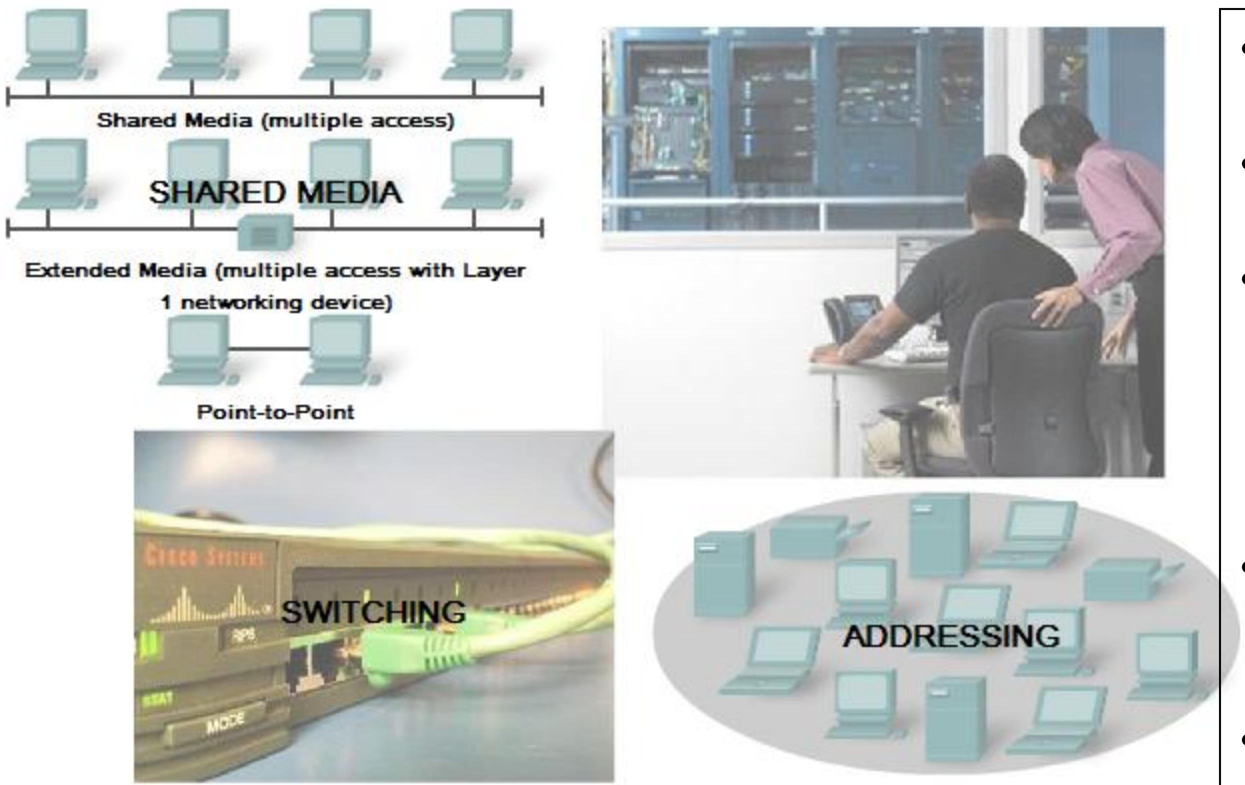
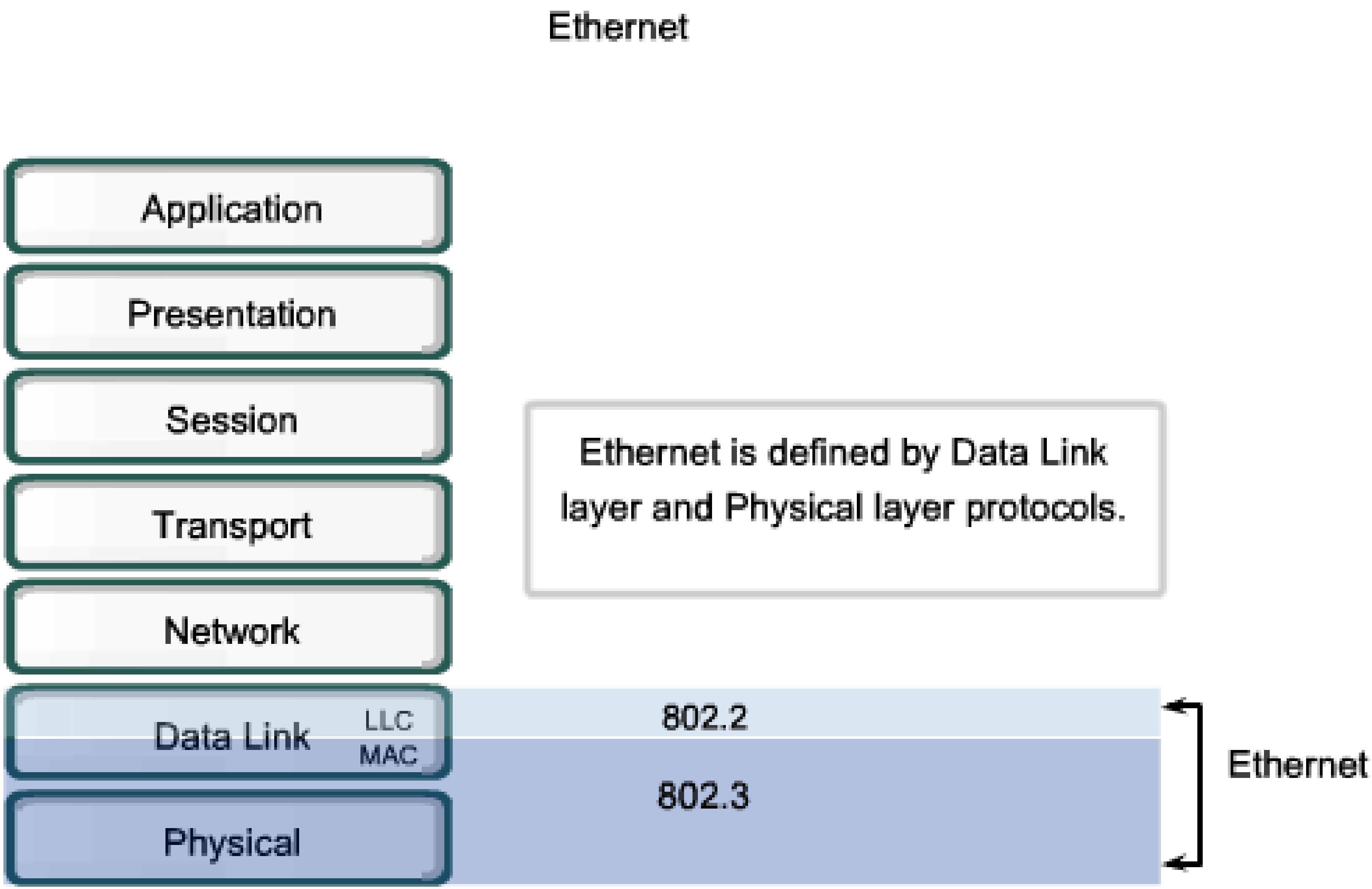
9.0.1 Introduction



Ethernet is the predominant LAN technology in use today.

