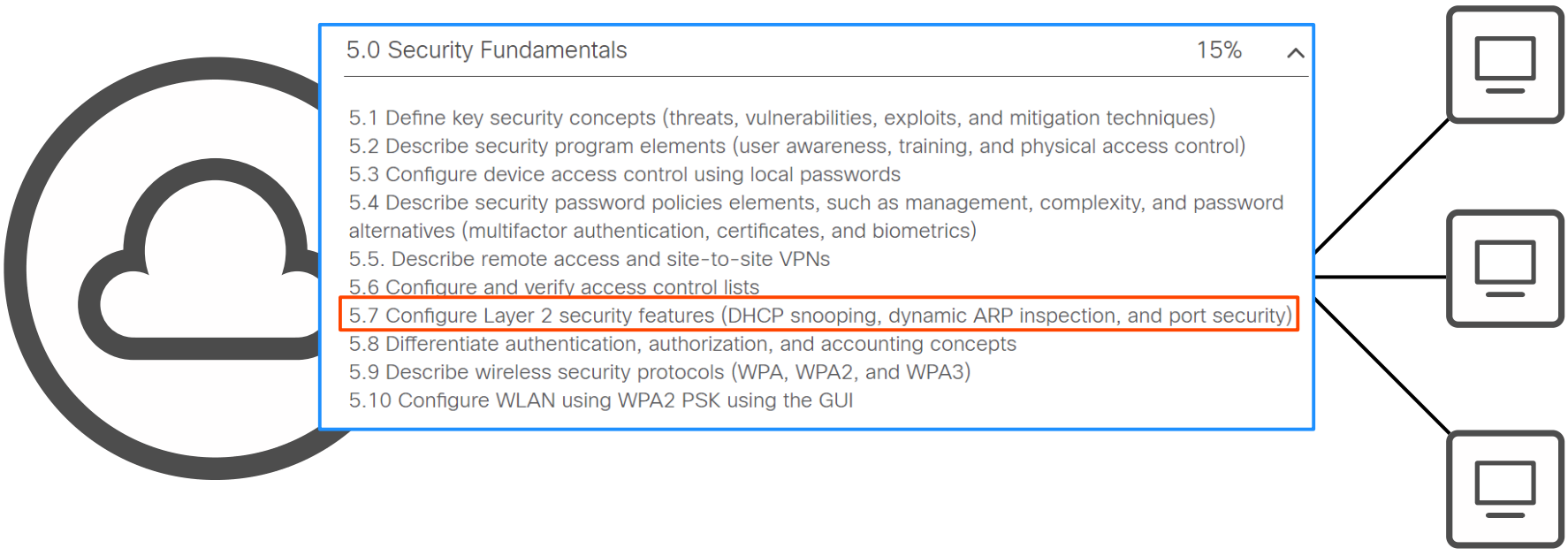
JEREMY'S IT LAB

# CCNA Day 51

## Dynamic ARP Inspection



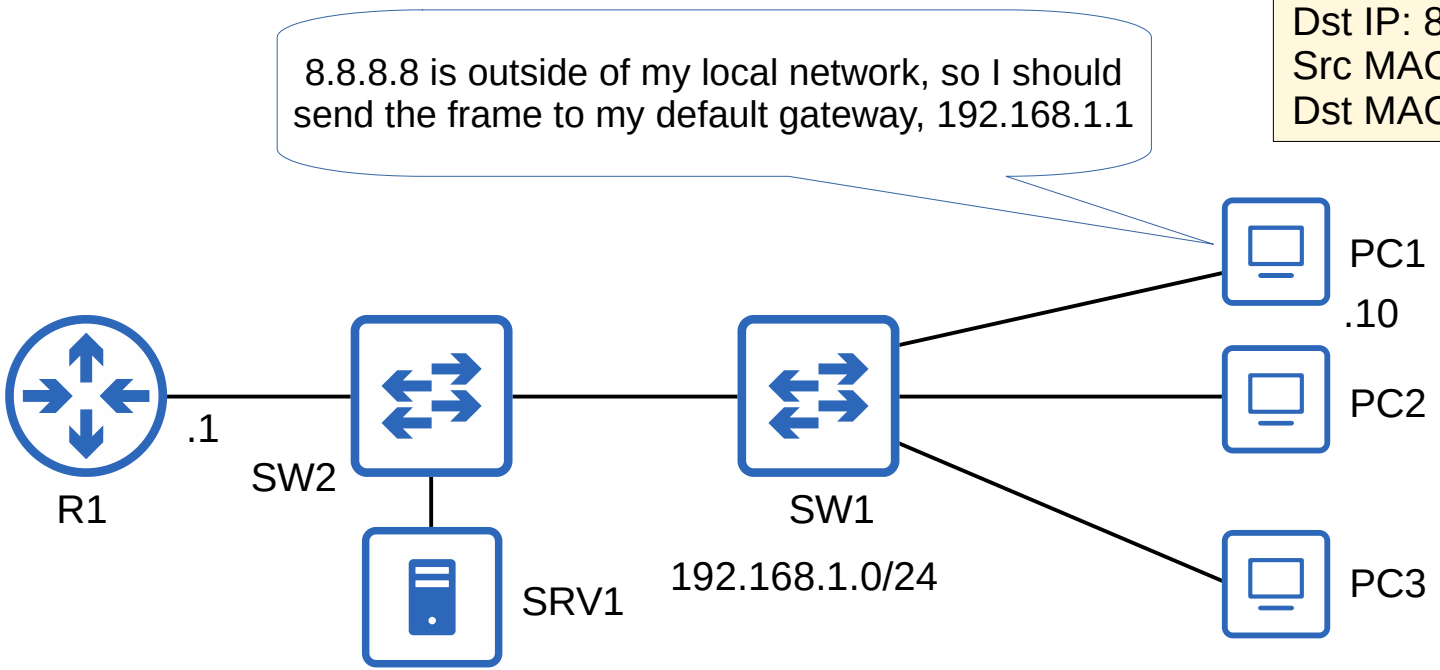
# Things we'll cover

- What is Dynamic ARP Inspection?
- How does it work?
- What attacks does it prevent?
- DAI configuration

# ARP Review

- ARP is used to learn the MAC address of another device with a known IP address.
- For example, a PC will use ARP to learn the MAC address of its default gateway to communicate with external networks.
- Typically it is a two message exchange: **request** and **reply**

