

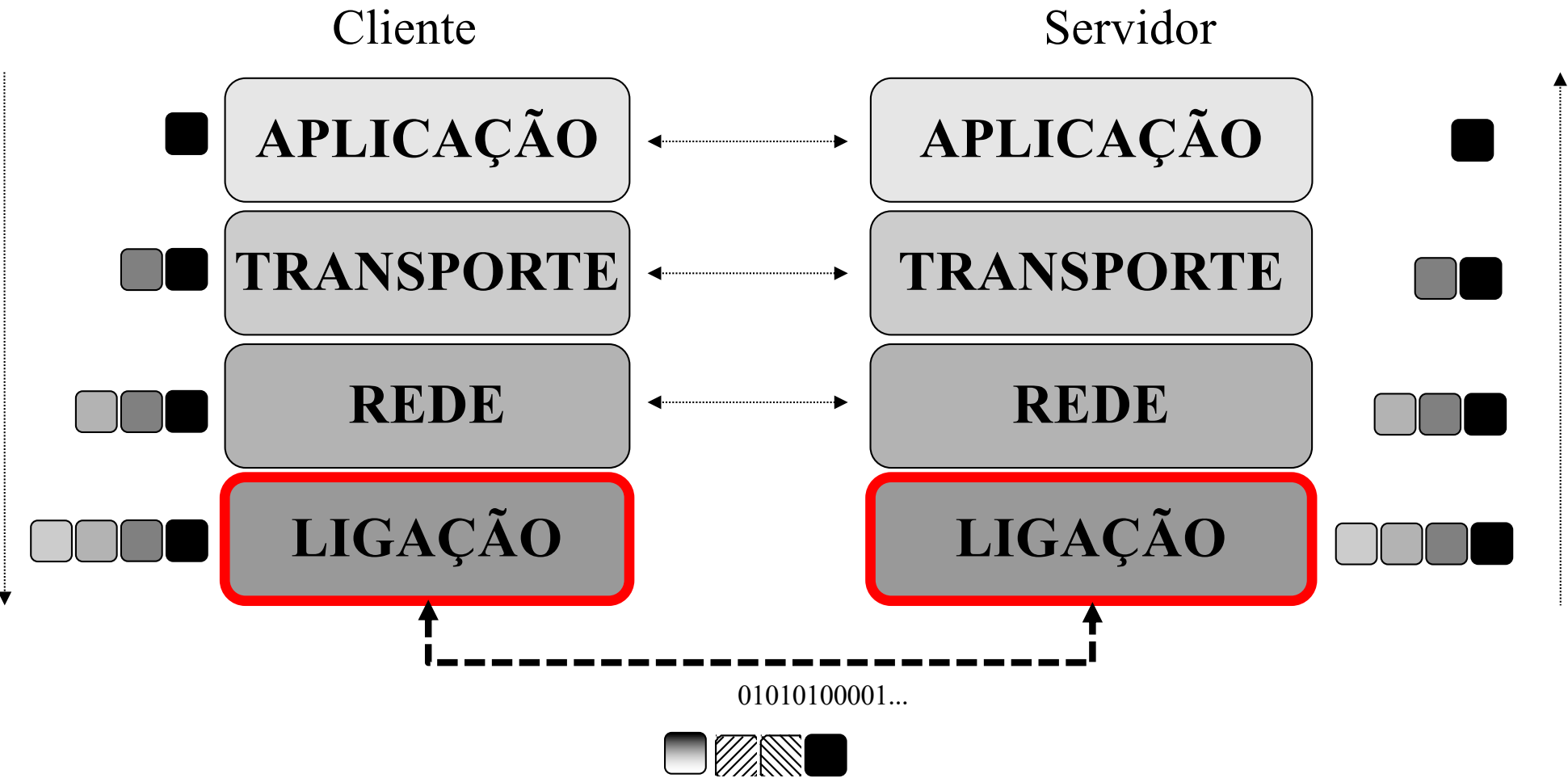
REDES DE COMPUTADORES

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Outubro de 2019

Modelo de comunicação TCP/IP





Ethernet Operation

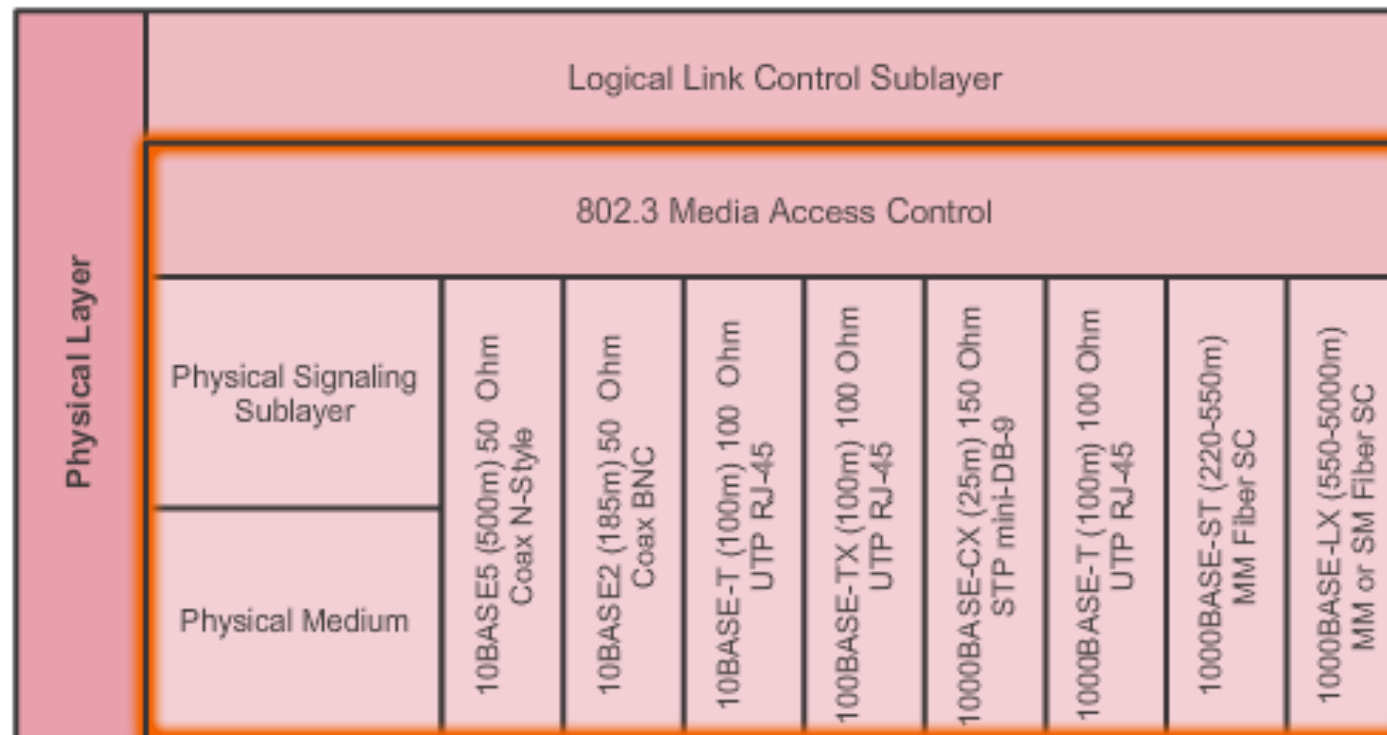
MAC Sublayer

Data Encapsulation

- Frame delimiting
- Addressing
- Error detection

Media Access Control

- Control of frame placement on and off the media
- Media recovery

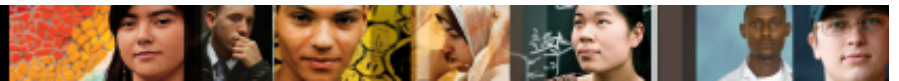


Ethernet

MAC Sublayer

Três funções principais:

- **Frame delimiting** – início de frame + sincronização
- **Addressing** – Endereço físico - MAC address
- **Error detection** – cyclic redundancy check (CRC) do conteúdo da frame Ethernet.



Ethernet Operation

MAC Sublayer (cont.)



Medium Access Control

- Colocar o conteúdo da frame no meio físico
- Receber o conteúdo de uma frame do meio físico
- Comunicar diretamente com a camada física
- **Colisão**: quando vários equipamentos tentam aceder ao meio físico

Controlo de acesso ao meio = Carrier Sense Multiple Access (CSMA)

1. Estação deteta se o meio físico transporta algum sinal
2. Se não = transmite
3. Se duas estações transmitem em simultâneo = colisão



Ethernet Frame Attributes

Ethernet Encapsulation

- Early versions of Ethernet were slow at 10 Mb/s.
- Now operate at 10 Gb/s and faster.
- Ethernet frame structure adds headers and trailers to encapsulate the message being sent.
- Ethernet II is the Ethernet frame format used in TCP/IP networks.