- Describe the evolution of Ethernet
- Explain the fields of the Ethernet Frame
- Describe the function and characteristics of the media access control method used by Ethernet protocol
- Describe the Physical and Data Link layer features of Ethernet
- Compare and contrast Ethernet hubs and switches
- Explain the Address Resolution Protocol (ARP)

9.1.1 Ethernet Standards



9.1.2 Ethernet Layer 1 and Layer 2

Layer 2 Addresses Layer 1 Limitations

Layer 1 Limitations	Layer 2 Functions
Cannot communicate with upper layers	Connects to upper layers via Logical Link Control (LLC)
Cannot identify devices	Uses addressing schemes to identify devices
Only recognizes streams of bits	Uses frames to organize bits into groups
Cannot determine the source of a transmission when multiple devices are transmitting	Uses Media Access Control (MAC) to identify transmission sources

9.1.3 Logical Link Control – Connecting to Upper Layers

Logical Link Control (LLC)

- Makes the connection with the upper layers
- Frames the Network layer packet
- Identifies the Network layer protocol
- Remains relatively independent of the physical equipment

802.2	Logical Link Control Sublayer
802.3 Media Access Control	

Physical Signaling Sublayer Physical Medium	10BASE5 (500m) 50 Ohm Coax N-Style	10BASE2 (185m) 50 Ohm Coax BNC	10BASE-T (100m) 100 Ohm UTP RJ-45	100BASE-TX (100m) 100 Ohm UTP RJ-45	1000BASE-CX (25m) 150 Ohm STP mini-DB-9	1000BASE-T (100m) 100 Ohm UTP RJ-45	1000BASE-SX (220-550m) MM Fiber SC	1000BASE-LX (550-5000m) MM or SM Fiber SC

9.1.4 MAC – Getting Data to the Media

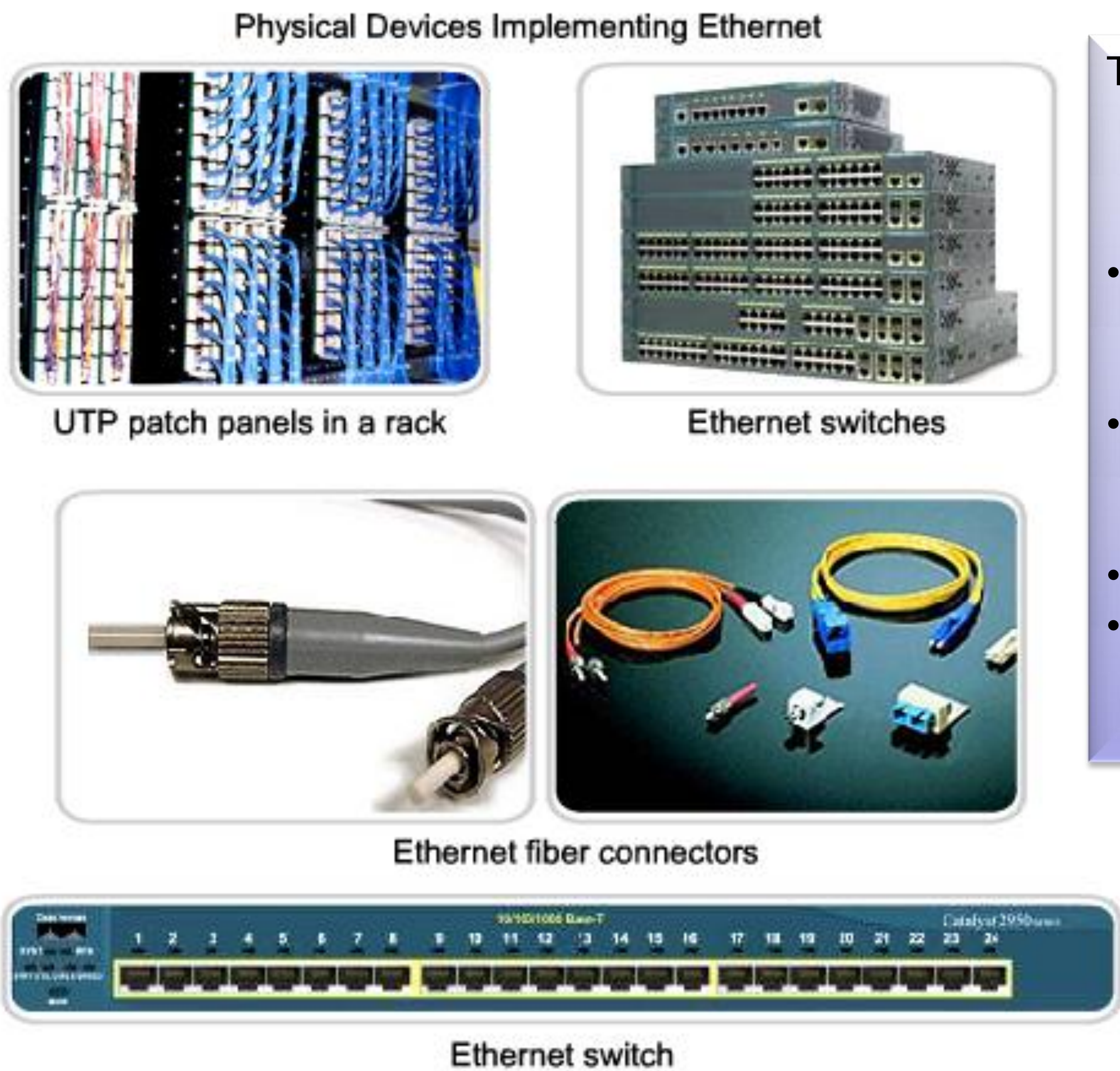
MAC—Getting Data to the Media

Media Access Control is implemented by hardware, typically in the computer Network Interface Card (NIC).

MEDIA ACCESS CONTROL

- Data Encapsulation
  - Frame delimiting
  - Addressing
  - Error detection
- Media Access Control
  - Control of frame placement on and off the media
  - Media recovery

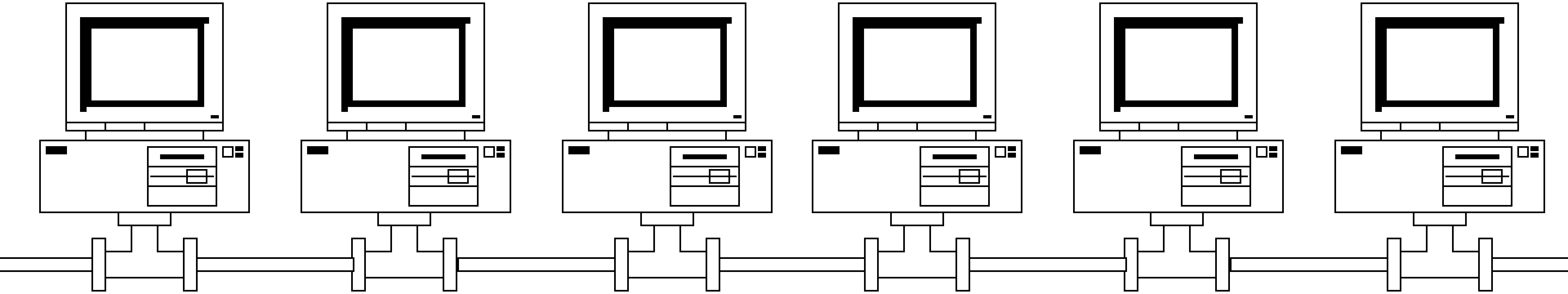
9.1.5 Physical Implementation – of Ethernet



The success of Ethernet is due to the following factors:

- Simplicity and ease of maintenance
- Ability to incorporate new technologies
- Reliability
- Low cost of installation and upgrade