**DNS Query**
Src IP: 192.168.1.10
Dst IP: 8.8.8.8
Src MAC: (PC1 MAC)
Dst MAC: ???



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**DNS Query**
Src IP: 192.168.1.10
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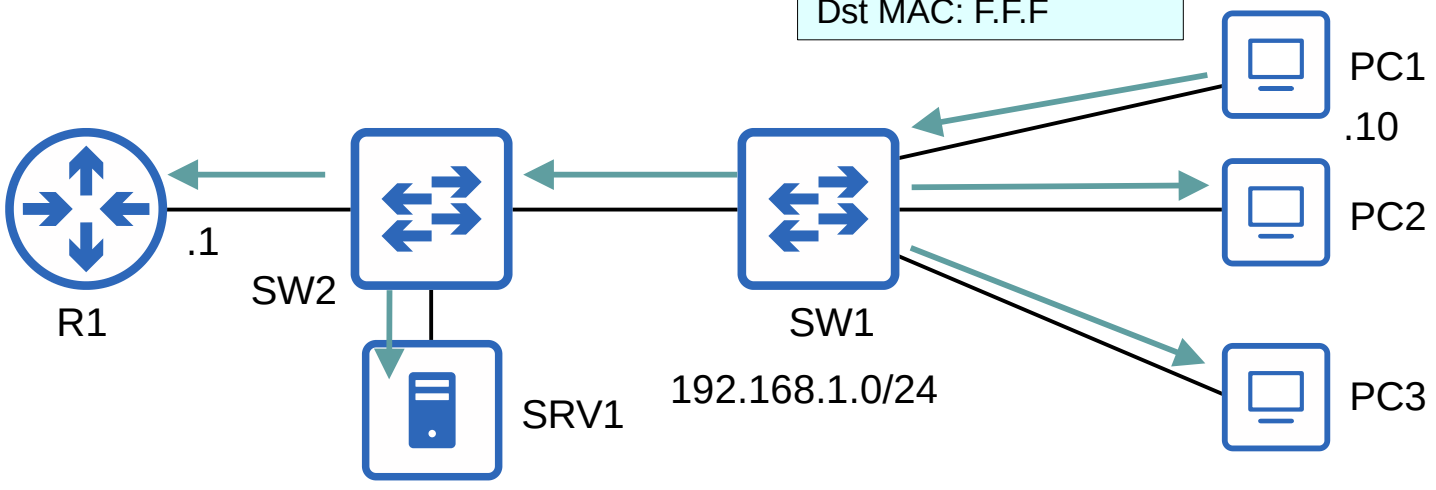
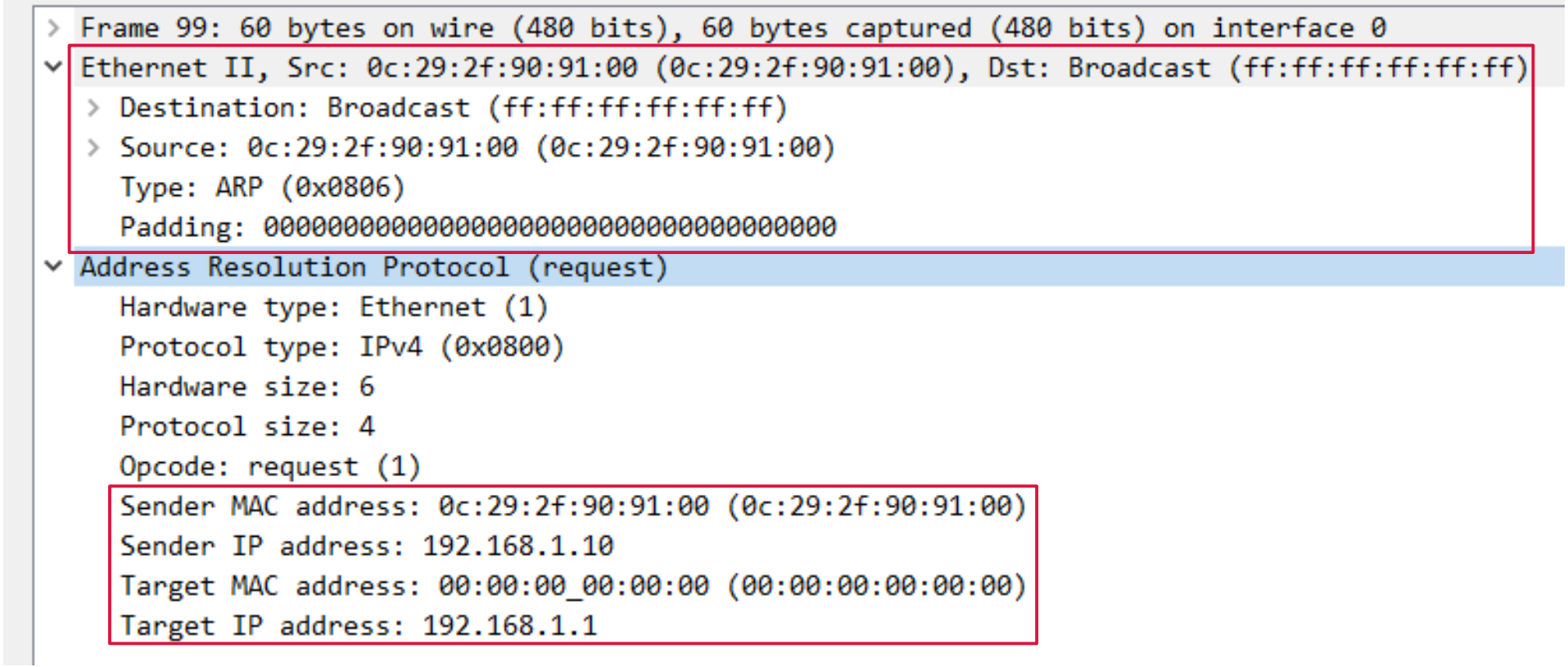
**ARP Request**
Src IP: 192.168.1.10
Dst IP: 192.168.1.1
Src MAC: (PC1 MAC)
Dst MAC: F.F.F



# ARP Review


Frame 99: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
Ethernet II, Src: 0c:29:2f:90:91:00 (0c:29:2f:90:91:00), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Destination: Broadcast (ff:ff:ff:ff:ff:ff)
Source: 0c:29:2f:90:91:00 (0c:29:2f:90:91:00)
Type: ARP (0x0806)
Padding: 000000000000000000000000000000000000
Address Resolution Protocol (request)
Hardware type: Ethernet (1)
Protocol type: IPv4 (0x0800)
Hardware size: 6
Protocol size: 4
Opcode: request (1)
Sender MAC address: 0c:29:2f:90:91:00 (0c:29:2f:90:91:00)
Sender IP address: 192.168.1.10
Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)
Target IP address: 192.168.1.1

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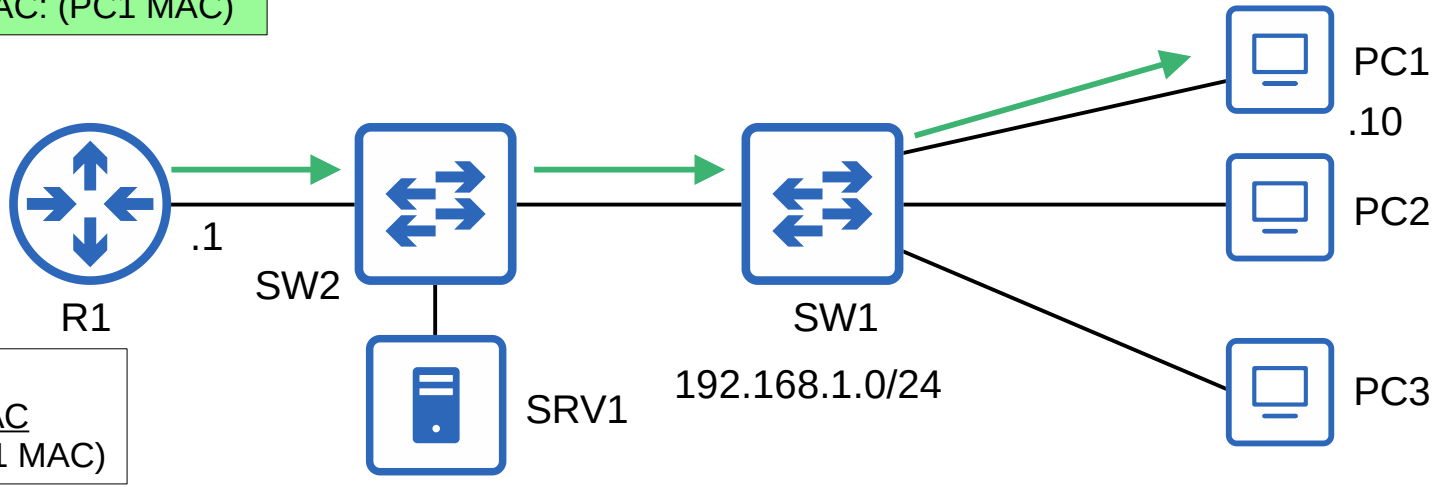
- For example, a PC will use ARP to learn the MAC address of its default gateway to communicate with external networks.
- Typically it is a two message exchange: **request** and **reply**

