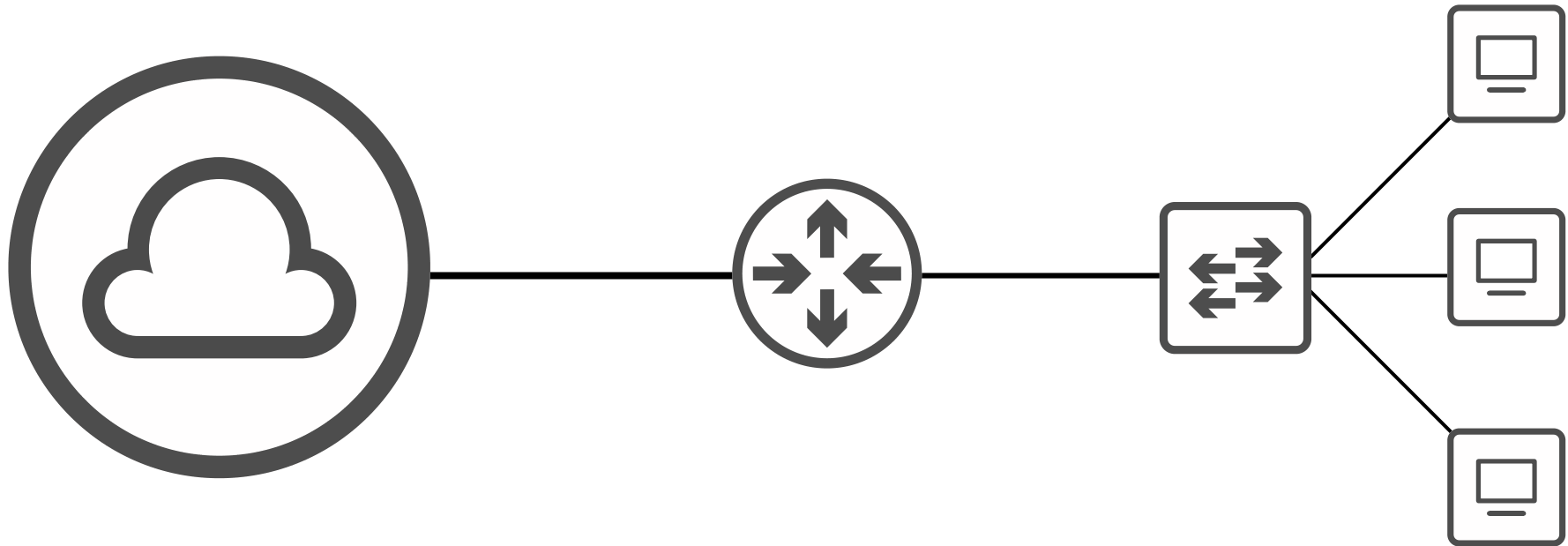




# CCNA 200-301 Day 17

## VLANs (Virtual Local Area Networks) Part 2

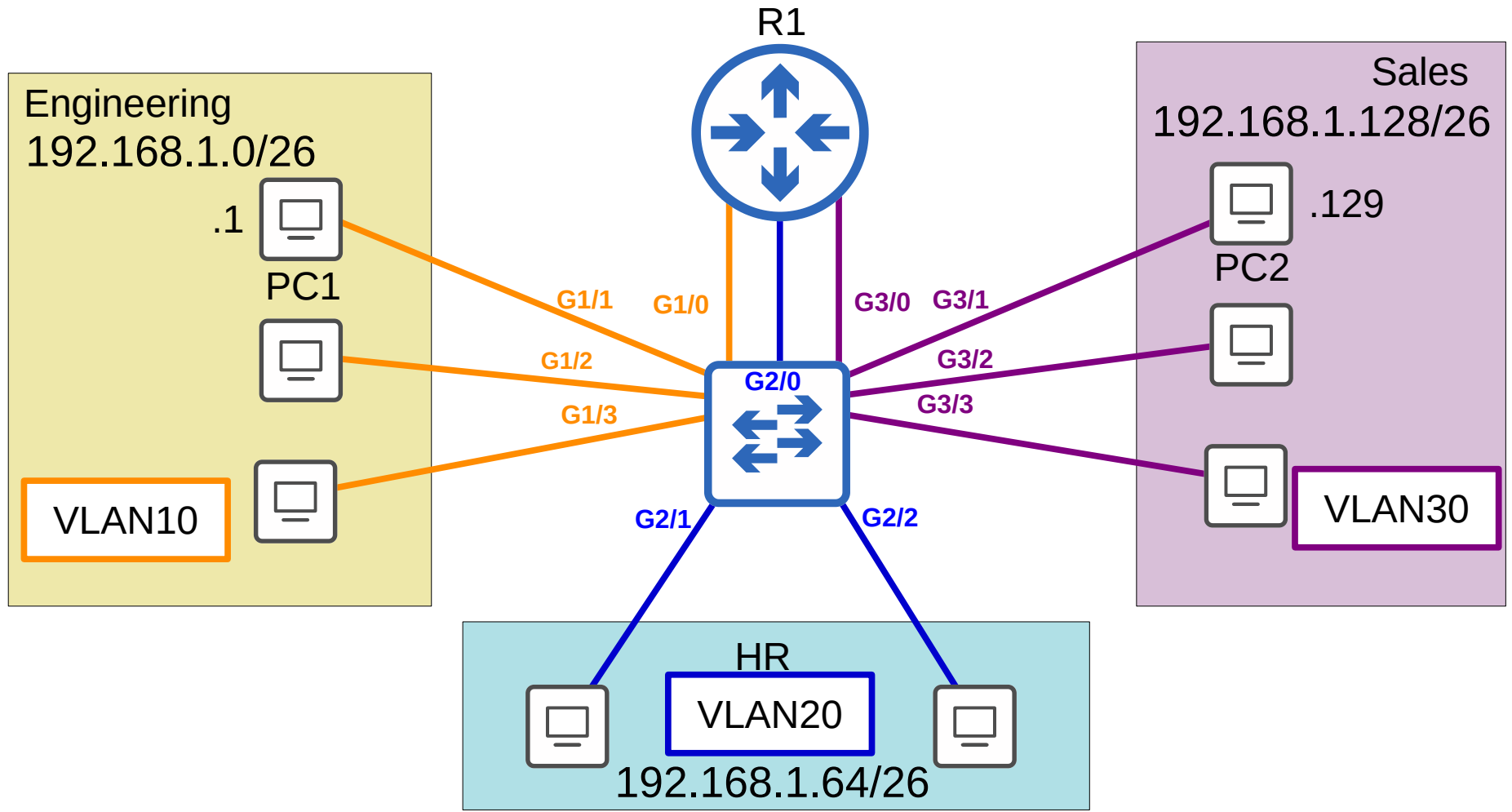


# Things we'll cover

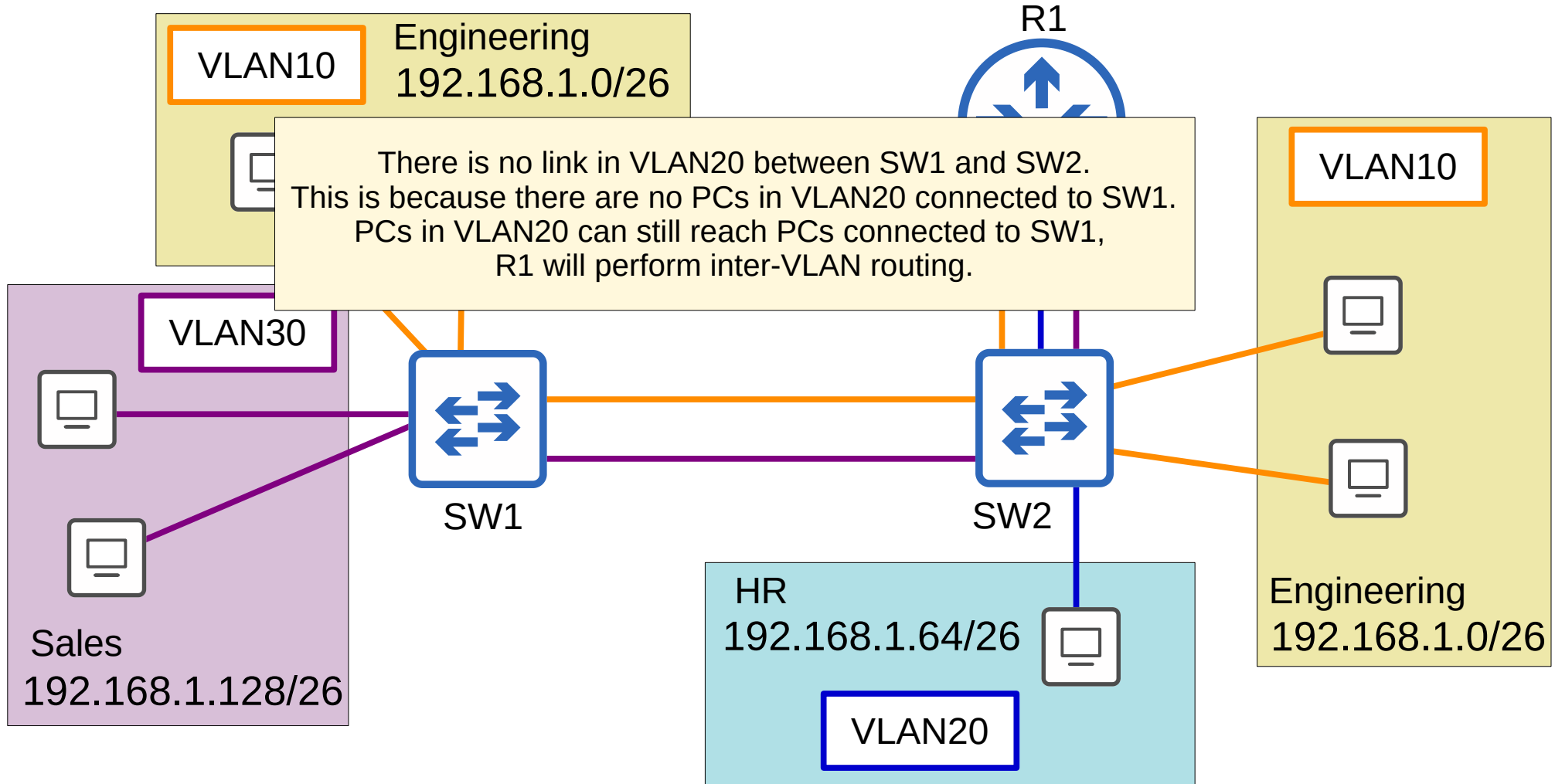
- What is a trunk port?
- What is the purpose of trunk ports?
- 802.1Q Encapsulation
- How to configure trunk ports
- 'Router on a Stick' (ROAS)