9.1.5 Physical Implementation – of Ethernet



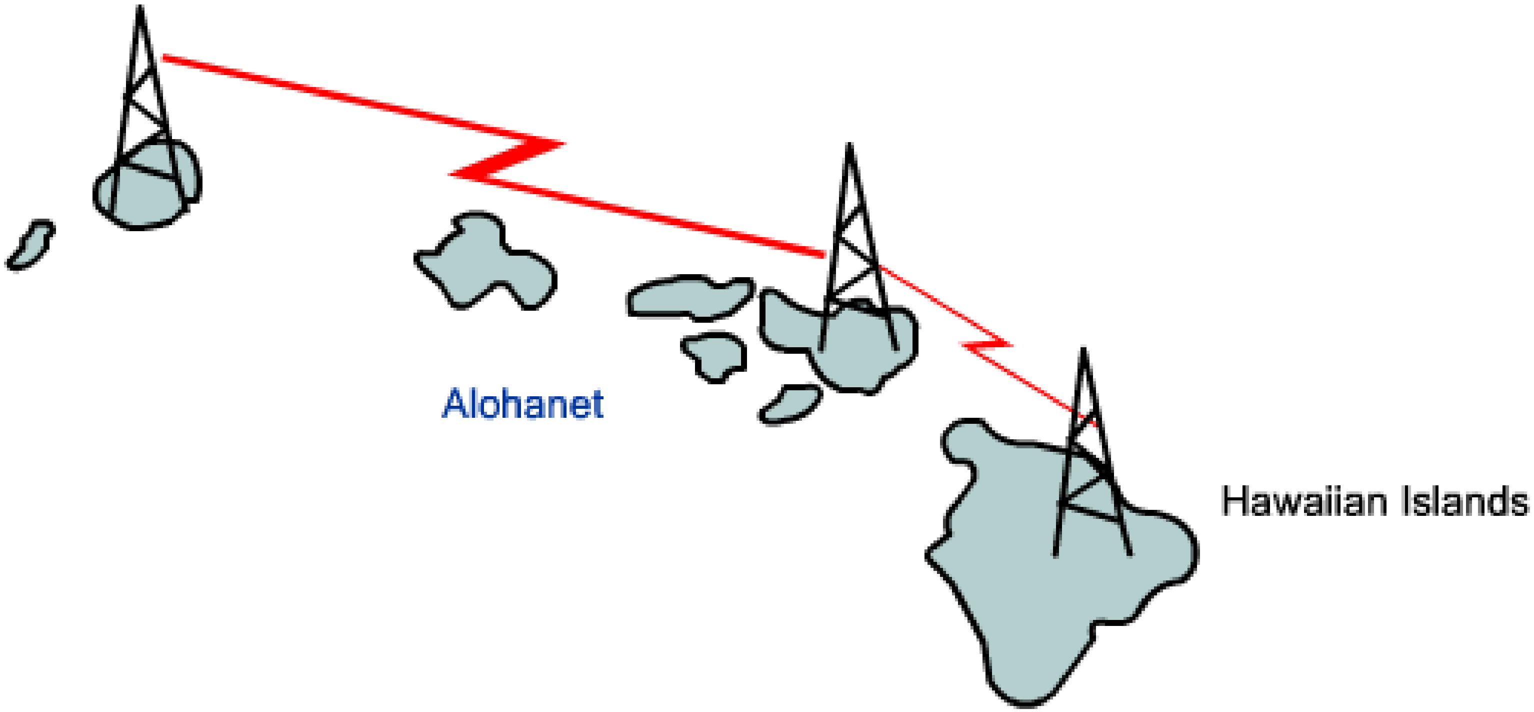
10BASE 2

9.1.5 Physical Implementation – of Ethernet

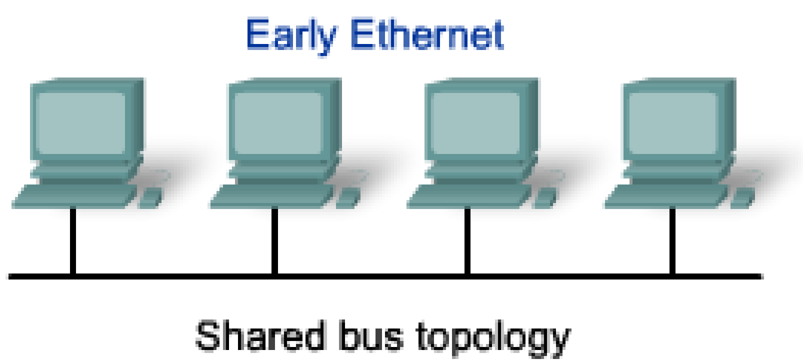
10BASE5 Thicknet Cable

9.2.1 Historic Ethernet

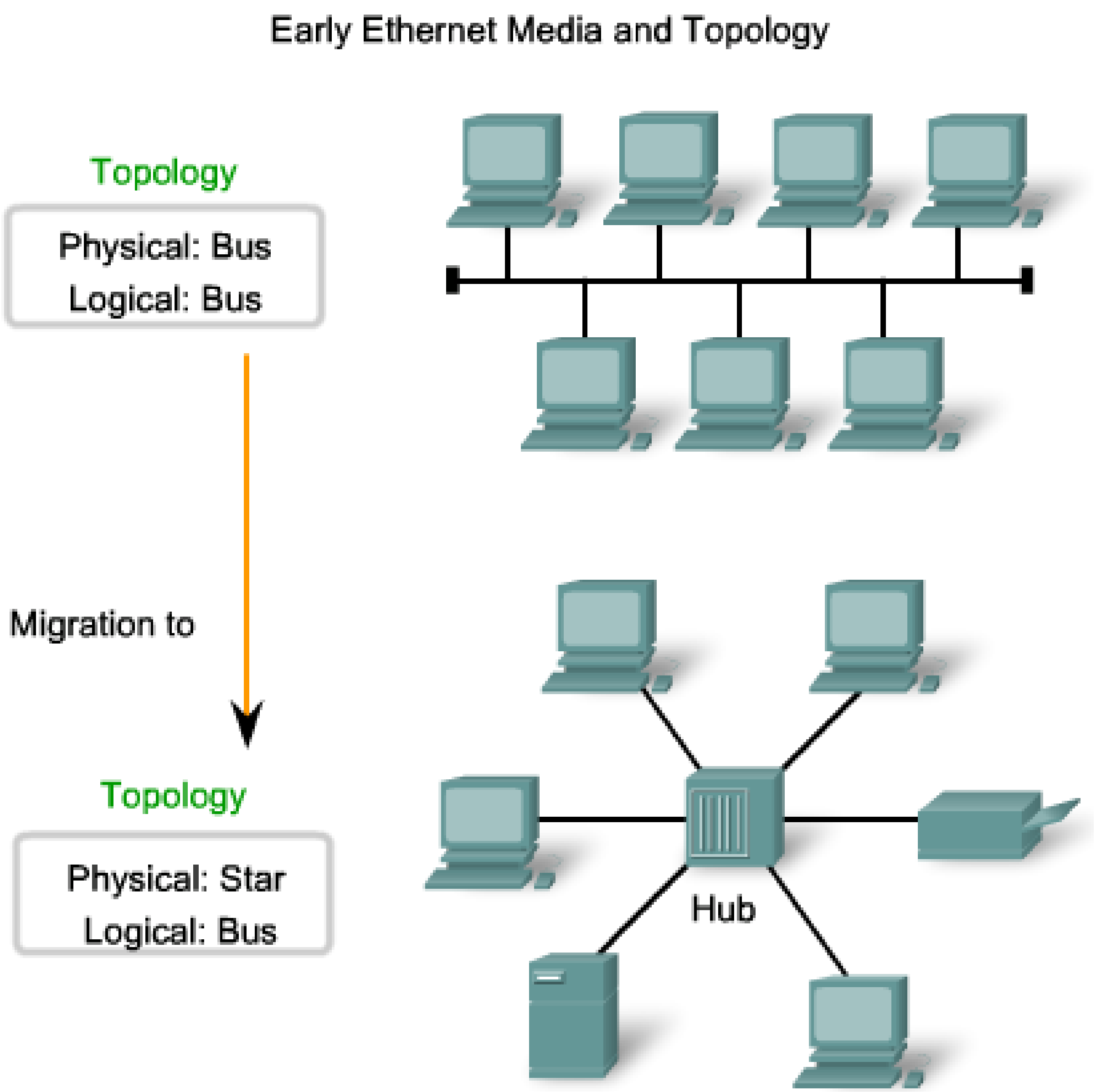
Historic Ethernet



Ethernet's shared media and collision detection techniques were adapted from the Alohanet radio network.