**ARP Reply**
Src IP: 192.168.1.1
Dst IP: 192.168.1.10
Src MAC: (R1 MAC)
Dst MAC: (PC1 MAC)

**ARP Table:**

| IP | MAC |
|---|---|
| 192.168.1.1 | (R1 MAC) |

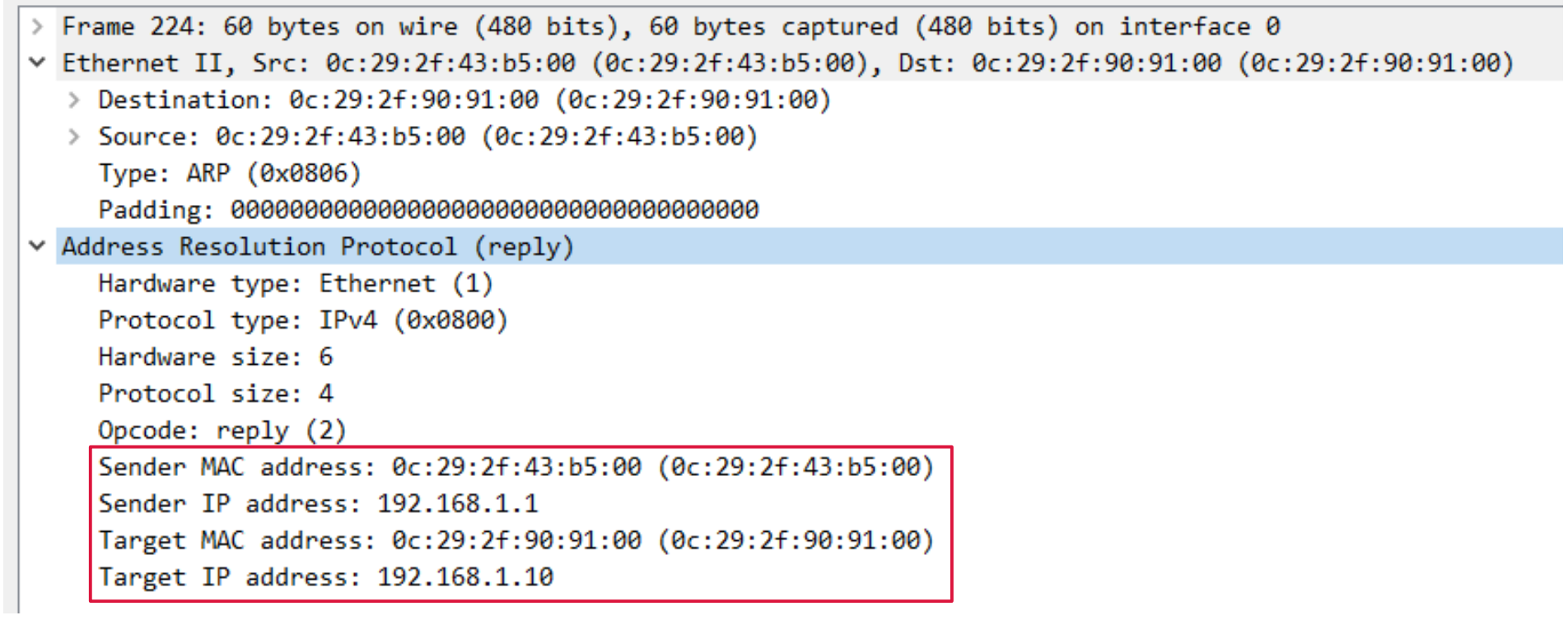
**DNS Query**
Src IP: 192.168.1.10
Dst IP: 8.8.8.8
Src MAC: (PC1 MAC)
Dst MAC: ???




**ARP Table:**

| IP | MAC |
|---|---|
| 192.168.1.10 | (PC1 MAC) |

# ARP Review


Frame 224: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
Ethernet II, Src: 0c:29:2f:43:b5:00 (0c:29:2f:43:b5:00), Dst: 0c:29:2f:90:91:00 (0c:29:2f:90:91:00)
Destination: 0c:29:2f:90:91:00 (0c:29:2f:90:91:00)
Source: 0c:29:2f:43:b5:00 (0c:29:2f:43:b5:00)
Type: ARP (0x0806)
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Address Resolution Protocol (reply)
Hardware type: Ethernet (1)
Protocol type: IPv4 (0x0800)
Hardware size: 6
Protocol size: 4
Opcode: reply (2)
Sender MAC address: 0c:29:2f:43:b5:00 (0c:29:2f:43:b5:00)
Sender IP address: 192.168.1.1
Target MAC address: 0c:29:2f:90:91:00 (0c:29:2f:90:91:00)
Target IP address: 192.168.1.10

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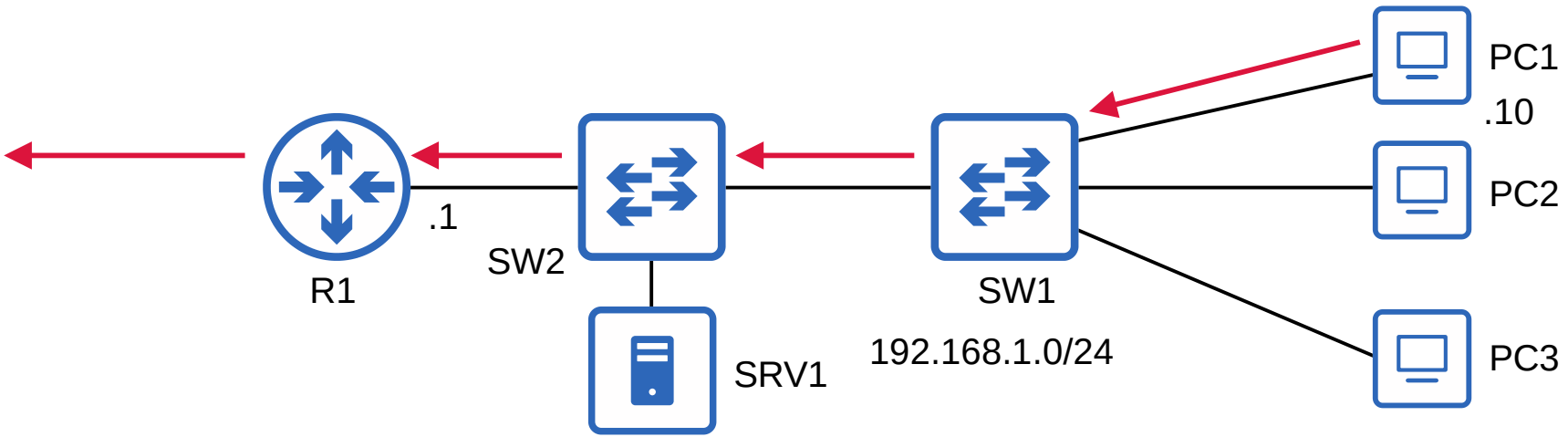
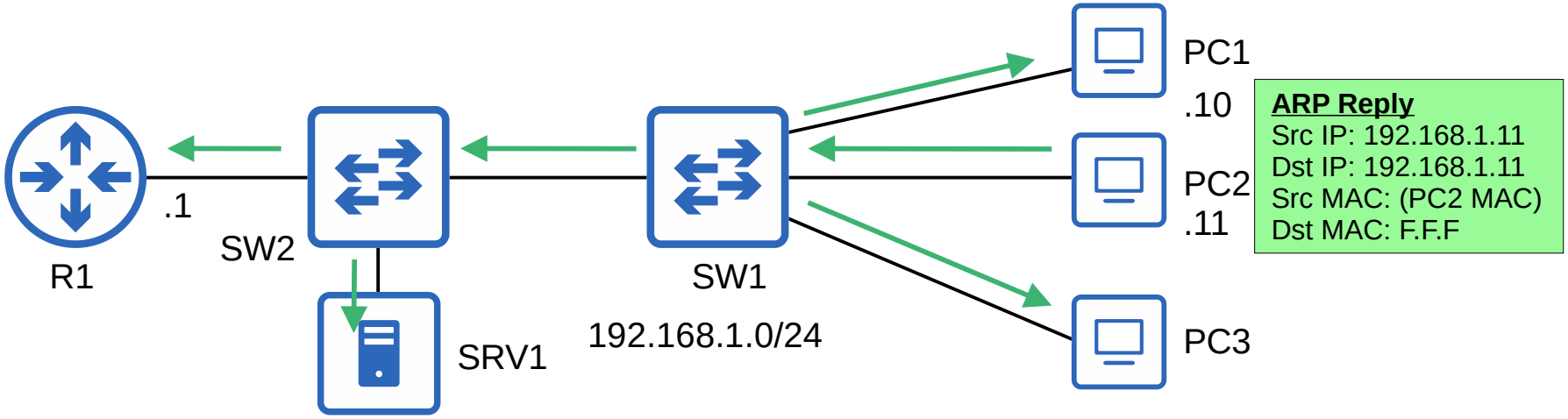