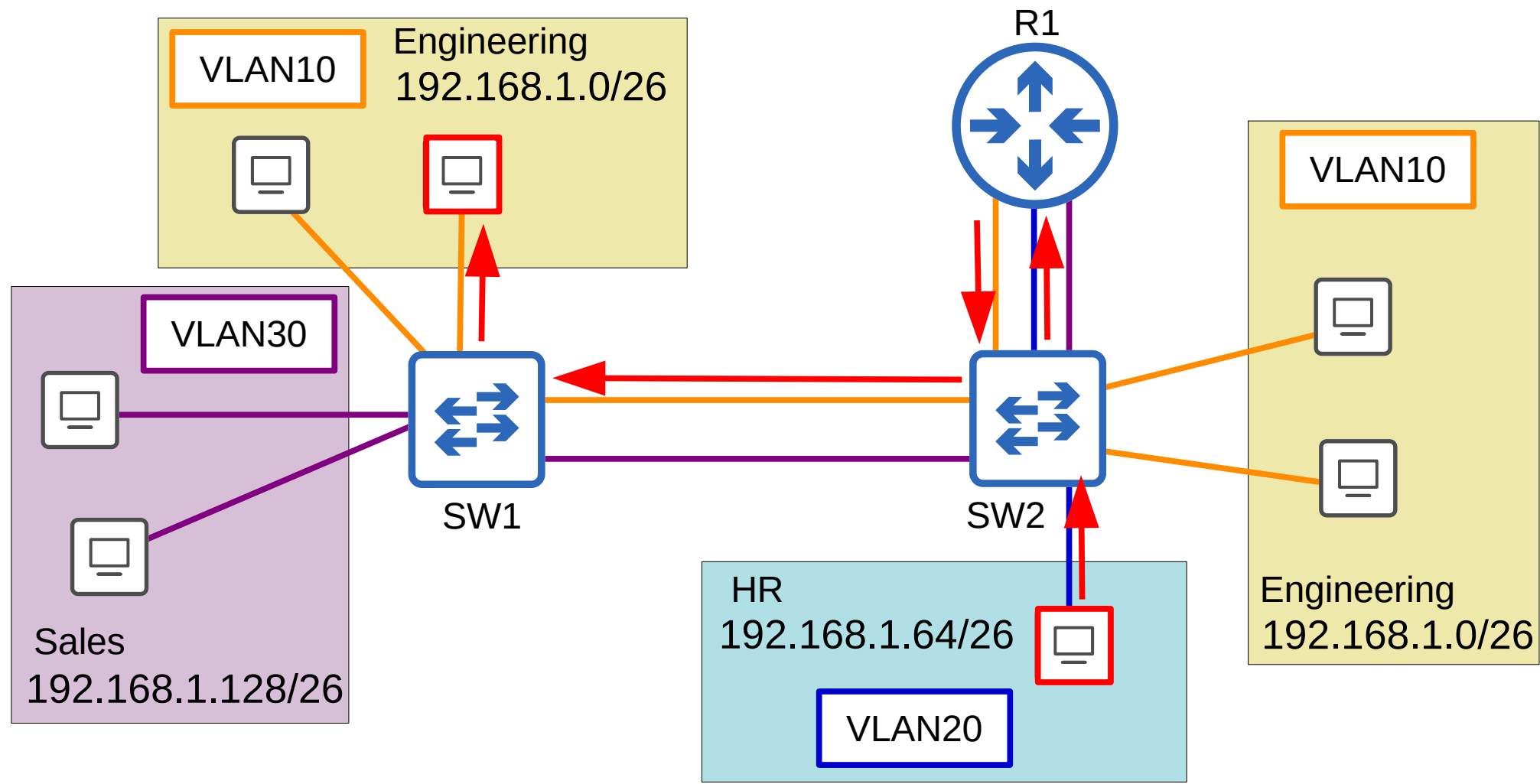
# VLANs



# Network Topology



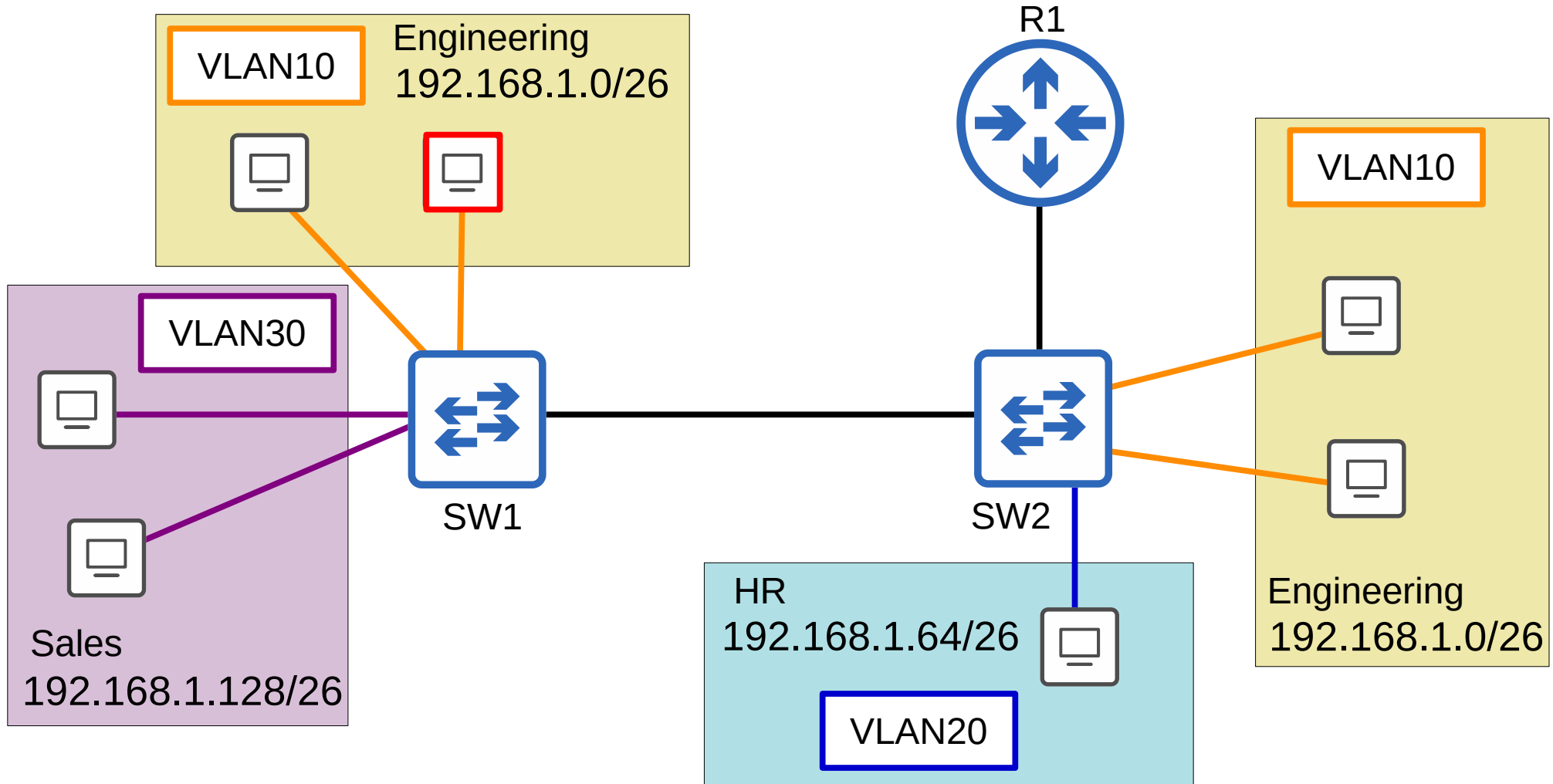
# Network Topology



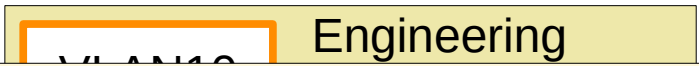
# Trunk Ports

- In a small network with few VLANs, it is possible to use a separate interface for each VLAN when connecting switches to switches, and switches to routers.
- However, when the number of VLANs increases, this is not viable. It will result in wasted interfaces, and often routers won't have enough interfaces for each VLAN.
- You can use **trunk ports** to carry traffic from multiple VLANs over a single interface.

# Trunk Ports

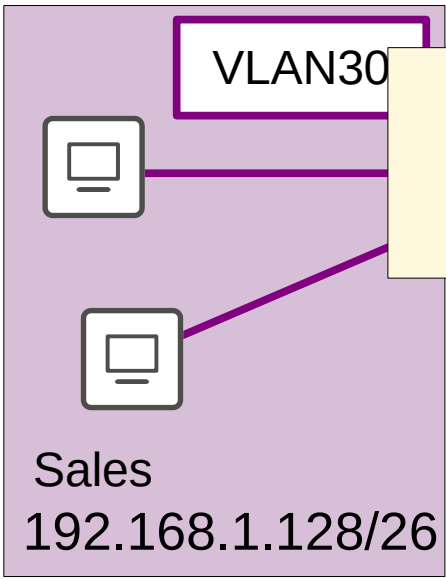
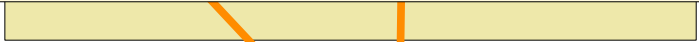


# Trunk Ports



R1

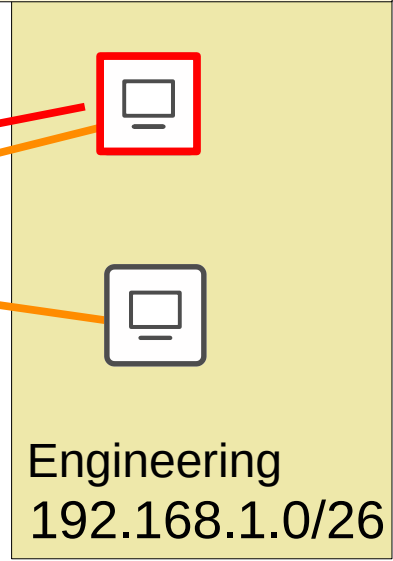
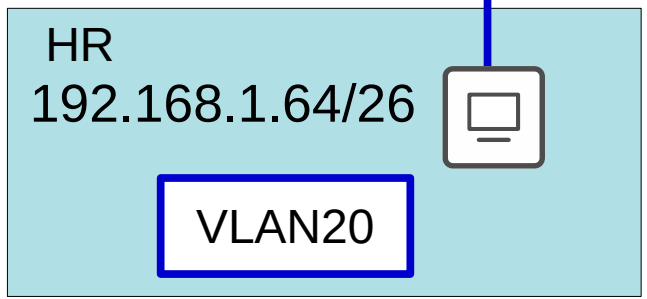
Switches will 'tag' all frames that they send over a trunk link. This allows the receiving switch to know which VLAN the frame belongs to.