Comparison of 802.3 and Ethernet II Frame Structures and Field Size

IEEE 802.3						
7	1	6	6	2	46 to 1500	4
Preamble	Start of Frame Delimiter	Destination Address	Source Address	Length	802.2 Header and Data	Frame Check Sequence

Ethernet II					
8	6	6	2	46 to 1500	4
Preamble	Destination Address	Source Address	Type	Data	Frame Check Sequence

Field size in bytes



Ethernet Frame Attributes

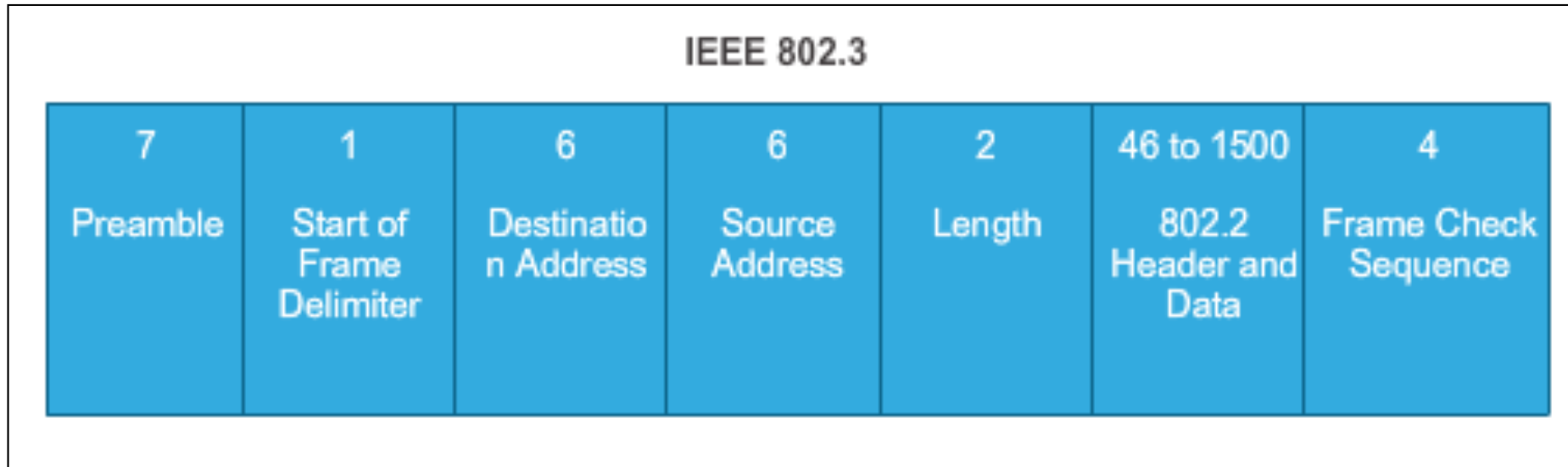
Ethernet Frame Size

- Ethernet II and IEEE 802.3 standards define the **minimum frame size as 64 bytes and the maximum as 1518 bytes**
- Less than 64 bytes in length is considered a *"collision fragment"* or *"runt frame"*
- If size of a transmitted frame is less than the minimum or greater than the maximum, the receiving device drops the frame
- At the physical layer, different versions of Ethernet vary in their method for detecting and placing data on the media



Ethernet Frame Attributes

Introduction to the Ethernet Frame



Preamble and Start Frame Delimiter Fields –
Used for synchronization between the sending and receiving devices.

Length/Type Field –
Defines the exact length of the frame's data field; describes which protocol is implemented.

Data and Pad Fields –
Contains the encapsulated data from a higher layer, an IPv4 packet.

Preamble + SFD = 8 bytes

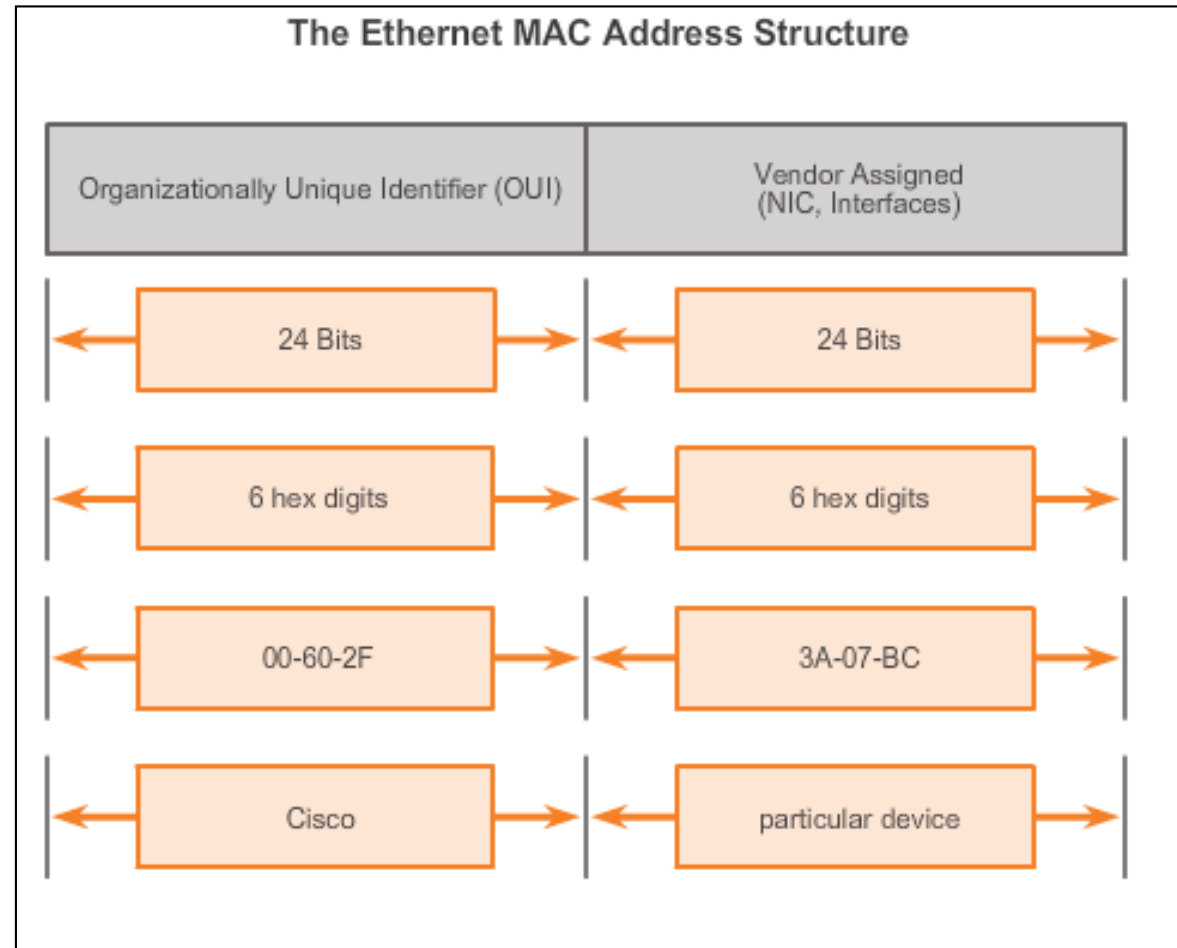
10101010 10101010 10101010 10101010 10101010 10101010 10101010 10101011



Ethernet Operation

MAC Address: Ethernet Identity

- Layer 2 Ethernet MAC address is a **48-bit binary** value expressed as **12 hexadecimal digits**.
- IEEE requires a vendor to follow these rules:
 - Must use that vendor's assigned OUI as the first 3 bytes.
 - All MAC addresses with the same OUI must be assigned a unique value in the last 3 bytes.



Endereço MAC - representação

Exemplo:

00100100	11100101	10110010	00100110	00001001	01001110
0010 0100	1110 0101	1011 0010	0010 0110	0000 1001	0100 1110

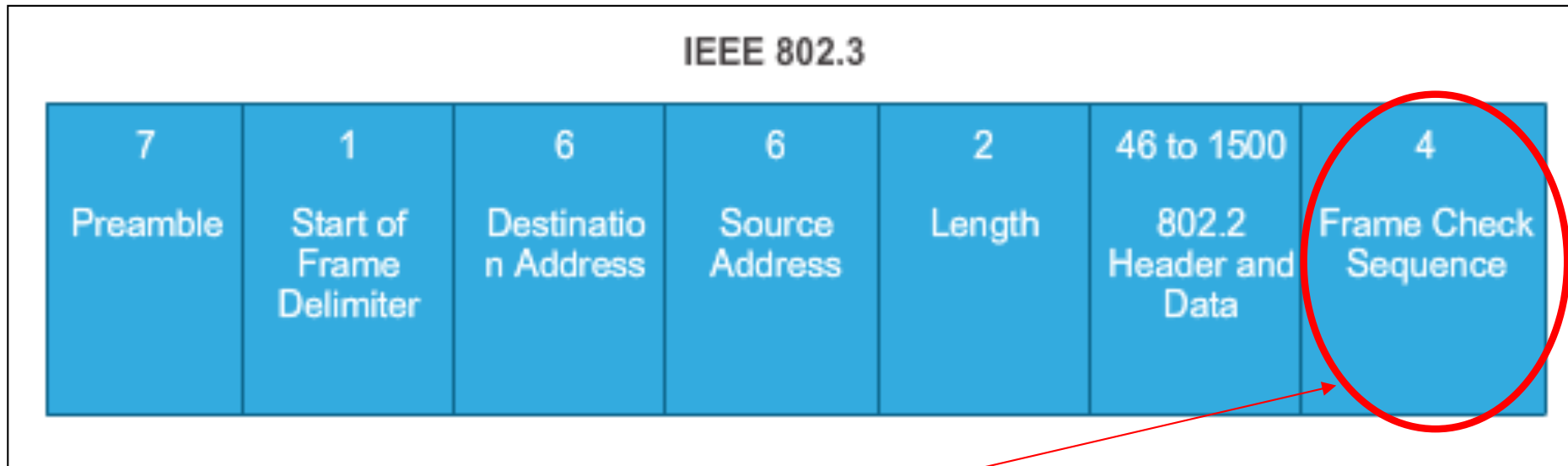
2	4	:	E	5	:	B	2	:	2	6	:	0	9	:	4	E
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

- Endereço MAC = 48 bits
- Representação “column-hexadecimal” = 12 símbolos em hexadecimal
- 1 símbolo hexadecimal = 4 bits



Ethernet Frame Attributes

Introduction to the Ethernet Frame (cont.)



Frame Check Sequence Field

Used to detect errors in a frame with cyclic redundancy check (4 bytes); if calculations match at source and receiver, no error occurred.

CRC-32 bits detects if changes in the header occurred in transit.