# Gratuitous ARP

- A *Gratuitous ARP* message is an ARP reply that is sent without receiving an ARP request.
- It is sent to the broadcast MAC address.
- It allows other devices to learn the MAC address of the sending device without having to send ARP requests.
- Some devices automatically send GARP messages when an interface is enabled, IP address is changed, MAC address is changed, etc.

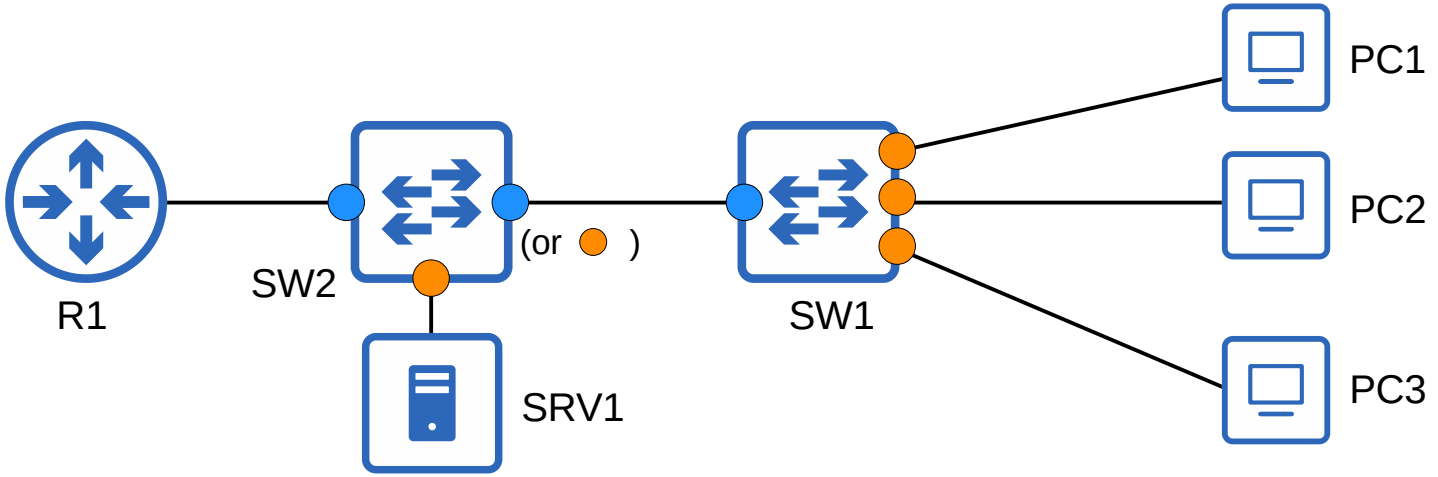


# Dynamic ARP Inspection

- DAI is a security feature of switches that is used to filter ARP messages received on *untrusted* ports.

- DAI only filters ARP messages.  Non-ARP messages aren't affected.

- All ports are *untrusted* by default.
  → Typically, all ports connected to other network devices (switches, routers) should be configured as **trusted**, while interfaces connected to end hosts should remain **untrusted**.



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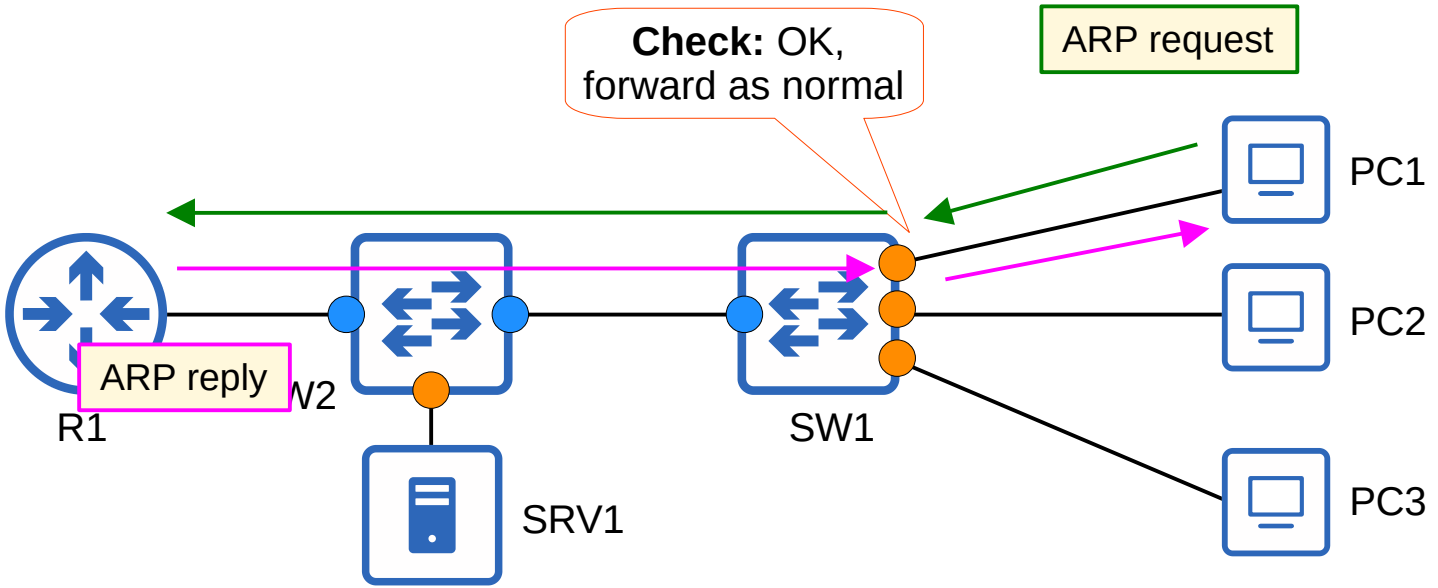