Trunk ports = 'tagged' ports  
Access ports = 'untagged' ports


SW1

SW2

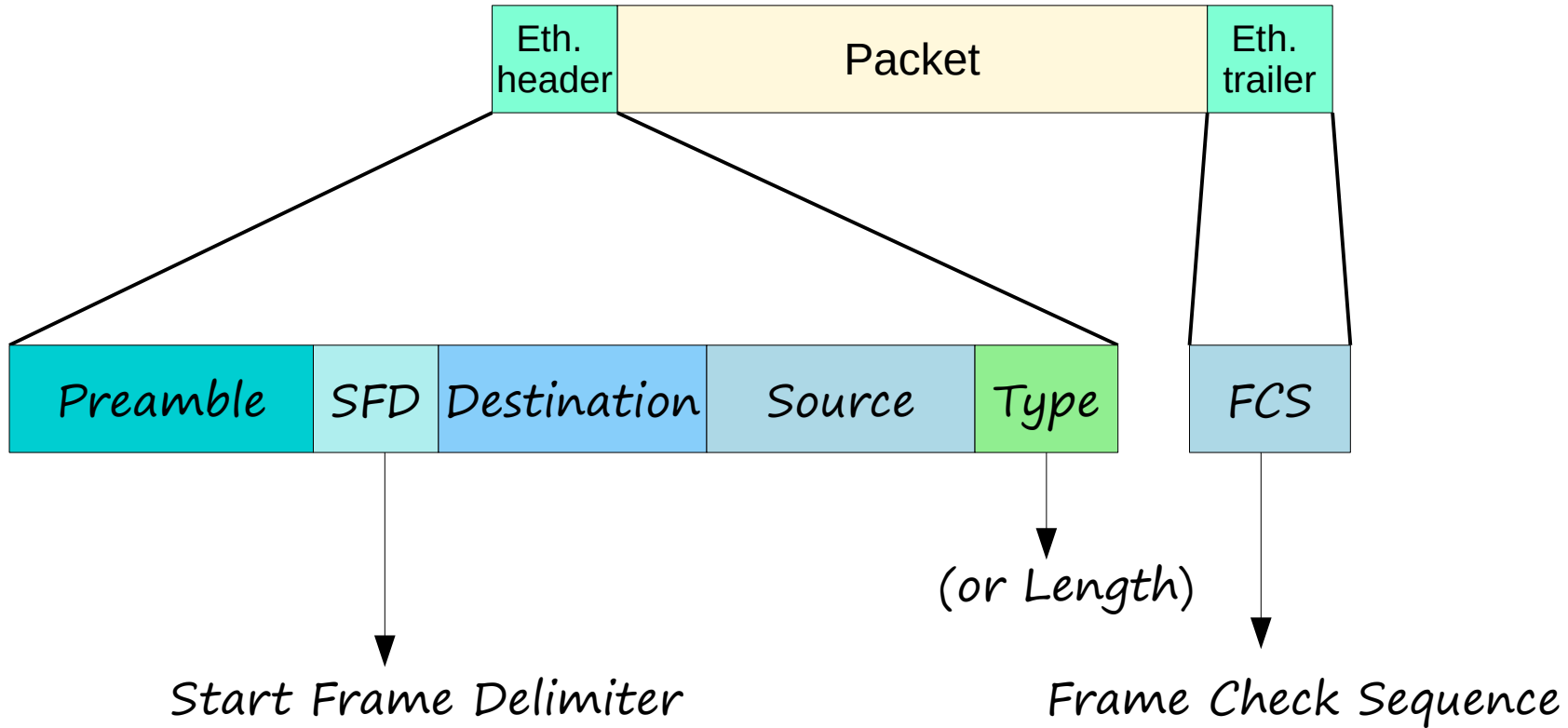




# VLAN Tagging

- There are two main trunking protocols: ISL (Inter-Switch Link) and IEEE 802.1Q. 
- ISL is an old Cisco proprietary protocol created before the industry standard IEEE 802.1Q.
- IEEE 802.1Q is an industry standard protocol created by the IEEE (Institute of Electrical and Electronics Engineers).
- You will probably NEVER use ISL in the real world. Even modern Cisco equipment doesn't support it. For the CCNA, you only need to learn 802.1Q.

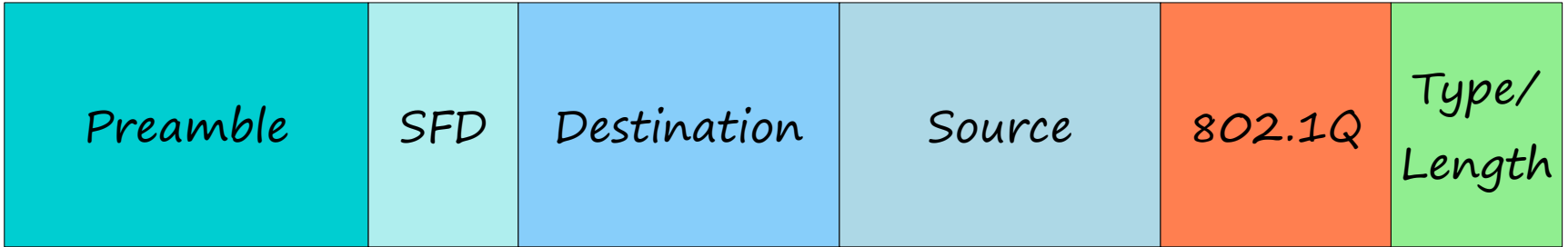
# Ethernet Frame



# Ethernet Header



# Ethernet Header w/ 802.1Q Tag





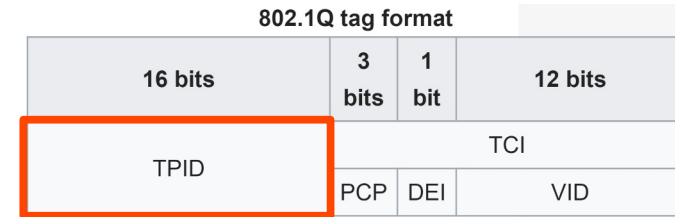
- The 802.1Q tag is inserted between the **Source** and **Type/Length** fields of the Ethernet frame.
- The tag is 4 bytes (32 bits) in length.
- The tag consists of two main fields:
  - Tag Protocol Identifier (TPID)
  - Tag Control Information (TCI)
- The TCI consists of three sub-fields.

## 802.1Q tag format

<b>16 bits</b>	<b>3 bits</b>	<b>1 bit</b>	<b>12 bits</b>
TPID	TCI		
	PCP	DEI	VID

# 802.1Q Tag – TPID (Tag Protocol Identifier)

- 16 bits (2 bytes) in length



- Always set to a value of 0x8100. This indicates that the frame is 802.1Q-tagged.

0x = hexadecimal

# 802.1Q Tag – PCP (Priority Code Point)

- 3 bits in length

802.1Q tag format

16 bits	3 bits	1 bit	12 bits
TPID	TCI		
	PCP	DEI	VID

- Used for Class of Service (CoS), which prioritizes important traffic in congested networks.



# 802.1Q Tag – DEI (Drop Eligible Indicator)

- 1 bit in length

802.1Q tag format

16 bits	3 bits	1 bit	12 bits
TPID	TCI		
	PCP	DEI	VID

- Used to indicate frames that can be dropped if the network is congested.

# 802.1Q Tag - VID (VLAN ID)

802.1Q tag format

16 bits	3 bits	1 bit	12 bits
TPID	TCI		
	PCP	DEI	VID

- 12 bits in length
- Identifies the VLAN the frame belongs to.
- 12 bits in length = 4096 total VLANs ( $2^{12}$ ), range of 0 - 4095
- VLANs 0 and 4095 are reserved and can't be used.
- Therefore, the actual range of VLANs is 1 – 4094
- Cisco's proprietary ISL also has a VLAN range of 1 - 4094

# 802.1Q Tag

## 802.1Q tag format

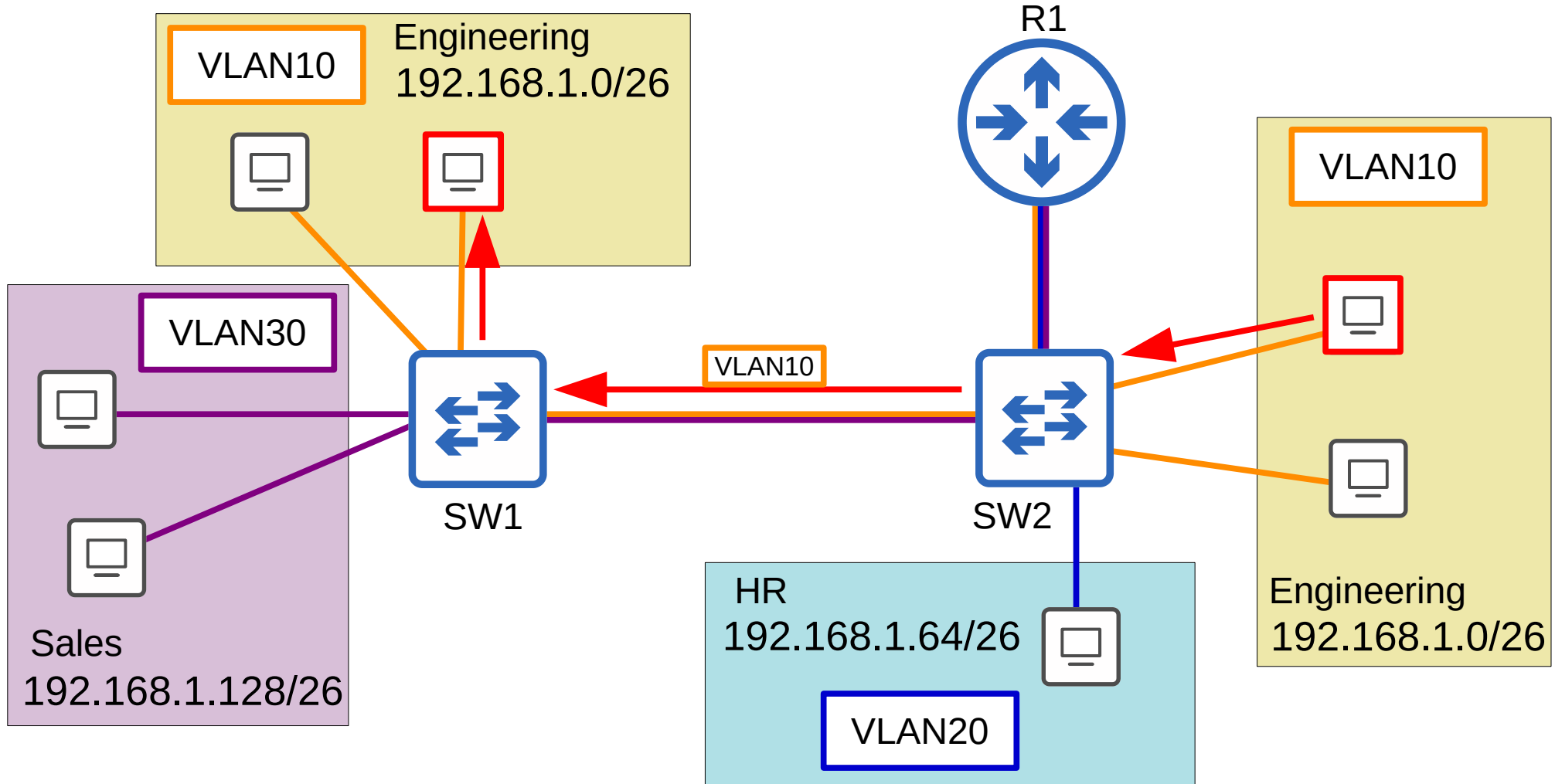
<b>16 bits</b>	<b>3 bits</b>	<b>1 bit</b>	<b>12 bits</b>
TPID	TCI		
	PCP	DEI	VID

[https://en.wikipedia.org/wiki/IEEE\\_802.1Q](https://en.wikipedia.org/wiki/IEEE_802.1Q)

# VLAN Ranges

- The range of VLANs (1 – 4094) is divided into two sections:
  - Normal VLANs: 1 – 1005
  - Extended VLANs: 1006 – 4094
- Some older devices cannot use the extended VLAN range, however it's safe to expect that modern switches will support the extended VLAN range.