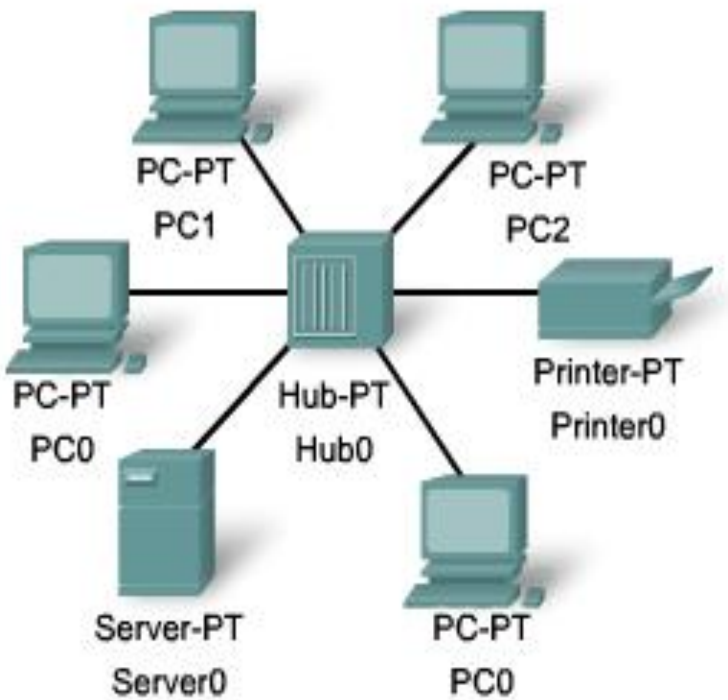


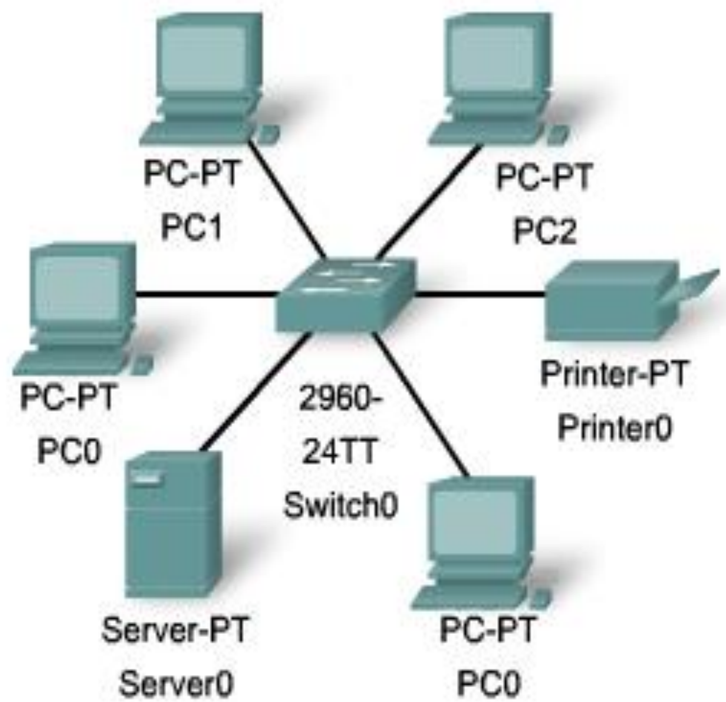
9.2.1 Historic Ethernet



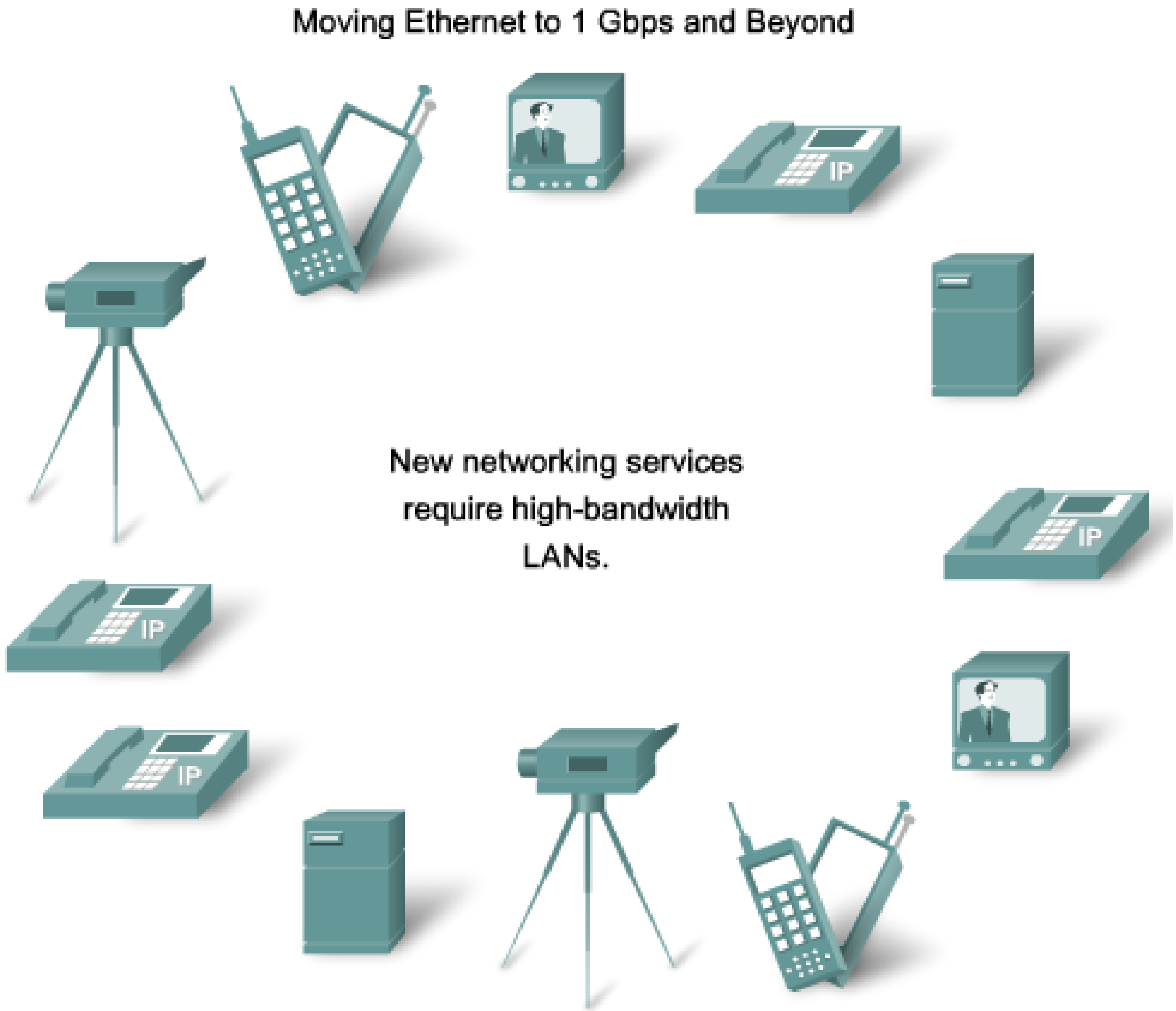
9.2.2 Ethernet Collision Management

Switches can control the flow of data by isolating each port and sending a frame only to its proper destination (if the destination is known), rather than send every frame to every device

