Chapter 5A:

Ethernet

Introduction to Networks

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Chapter 5: Objectives

Upon completion of this chapter, you will be able to:

- Describe the operation of the Ethernet sublayers.
- Identify the major fields of the Ethernet frame.
- Describe the purpose and characteristics of the Ethernet MAC address.
- Describe the purpose of ARP.
- Explain how ARP requests impact network and host performance.
- Explain basic switching concepts.
- Compare fixed configuration and modular switches.
- Configure a Layer 3 switch.

Chapter 5

5.0 Introduction

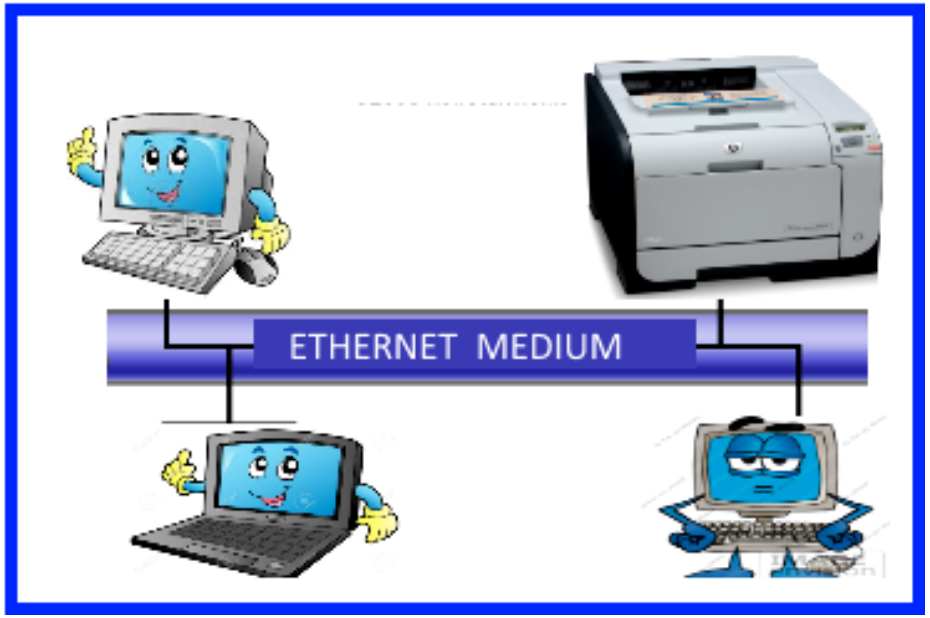
5.1 Ethernet Protocol

5.2 Address Resolution Protocol

5.3 LAN Switches

5.4 Summary

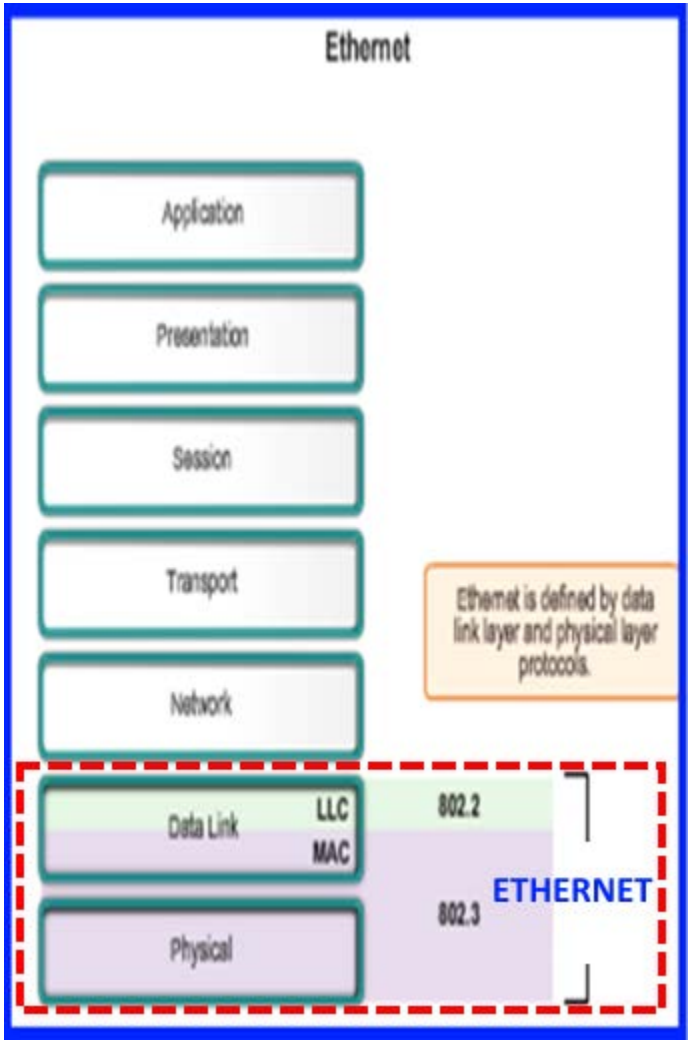
Ethernet Protocol



Ethernet Protocol

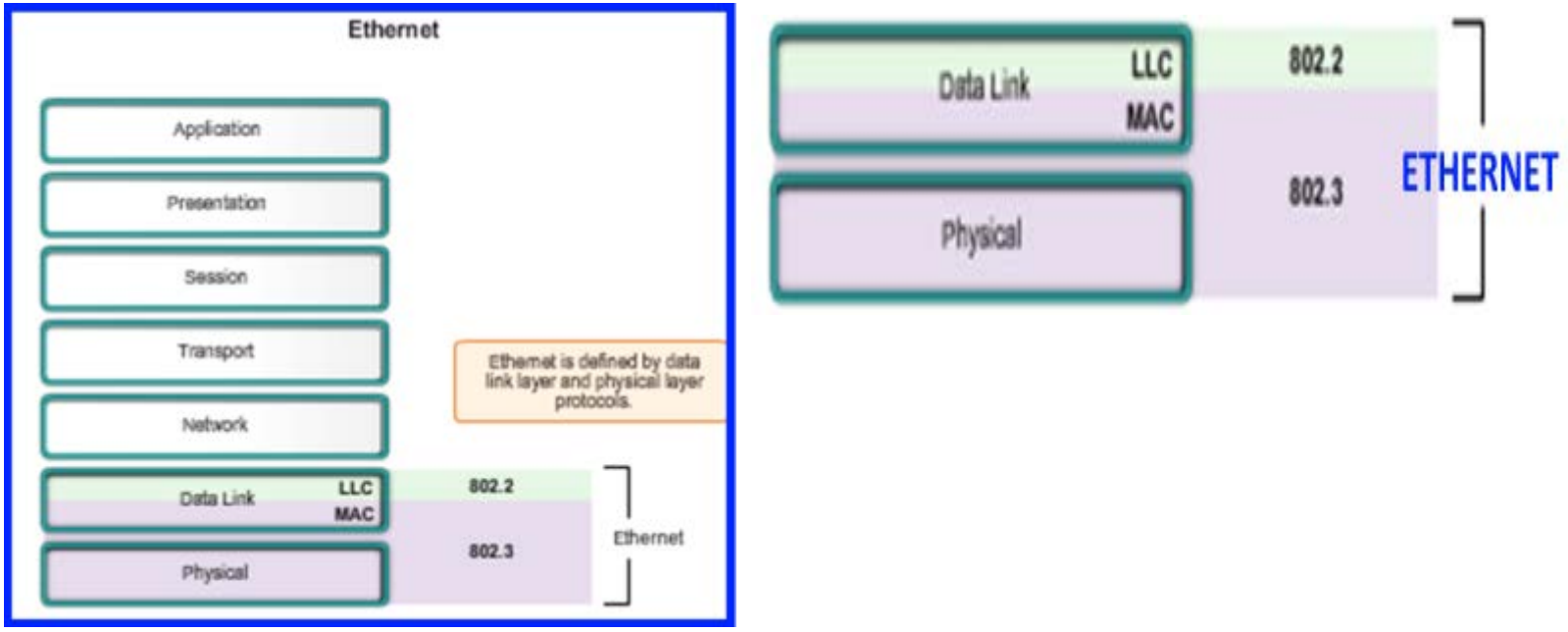
What is Ethernet?

- It is one of the most widely used LAN technologies
- It operates in the data link layer and the physical layer
- It is part of family of networking technologies that are defined in the IEEE 802.2 and 802.3 standards
- It supports data bandwidths of 10, 100, 1000, 10,000, 40,000, and 100,000 Mbps (100 Gbps)



Ethernet Standards

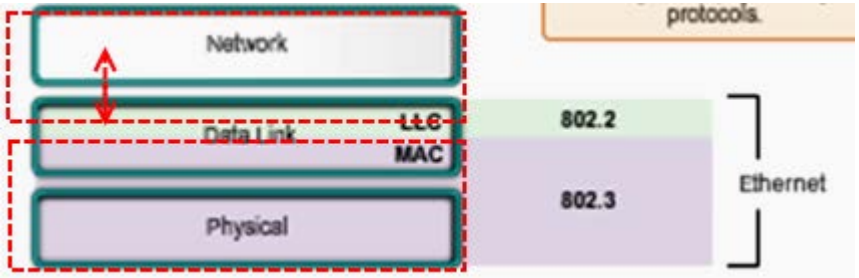
- Layer 2 protocols and Layer 1 technologies are defined by Ethernet Standards
- Two separate sub-layers of the data link layer to operate – Logical link control (LLC) and the MAC sublayers



LLC and MAC Sublayers

LLC

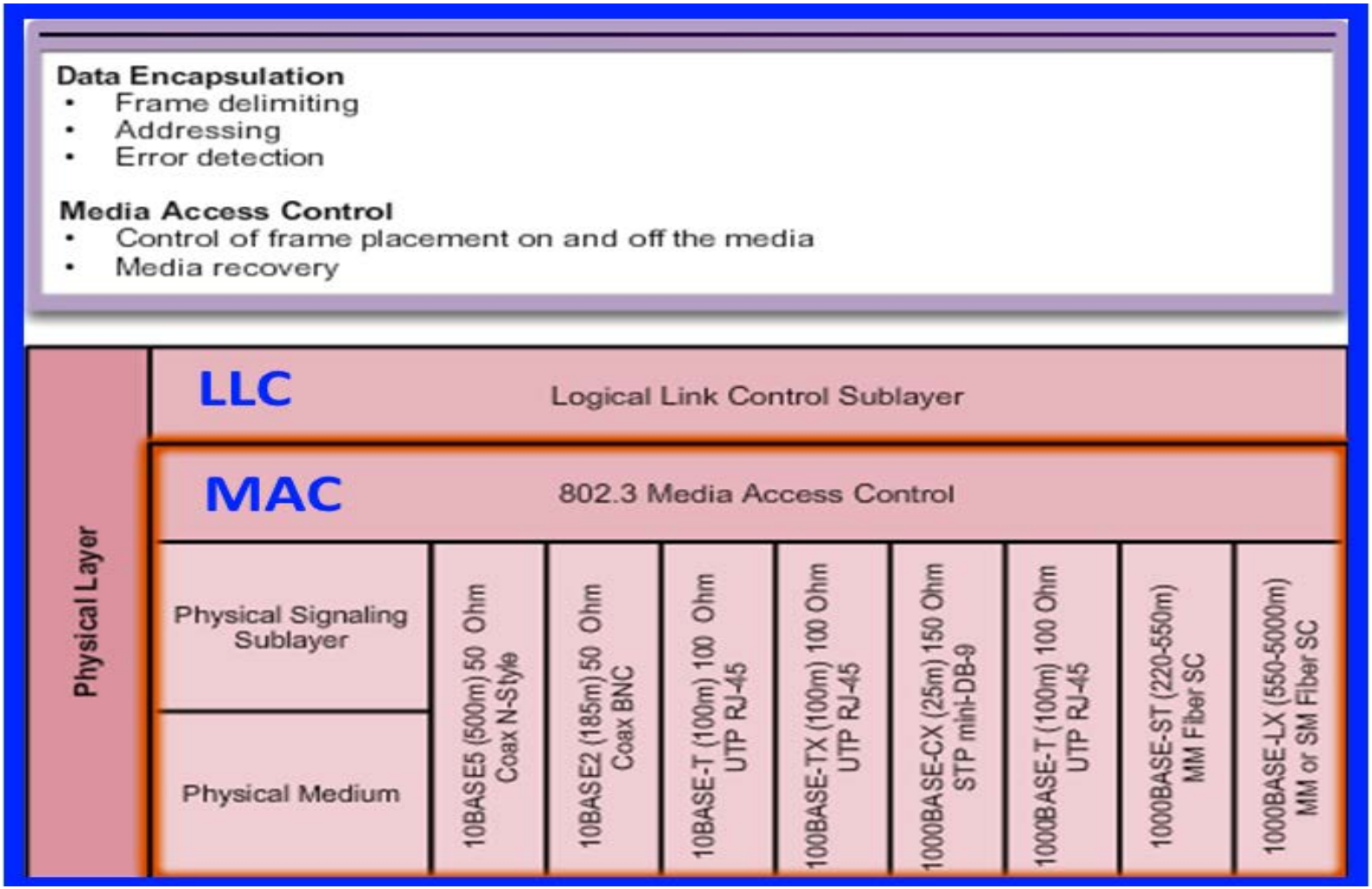
- Handles communication between upper and lower layers.
- Takes the network protocol data and adds control information to help deliver the packet to the destination.