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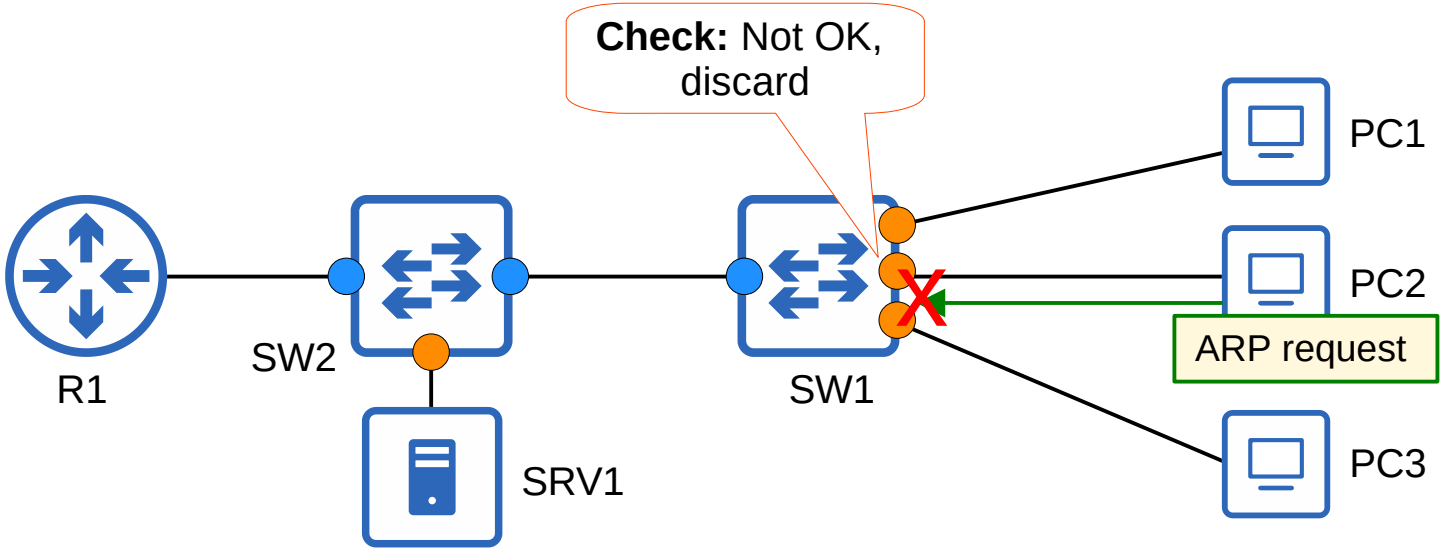
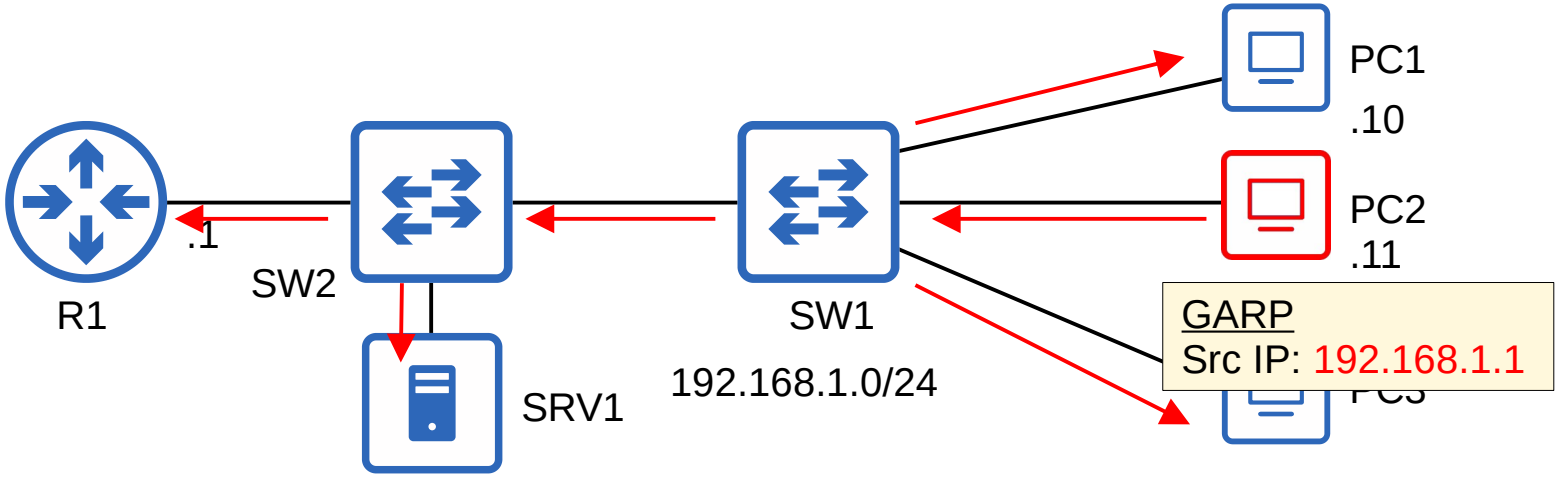


# ARP Poisoning (Man-in-the-Middle)

- Similar to DHCP poisoning, ARP poisoning involves an attacker manipulating targets' ARP tables so traffic is sent to the attacker.
- To do this, the attacker can send gratuitous ARP messages using another device's IP address.
- Other devices in the network will receive the GARP and update their ARP tables, causing them to send traffic to the attacker instead of the legitimate destination.



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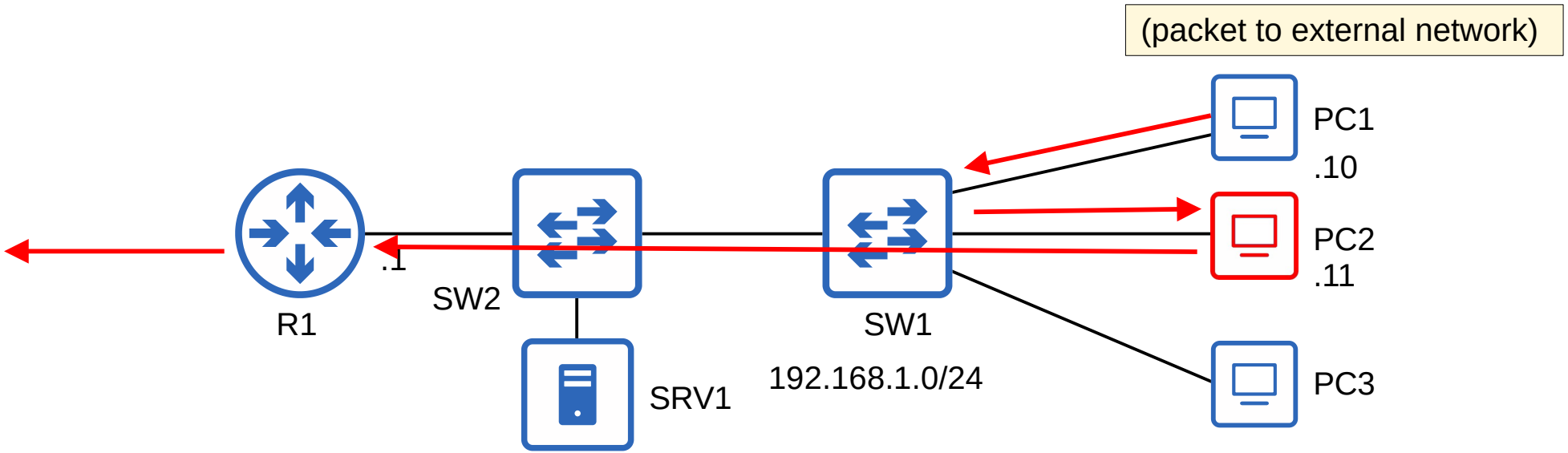


# Dynamic ARP Inspection Operations

- DAI inspects the sender MAC and sender IP fields of ARP messages received on **untrusted** ports and checks that there is a matching entry in the DHCP snooping binding table.
  → If there is a matching entry, the ARP message is forwarded normally.
  → If there isn't a matching entry, the ARP message is discarded.

```
SW1#show ip dhcp snooping binding
MacAddress          IpAddress        Lease(sec)  Type           VLAN  Interface
------------------  ---------------  ----------  -------------  ----  --------------------
0C:29:2F:18:79:00   192.168.100.10   86294       dhcp-snooping   1     GigabitEthernet0/3
0C:29:2F:90:91:00   192.168.100.11   86302       dhcp-snooping   1     GigabitEthernet0/1
0C:29:2F:67:E9:00   192.168.100.12   86314       dhcp-snooping   1     GigabitEthernet0/2
Total number of bindings: 3
```

- DAI doesn't inspect messages received on **trusted** ports. They are forwarded as normal.

- **ARP ACLs** can be manually configured to map IP addresses/MAC addresses for DAI to check.
  → Useful for hosts that don't use DHCP.

- DAI can be configured to perform more in-depth checks also, but these are optional.