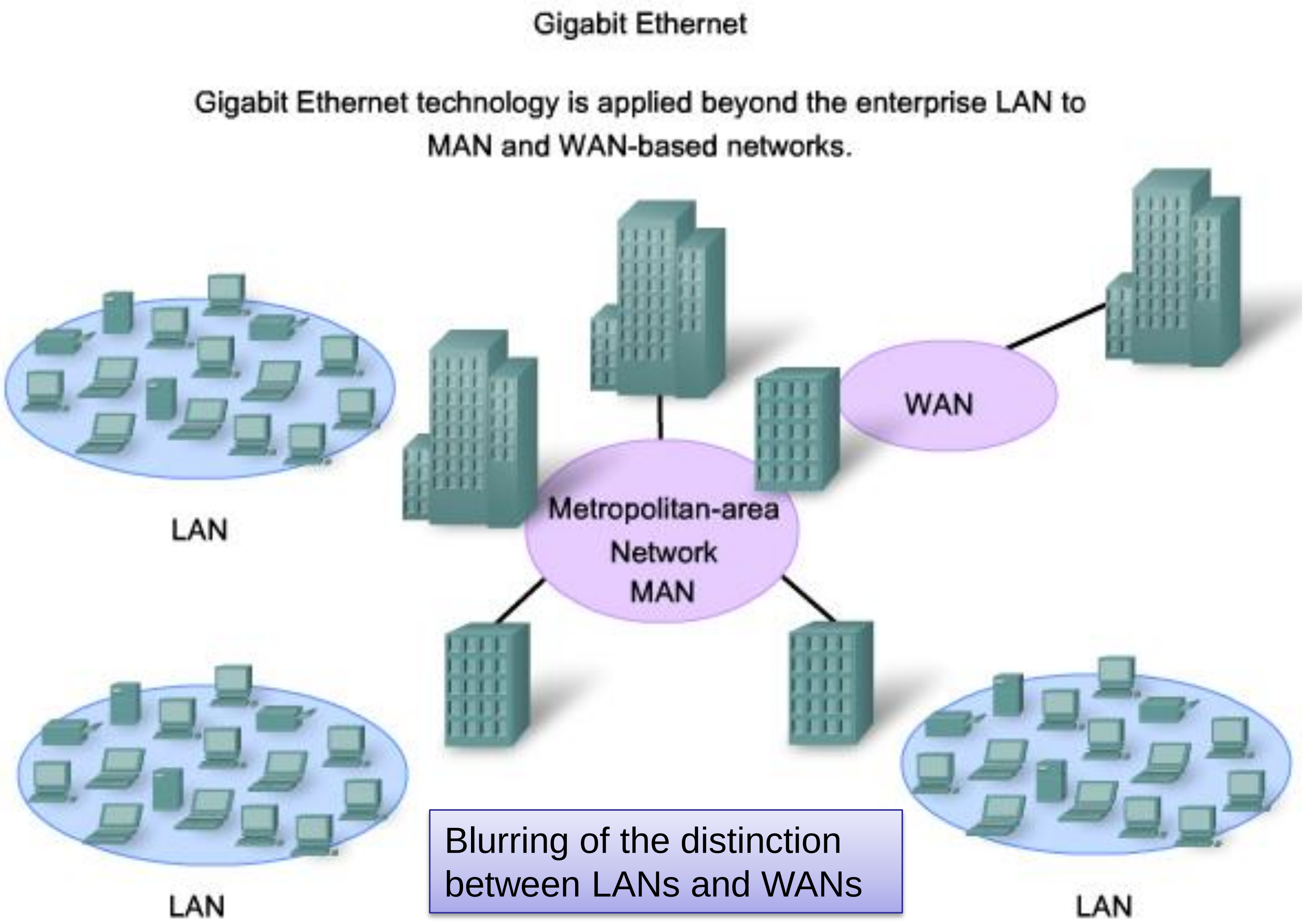




9.2.3 Moving to 1Gbps and Beyond



9.2.3 Moving to 1Gbps and Beyond



Blurring of the distinction between LANs and WANs

9.3.1 The Frame – Encapsulating the Packet

Comparison of 802.3 and Ethernet Frame Structures and Field Size

Field size in bytes

Revised

IEEE 802.3

7	1	6	6	2	46 to 1500	4
Preamble	Start of Frame delimiter	Destination Address	Source Address	Length/ Type	802.2 Header and Data	Frame Check Sequence

Original

Ethernet

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

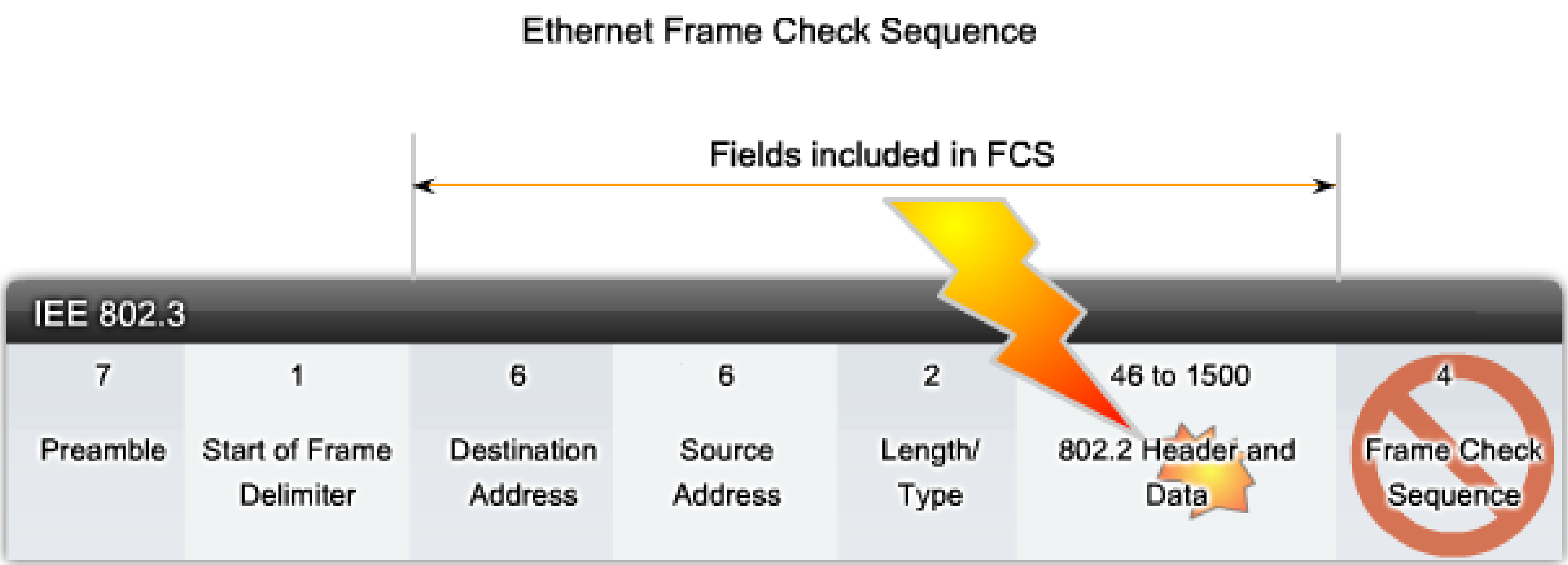
The IEEE 802.3ac standard, released in 1998, extended the maximum allowable frame size to 1522 bytes. The frame size was increased to accommodate a technology called Virtual Local Area Network (VLAN). VLANs are created within a switched network and will be presented in a later course.

9.3. Encapsulating the Packet

Ethernet Frame Fields

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

9.3.1 Encapsulating the Packet

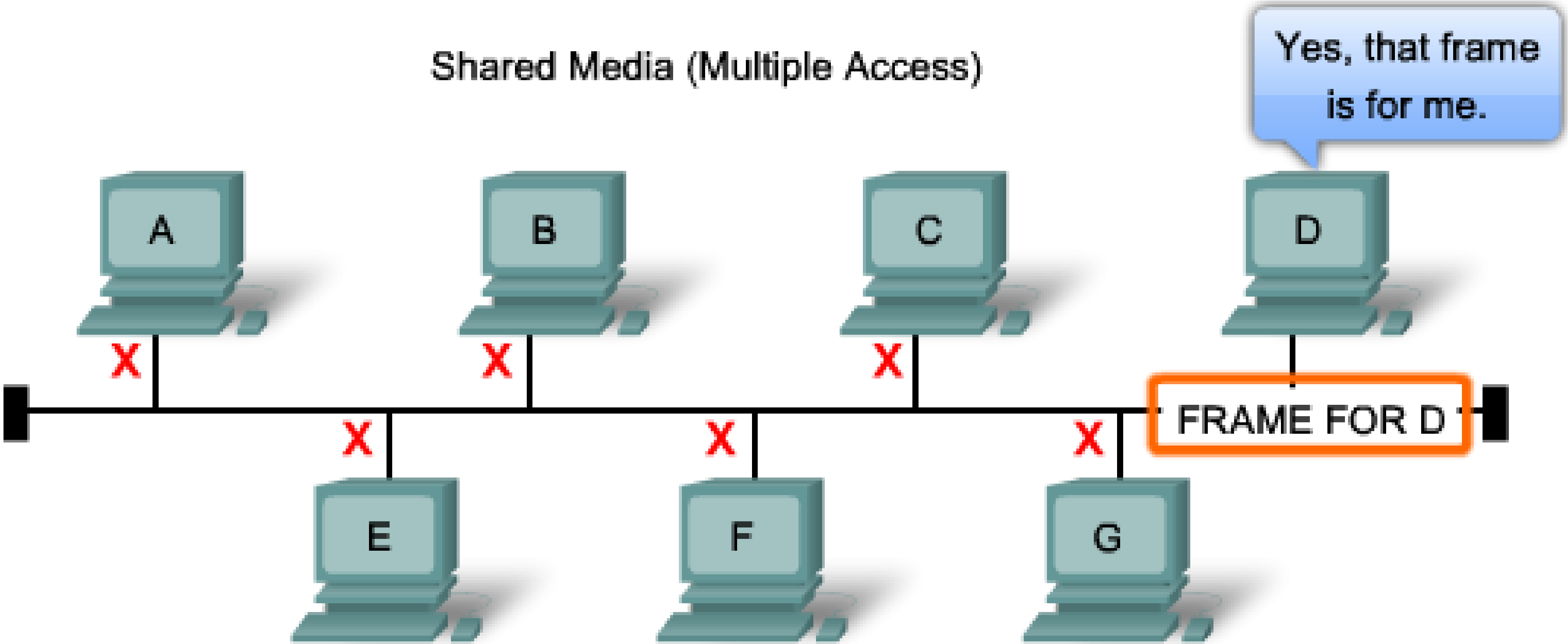


If the FCS calculated by the receiver (based on the contents of the received frame), does not equal the FCS calculated by the source (which is included in the frame), the frame is considered invalid and is dropped.