MAC

- Constitutes the lower sub-layer of the data link layer.
- Implemented by hardware, typically in the computer NIC.
- Two primary responsibilities:
  - Data encapsulation
  - Media access control

MAC Sublayer



MAC Sublayer

Data encapsulation takes place in the MAC sublayer

- Data are sent using ethernet frames
- Frames are assembled before transmission
- Frames disassembled upon reception of a frame
- MAC layer adds a header and trailer to the network layer PDU.

MAC Sublayer

MAC Sublayer provides three primary functions:

- Frame delimiting – Identifies a group of bits that make up a frame, synchronization between the transmitting and receiving nodes.
- Addressing – Each Ethernet header added in the frame contains the physical address (MAC address) that enables a frame to be delivered to a destination node.
- Error detection – Each Ethernet frame contains a trailer with a cyclic redundancy check (CRC) of the frame contents.

MAC Sub-layer

The Ethernet MAC sub-layer,

- Is responsible for the placement of frames on the media and the removal of frames from the media
- Communicates directly with the physical layer
- provides a method for controlling how the nodes share access through the use a Carrier Sense Multiple Access (CSMA) technology

(Note : If multiple devices on a single medium attempt to forward data simultaneously, the data will collide resulting in corrupted, unusable data; this needs to be prevented)

MAC - CSMA

Carrier Sense Multiple Access (CSMA) process

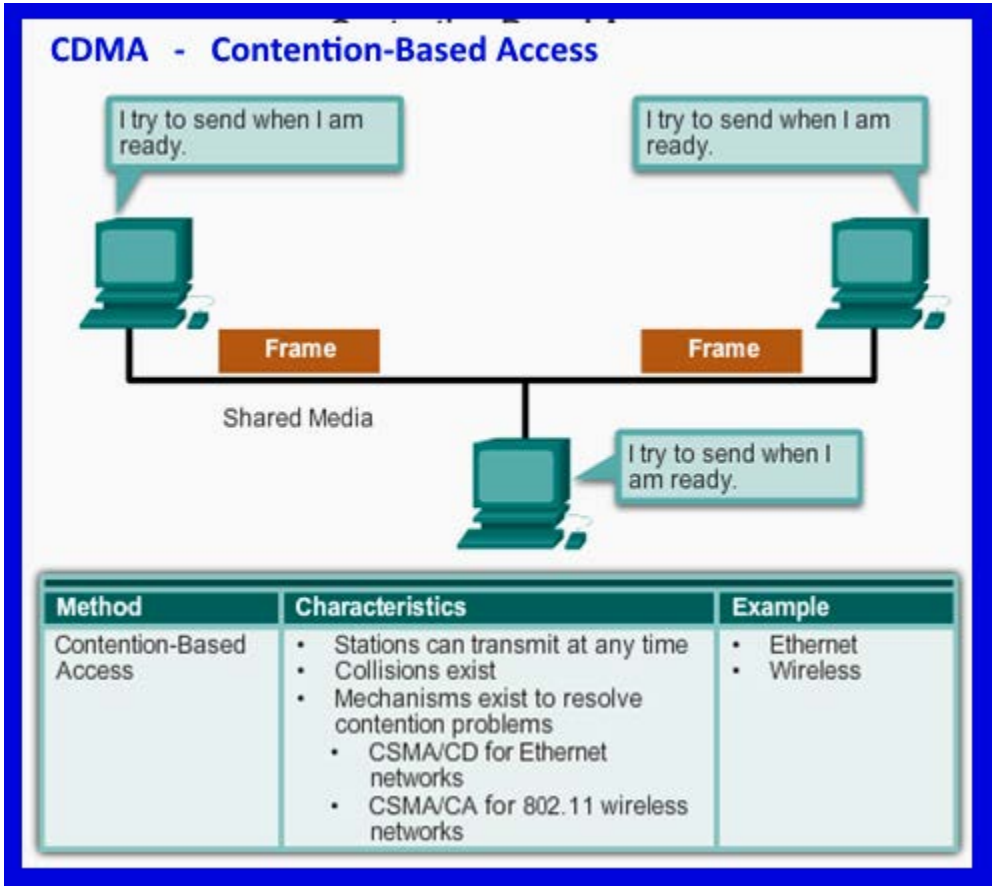
- Used to first detect if the media is carrying a signal
- If no carrier signal is detected, the device transmits its data
- If two devices transmit at the same time - data collision takes place

MAC - CSMA

CSMA is usually implemented in conjunction with a method for resolving media contention.

The two commonly used methods are:

- **CSMA/Collision Detection** and
- **CSMA/Collision Avoidance**



Method	Characteristics	Example

Contention-Based Access	• Stations can transmit at any time
	• Collisions exist
	• Mechanisms exist to resolve contention problems
	  • CSMA/CD for Ethernet networks
	  • CSMA/CA for 802.11 wireless networks
		• Ethernet
		• Wireless

MAC – CSMA/CD

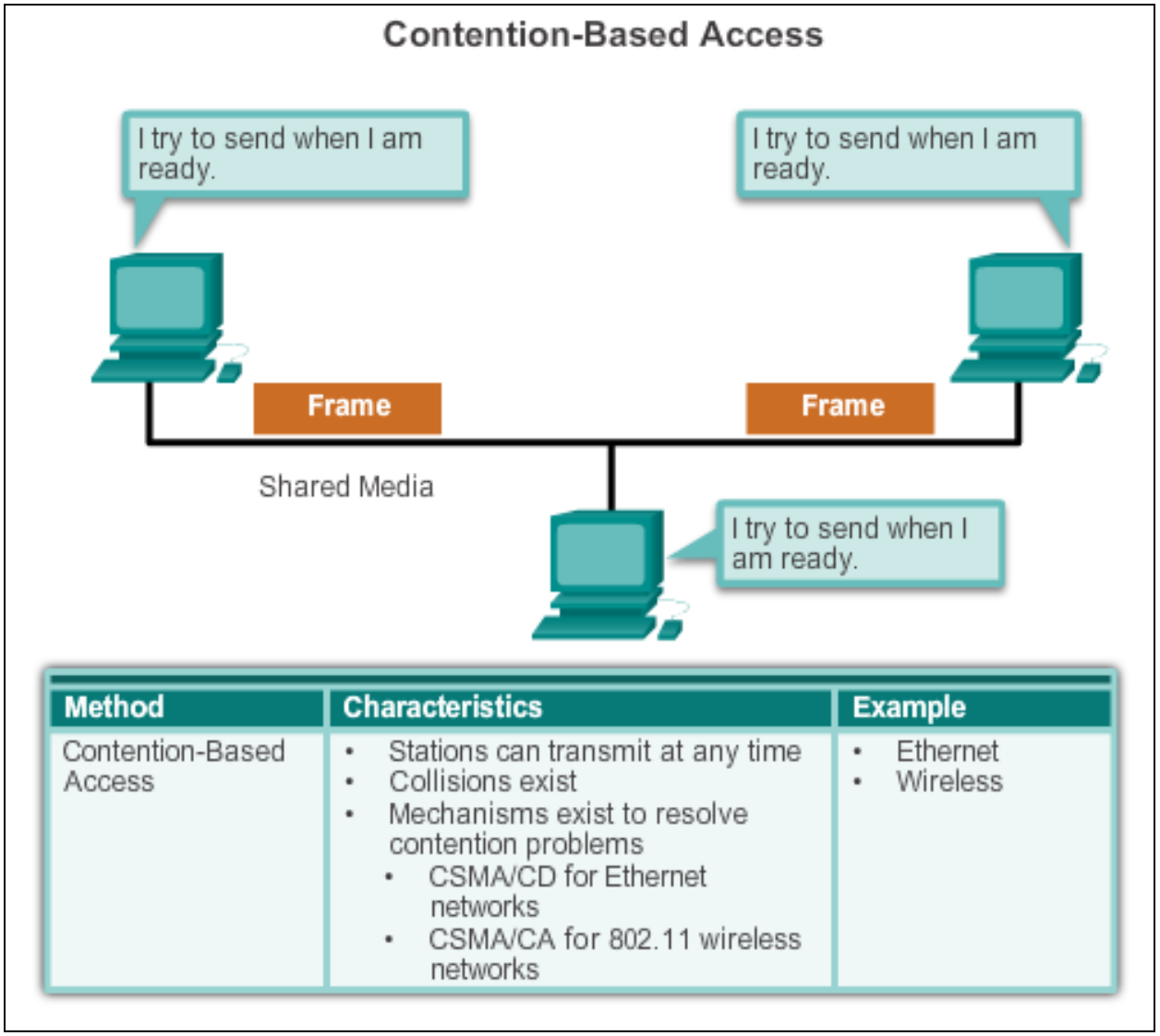
CSMA/Collision Detection (CSMA/CD) Method

- The device monitors the media for the presence of a data signal
- If a data signal is absent, the device transmits the data
- If signals are then detected that show another device was transmitting at the same time, all devices stop sending & try again later

While Ethernet networks are designed with CSMA/CD technology, with today's intermediate devices, collisions do not occur and the processes utilized by CSMA/CD are really unnecessary

Wireless connections in a LAN environment still have to take collisions into account