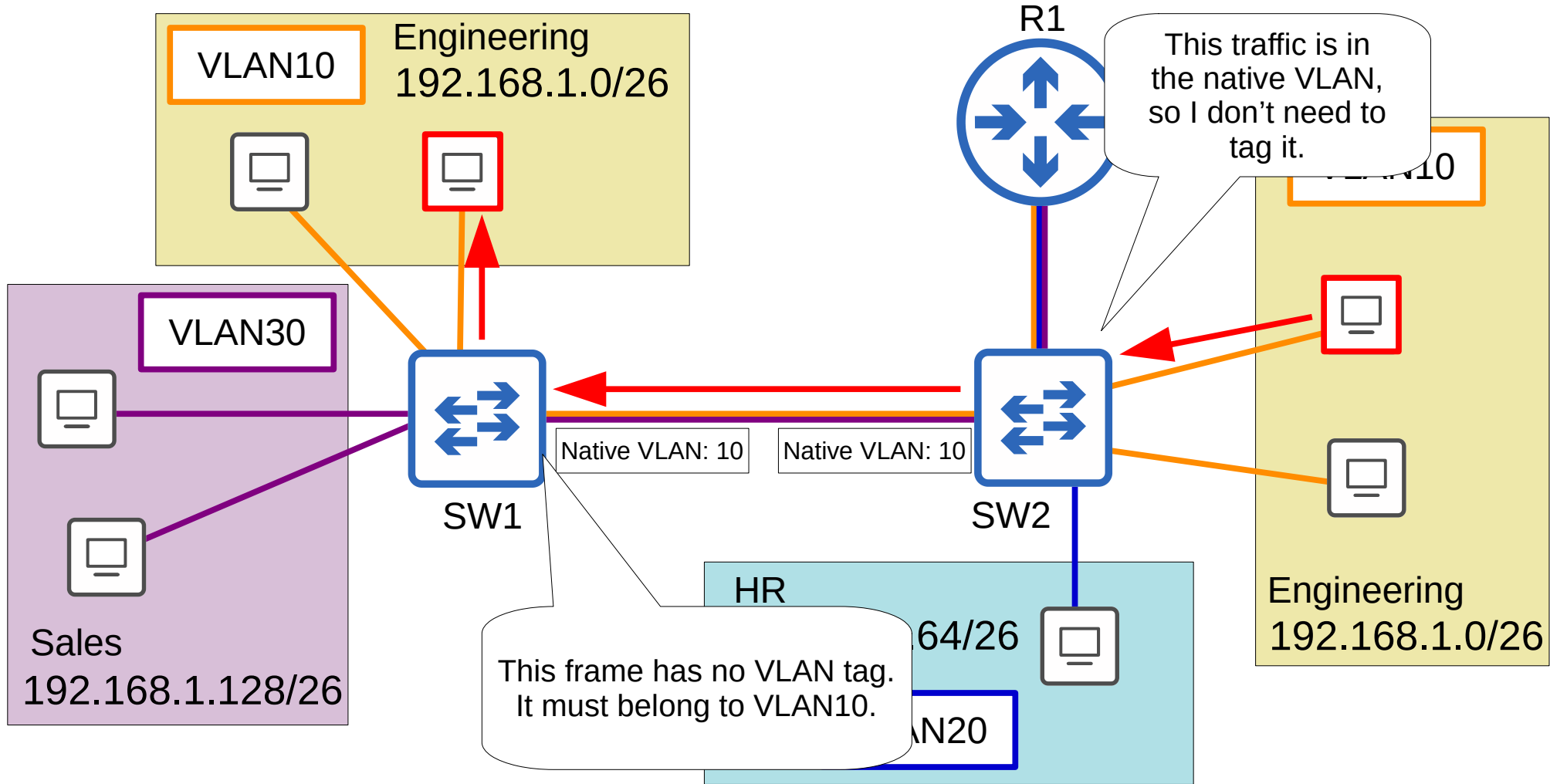
# Trunk Ports



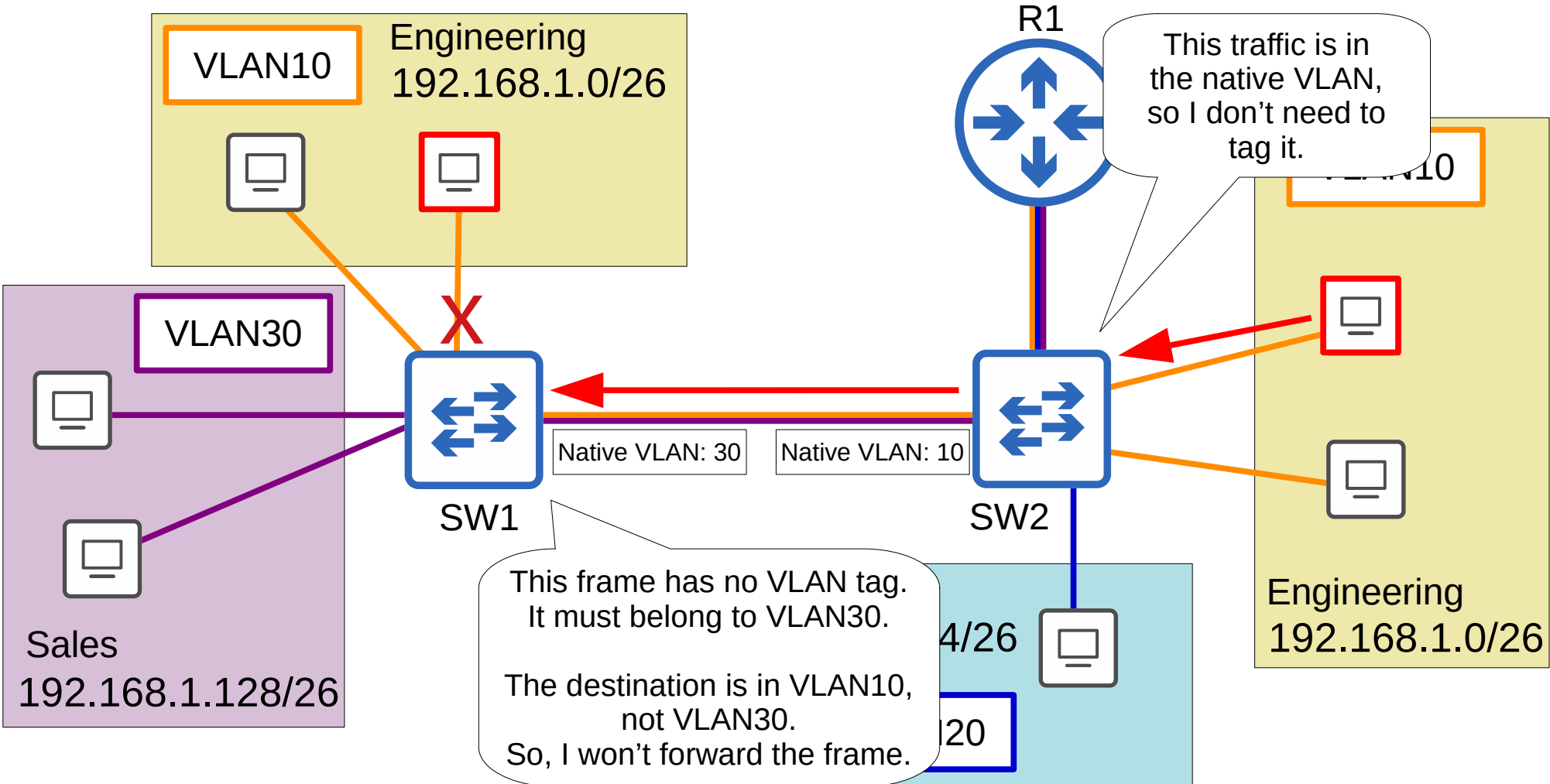
# Native VLAN

- 802.1Q has a feature called the **native VLAN**. (ISL does not have this feature)
- The native VLAN is VLAN 1 by default on all trunk ports, however this can be manually configured on each trunk port.
- The switch does not add an 802.1Q tag to frames in the native VLAN.
- When a switch receives an untagged frame on a trunk port, it assumes the frame belongs to the native VLAN.  
**It's very important that the native VLAN matches!**