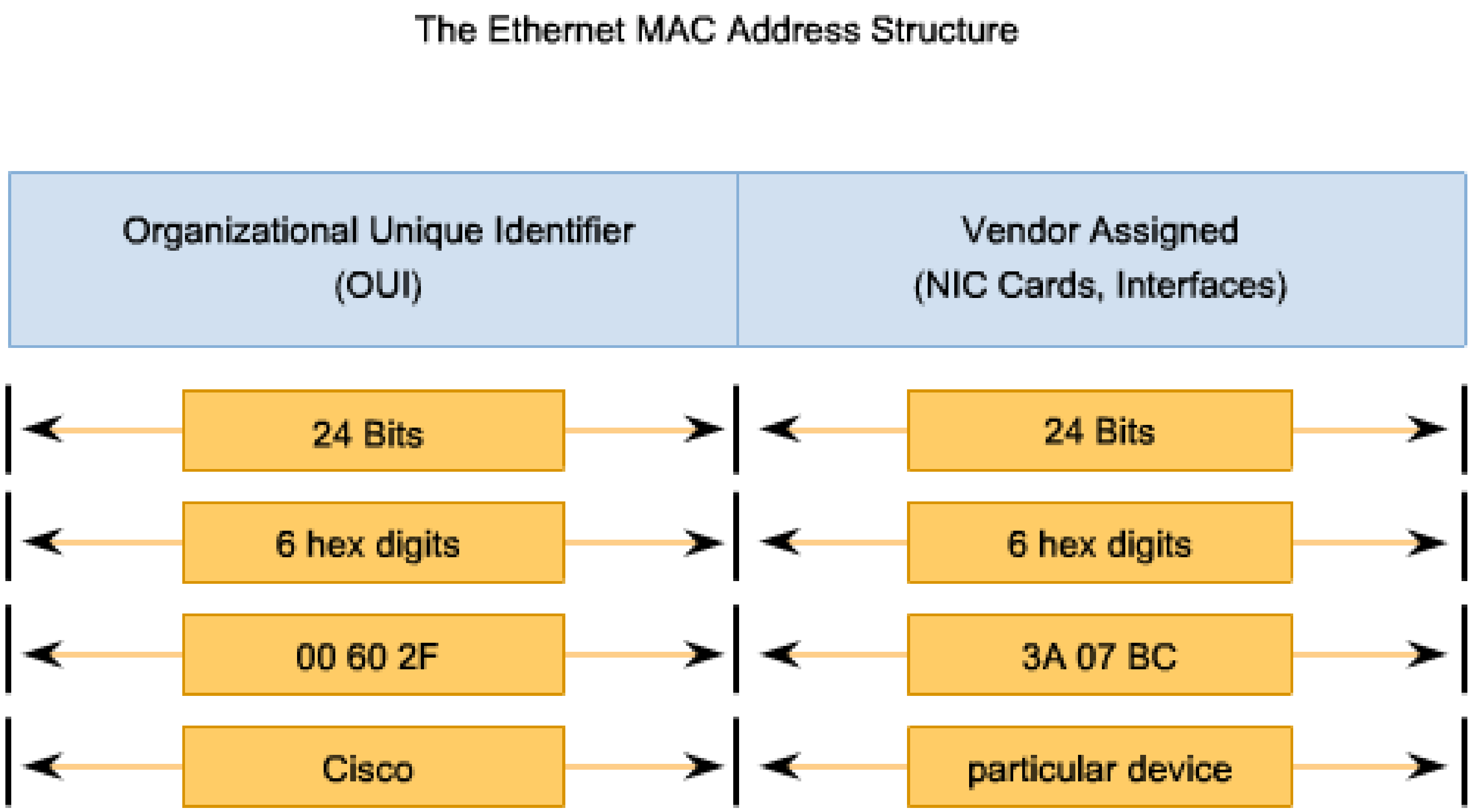
9.3.2 The Ethernet MAC Address

The MAC Address—Addressing in Ethernet

All Ethernet nodes share the media.
To receive the data sent to it, each node needs a unique address.



9.3.2 The Ethernet MAC Address



Different representations of MAC Addresses

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

9.3.3 Hexadecimal Numbering and Addressing

Hexadecimal Numbering

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

9.3.3 Hexadecimal Numbering and Addressing

Viewing the MAC Address

```
C:\>ipconfig /all
Ethernet adapter Network Connection:
        Connection-specific DNS Suffix: example.com
        Description . . . . . . . . . . . : Intel(R) PRO/Wireless 3945ABG Network
Connection
        Physical Address. . . . . . . . . : 00-18-DE-C7-F3-FB
        Dhcp Enabled. . . . . . . . . . . : Yes
        Autoconfiguration Enabled . . . . : Yes
        IP Address. . . . . . . . . . . . : 10.2.3.4
        Subnet Mask . . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . . : 10.2.3.254
        DHCP Server . . . . . . . . . . . : 10.2.3.69
        DNS Servers . . . . . . . . . . . : 192.168.226.120
        Lease Obtained. . . . . . . . . . : Thursday, May 03, 2007 3:47:51 PM
        Lease Expires . . . . . . . . . . : Friday, May 04, 2007 6:57:11 AM
C:\>
```

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

Only need 4 Hex positions:

4096 256 16 1

Converting Binary Number to Hexadecimal Number

100100100010111110111110111001001

Converts to:

0001 0010 0100 0101 1111 0111 1101 1100 1001

Converts to:

1 2 4 5 F 7 D C 9

So:

100100100010111110111110111001001 binary

= 1245F7DC9 hexadecimal

Converting Hexadecimal Number to Binary Number

0x2102

Converts to:

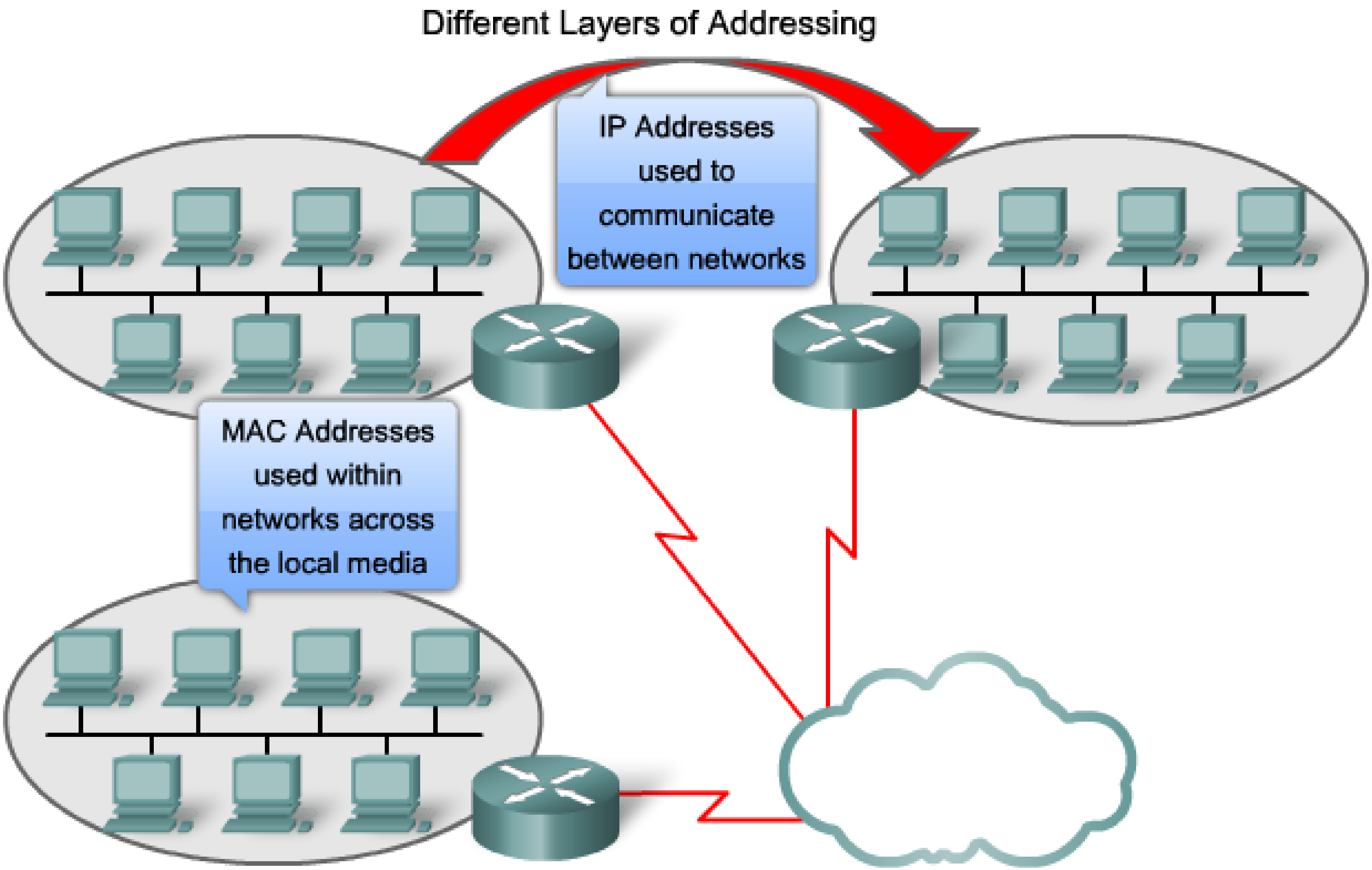
2	1	0	2
0010	0001	0000	0010

So:

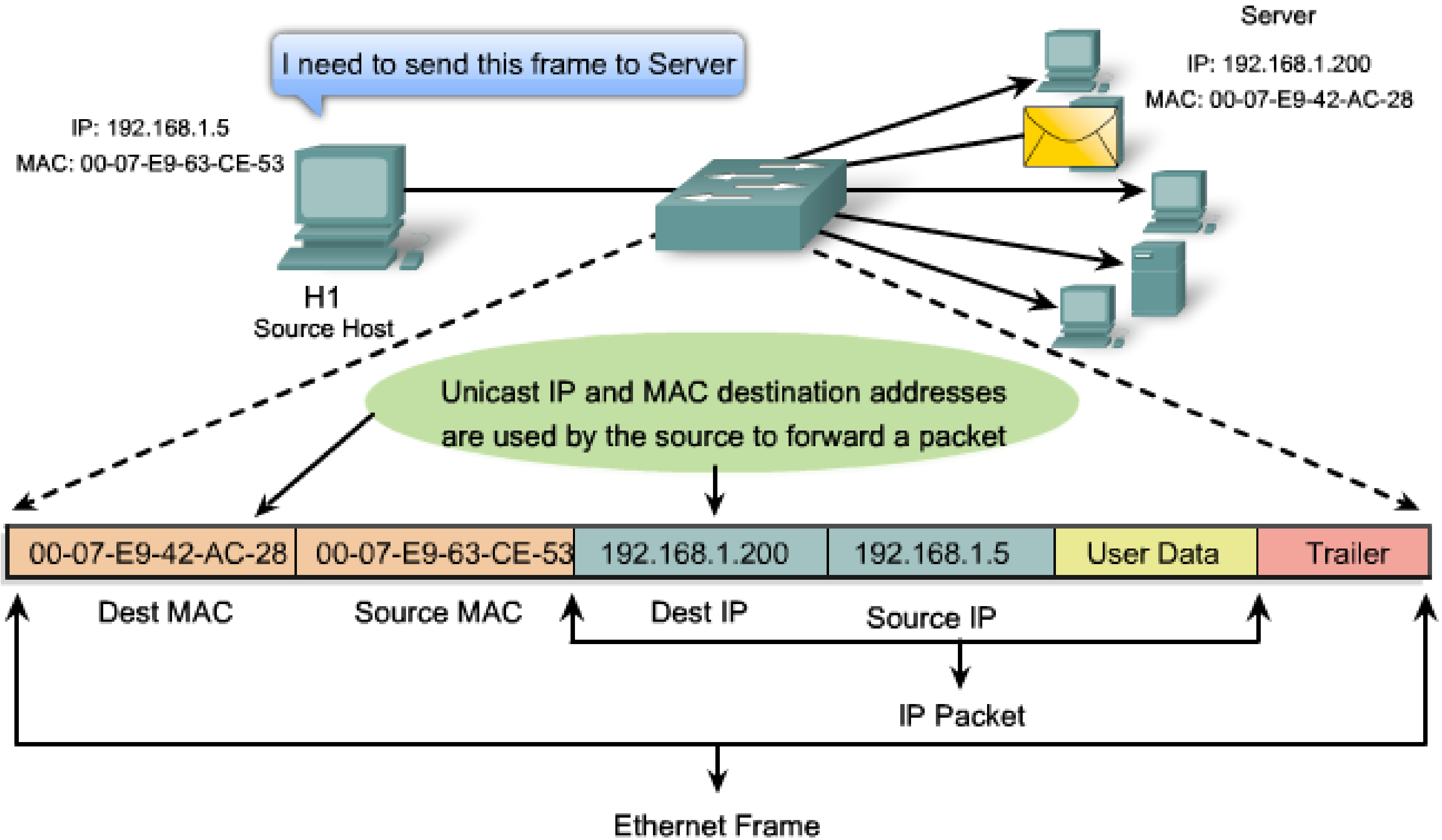
2102 hexadecimal converts to: 0010 0001 0000 0010 binary