MAC - CSMA



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Media Access Control

CSMA/Collision Avoidance (CSMA/CA) Method

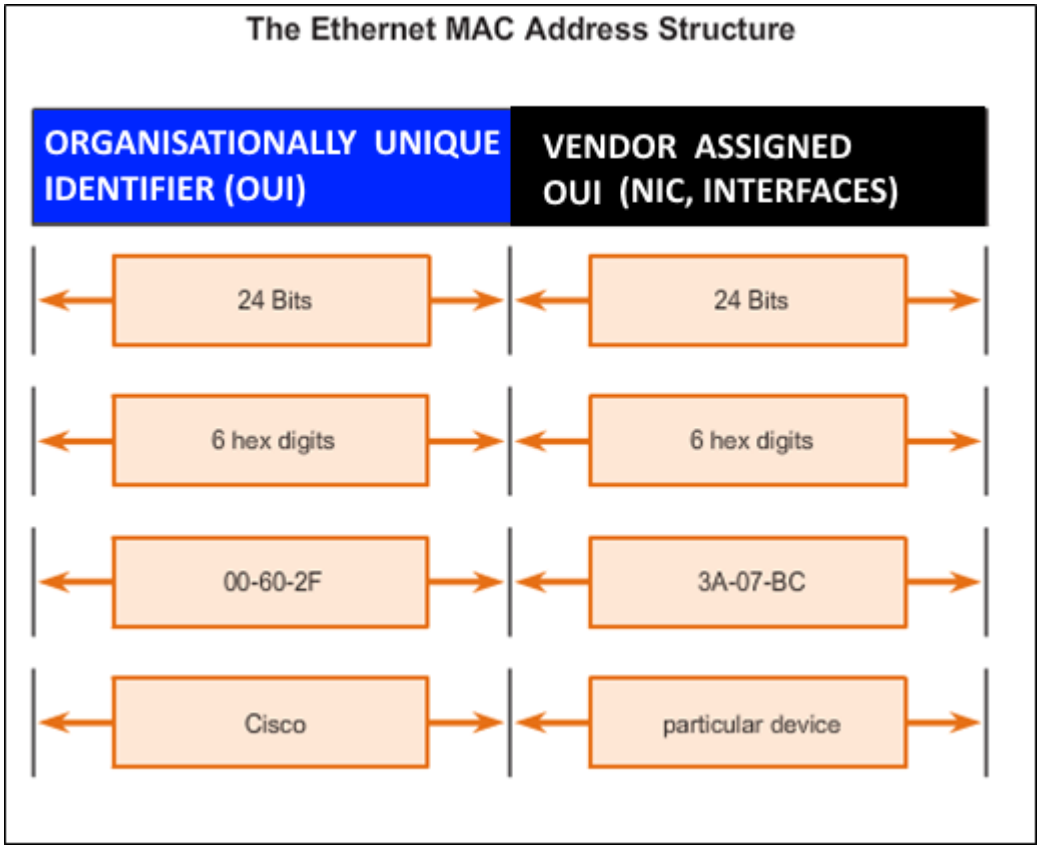
The process used in this method is:

- Network device examines the media for the presence of data signal
- If the media is free, the device sends a notification across the media of its intent to use it
- The device then sends the data.

This method is used by 802.11 wireless networking technologies

MAC Address: Ethernet Identity

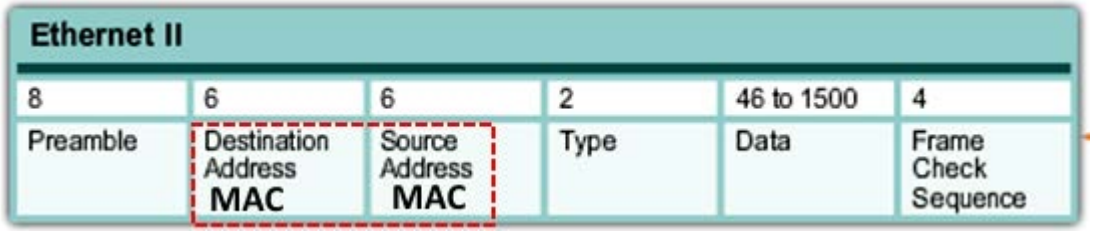
- Layer 2 Ethernet MAC address is a 48-bit binary value expressed as 12 hexadecimal digits.
- IEEE requires a vendor to follow these rules:
  - Must use that vendor's assigned OUI as the first 3 bytes.
  - All MAC addresses with the same OUI must be assigned a unique value in the last 3 bytes.



* OUI – Organizationally Unique Identifier

MAC - Frame Processing

- workstations, servers, printers, switches, and routers all have MAC addresses assigned to them.
- Example MAC addresses:
  - 00-05-9A-3C-78-00
  - 00:05:9A:3C:78:00
  - 0005.9A3C.7800.
- When a device is forwarding a message to an Ethernet network, attached header information to the packet contains the source and destination MAC address.



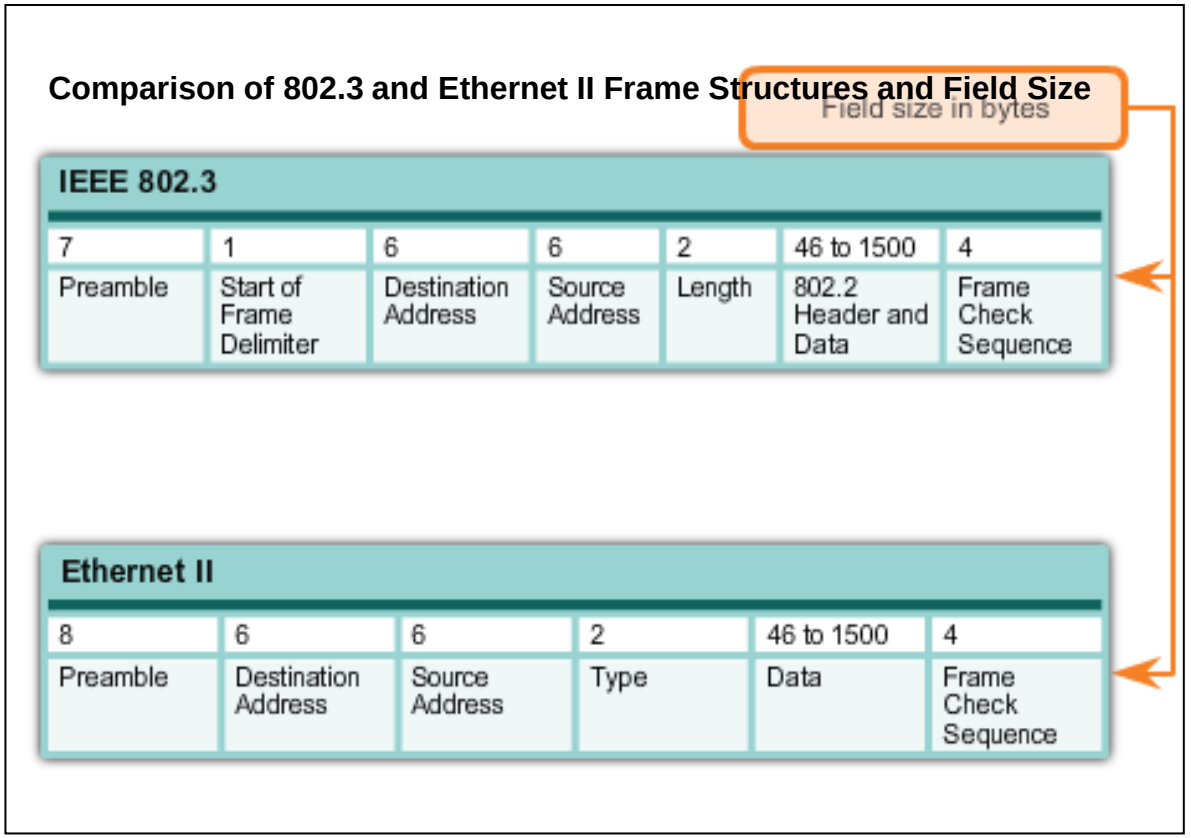
MAC - Frame Processing

- Each NIC views information to see if the destination MAC address in the frame matches the device's physical MAC address stored in RAM.
- If there is no match found, the device discards the frame.
- If a match for the destination MAC of the frame is found, the NIC passes the frame up the OSI layers, where the de-encapsulation process takes place.

* NIC – Network Interface Card

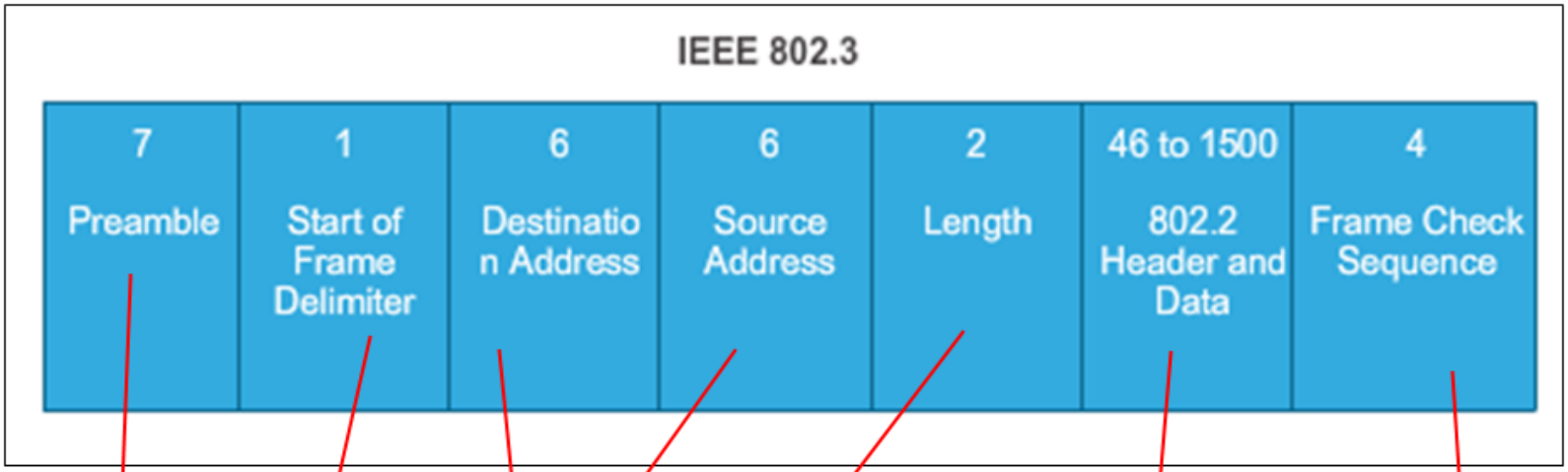
Ethernet Encapsulation

- Early versions of Ethernet were slow at 10 Mb/s.
- Now (2016) operates at 10 Gb/s and faster.
- Ethernet frame structure adds headers and trailers around the Layer 3 PDU to encapsulate the message being sent.
- Ethernet II is the Ethernet frame format used in TCP/IP networks.



Ethernet Frame fields

Each field of the ethernet frame contains some information needed for the delivery of the frame.