# Trunk Ports

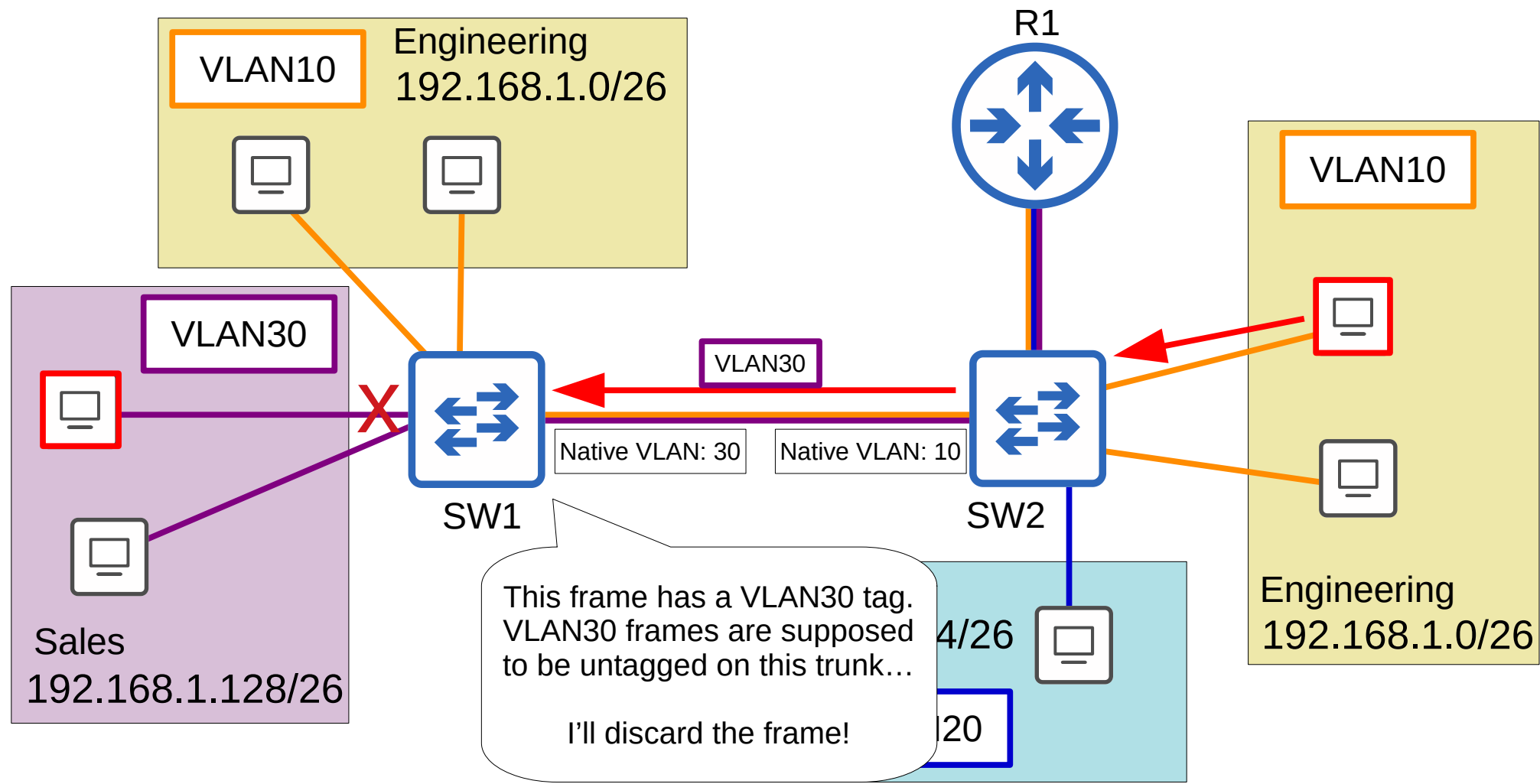


# Trunk Ports

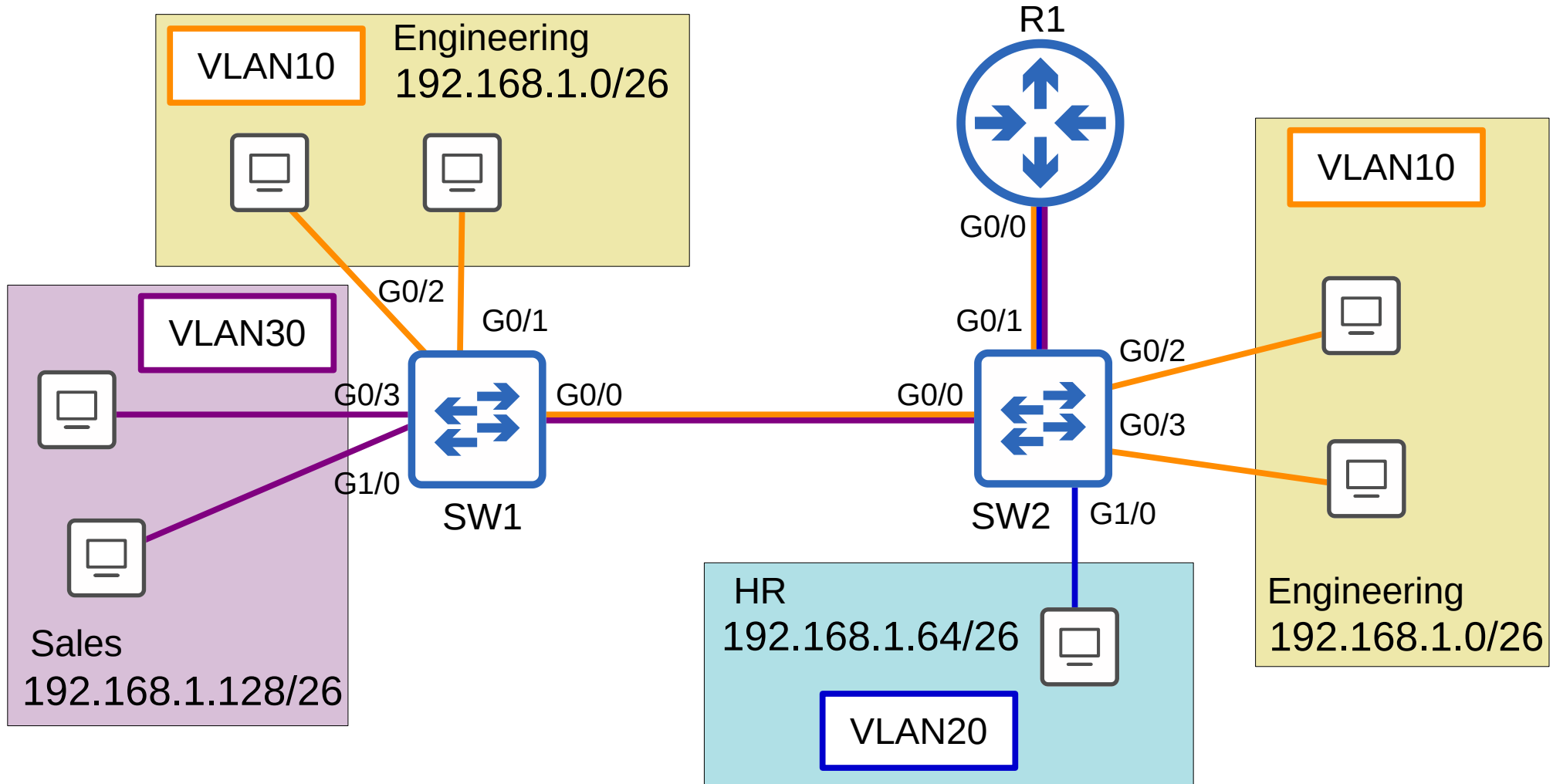




# Trunk Ports



# Trunk Configuration



# Trunk Configuration

```
SW1(config)#interface g0/0
SW1(config-if)#switchport mode trunk
Command rejected: An interface whose trunk encapsulation is "Auto" can not be configured to "trunk" mode.
SW1(config-if)#switchport trunk encapsulation ?
 dot1q      Interface uses only 802.1q trunking encapsulation when trunking
 isl        Interface uses only ISL trunking encapsulation when trunking
 negotiate  Device will negotiate trunking encapsulation with peer on
            interface
SW1(config-if)#switchport trunk encapsulation dot1q
SW1(config-if)#switchport mode trunk
SW1(config-if)#
```

- Many modern switches do not support Cisco's ISL at all. They only support 802.1Q (dot1q)
- However, switches that do support both (like the one I'm using in this example) have a trunk encapsulation of 'Auto' by default.
- To manually configure the interface as a trunk port, you must first set the encapsulation to 802.1Q or ISL. On switches that only support 802.1Q, this is not necessary.
- After you set the encapsulation type, you can then configure the interface as a trunk.

# Trunk Configuration

```
SW1#show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Gi0/0	1-4094

Port	Vlans allowed and active in management domain
Gi0/0	1,10,30

Port	Vlans in spanning tree forwarding state and not pruned
Gi0/0	1,10,30

```
SW1#
```

```
SW1#show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Gi1/1, Gi1/2, Gi1/3, Gi2/0 Gi2/1, Gi2/2, Gi2/3, Gi3/0 Gi3/1, Gi3/2, Gi3/3
10	ENGINEERING	active	Gi0/1, Gi0/2
30	SALES	active	Gi0/3, Gi1/0
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

```
SW1#
```

# Trunk Configuration

```
SW1(config)#int g0/0
SW1(config-if)#
SW1(config-if)#switchport trunk allowed vlan ?
WORD      VLAN IDs of the allowed VLANs when this port is in trunking mode
add       add VLANs to the current list
all       all VLANs
except    all VLANs except the following
none     no VLANs
remove    remove VLANs from the current list

SW1(config-if)#switchport trunk allowed vlan █
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan 10,30
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Gi0/0	10,30

Port	Vlans allowed and active in management domain
Gi0/0	10,30

Port	Vlans in spanning tree forwarding state and not pruned
Gi0/0	10,30

```
SW1(config-if)#
```

# Trunk Configuration

```
SW1(config)#int g0/0
SW1(config-if)#
SW1(config-if)#switchport trunk allowed vlan ?
WORD      VLAN IDs of the allowed VLANs when this port is in trunking mode
add       add VLANs to the current list
all       all VLANs
except    all VLANs except the following
none     no VLANs
remove    remove VLANs from the current list

SW1(config-if)#switchport trunk allowed vlan █
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan add 20
```

```
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

```
Port          Vlans allowed on trunk
```

```
Gi0/0         10,20,30
```

```
Port          Vlans allowed and active in management domain
```

```
Gi0/0         10,30
```

```
Port          Vlans in spanning tree forwarding state and not pruned
```

```
Gi0/0         10,30
```

```
SW1(config-if)#
```



# Trunk Configuration

```
SW1(config)#int g0/0
SW1(config-if)#
SW1(config-if)#switchport trunk allowed vlan ?
WORD      VLAN IDs of the allowed VLANs when this port is in trunking mode
add       add VLANs to the current list
all       all VLANs
except    all VLANs except the following
none     no VLANs
remove    remove VLANs from the current list

SW1(config-if)#switchport trunk allowed vlan █
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan remove 20  
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Gi0/0	10,30

Port	Vlans allowed and active in management domain
Gi0/0	10,30

Port	Vlans in spanning tree forwarding state and not pruned
Gi0/0	10,30

```
SW1(config-if)#
```

# Trunk Configuration

```
SW1(config)#int g0/0
SW1(config-if)#
SW1(config-if)#switchport trunk allowed vlan ?
WORD      VLAN IDs of the allowed VLANs when this port is in trunking mode
add       add VLANs to the current list
all       all VLANs
except    all VLANs except the following
none      no VLANs
remove    remove VLANs from the current list

SW1(config-if)#switchport trunk allowed vlan █
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan all
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