Ethernet MAC MAC Address Representations

Ethernet adapter Ethernet 2:

```

Connection-specific DNS Suffix . : IPLeiria.pt
Description . . . . . : Intel(R) Ethernet Connection I219-V #2
Physical Address. . . . . : B8-6B-23-D0-8E-C6
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
IPv6 Address. . . . . : 2001:690:2060:0:3096:3e7c:cdff:da2e(Preferred)
Temporary IPv6 Address. . . . . : 2001:690:2060:0:5038:ff2c:2b7d:f214(Deprecated)
Temporary IPv6 Address. . . . . : 2001:690:2060:0:701c:36d3:362d:da7b(Preferred)
Link-local IPv6 Address . . . . . : fe80::3096:3e7c:cdff:da2e%15(Preferred)
IPv4 Address. . . . . : 10.20.5.11(Preferred)
Subnet Mask . . . . . : 255.255.254.0
Lease Obtained. . . . . : 29 de agosto de 2017 13:54:30
Lease Expires . . . . . : 5 de outubro de 2153 21:06:20
Default Gateway . . . . . : fe80::2d0:4ff:fe72:3fc%15
                             10.20.5.254
DHCP Server . . . . . : 172.20.1.250
DHCPv6 IAID . . . . . : 263744291
DHCPv6 Client DUID. . . . . : 00-01-00-01-1F-EF-1E-AF-B8-6B-23-D0-8E-C6
DNS Servers . . . . . : 172.20.1.12
                             172.20.1.11
                             172.20.1.10
NetBIOS over Tcpip. . . . . : Disabled
  
```

Wireless LAN adapter Wi-Fi 2:

```

Media State . . . . . : Media disconnected
Connection-specific DNS Suffix . : funcionarios.ipleiria.pt
Description . . . . . : Intel(R) Dual Band Wireless-AC 8260 #2
Physical Address. . . . . : 44-85-00-26-1F-42
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
  