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

Destination And Source Address

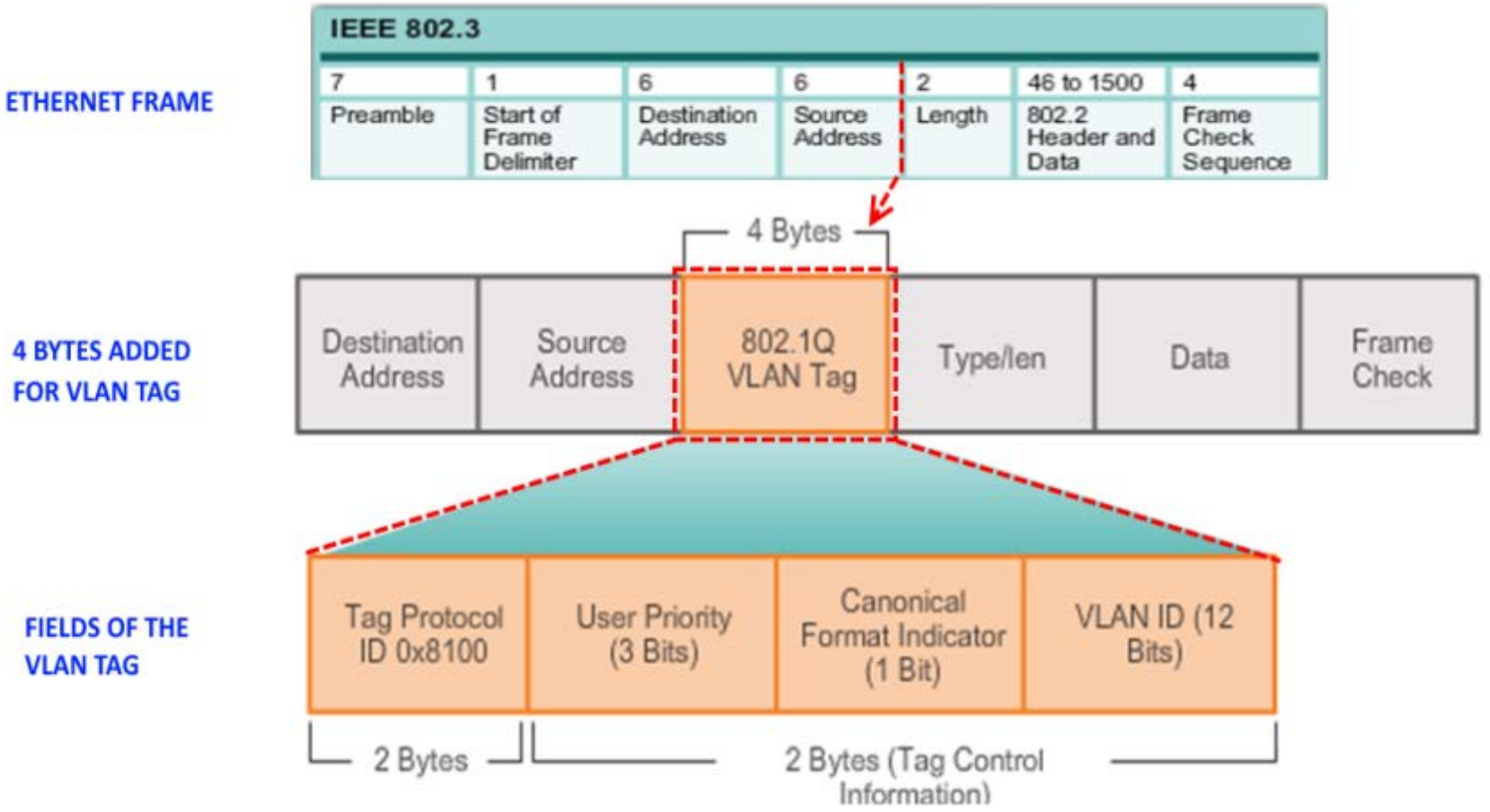
Length/Type Field – Defines the exact length of the frame's data field; describes which protocol is implemented.

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

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.

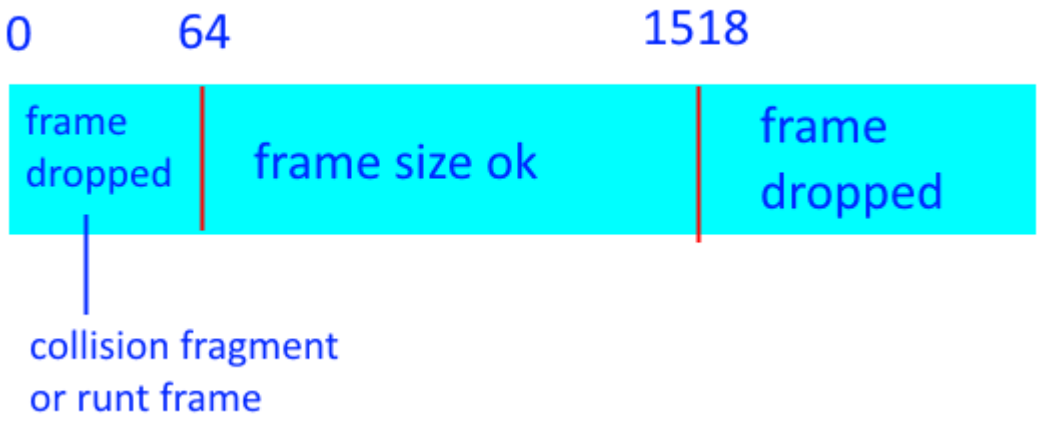
Ethernet Frame Size

4 Bytes added to the Ethernet frame allows QoS and VLAN technologies to be implemented



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 outside the 64 – 1518 bytes range, 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



MAC Addresses and Hexadecimal

MAC addresses are usually stated in Hexadecimal.

Decimal and Binary equivalents of 0 to F Hexadecimal

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Selected Decimal, Binary and Hexadecimal equivalents

Decimal	Binary	Hexadecimal
0	0000 0000	00
1	0000 0001	01
2	0000 0010	02
3	0000 0011	03
4	0000 0100	04
5	0000 0101	05
6	0000 0110	06
7	0000 0111	07
8	0000 1000	08
10	0000 1010	0A
15	0000 1111	0F
16	0001 0000	10
32	0010 0000	20
64	0100 0000	40
128	1000 0000	80
192	1100 0000	C0
202	1100 1010	CA
240	1111 0000	F0
255	1111 1111	FF

MAC Address Representations

There are 3 ways of representing MAC addresses:

DASHES	00-60-2F-3A-07-BC
COLON	00:60:2F:3A:07:BC
PERIOD	0060.2F3A.07BC

```
ipconfig /all

Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . : example.com
   Description . . . . . . . . . . . : Intel(R) Gigabit Network Connection
   Physical Address. . . . . . . . . : 00-18-DE-C7-F3-FB
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   IPv4 Address. . . . . . . . . . . : 192.168.1.67(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Lease Obtained. . . . . . . . . . : Monday, November 26, 2012 12:14:48 PM
   Lease Expires . . . . . . . . . . : Saturday, December 01, 2012 12:15:02 AM
   Default Gateway . . . . . . . . . : 192.168.1.254
   DHCP Server . . . . . . . . . . . : 192.168.1.254
   DNS Servers . . . . . . . . . . . : 192.168.1.254
```

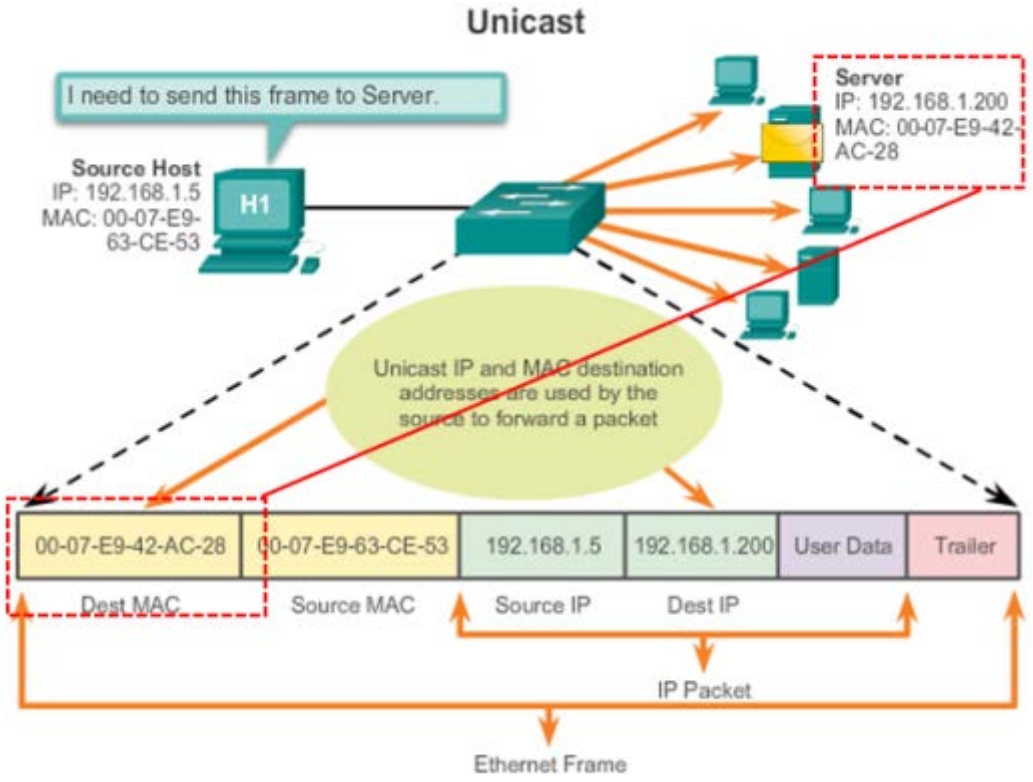
Ethernet Frame information

Information stored in an ethernet frame depends on the delivery option,

- Unicast
- Multicast
- Broadcase

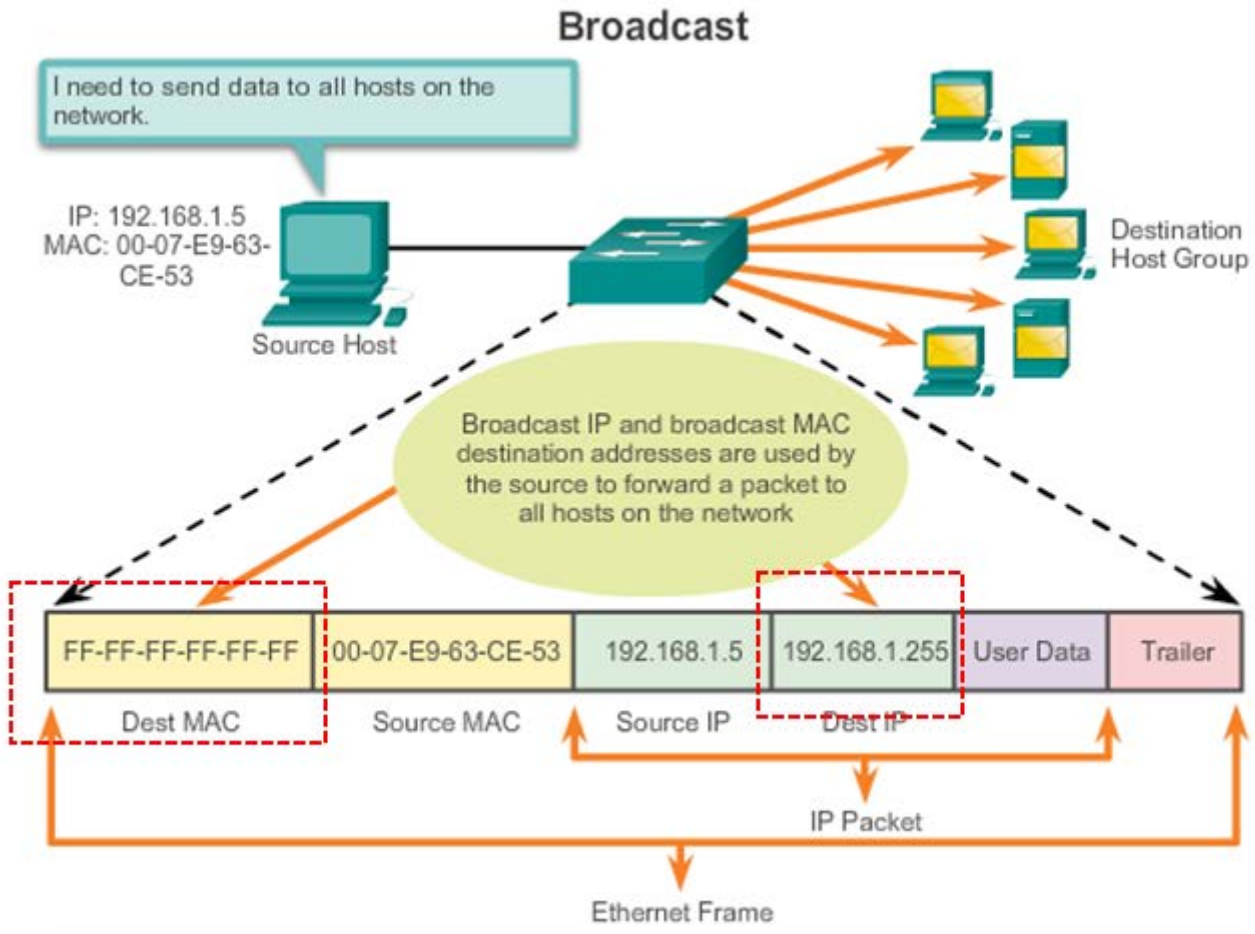
Ethernet MAC
Unicast

A Unicast frame contains one MAC adress.
The frame will be sent to the device that has the destination MAC address stored in the frame.



