter-VLAN Routing (continued)
  - legacy inter-VLAN routing (continued)
  - Common Inter-VLAN Issues (continued)
    - When using legacy inter-VLAN routing, ensure that the router has the correct IP address and mask on the interfaces connecting to the switch (in the same network)
    - Ensure that the network devices are configured with the correct IP address and mask (in the same network)
    - Use **show ip interface brief** command to verify correct IP address configured

Inter-VLAN Routing (continued)

- Troubleshoot Inter-VLAN Routing (continued)
  - Router on a Stick
  - Trunk Configuration Issue

Fa0/5 to router fa0/0 needs to be a trunk


```
Switch#show interface f0/5 switchport
Name: Fa0/5
Switchport: Enabled
Administrative Mode: static access
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
<output Truncated>


Switch#sh runn
Building configuration...
<output Truncated>
!
interface FastEthernet0/5
 switchport mode access
!
<output Truncated>
```

Inter-VLAN Routing (continued)

- Troubleshoot Inter-VLAN Routing (continued)
  - Layer 3 Switch Configuration Issues
    - To troubleshoot Layer 3 switching issues, verify the following for accuracy:
      - **VLANs**
        - VLANs must be defined across all the switches
        - VLANs must be enabled on the trunk ports
        - Ports must be in the right VLANs
          - **show VLAN**
      - **SVIs**
        - SVIs must have the correct IP address and subnet mask
        - SVIs must be up (no shut)
        - SVIs must match with the VLAN number
          - **show ip interface brief**

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Inter-VLAN Routing (continued)

- Troubleshoot Inter-VLAN Routing (continued)
  - Layer 3 Switch Configuration Issues (continued)
    - **Routing**
      - Routing must be enabled
   - Each interface or network should be added to the routing protocol, if used. (RIP, EIGRP, OSPF, ect…)
    - **Hosts**
      - Hosts must have the correct IP address or subnet mask
      - Hosts must have a default gateway associated with an SVI or routed port

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Inter-VLAN Routing (continued)

- Troubleshooting general tools
  - Check physical connections
    - **show cdp neighbours**
  - Check switchport VLAN assignment
    - **show VLAN**
  - Check trunking on switches
    - **show interface trunk**
  - Check IP addressing and subnetting scheme in relation to VLANs
    - **show ip interface brief**
 - Check router sub-interface configuration
    - **show ip interface brief**

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LAB

Router on a stick 6.1
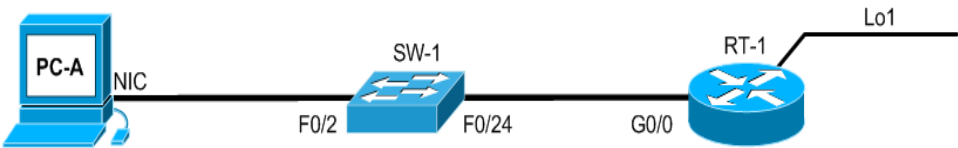
Device	interface	IP Address	Subnet Mask	Default Gateway	Ports	Vlan name
RT-1	G0/0	no address				
	G0/0.10	192.168.10.254	/24			
		2001:db8:acad:10::254	/64			
	G0/0.20	192.168.20.254	/24			
		2001:db8:acad:10::254	/64			
	G0/0.30	192.168.30.254	/24			
		2001:db8:acad:10::254	/64			
	G0/0.99	192.168.1.254	/24			
		2001:db8:acad:1::254	/64			
	Lo1	10.10.10.10	/32			
		2001:db8:acad:50:10:10:10:10	/128			
SW-1	Vlan 10				1 - 6	Student
	Vlan 20				7 - 12	Faculty
	Vlan 30				13 - 18	Server
	Vlan 99	192.168.1.253	/24	192.168.1.254	19 - 23	Mgmt
	Trunk				24	
PC-A	NIC					

Legacy 6.2
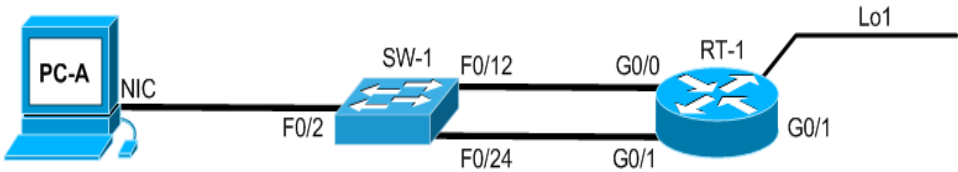
Device	Interface	IP Address	Subnet Mask	Default Gateway	Ports	Vlan name
RT-1	G0/0	192.168.10.254	/24			
		2001:db8:acad:10::254	/64			
	G0/1	192.168.20.254	/24			
		2001:db8:acad:20::254	/64			
	Lo1	10.10.10.10	/32			
		2001:db8:acad:50:10:10:10:10	/128			
SW-1	Vlan 10				1 - 12	Student
	Vlan 20				12 -24	Faculty
PC-A	NIC					
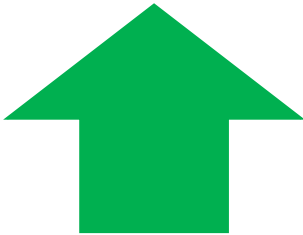
Do this part of the lab first!

Lab

- No PowerPoint file this week.

- Answers to be put into the PDF

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QUESTIONS

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