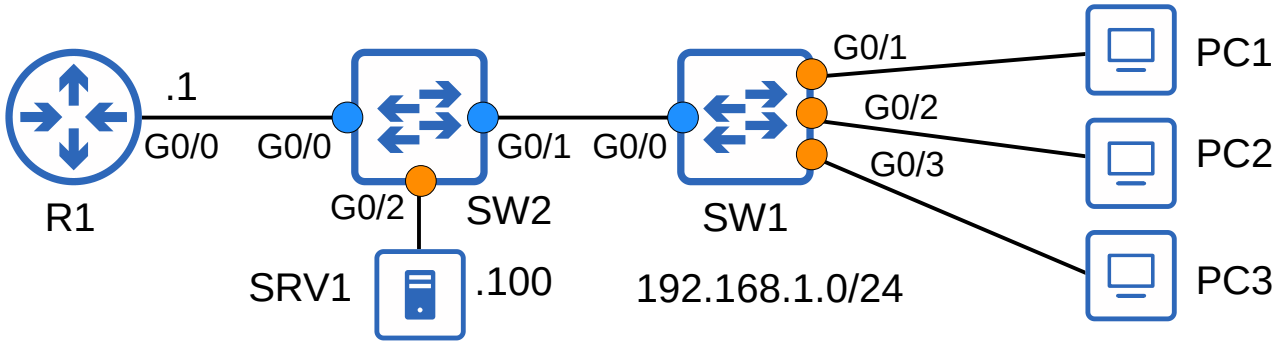
- Like DHCP snooping, DAI also supports rate-limiting to prevent attackers from overwhelming the switch with ARP messages.
  → DHCP snooping and DAI both require work from the switch's CPU.
  → Even if the attacker's messages are blocked, they can overload the switch CPU with ARP messages.

# DAI Configuration

```
SW2(config)#ip arp inspection vlan 1
SW2(config)#interface range g0/0 - 1
SW2(config-if-range)#ip arp inspection trust
```

```
SW1(config)#ip arp inspection vlan 1
SW1(config)#interface g0/0
SW1(config-if)#ip arp inspection trust
```

DHCP snooping requires two commands to enable it:
**ip dhcp snooping**
**ip dchp snooping vlan** *vlan-number*
DAI only requires one:
**ip arp inspection vlan** *vlan-number*



# show ip arp inspection interfaces

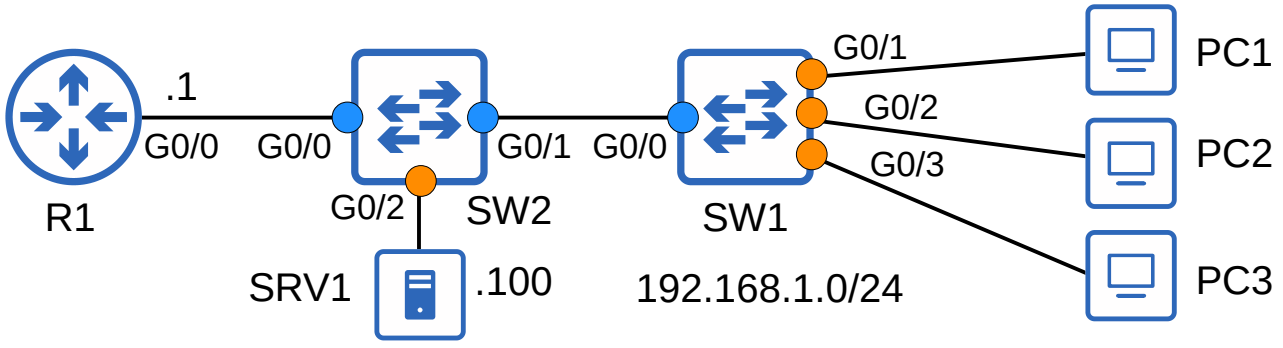
```
SW1#show ip arp inspection interfaces

 Interface        Trust State     Rate (pps)     Burst Interval
 ---------------  -----------     ----------     --------------
 Gi0/0            Trusted               None                N/A
 Gi0/1            Untrusted               15                  1
 Gi0/2            Untrusted               15                  1
 Gi0/3            Untrusted               15                  1
 Gi1/0            Untrusted               15                  1
 Gi1/1            Untrusted               15                  1
 Gi1/2            Untrusted               15                  1
 Gi1/3            Untrusted               15                  1
 Gi2/0            Untrusted               15                  1
 Gi2/1            Untrusted               15                  1
 Gi2/2            Untrusted               15                  1
 Gi2/3            Untrusted               15                  1
 Gi3/0            Untrusted               15                  1
 Gi3/1            Untrusted               15                  1
 Gi3/2            Untrusted               15                  1
 Gi3/3            Untrusted               15                  1
```

DAI rate limiting is enabled on untrusted ports by default with a rate of 15 packets per second.
It is disabled on trusted ports by default.
*DHCP snooping rate limiting is disabled on all interfaces by default.

DHCP snooping rate limiting is configured like this:
*x packets per second*.

The DAI **burst interval** allows you to configure rate limiting like this:
*x packets per y seconds*



# DAI Rate Limiting

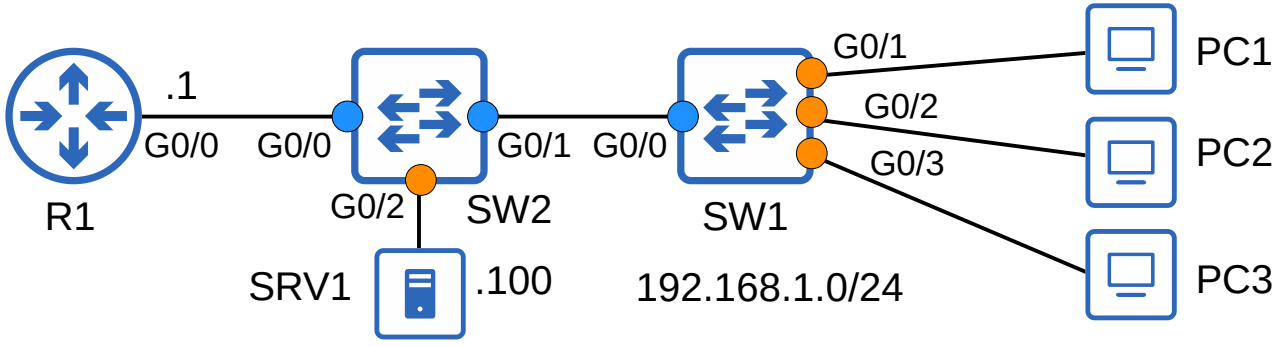
```
SW1(config)#interface range g0/1 - 2
SW1(config-if-range)#ip arp inspection limit rate 25 burst interval 2
SW1(config-if-range)#interface range g0/3
SW1(config-if)#ip arp inspection limit rate 10
SW1(config-if)#do show ip arp inspection interfaces

 Interface        Trust State     Rate (pps)    Burst Interval
 --------------   -----------     ----------    --------------
 Gi0/0            Trusted               None               N/A
 Gi0/1            Untrusted               25                 2
 Gi0/2            Untrusted               25                 2
 Gi0/3            Untrusted               10                 1
![output omitted]

SW1(config)#errdisable recovery cause arp-inspection
SW1(config)#do show errdisable recovery
ErrDisable Reason            Timer Status
-----------------            --------------
arp-inspection               Enabled
![outputed omitted]
```

The burst interval is optional. If you don't specify it, the default is 1 second.