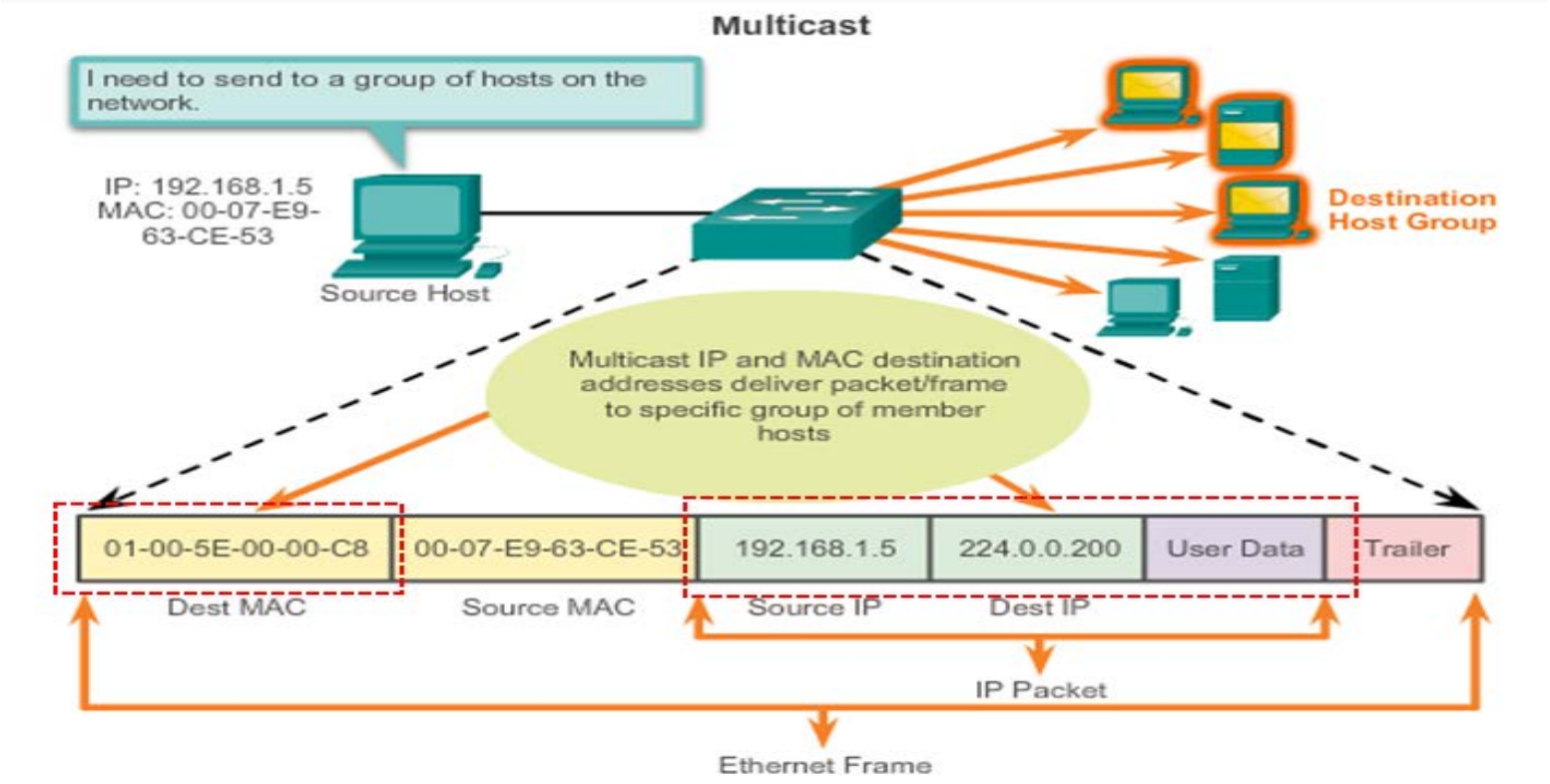
Ethernet MAC
Broadcast

For broadcasting, the frame has the destination MAC and destination IP.



Ethernet MAC
Multicast

The Multicast frame contains destination MAC, source IP, destination IP and User Data.



Multicast MAC address is a special value that begins with 01-00-5E in hexadecimal

Range of IPV4 multicast addresses is 224.0.0.0 to 239.255.255.255

MAC and IP addresses

MAC Address

- This address does not change (fixed for a device)
- Similar to the name of a person
- Known as physical address because physically assigned to the host NIC (Network Interface Card)

IP Address

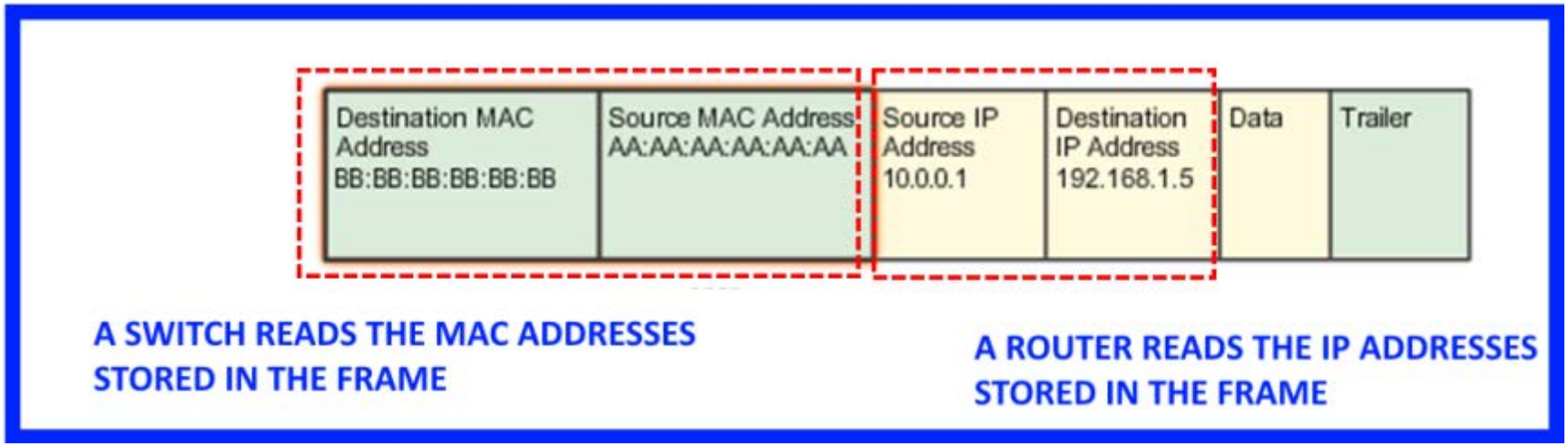
- This address is not fixed for a device
- Similar to the address of a person
- Based on where the host is actually located
- Known as a logical address because assigned logically
- Assigned to each host by a network administrator

Both the physical MAC and logical IP addresses are required for a computer to communicate, just like both the name and address of a person are required to send a letter.

End-to-End Connectivity, MAC, and IP

A switch reads the MAC addresses of the ethernet frame, and sends the frame to the destination.

A router reads the IP addresses of the ethernet frame, and send the frame to the destination IP address.



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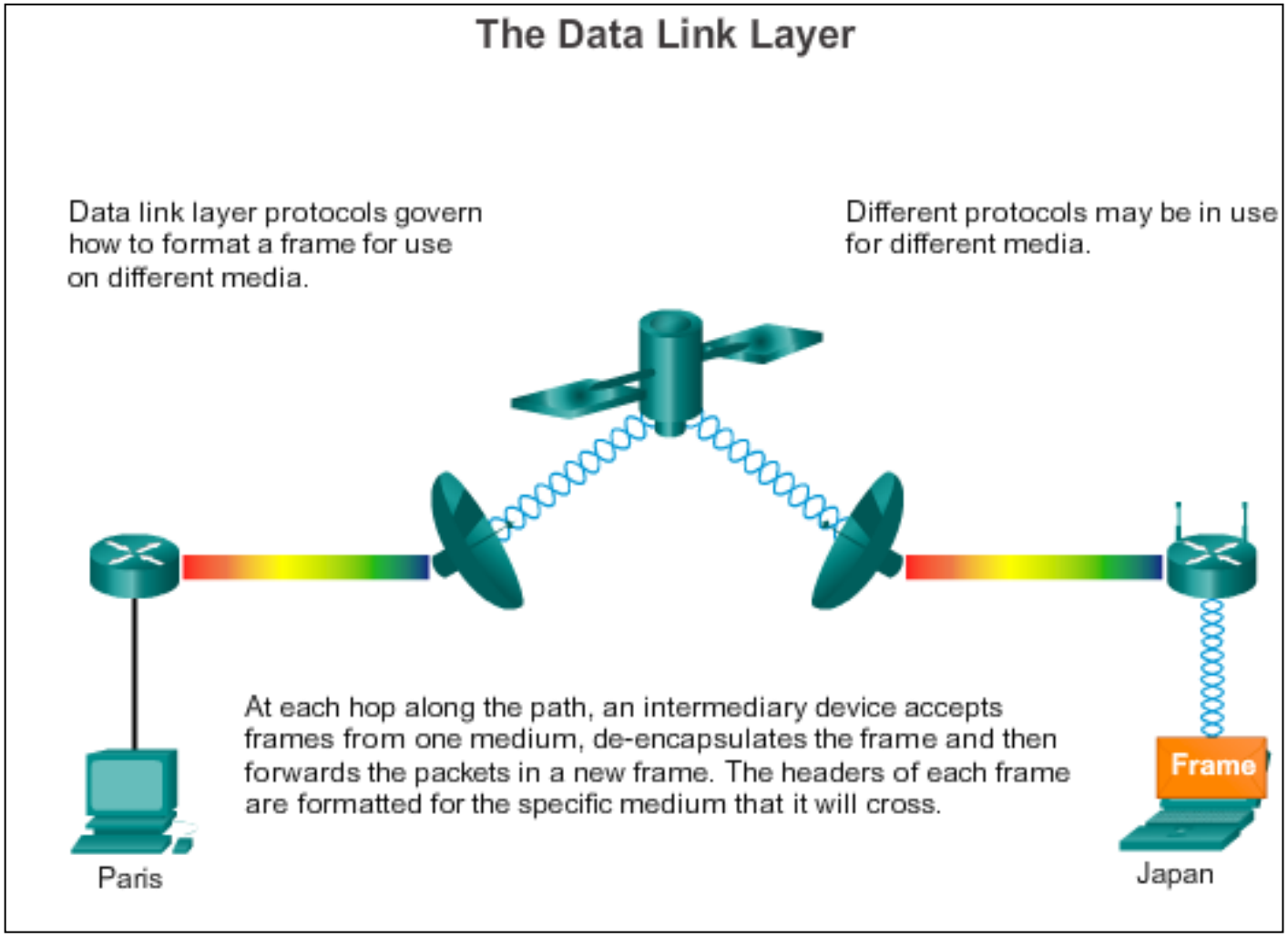

REVIEW

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Review

1. What is Ethernet?

- It is one of the most widely used _____ technologies
- It operates in the _____layer and the _____ layer