```

With Dashes 00-60-2F-3A-07-BC

With Colons 00:60:2F:3A:07:BC

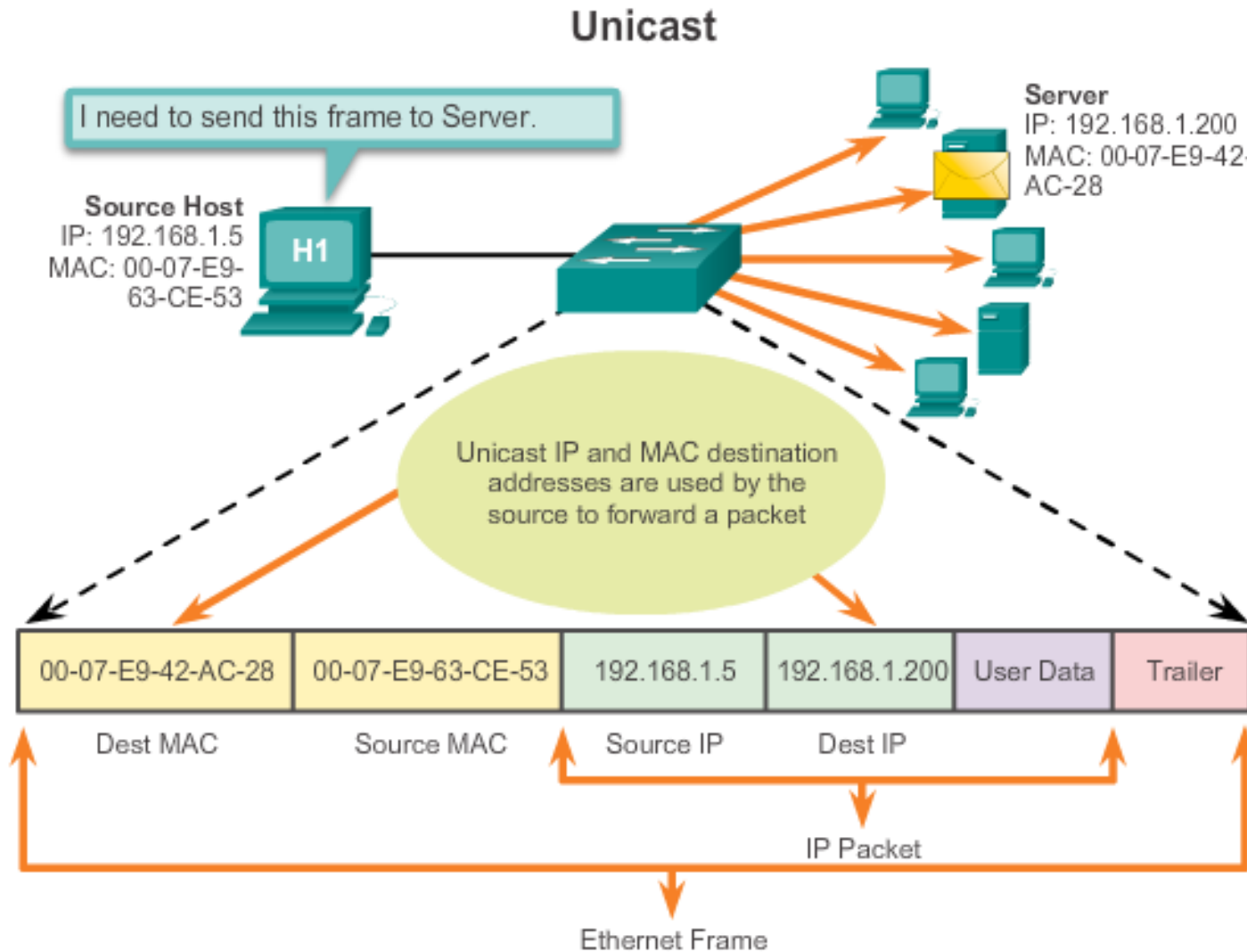
With Periods 0060.2F3A.07BC

`ipconfig /all`



Ethernet MAC

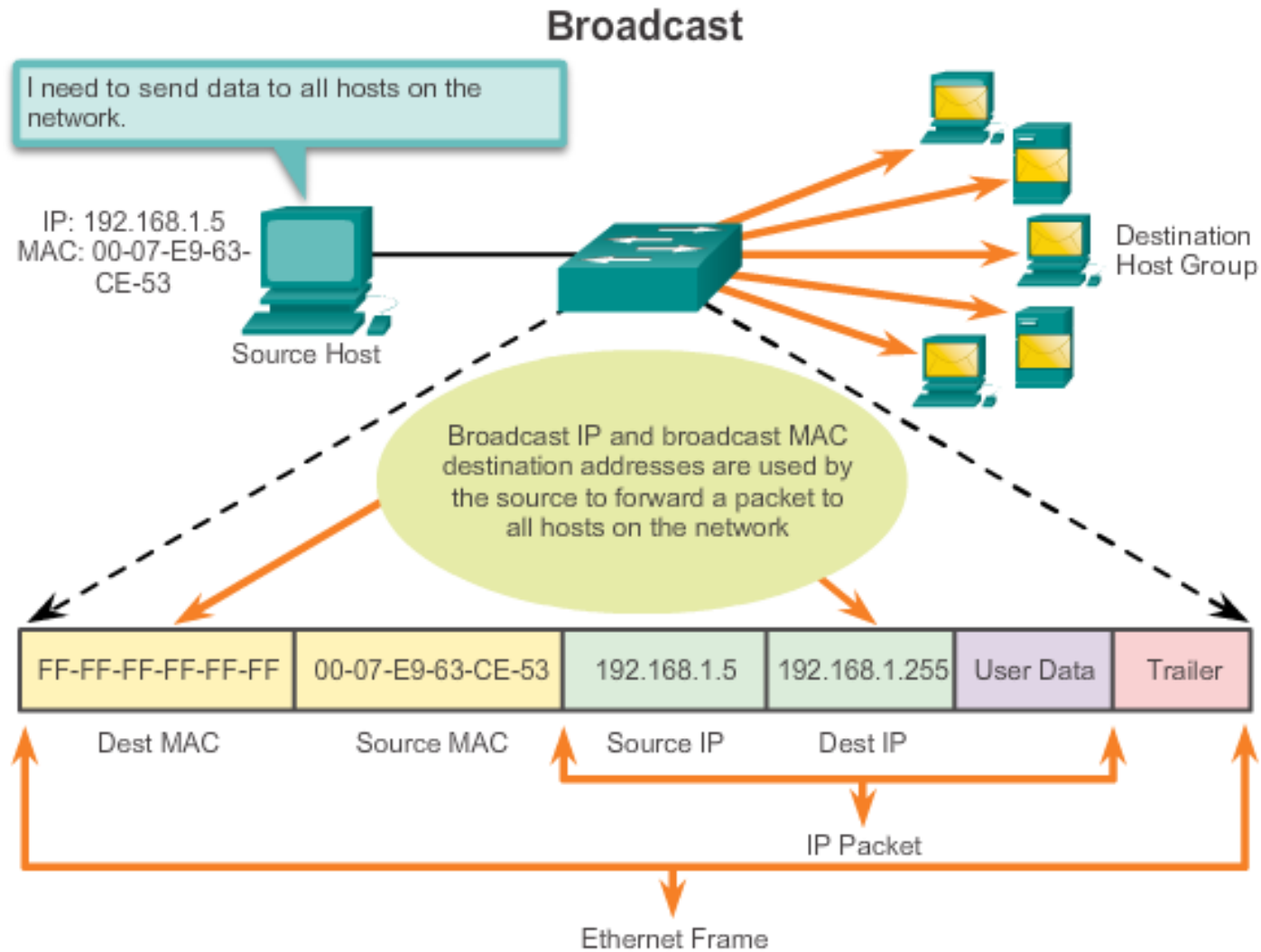
Unicast MAC Address





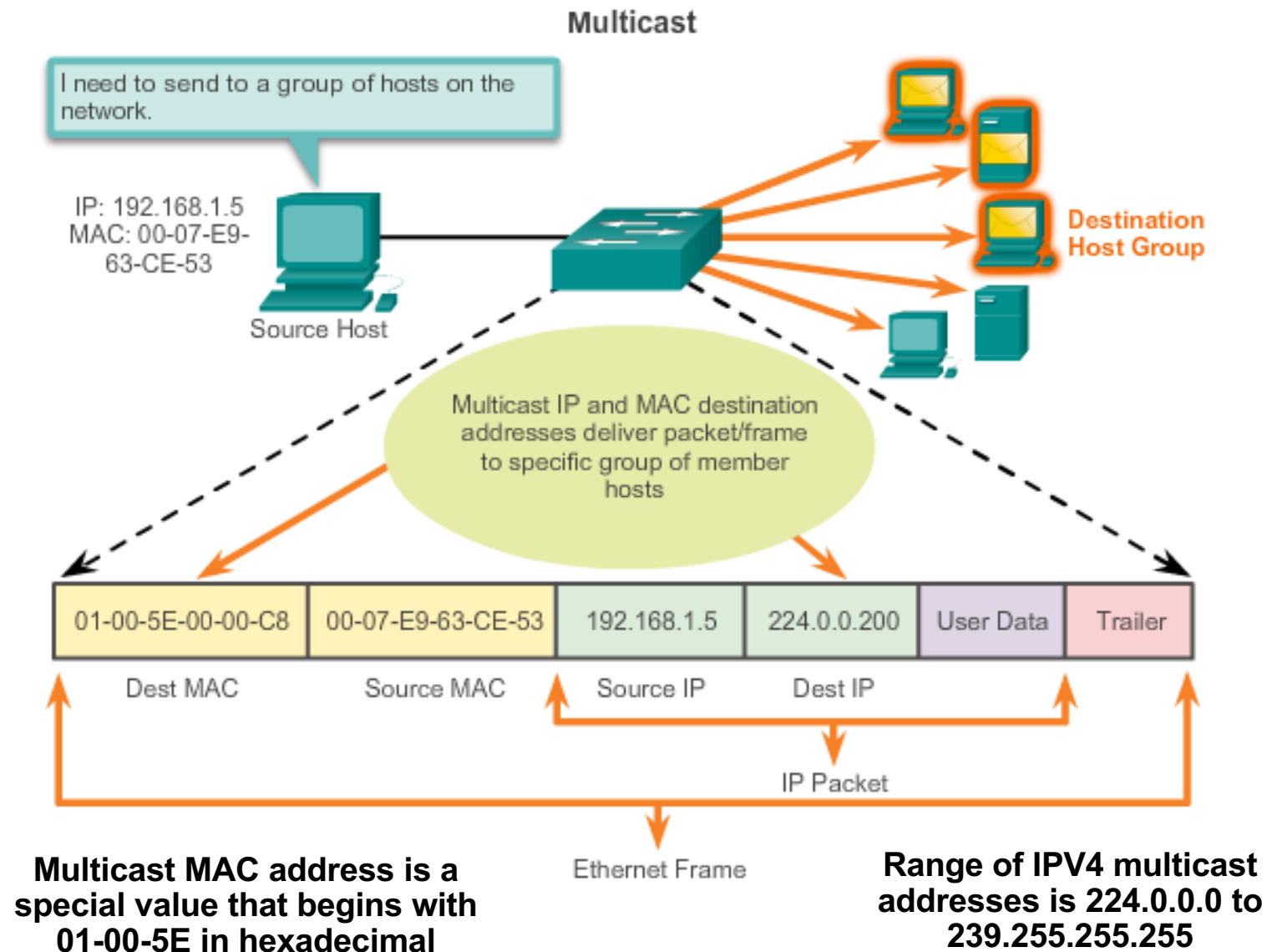
Ethernet MAC

Broadcast MAC Address





Ethernet MAC Multicast MAC Address

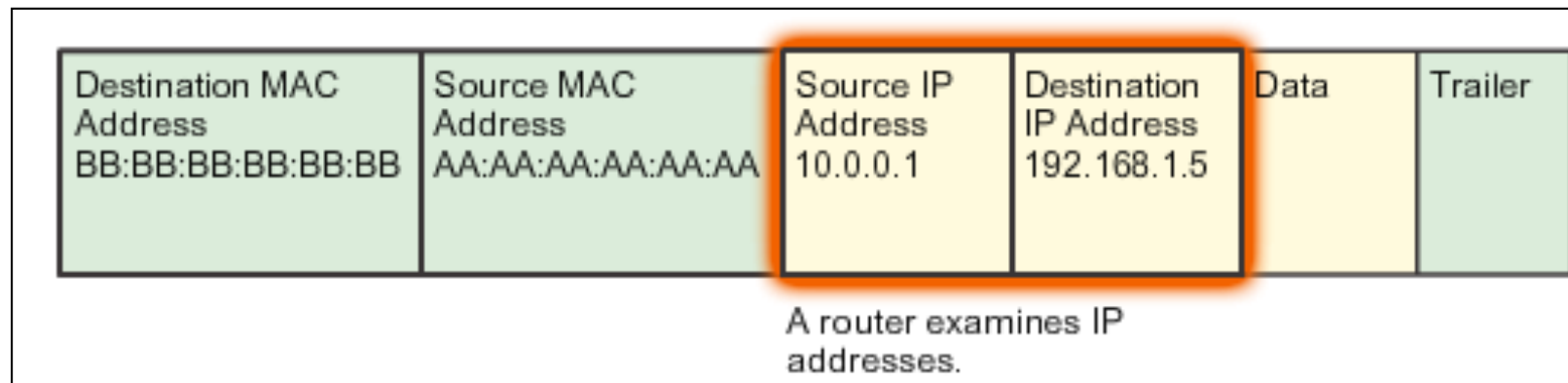
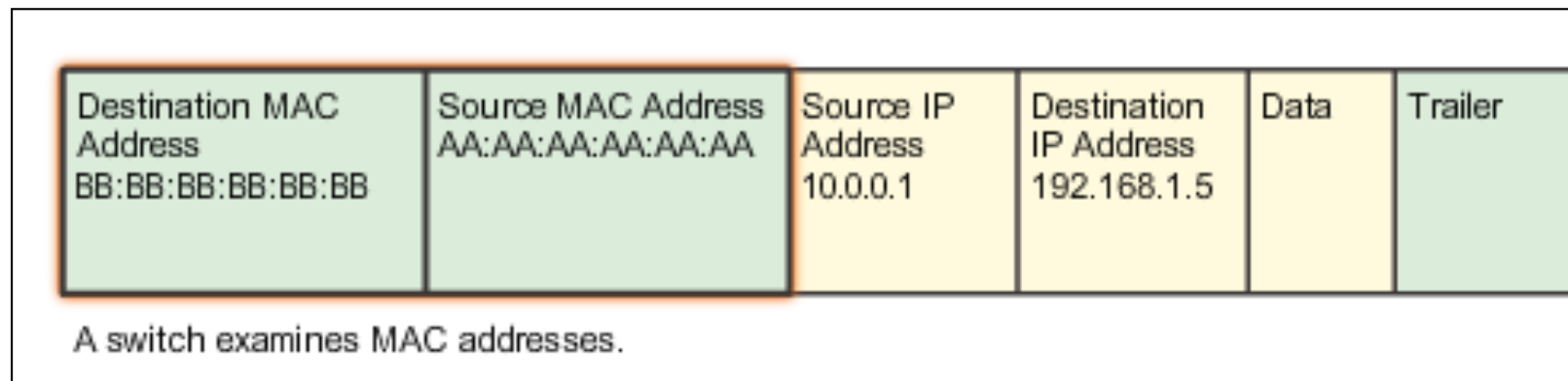




Ethernet MAC

End-to-End Connectivity, MAC, and IP

IP Packet Encapsulated in an Ethernet Frame





ARP

Introduction to ARP

ARP Purpose

- Sending node needs a way to find the MAC address of the destination for a given Ethernet link

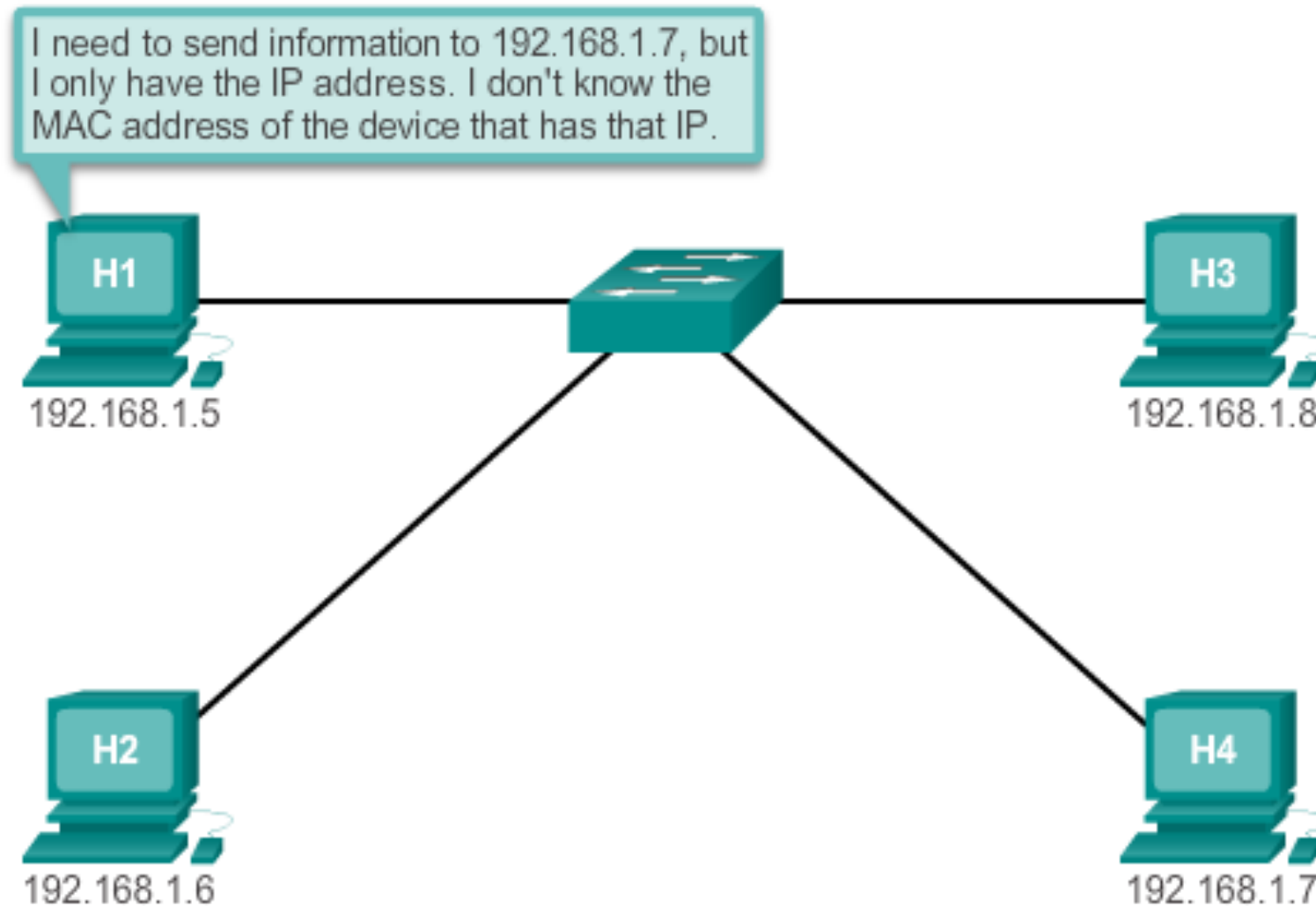
The ARP protocol provides two basic functions:

- Resolving IPv4 addresses to MAC addresses
- Maintaining a table of mappings



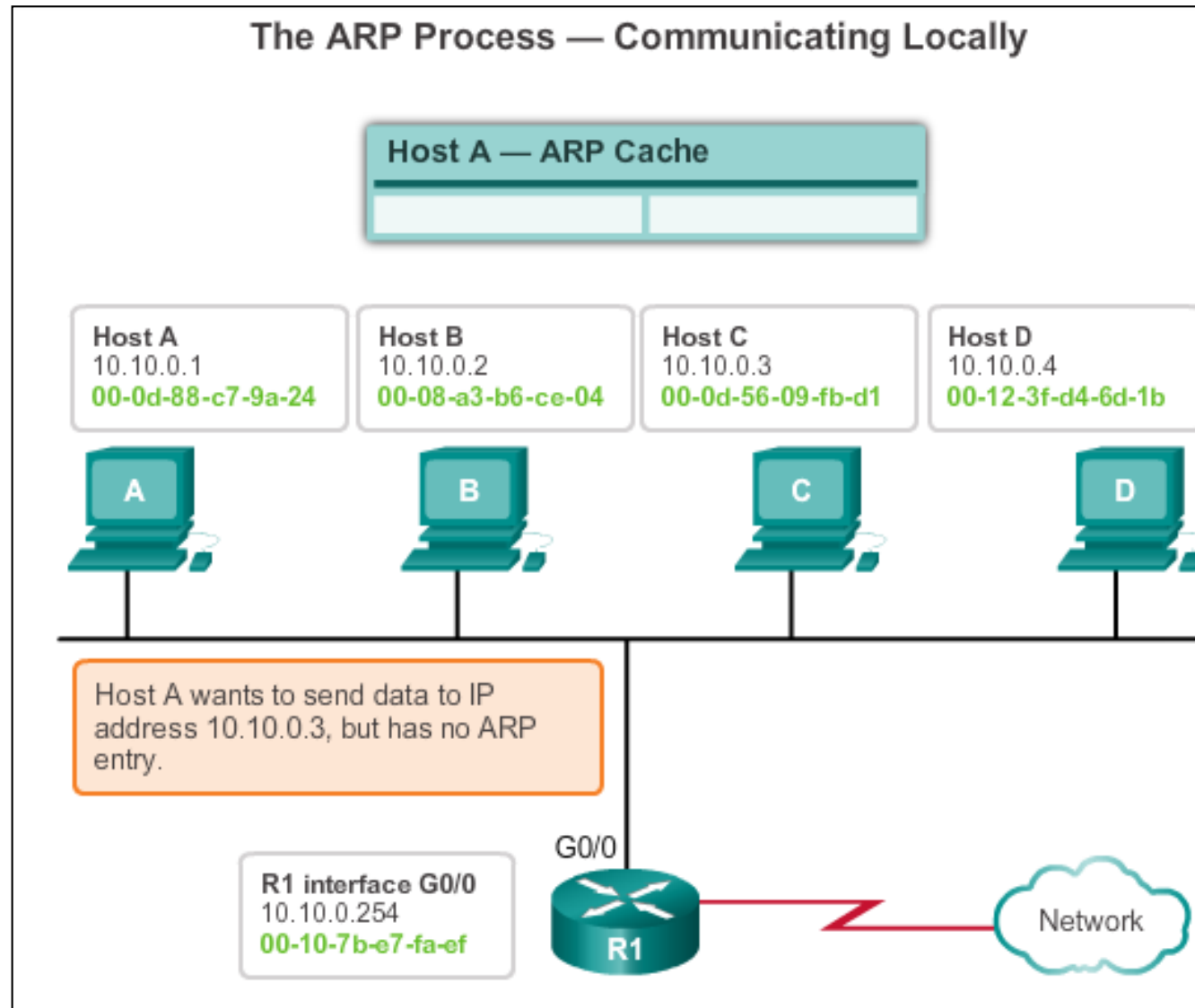
ARP

Introduction to ARP (cont.)