Port	Vlans allowed on trunk
Gi0/0	1-4094

Port	Vlans allowed and active in management domain
Gi0/0	1,10,30

Port	Vlans in spanning tree forwarding state and not pruned
Gi0/0	1,10,30

```
SW1(config-if)#
```

# Trunk Configuration

```
SW1(config)#int g0/0
SW1(config-if)#
SW1(config-if)#switchport trunk allowed vlan ?
WORD      VLAN IDs of the allowed VLANs when this port is in trunking mode
add       add VLANs to the current list
all       all VLANs
except   all VLANs except the following
none      no VLANs
remove    remove VLANs from the current list

SW1(config-if)#switchport trunk allowed vlan █
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan except 1-5,10
```

```
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

```
Port Vlans allowed on trunk
```

```
Gi0/0 6-9,11-4094
```

```
Port Vlans allowed and active in management domain
```

```
Gi0/0 30
```

```
Port Vlans in spanning tree forwarding state and not pruned
```

```
Gi0/0 30
```

```
SW1(config-if)#
```

# Trunk Configuration

```
SW1(config)#int g0/0
SW1(config-if)#
SW1(config-if)#switchport trunk allowed vlan ?
WORD      VLAN IDs of the allowed VLANs when this port is in trunking mode
add       add VLANs to the current list
all       all VLANs
except    all VLANs except the following
none     no VLANs
remove    remove VLANs from the current list

SW1(config-if)#switchport trunk allowed vlan █
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan none
```

```
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

```
Port          Vlans allowed on trunk  
Gi0/0         none
```

```
Port          Vlans allowed and active in management domain  
Gi0/0         none
```

```
Port          Vlans in spanning tree forwarding state and not pruned  
Gi0/0         none
```

```
SW1(config-if)#
```



# Trunk Configuration

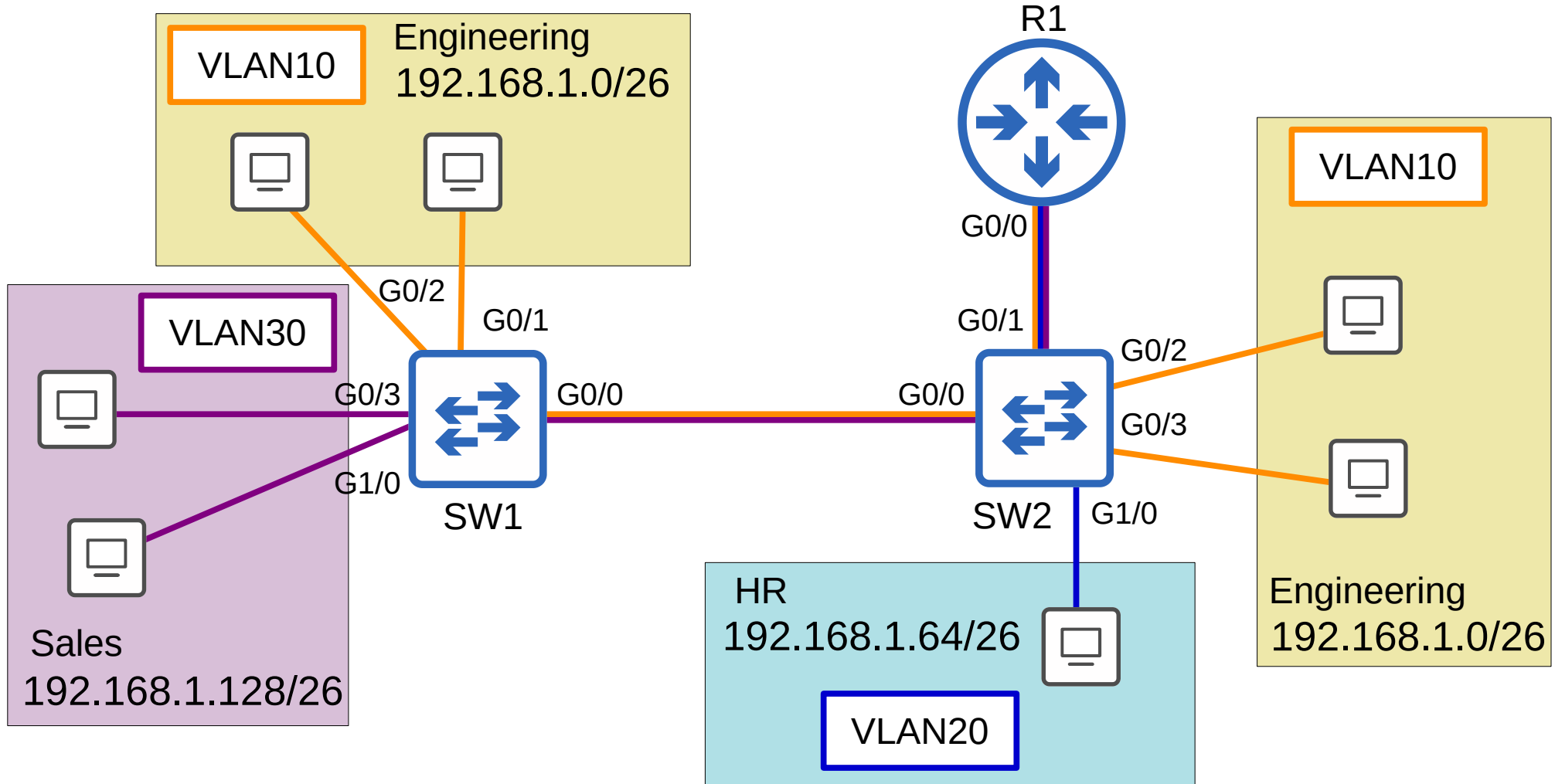
```
SW1#show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Gi1/1, Gi1/2, Gi1/3, Gi2/0 Gi2/1, Gi2/2, Gi2/3, Gi3/0 Gi3/1, Gi3/2, Gi3/3
10 ENGINEERING	active	Gi0/1, Gi0/2
30 SALES	active	Gi0/3, Gi1/0
1002 fddi-default	act/unsup	

The **show vlan brief** command shows the access ports assigned to each VLAN, NOT the trunk ports that allow each VLAN.

Use the **show interfaces trunk** command instead to confirm trunk ports.

# Trunk Configuration



# Trunk Configuration

```
SW1(config-if)#switchport trunk allowed vlan 10,30
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1

For security purposes, it is best to change the native VLAN to an **unused VLAN**.  
 (network security will be explained more in-depth later in the course)  
 \*\*Make sure the native VLAN matches on between switches\*\*

```
Port      Vlans allowed and active in management domain
Gi0/0     10,30
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Gi0/0     10,30
SW1(config-if)#
```

# Trunk Configuration

```
SW1(config-if)#switchport trunk native vlan 1001
```

```
SW1(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1001

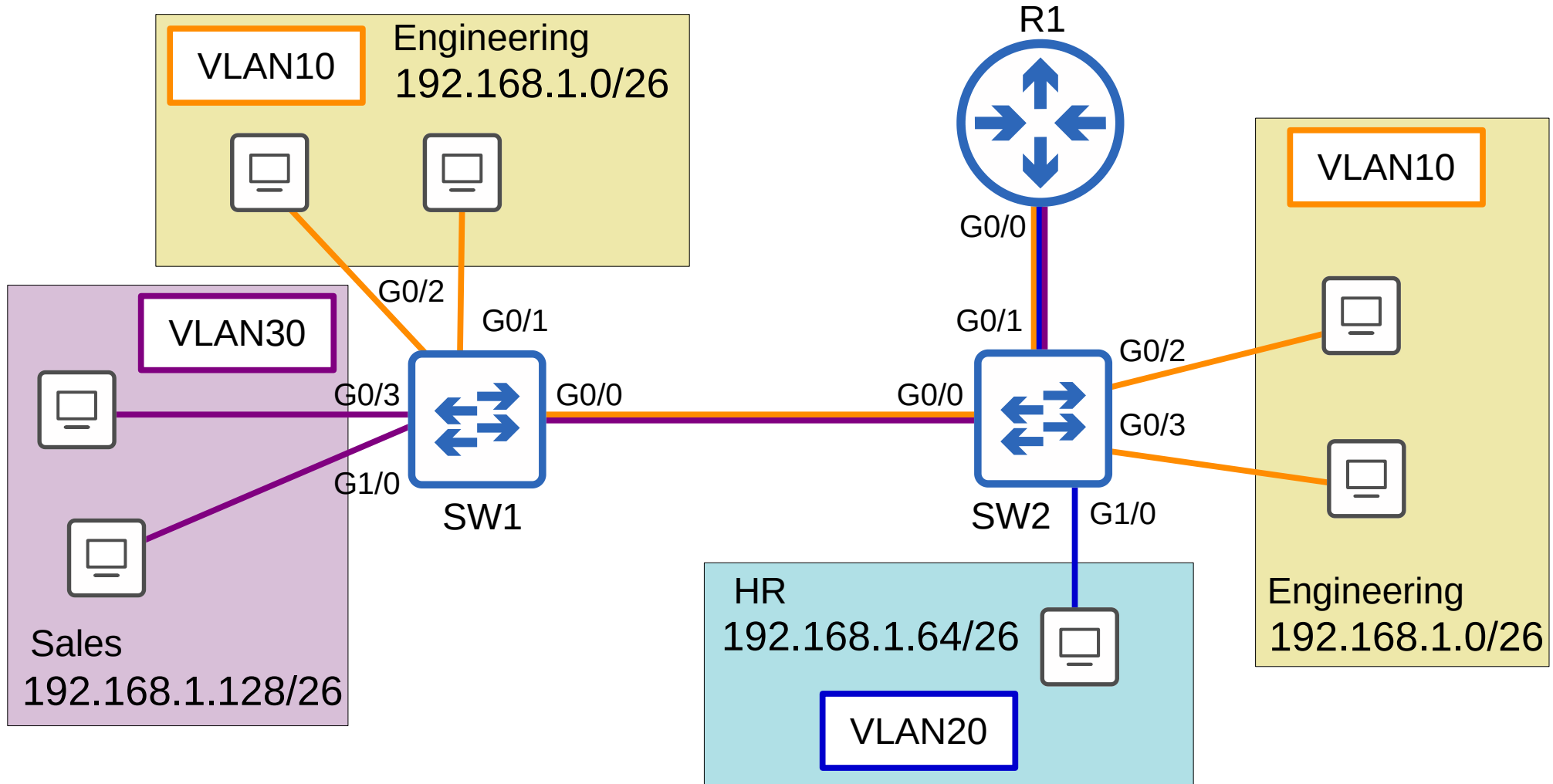
```
Port          Vlans allowed on trunk  
Gi0/0         10,30
```

```
Port          Vlans allowed and active in management domain  
Gi0/0         10,30
```

```
Port          Vlans in spanning tree forwarding state and not pruned  
Gi0/0         10,30
```