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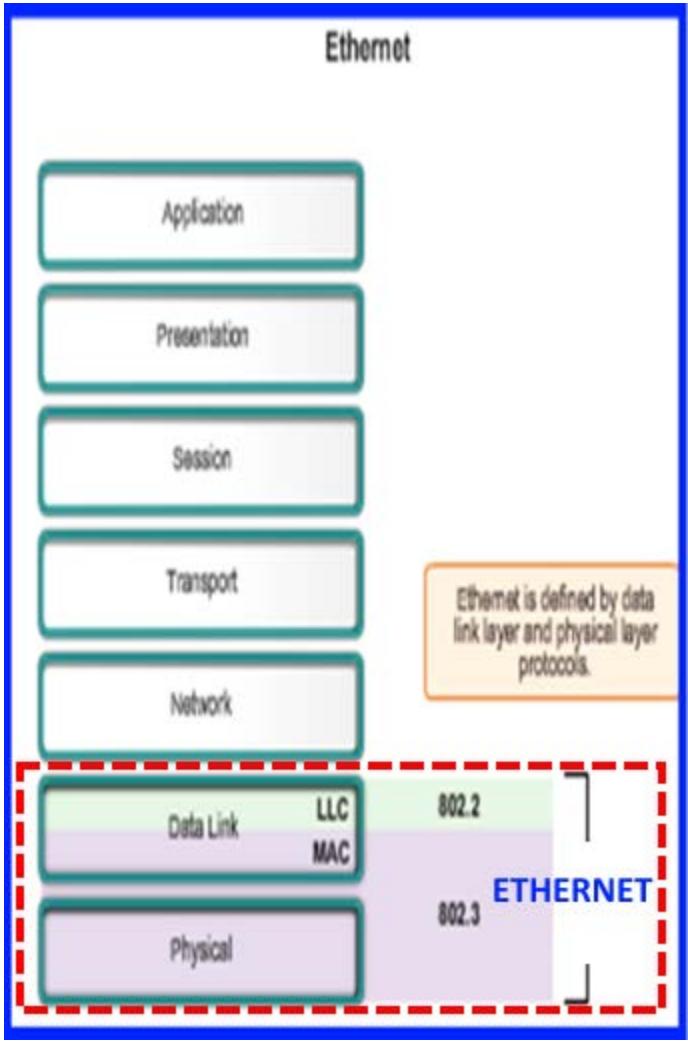

Review

2. Ethernet operates at the sub-layers of the data link layer
- _____(LLC) and the ____ sublayers

Review

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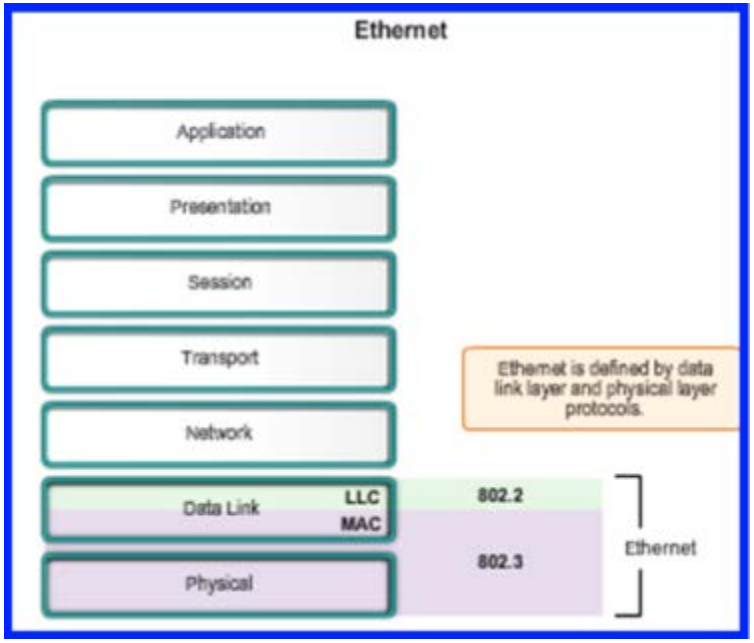
- Logical link control (LLC) and the MAC sublayers



Review

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It takes the network protocol data and _____ to help deliver the packet to the destination.

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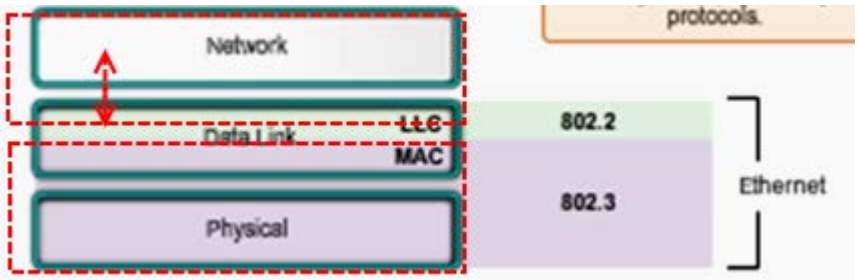

Review

4. The MAC sublayer constitutes the lower sub-layer of the data link layer.

It is implemented by _____, typically in the computer NIC.

Its two primary responsibilities are data _____ and

Media _____.

Review

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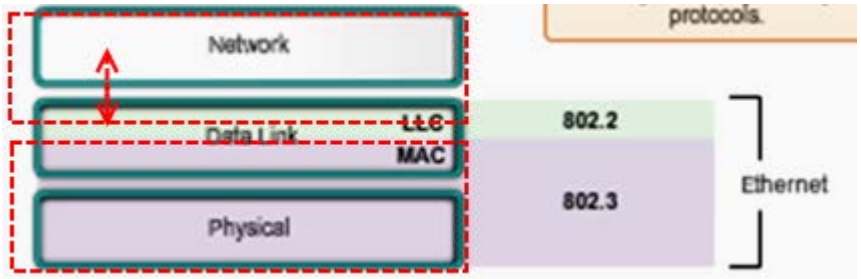
Media access control



Review

5. Data encapsulation takes place in the MAC sublayer

- Data are sent using _____ frames
- Frames are _____ before transmission
- Frames _____ upon reception of a frame
- MAC layer adds a header and _____ to the network layer PDU.

5. Data encapsulation takes place in the MAC sublayer

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- Frame _____ – Identifies a group of bits that make up a frame, synchronization between the transmitting and receiving nodes.
- _____ – Each Ethernet header added in the frame contains the physical address (MAC address) that enables a frame to be delivered to a destination node.
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7. The Ethernet MAC sub-layer is responsible for the _____ of frames on the media, and the removal of frames from the media.

It communicates directly with the _____ layer

It provides a method for controlling how the nodes share access through the use a _____(CSMA) technology

7. The Ethernet MAC sub-layer is responsible for the placement of frames on the media, and the removal of frames from the media.

It communicates directly with the physical layer

It provides a method for controlling how the nodes share access through the use a Carrier Sense Multiple Access (CSMA) technology

Review

8. The Carrier Sense Multiple Access (CSMA) process

- It first detects if the media is carrying a signal
- If no carrier signal is detected, the device transmits its data
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The two commonly used methods are:

- **CSMA/**_____ and
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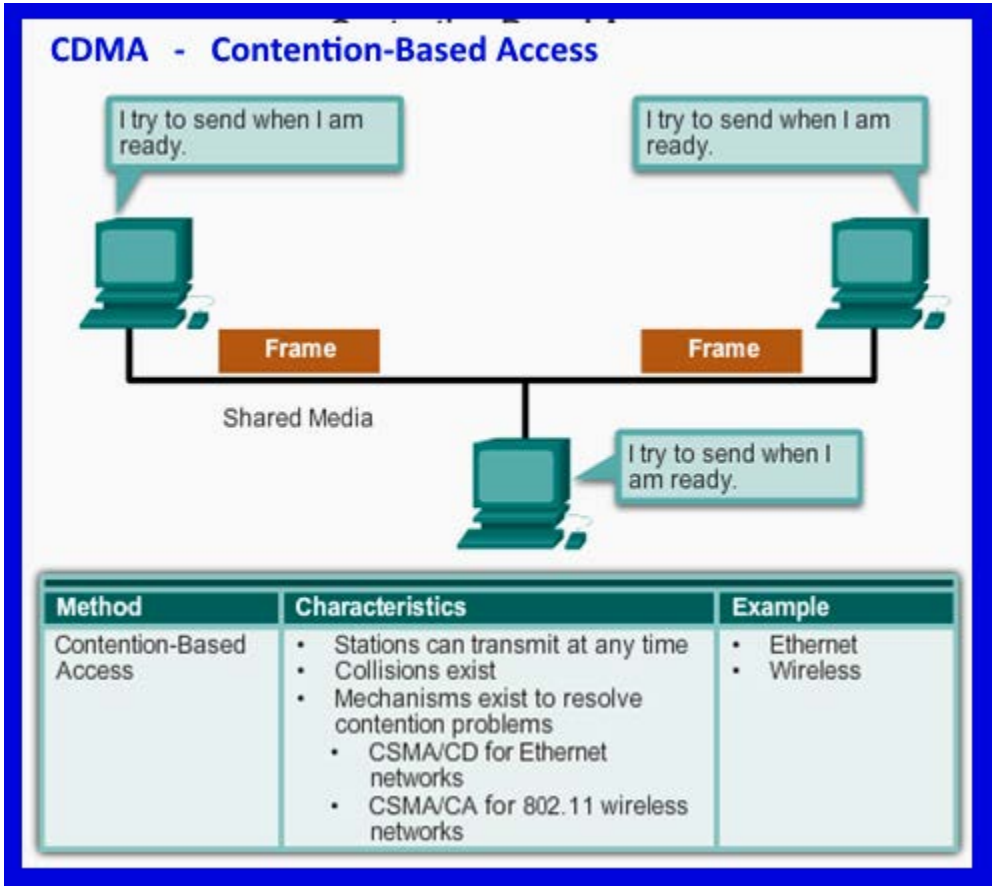

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		• Ethernet
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Review

10. CSMA/Collision Detection (CSMA/CD) Method

- The device monitors the media for the _____ of a data signal
- If a data signal is _____, the device transmits the data
- If signals are detected, all devices stop sending & try again later

Review

10. CSMA/Collision Detection (CSMA/CD) Method

- The device monitors the media for the presence of a data signal
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Review

11. CSMA/Collision Avoidance (CSMA/CA) Method

The process used in this method is:

- Network device examines the media for the presence of data signal
- If the media is free, the device sends a _____ across the media of its intent to use it
- The device then _____ the data.

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The process used in this method is:

- Network device examines the media for the presence of data signal
- If the media is free, the device sends a notification across the media of its intent to use it
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12. The Layer 2 Ethernet MAC address is a _____ binary value expressed as 12 hexadecimal digits.

- IEEE requires a vendor to assign OUI as the first 3 bytes.
- All MAC addresses with the same _____ must be assigned a unique value in the last 3 bytes.

* OUI – Organizationally Unique Identifier

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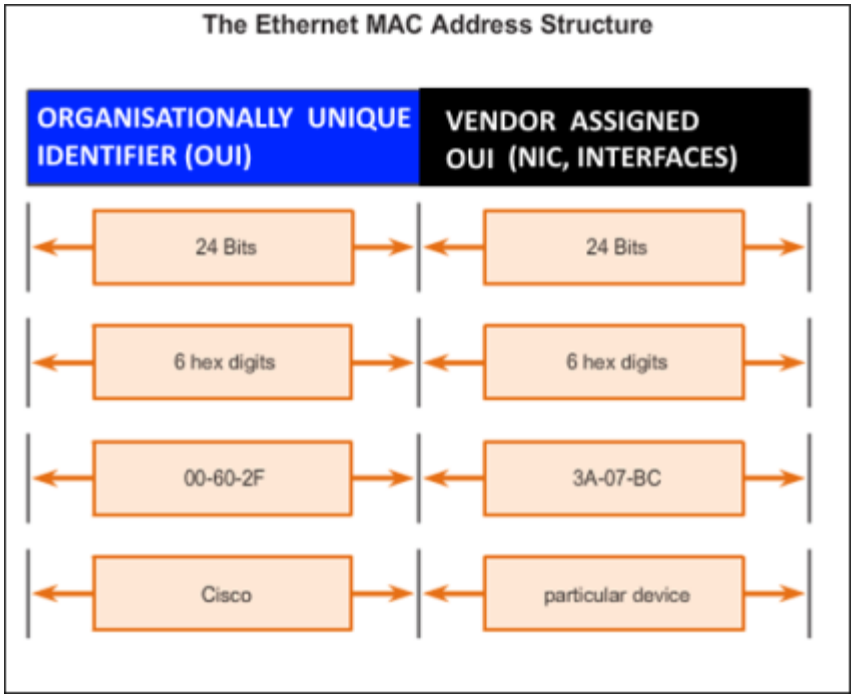

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12. workstations, servers, printers, switches, and routers all have ___ addresses assigned to them.