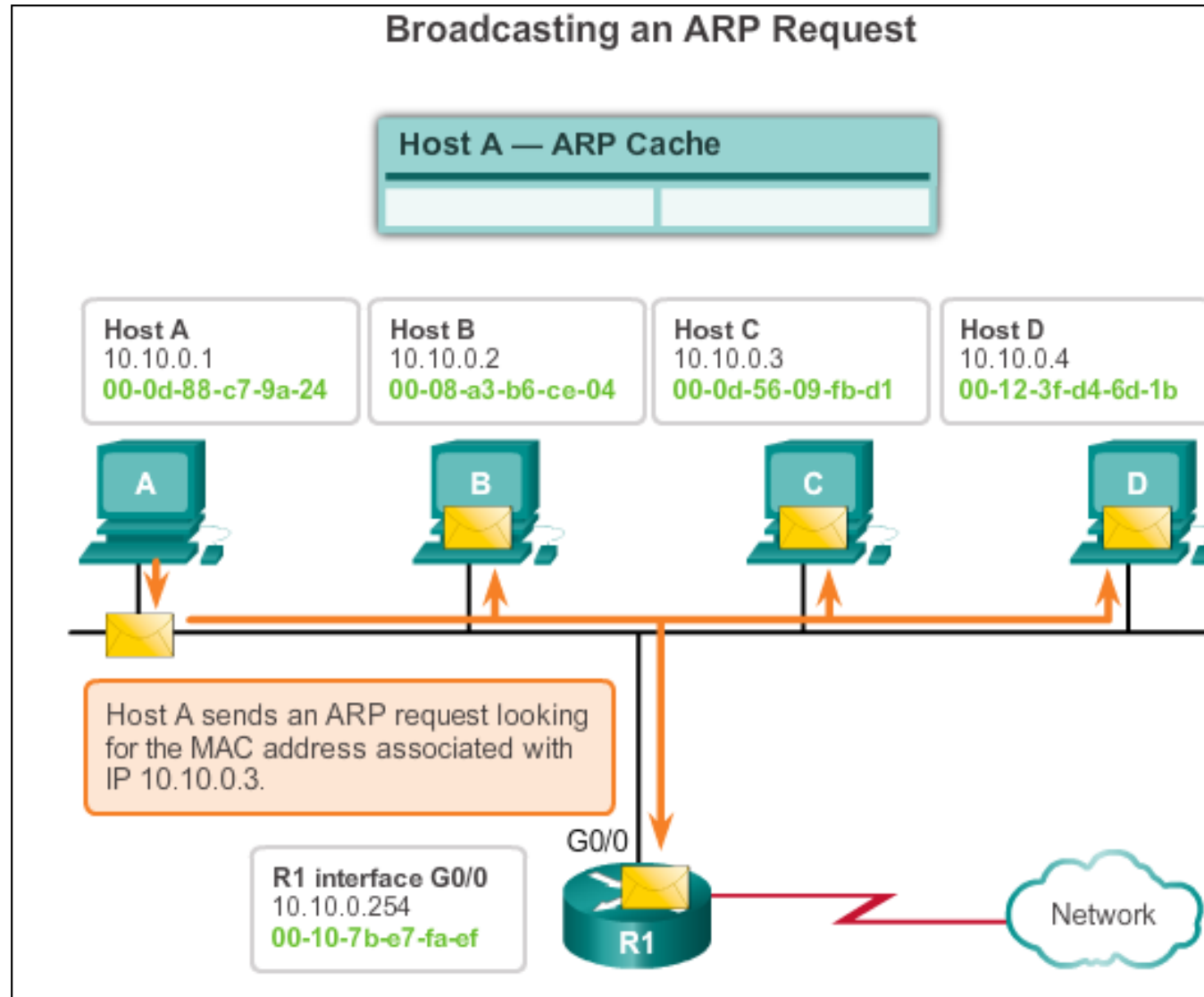
ARP Operation





ARP

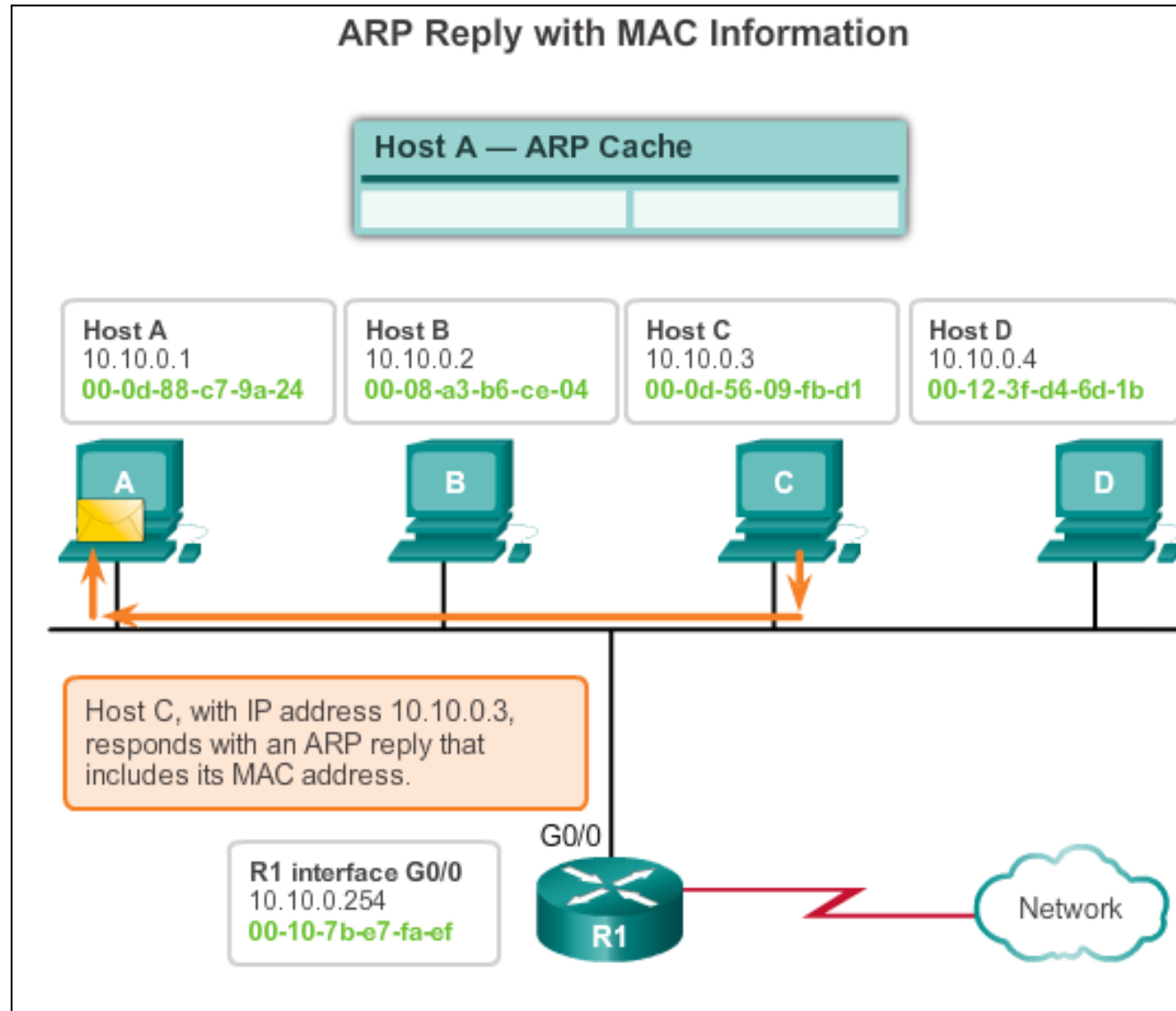
ARP Operation (cont.)





ARP

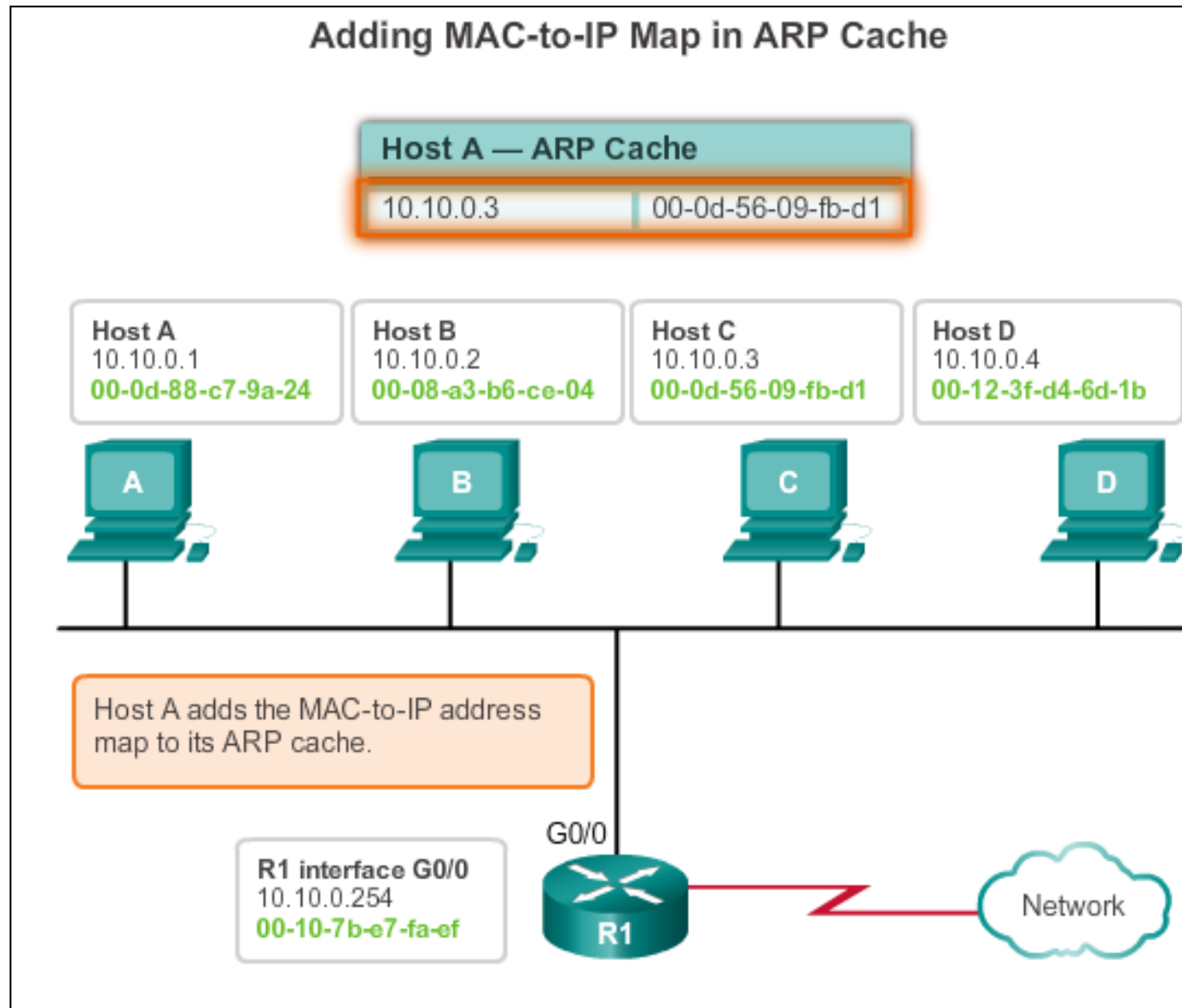
ARP Operation (cont.)





ARP

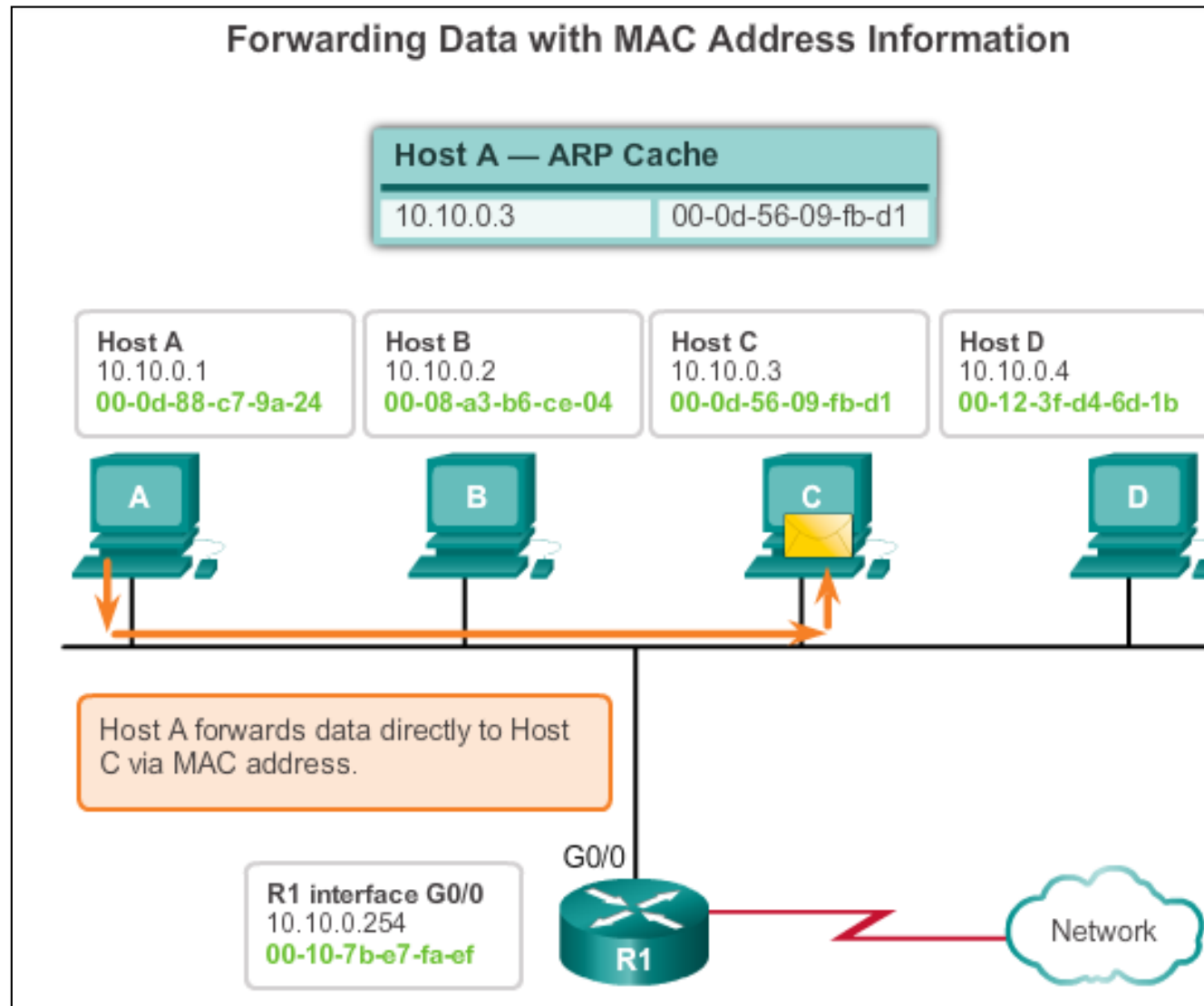
ARP Operation (cont.)