```
SW1(config-if)#
```

# Trunk Configuration



# Trunk Configuration

```
SW2(config)#interface g0/0
SW2(config-if)#switchport trunk encapsulation dot1q
SW2(config-if)#switchport mode trunk
SW2(config-if)#switchport trunk allowed vlan 10,30
SW2(config-if)#switchport trunk native vlan 1001
SW2(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1001

Port	Vlans allowed on trunk
Gi0/0	10,30

Port	Vlans allowed and active in management domain
Gi0/0	10,30

Port	Vlans in spanning tree forwarding state and not pruned
Gi0/0	10,30

```
SW2(config-if)#
```

# Trunk Configuration

```
SW2(config)#interface g0/1
SW2(config-if)#switchport trunk encapsulation dot1q
SW2(config-if)#switchport mode trunk
SW2(config-if)#switchport trunk allowed vlan 10,20,30
SW2(config-if)#switchport trunk native vlan 1001
SW2(config-if)#do show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Gi0/0	on	802.1q	trunking	1001
Gi0/1	on	802.1q	trunking	1001

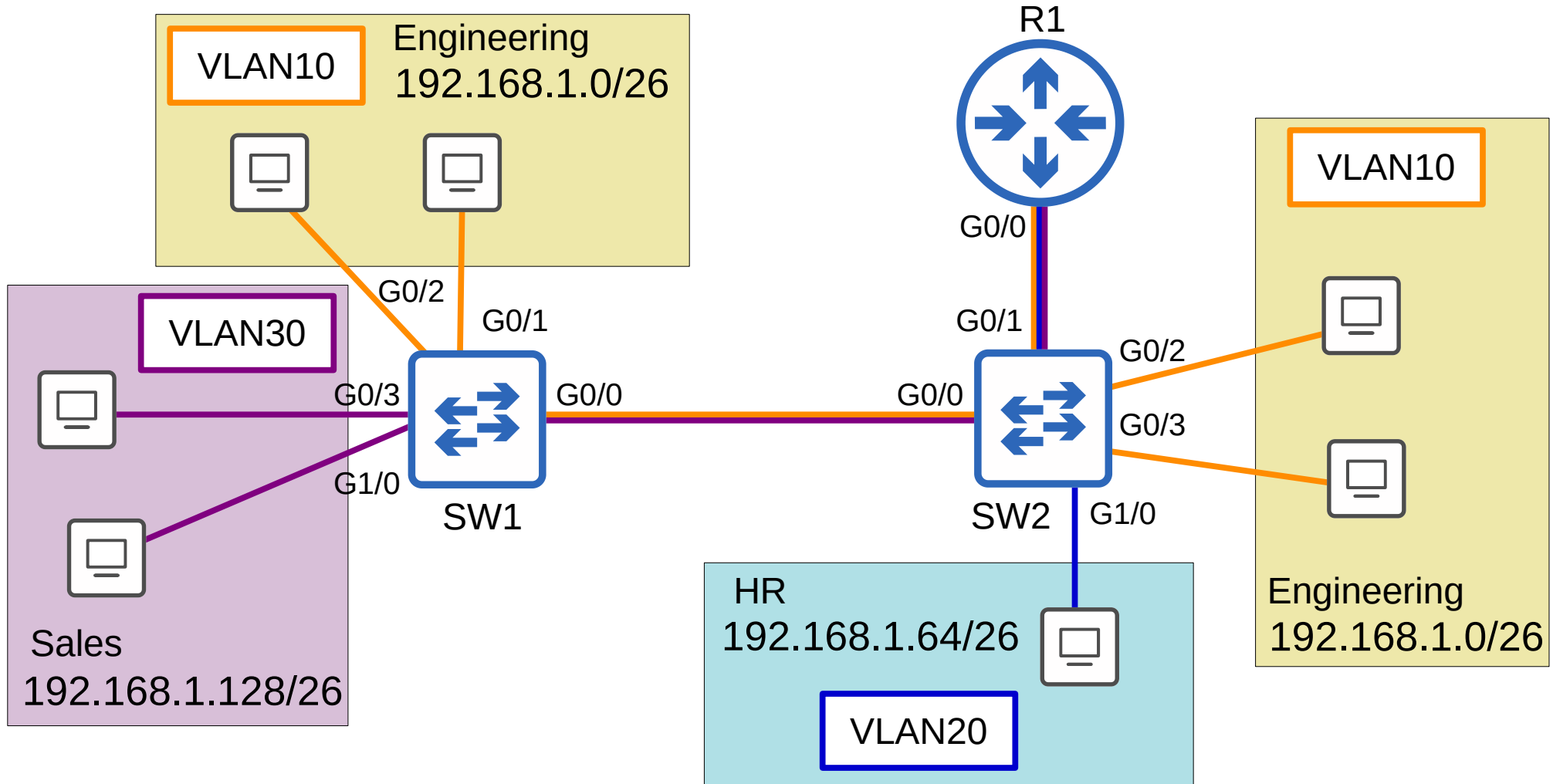
Port	Vlans allowed on trunk
Gi0/0	10,30
Gi0/1	10,20,30

Port	Vlans allowed and active in management domain
Gi0/0	10,30
Gi0/1	10,20,30

Port	Vlans in spanning tree forwarding state and not pruned
Gi0/0	10,30
Gi0/1	none

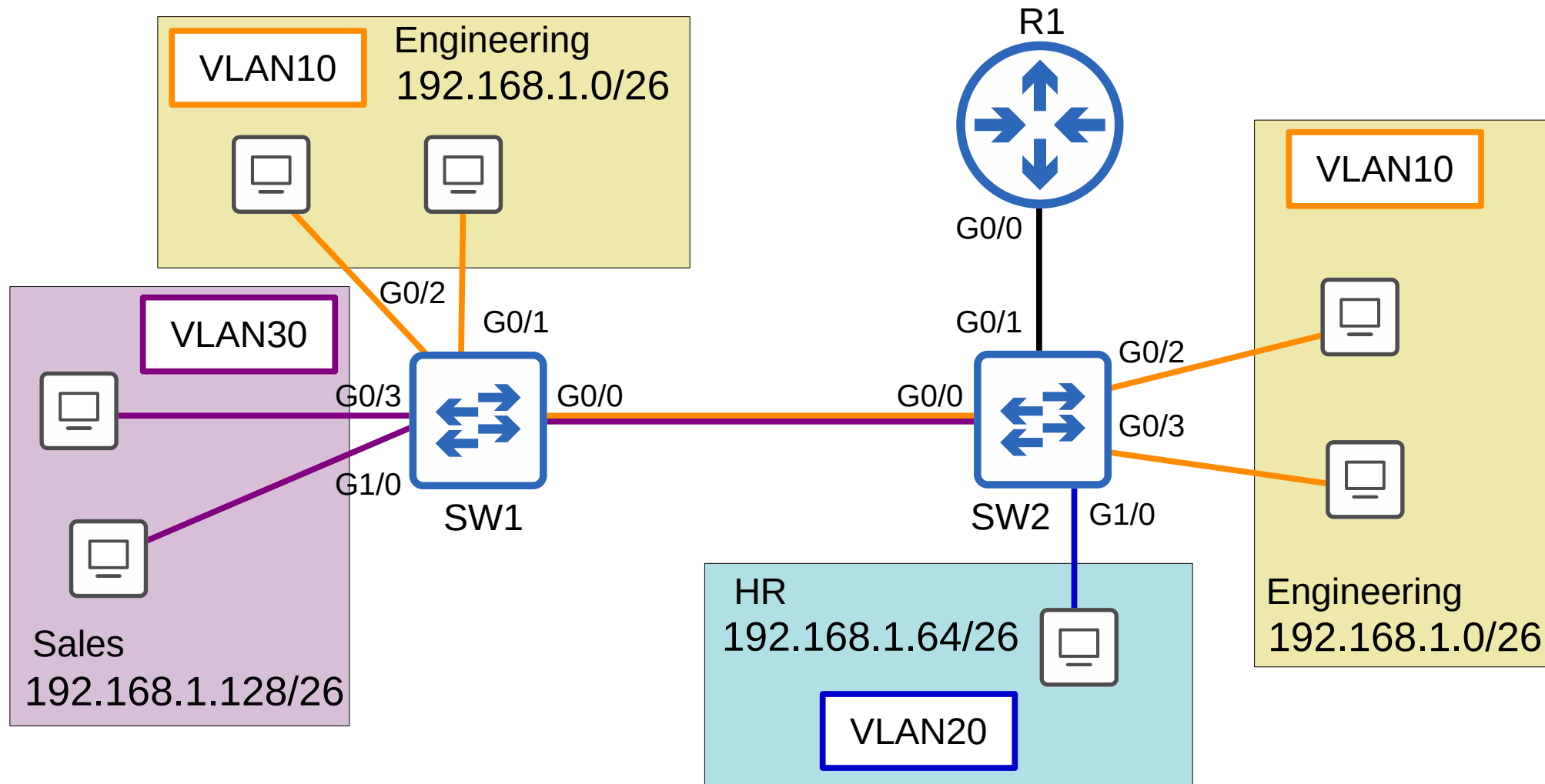
```
SW2(config-if)#
```

# Trunk Configuration

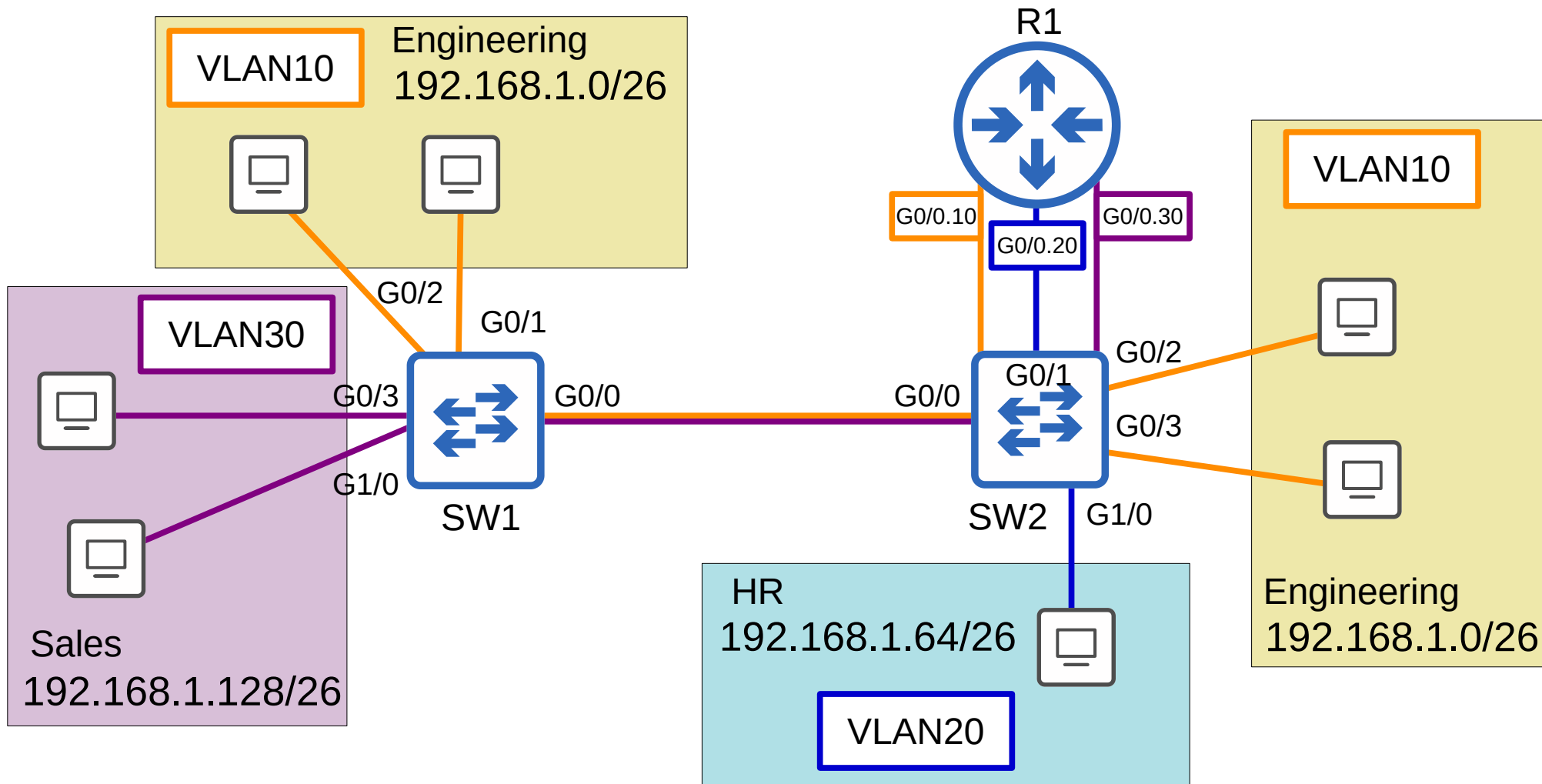




# Router on a Stick (ROAS)



# Router on a Stick (ROAS)



# Router on a Stick (ROAS)