- Example ____ addresses:
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When a device is forwarding a message to an Ethernet network, attached header information to the packet contains the _____ and _____ MAC address.

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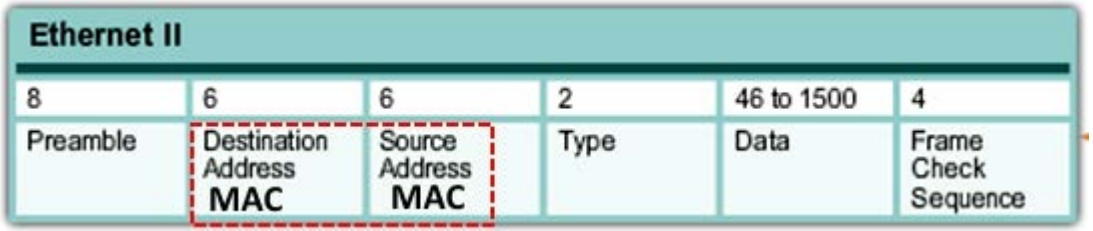


Review

13. Each NIC views information to see if the _____ MAC address in the frame matches the device's _____ MAC address stored in RAM.

If there is no match found, the device _____ the frame.

If a match for the destination MAC of the frame is found, the NIC passes the frame up the OSI layers, where the _____ process takes place.

* NIC – Network Interface Card

Review

13. Each NIC views information to see if the destination MAC address in the frame matches the device's physical MAC address stored in RAM.

If there is no match found, the device discards the frame.

If a match for the destination MAC of the frame is found, the NIC passes the frame up the OSI layers, where the de-encapsulation process takes place.

* NIC – Network Interface Card

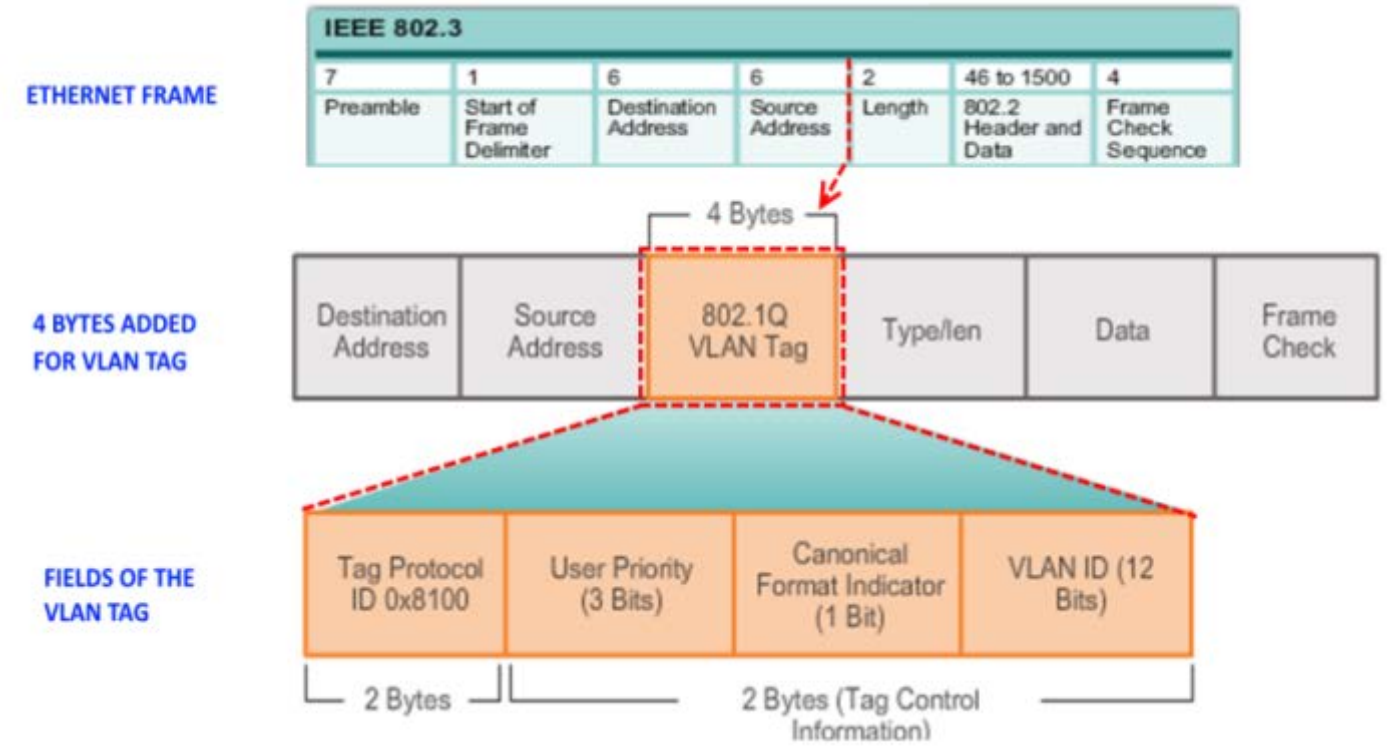
Review

14.

____Bytes are added to the Ethernet frame to allow QoS and _____ technologies to be implemented

Review

14.
4 Bytes are added to the Ethernet frame to allow QoS and VLAN technologies to be implemented



Review

15. Ethernet II and IEEE 802.3 standards define the minimum frame size as ____ bytes and the maximum as ____ bytes

A frame of less than 64 bytes in length is considered a "collision fragment" or "_____ frame"

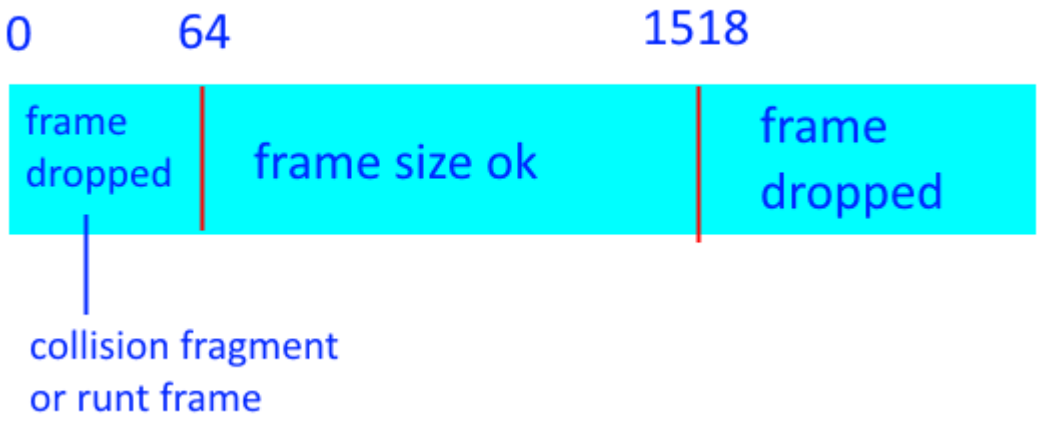
If size of a transmitted frame is outside the 64 – 1518 bytes range, the receiving device _____ the frame

Review

15. Ethernet II and IEEE 802.3 standards define the minimum frame size as 64 bytes and the maximum as 1518 bytes

A frame of less than 64 bytes in length is considered a "collision fragment" or "runt frame"

If size of a transmitted frame is outside the 64 – 1518 bytes range, the receiving device drops the frame



Review

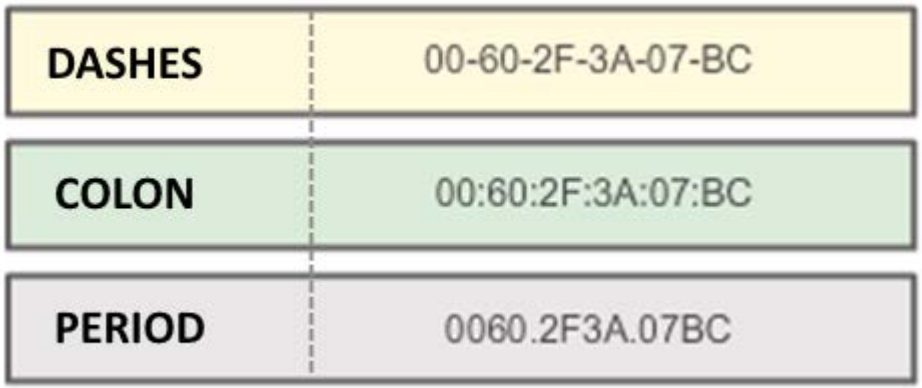
16. There are 3 ways of representing MAC addresses:
Using dashes
Using _____
Using _____

-

Review

16. There are 3 ways of representing MAC addresses:
Using dashes
Using colons
Using periods

-



Review

17. Information stored in an ethernet frame depends on the delivery option,

- _____
- Multicast
- _____

Review

17. Information stored in an ethernet frame depends on the delivery option,

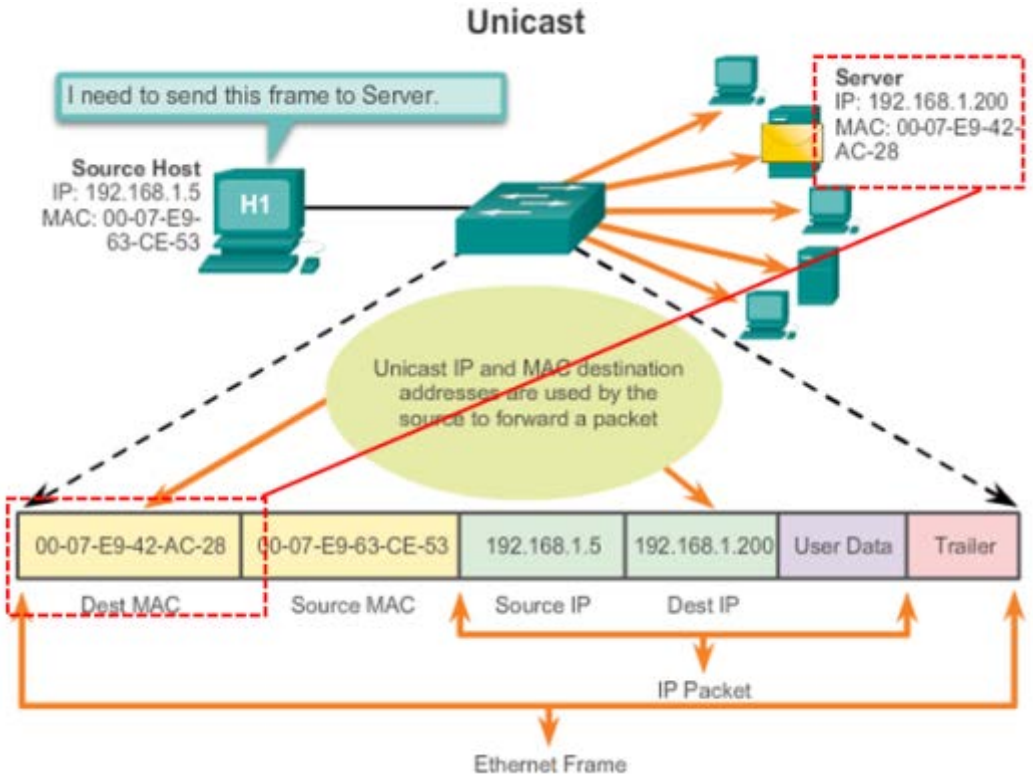
- Unicast
- Multicast
- Broadcast

Review

A Unicast frame contains one _____ _____.
The frame will be sent to the device that has the destination MAC address stored in the frame.