If ARP messages are received faster than the specified rate, the interface will be err-disabled. It can be re-enabled in two ways:
1: **shutdown** and **no shutdown**
2: **errdisable recovery cause arp-inspection**



# DAI Optional Checks

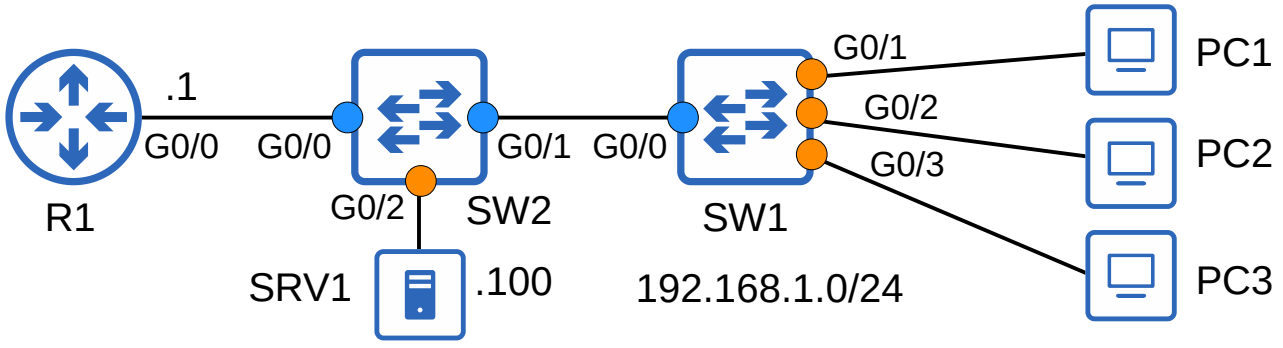
```
SW1(config)#ip arp inspection validate ?
  dst-mac  Validate destination MAC address
  ip       Validate IP addresses
  src-mac  Validate source MAC address
```

**dst-mac:** Enables validation of the destination MAC address in the Ethernet header against the target MAC address in the ARP body for ARP responses. The device classifies packets with different MAC addresses as invalid and drops them

**ip:** Enables validation of the ARP body for invalid and unexpected IP addresses. Addresses include 0.0.0.0, 255.255.255.255, and all IP multicast addresses. The device checks the sender IP addresses in all ARP requests and responses and checks the target IP addresses only in ARP responses.

**src-mac**: Enables validation of the source MAC address in the Ethernet header against the sender MAC address in the ARP body for ARP requests and responses. The devices classifies packets with different MAC addresses as invalid and drops them.

(source: https://www.cisco.com/c/m/en_us/techdoc/dc/reference/cli/n5k/commands/ip-arp-inspection-validate.html)



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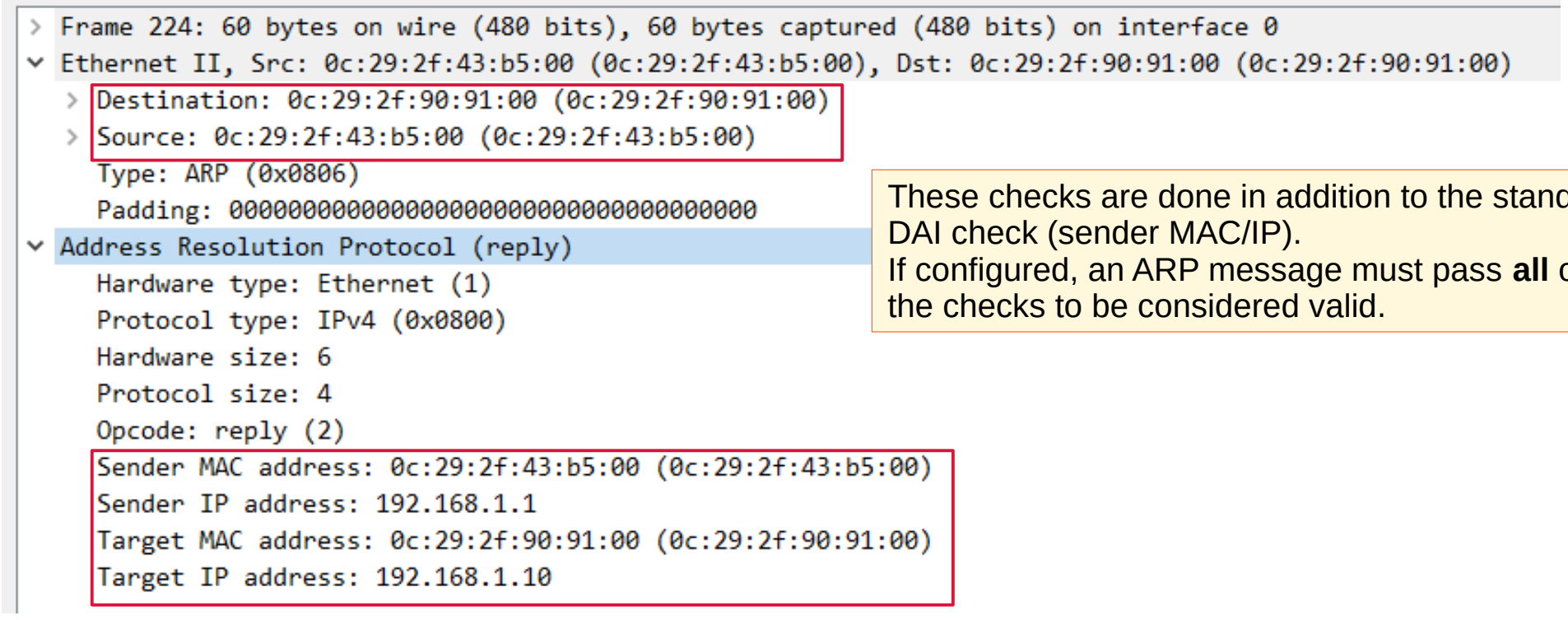



These checks are done in addition to the standard DAI check (sender MAC/IP).
If configured, an ARP message must pass **all** of the checks to be considered valid.

# DAI Optional Checks

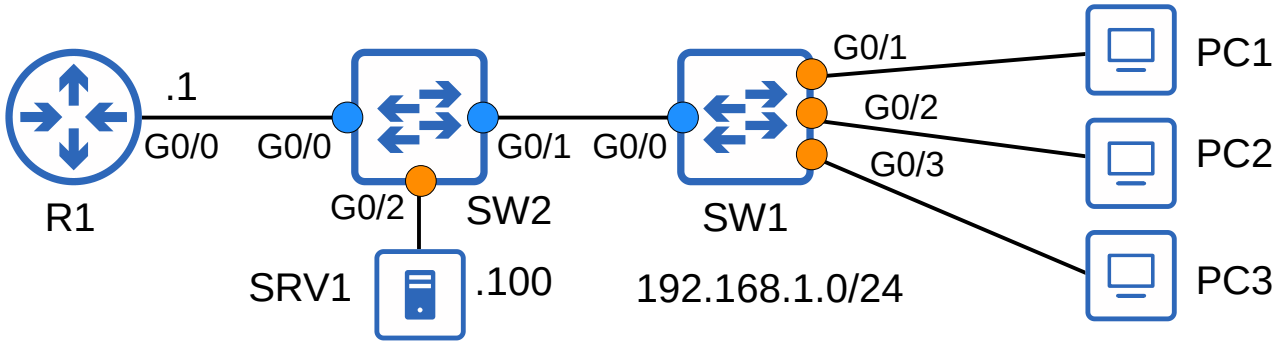
```
SW1(config)#ip arp inspection validate dst-mac
SW1(config)#ip arp inspection validate ip
SW1(config)#ip arp inspection validate src-mac

SW1(config)#do show running-config | include validate
ip arp inspection validate src-mac

SW1(config)#ip arp inspection validate ip src-mac dst-mac

SW1(config)#do show running-config | include validate
ip arp inspection validate src-mac dst-mac ip
```

You must enter all of the validation checks you want in a single command.
*You can specify one, two, or all three.
*The order isn't significant.