ARP

ARP Functions/Operation (cont.)





ARP

ARP Tables on Networking Devices

```
Router#show ip arp
```

		Age			
Protocol	Address	(min)	Hardware Addr	Type	Interface
Internet	172.16.233.229	-	0000.0c59.f892	ARPA	Ethernet0/0
Internet	172.16.233.218	-	0000.0c07.ac00	ARPA	Ethernet0/0
Internet	172.16.168.11	-	0000.0c63.1300	ARPA	Ethernet0/0
Internet	172.16.168.254	9	0000.0c36.6965	ARPA	Ethernet0/0

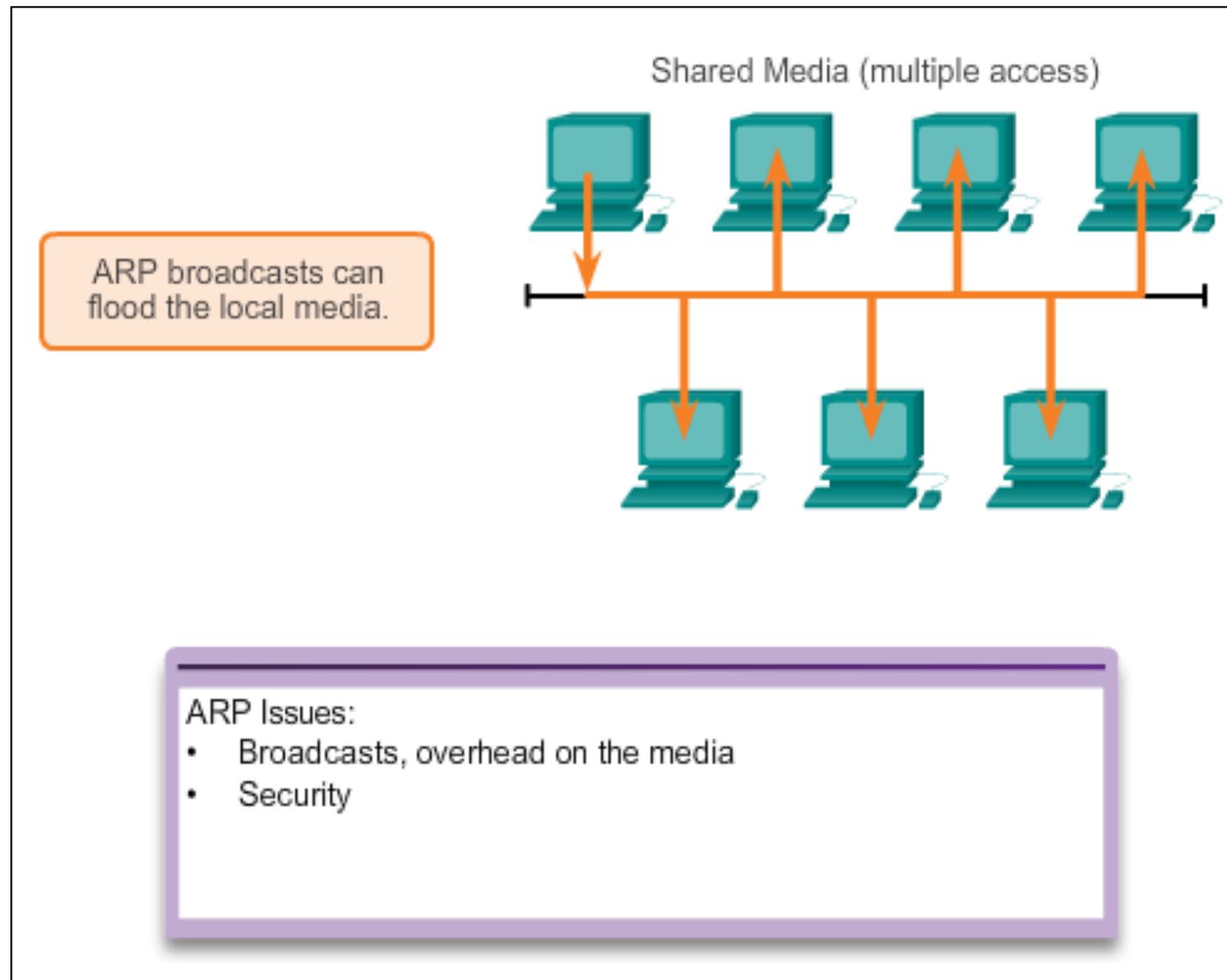
```
C:\>arp -a
```

```
Interface: 192.168.1.67 --- 0xa
Internet Address      Physical Address      Type
192.168.1.254         64-0f-29-0d-36-91    dynamic
192.168.1.255         ff-ff-ff-ff-ff-ff    static
224.0.0.22            01-00-5e-00-00-16    static
224.0.0.251           01-00-5e-00-00-fb    static
224.0.0.252           01-00-5e-00-00-fc    static
255.255.255.255       ff-ff-ff-ff-ff-ff    static
```