```
R1(config)#interface g0/0
R1(config-if)#no shutdown
R1(config-if)#
*Apr 15 04:29:49.681: %LINK-3-UPDOWN: Interface GigabitEthernet0/0, changed state to up
*Apr 15 04:29:50.682: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/0, changed state to up
R1(config-if)#interface g0/0.10
R1(config-subif)#encapsulation dot1q 10
R1(config-subif)#ip address 192.168.1.62 255.255.255.192
R1(config-subif)#interface g0/0.20
R1(config-subif)#encapsulation dot1q 20
R1(config-subif)#ip address 192.168.1.126 255.255.255.192
R1(config-subif)#interface g0/0.30
R1(config-subif)#encapsulation dot1q 30
R1(config-subif)#ip address 192.168.1.190 255.255.255.192
R1(config-subif)#
```

The subinterface number **does not** have to match the VLAN number. However it is **highly recommended** that they do match, to make it easier to understand.

# Router on a Stick (ROAS)

```
R1#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
GigabitEthernet0/0	unassigned	YES	NVRAM	up	up
GigabitEthernet0/0.10	192.168.1.62	YES	manual	up	up
GigabitEthernet0/0.20	192.168.1.126	YES	manual	up	up
GigabitEthernet0/0.30	192.168.1.190	YES	manual	up	up
GigabitEthernet0/1	unassigned	YES	NVRAM	administratively down	down
GigabitEthernet0/2	unassigned	YES	NVRAM	administratively down	down
GigabitEthernet0/3	unassigned	YES	NVRAM	administratively down	down

# Router on a Stick (ROAS)

```
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
```

```
a - application route
```

```
+ - replicated route, % - next hop override, p - overrides from PfR
```

```
Gateway of last resort is not set
```

```
192.168.1.0/24 is variably subnetted, 6 subnets, 2 masks
```

```
C      192.168.1.0/26 is directly connected, GigabitEthernet0/0.10
```

```
L      192.168.1.62/32 is directly connected, GigabitEthernet0/0.10
```

```
C      192.168.1.64/26 is directly connected, GigabitEthernet0/0.20
```

```
L      192.168.1.126/32 is directly connected, GigabitEthernet0/0.20
```

```
C      192.168.1.128/26 is directly connected, GigabitEthernet0/0.30
```

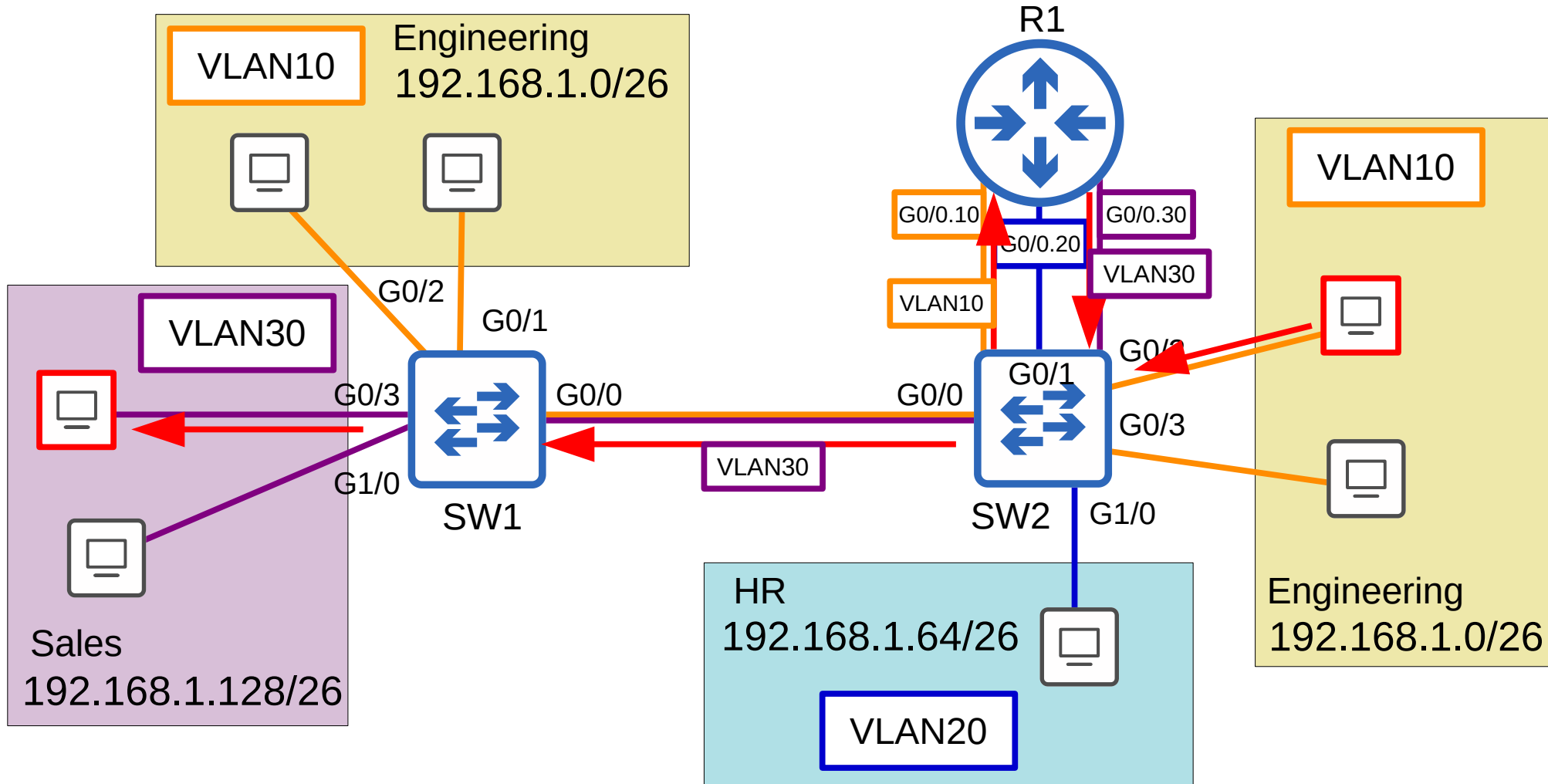
```
L      192.168.1.190/32 is directly connected, GigabitEthernet0/0.30
```

```
R1#
```

# Router on a Stick (ROAS)

- ROAS is used to route between multiple VLANs using a single interface on the router and switch.
- The switch interface is configured as a regular trunk.
- The router interface is configured using **subinterfaces**. You configure the VLAN tag and IP address on each subinterface.
- The router will behave as if frames arriving with a certain VLAN tag have arrived on the subinterface configured with that VLAN tag.
- The router will tag frames sent out of each subinterface with the VLAN tag configured on the subinterface.

# Router on a Stick (ROAS)



- What is a trunk port?
- What is the purpose of trunk ports?
- 802.1Q Encapsulation
- How to configure trunk ports
- 'Router on a Stick' (ROAS)



# QUIZ

# Quiz Question 1

You want to configure SW1 to send VLAN10 frames untagged over its GigabitEthernet0/1 interface, a trunk. Which command is appropriate?

- a) `encapsulation dot1q 10`
- b) `switchport trunk allowed vlan 10`
- c) `switchport trunk allowed vlan add 10`
- d) `switchport trunk native vlan 10`

## Quiz Question 2

After modifying the list of VLANs allowed on a trunk interface, you want to return it to the default state. Which command will do this?

- a) `switchport trunk allowed vlan default`
- b) `switchport trunk allowed vlan all`
- c) `switchport trunk allowed vlan none`
- d) `switchport trunk allowed vlan 1,1002-1005`

## Quiz Question 3

You try to configure an interface on a Cisco switch as a trunk port with the command `switchport mode trunk`, but the command is rejected. Which command might fix this issue?

- a) `switch port mode trunk`
- b) `switchport trunk encapsulation 802.1q`
- c) `switchport trunk encapsulation dot1q`
- d) `switchport trunk encapsulation auto`

# Quiz Question 4

Which field of the 802.1Q tag identifies the VLAN ID of the frame?

- a) **TPID**
- b) **VID**
- c) **PCP**
- d) **VLN**

## Quiz Question 5

You configured `switchport trunk allowed vlan add 10` on an interface, but `VLAN10` doesn't appear in the `Vlans allowed and active in management domain` section of the `show interfaces trunk` command output. What might be the reason?

- a) `VLAN10` doesn't exist on the switch.
- b) The command is invalid.
- c) The command should be **`switchport trunk allowed vlan 10`**
- d) `VLAN10` is reserved and cannot be used.