# ARP ACLs

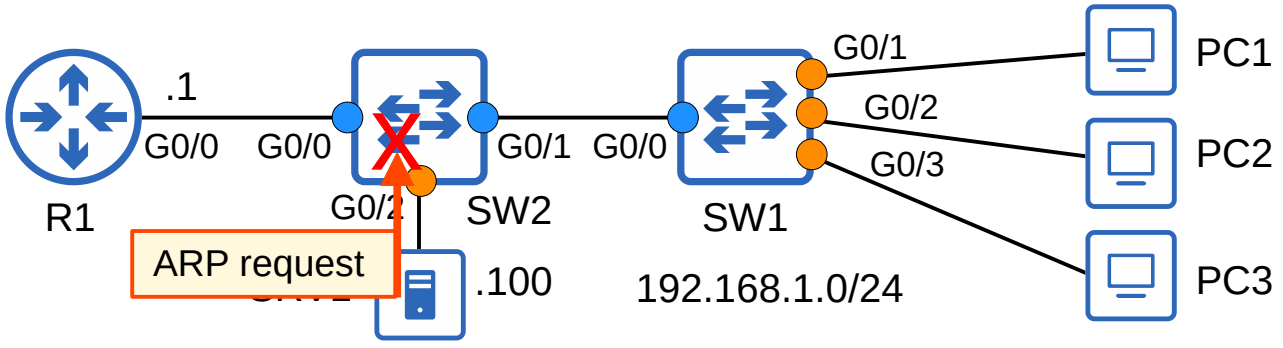
```
SW2#show ip dhcp snooping binding
MacAddress          IpAddress        Lease(sec)  Type           VLAN  Interface
------------------  ---------------  ----------  -------------  ----  --------------------
0C:29:2F:18:79:00   192.168.1.12     79226       dhcp-snooping   1     GigabitEthernet0/1
0C:29:2F:90:91:00   192.168.1.10     79188       dhcp-snooping   1     GigabitEthernet0/1
0C:29:2F:67:E9:00   192.168.1.11     79210       dhcp-snooping   1     GigabitEthernet0/1
Total number of bindings: 3

!SRV1 has a static IP address of 192.168.1.100, so it does not have an entry in SW2's DHCP
!snooping binding table.

*Jun 19 05:56:15.538: %SW_DAI-4-DHCP_SNOOPING_DENY: 1 Invalid ARPs (Req) on Gi0/2, vlan 1.
([0c29.2f1e.7700/192.168.1.100/0000.0000.0000/192.168.1.1/05:56:14 UTC Sat Jun 19 2021])

SW2(config)#arp access-list ARP-ACL-1
SW2(config-arp-nacl)#permit ip host 192.168.1.100 mac host 0c29.2f1e.7700

SW2(config)#ip arp inspection filter ARP-ACL-1 vlan 1
```



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SW2(config)#arp access-list ARP-ACL-1
SW2(config-arp-nacl)#permit ip host 192.168.1.100 mac host 0c29.2f1e.7700

SW2(config)#ip arp inspection filter ARP-ACL-1 vlan 1
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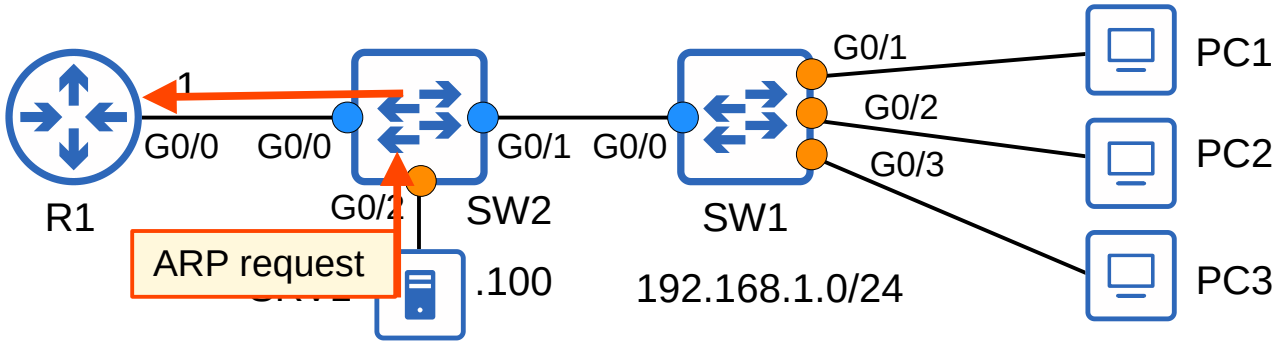

# ARP ACLs

```
SW2#show ip arp inspection

Source Mac Validation      : Enabled
Destination Mac Validation : Enabled
IP Address Validation      : Enabled

 Vlan     Configuration    Operation   ACL Match          Static ACL
 ----     -------------    ---------   ---------          ----------
    1     Enabled          Active      ARP-ACL-1          No

 Vlan     ACL Logging      DHCP Logging      Probe Logging
 ----     -----------      ------------      -------------
    1     Deny             Deny              Off

 Vlan      Forwarded        Dropped     DHCP Drops      ACL Drops
 ----      ---------        -------     ----------      ---------
    1             56              4              4              0

 Vlan   DHCP Permits    ACL Permits  Probe Permits   Source MAC Failures
 ----   ------------    -----------  -------------   -------------------
    1              0              1              0                     0

 Vlan   Dest MAC Failures   IP Validation Failures   Invalid Protocol Data
 ----   -----------------   ----------------------   ---------------------

 Vlan   Dest MAC Failures   IP Validation Failures   Invalid Protocol Data
 ----   -----------------   ----------------------   ---------------------
    1                   0                        0                      0
```

- If **static ACL** is set to **yes**, the implicit deny at the end of the ARP ACL will take effect.
- This will cause all ARP messages not permitted by the ARP ACL to be denied.
- In effect, this means that only the ARP ACL will be checked, the DHCP snooping table will not be checked.

# Command Review

```
SW1(config)# ip arp inspection vlan vlan-number
SW1(config)# errdisable recovery cause arp-inspection
SW1(config)# ip arp inspection validate (src-mac | dst-mac | ip)
SW1(config-if)# ip arp inspection trust
SW1(config-if)# ip arp inspection limit rate packets [burst interval seconds]

SW1(config)# arp access-list name
SW1(config-arp-nacl)# permit ip host ip-address mac host mac-address
SW1(config)# ip arp inspection filter arp-acl-name vlan vlan-number


SW1# show ip arp inspection
SW1# show ip arp inspection interfaces
```

# Things we covered

- What is Dynamic ARP Inspection?
- How does it work?
- What attacks does it prevent?
- DAI configuration

# Quiz 1

You issue the **ip arp inspection vlan 1** command on SW1. Which of the following statements is true about SW1 after issuing the command?

a) All interfaces in VLAN 1 are untrusted

b) DAI isn't fully enabled until globally enabled with **ip arp inspection**

c) Only ARP messages from hosts with a static IP address will be permitted.

d) DHCP snooping is enabled.

# Quiz 2

The following commands are configured on SW1. Which of the following statements is true after the commands have been issued?

```
SW1(config)#ip arp inspection validate ip
SW1(config)#ip arp inspection validate src-mac
SW1(config)#ip arp inspection validate dst-mac
```

a) DAI validation is only enabled for IP addresses

b) DAI validation is only enabled for source MAC addresses

c) DAI validation is only enabled for destination MAC addresses

d) DAI validation is enabled for all three causes

# Quiz 3

Which of the following are true about DAI rate limiting? (select two)

a) It is enabled on trusted and untrusted ports by default.

b) It is enabled on untrusted ports by default.

c) It is enabled at a rate of 10 packets per second by default.

d) It is enabled at a rate of 15 packets per second by default.

# Quiz 4

DAI inspects the sender IP and MAC addresses to determine whether an ARP packet should be forwarded or dropped.  Which of the following does it check the sender IP and MAC against?  (select two)

a) MAC address table

b) DHCP snooping binding table

c) ARP table

d) ARP ACLs

# Quiz 5

Which of the following commands limit ARP messages to a maximum average of 15 per second? (select two)

a) **ip arp inspection limit rate 15**

b) **ip arp inspection limit rate 30 burst interval 3**

c) **ip arp inspection limit rate 45 burst interval 3**

d) **ip arp inspection limit rate 30 burst interval 1**