ARP Issues

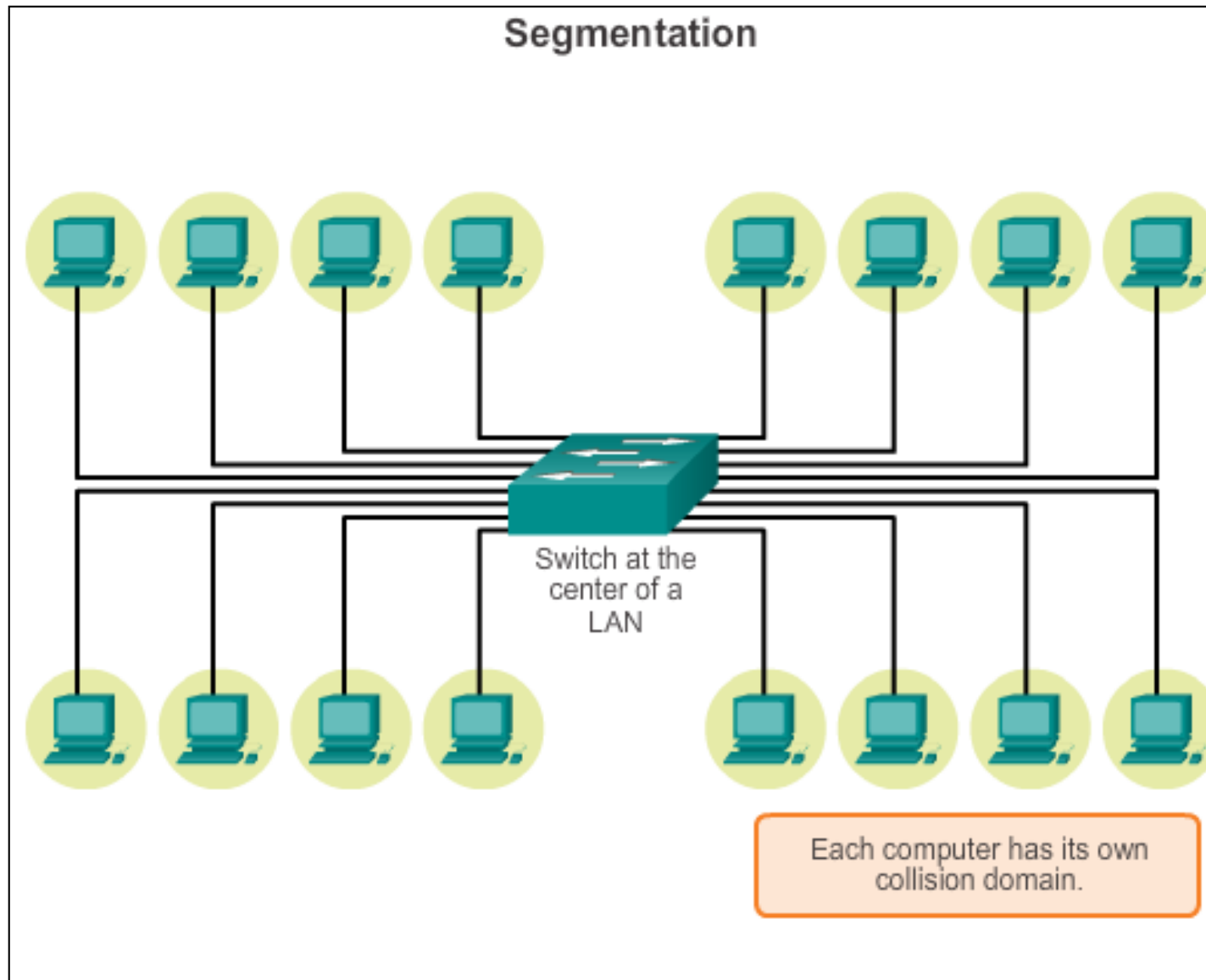
How ARP Can Create Problems





ARP Issues

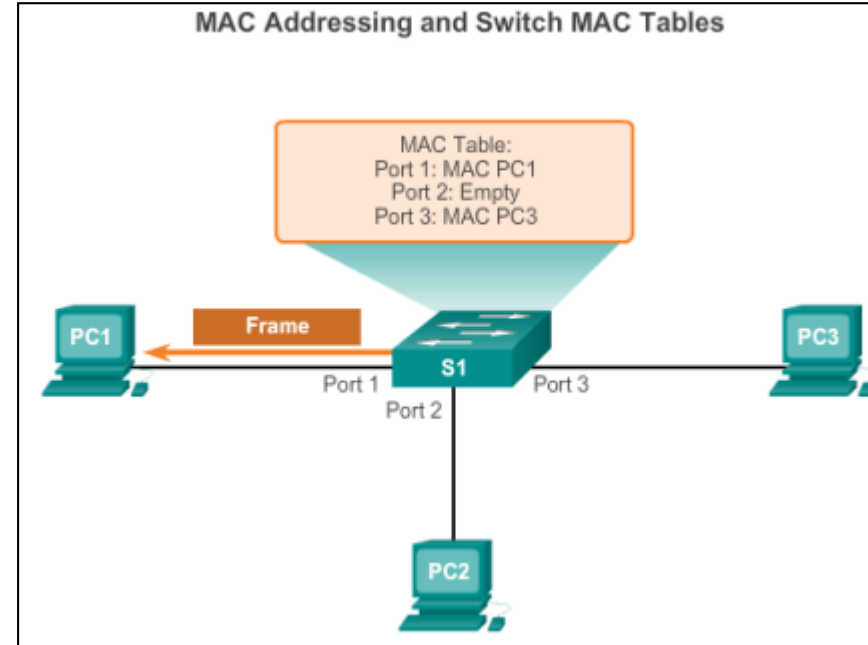
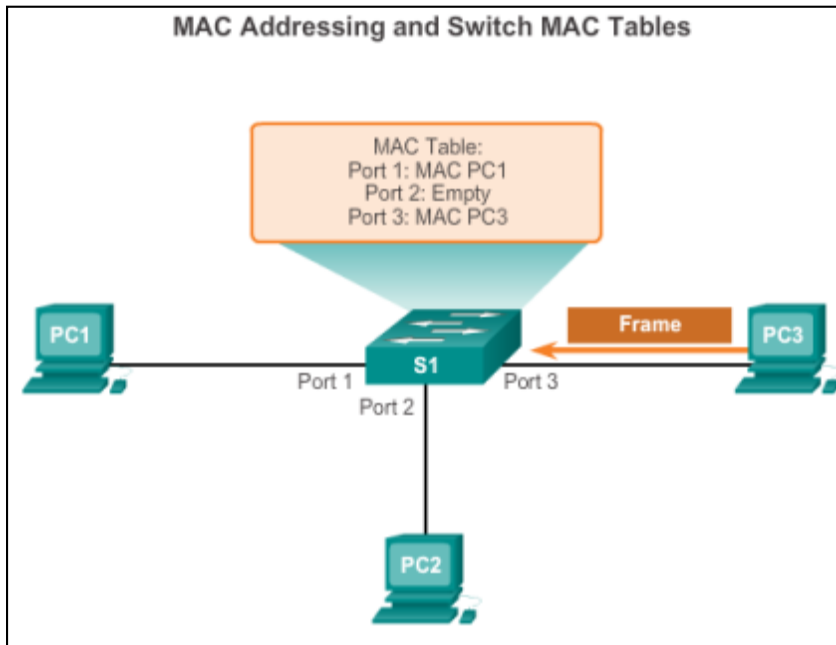
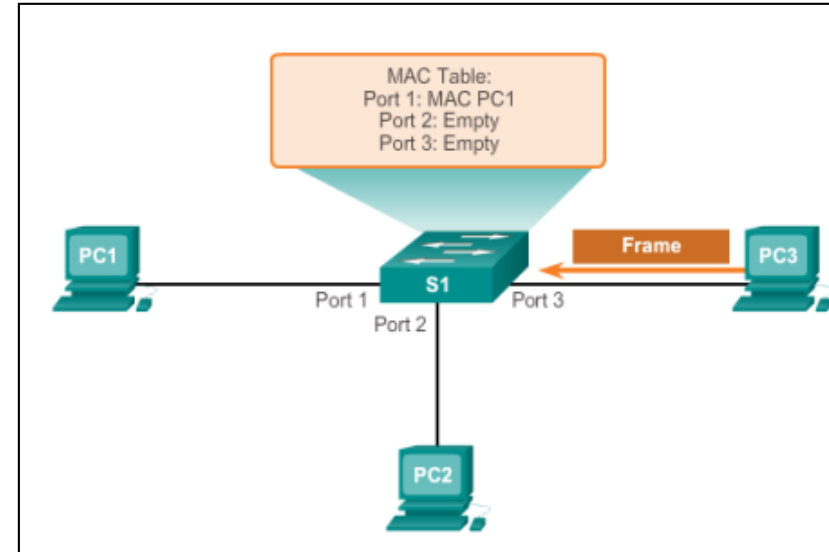
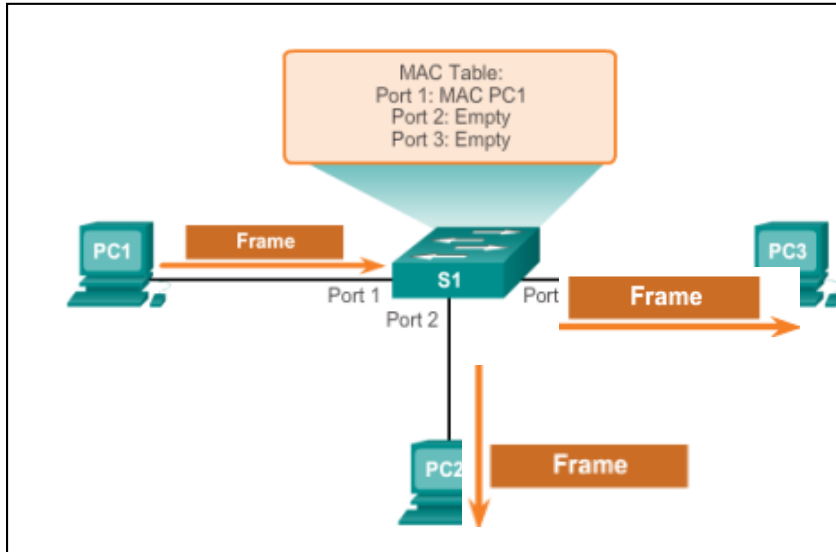
Mitigating ARP Problems





Switching

Switch MAC Address Table

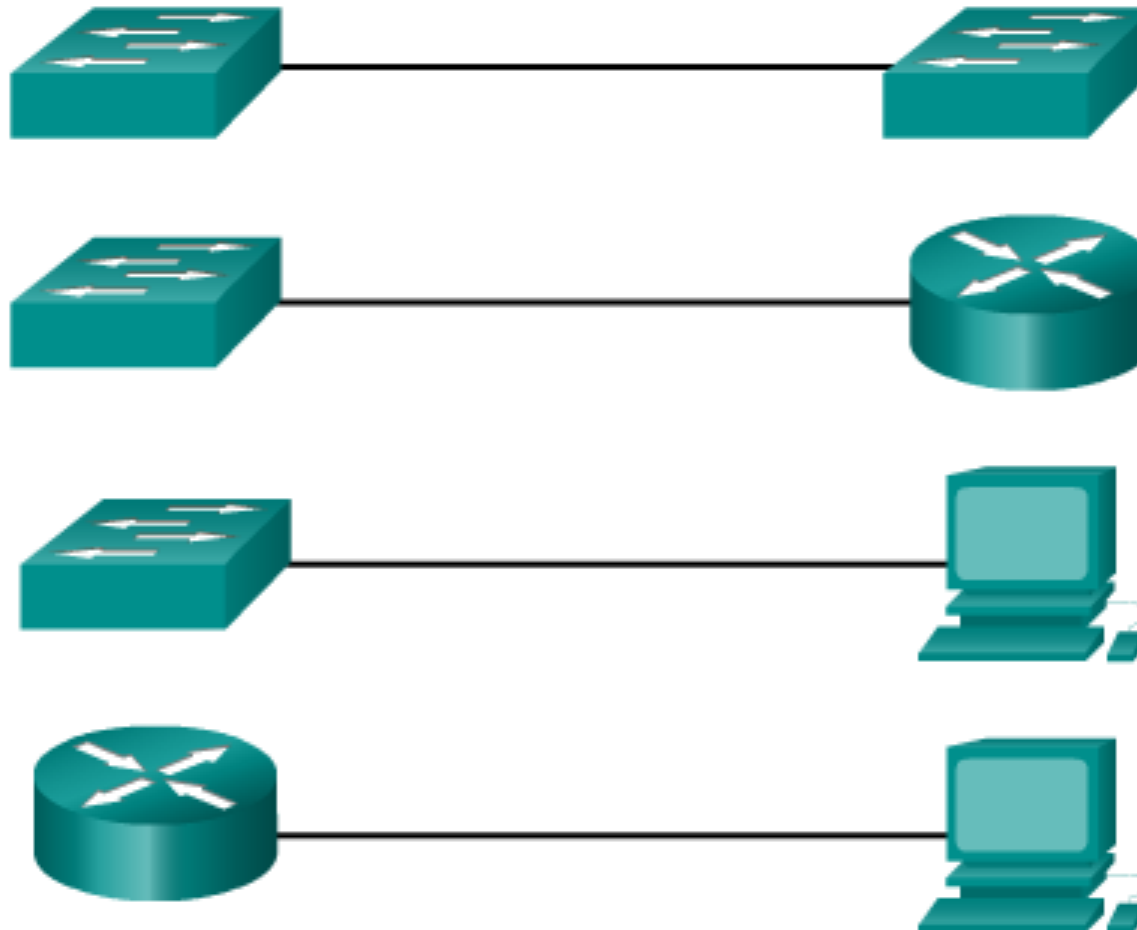




Switching

Auto-MDIX

MDIX auto detects the type of connection required and configures the interface accordingly





Switching

Frame Forwarding Methods on Cisco Switches

Store-and-forward



A store-and-forward switch receives the entire frame, and computes the CRC. If the CRC is valid, the switch looks up the destination address, which determines the outgoing interface. The frame is then forwarded out the correct port.

Cut-through



A cut-through switch forwards the frame before it is entirely received. At a minimum, the destination address of the frame must be read before the frame can be forwarded.



Fixed or Modular

Fixed versus Modular Configuration (cont.)

Switch Form Factors

Fixed Configuration Switches



Features and options are limited to those that originally come with the switch.

Modular Configuration Switches



The chassis accepts line cards that contain the ports.

Stackable Configuration Switches





Layer 3 Switching

Layer 2 versus Layer 3 Switching