Review

A Unicast frame contains one MAC adress.
The frame will be sent to the device that has the destination MAC address stored in the frame.

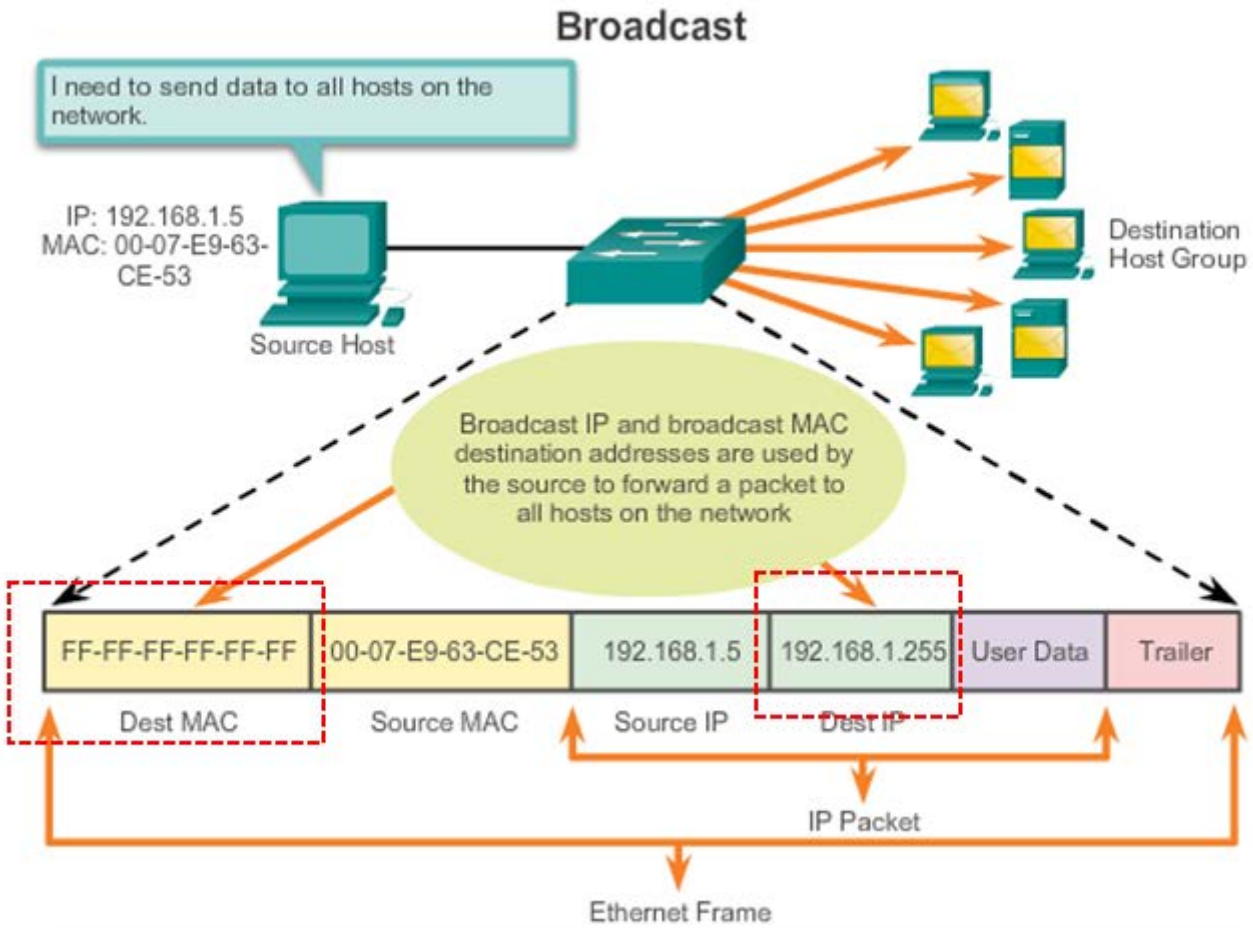


Review

19. For broadcasting, the frame has the destination ____ and destination _____.

Review

19. For broadcasting, the frame has the destination MAC and destination IP.

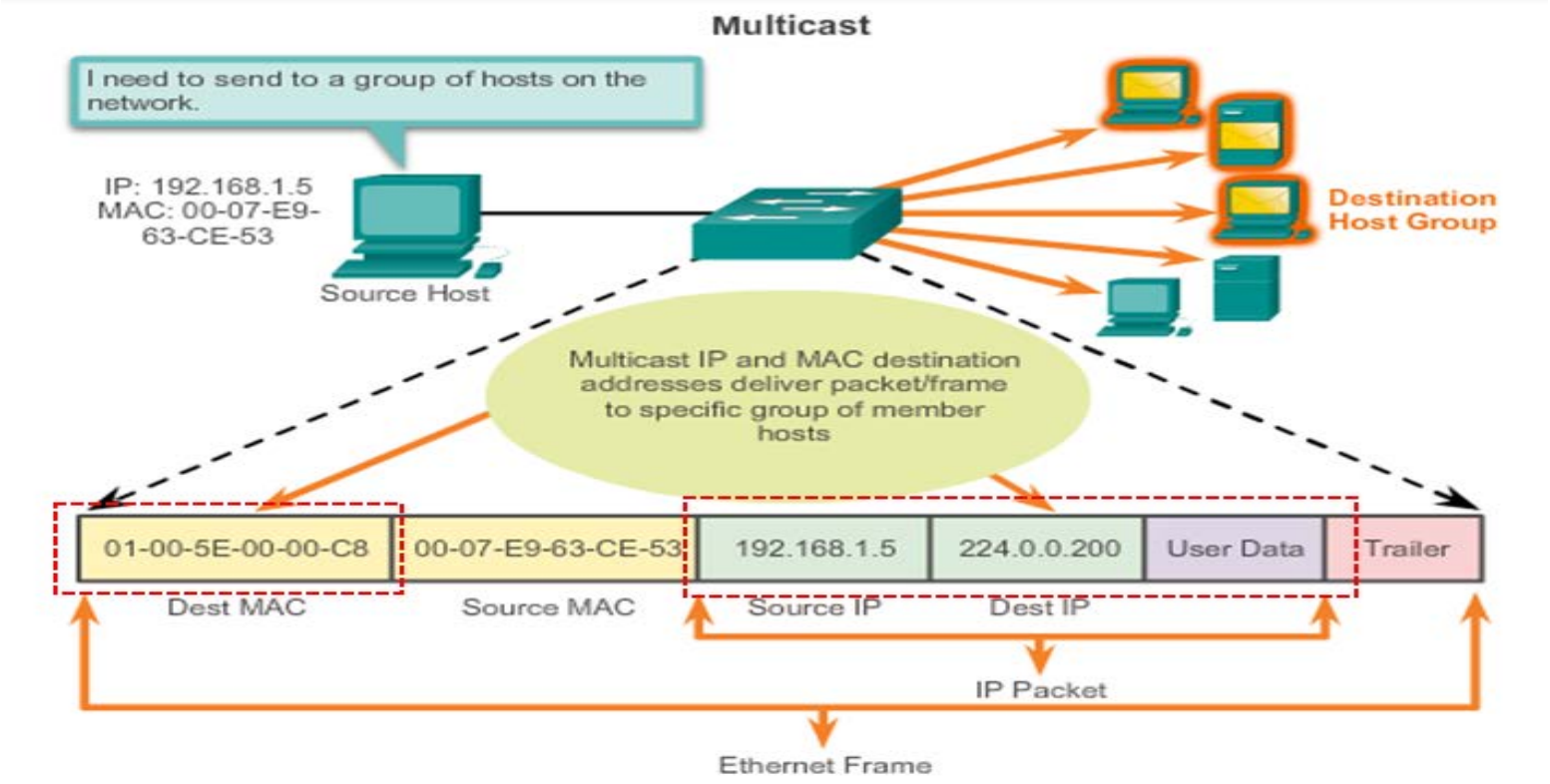


Review

20. The Multicast frame contains destination MAC, _____ IP, destination IP and _____ Data.

Review

20. The Multicast frame contains destination MAC, source IP, destination IP and User Data.



Multicast MAC address is a special value that begins with 01-00-5E in hexadecimal

Range of IPV4 multicast addresses is 224.0.0.0 to 239.255.255.255

Review

21. MAC Address

- This address _____
- Similar to the name of a person
- Known as _____ address.

Review

21. MAC Address

- This address does not change (fixed for a device)
- Similar to the name of a person
- Known as physical address because physically assigned to the host NIC (Network Interface Card)

Review

22. IP Address

- This address is not _____ for a device
- Similar to the address of a person
- Based on where the host is actually located
- Known as a _____ address because assigned logically
- Assigned to each host by a network administrator

Review

22. IP Address

- This address is not fixed for a device
- Similar to the address of a person
- Based on where the host is actually located
- Known as a logical address because assigned logically
- Assigned to each host by a network administrator

Review

23.

Both the physical MAC and logical IP addresses are required for a computer to _____, just like both the name and address of a person are required to send a letter.

Review

23.

Both the physical MAC and logical IP addresses are required for a computer to communicate, just like both the name and address of a person are required to send a letter.

Review 24

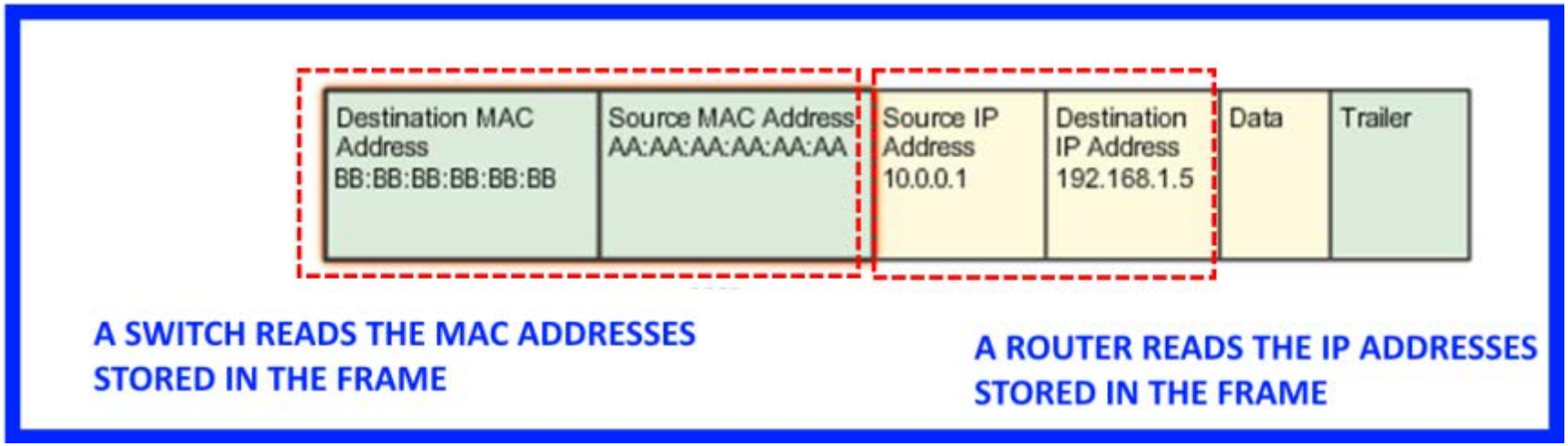
A switch reads the _____ addresses of the ethernet frame, and sends the frame to the destination.

A router reads the ___addresses of the ethernet frame, and send the frame to the destination IP address.

Review 24

A switch reads the MAC addresses of the ethernet frame, and sends the frame to the destination.

A router reads the IP addresses of the ethernet frame, and send the frame to the destination IP address.



THE END