Add more hex conversions

9.3.4 Another Layer of Addressing

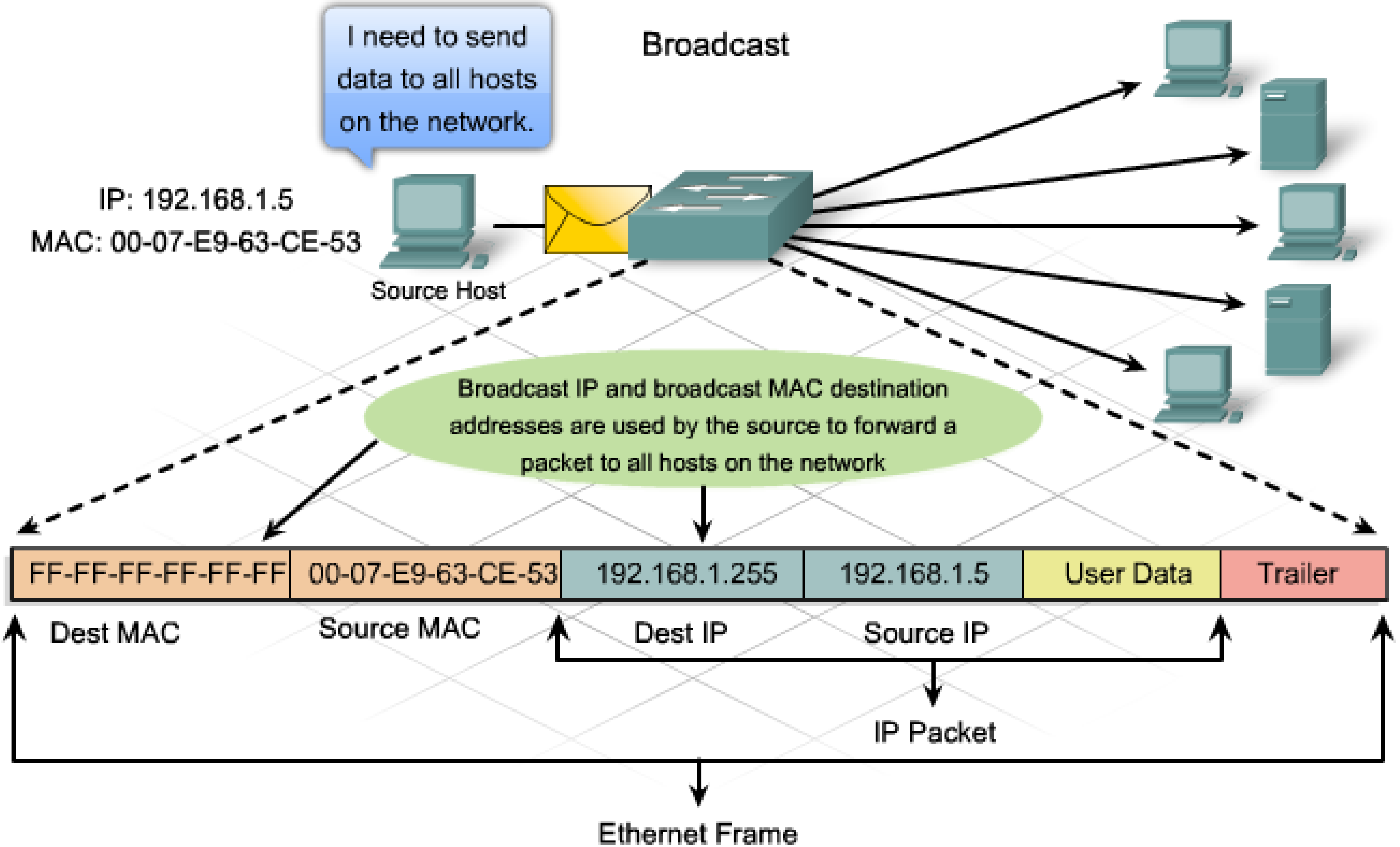


9.3.5 Ethernet Unicast, Multicast and Broadcast



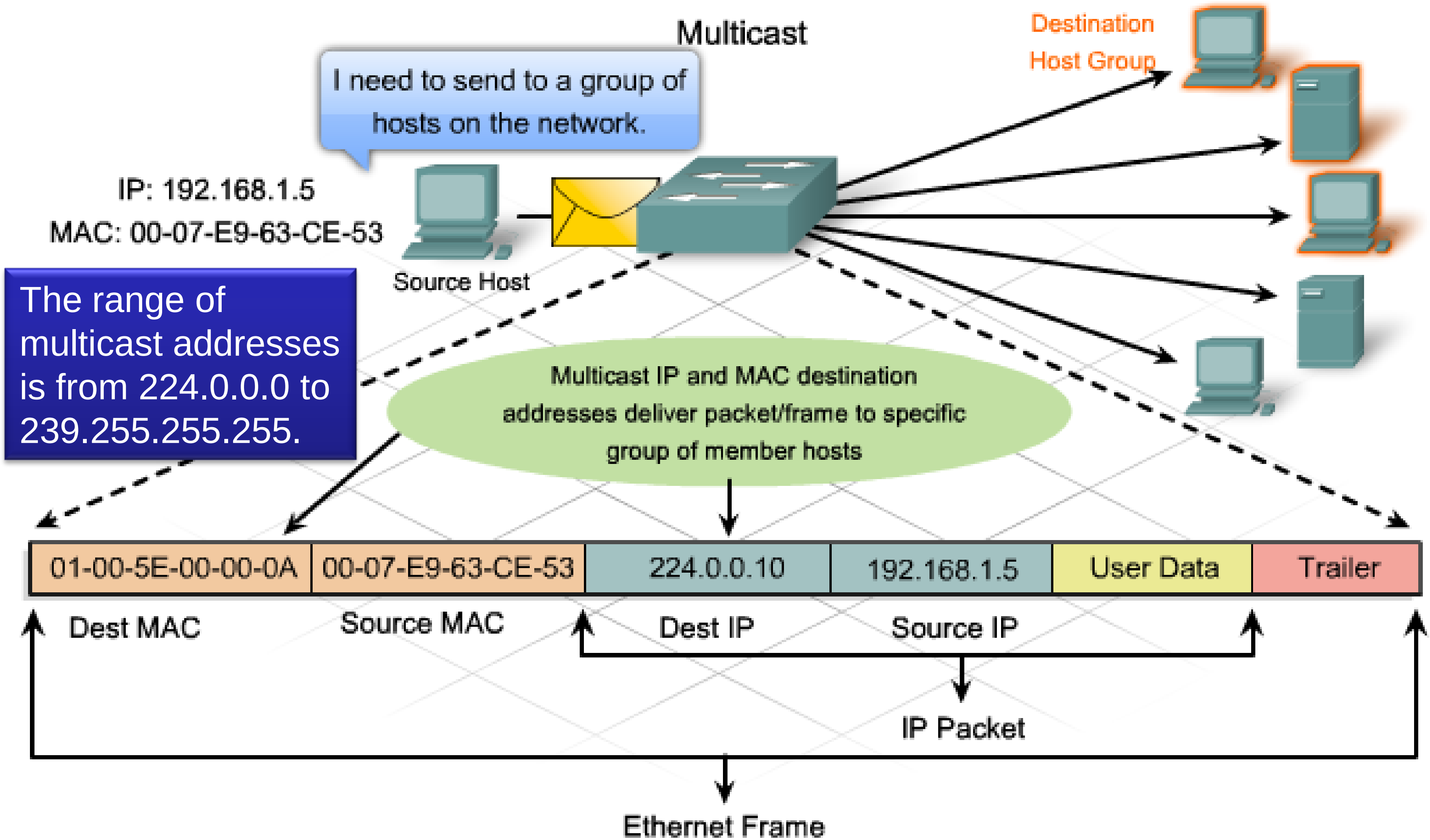
A unicast MAC address is the unique address used when a frame is sent from a single transmitting device to single destination device.

9.3.5 Ethernet Unicast, Multicast and Broadcast



On Ethernet networks, the broadcast MAC address is 48 ones displayed as Hexadecimal FF-FF-FF-FF-FF-FF.

9.3.5 Ethernet Unicast, Multicast and Broadcast

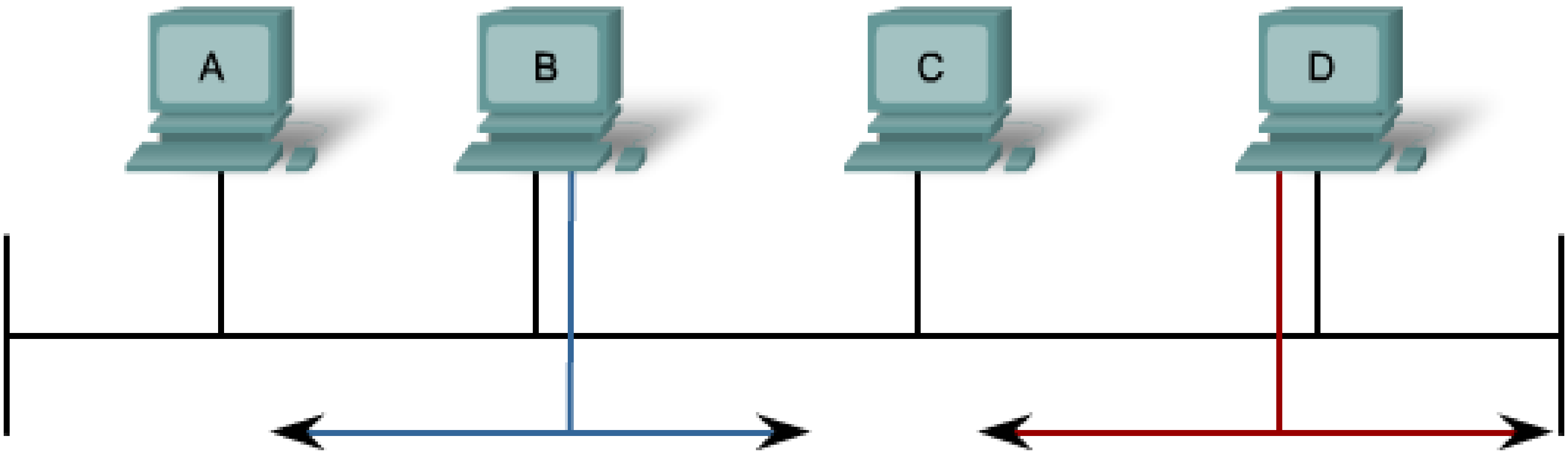


Multicast addresses allow a source device to send a packet to a group of devices

9.4.1 Media Access Control in Ethernet

Media Access Control in Ethernet

Carrier Sense Multiple Access with Collision Detection (CSMA/CD)



CSMA/CD controls access to the shared media. If there is a collision, it is detected and frames are retransmitted.

9.4.2 CSMA/CD Process

Carrier Sense

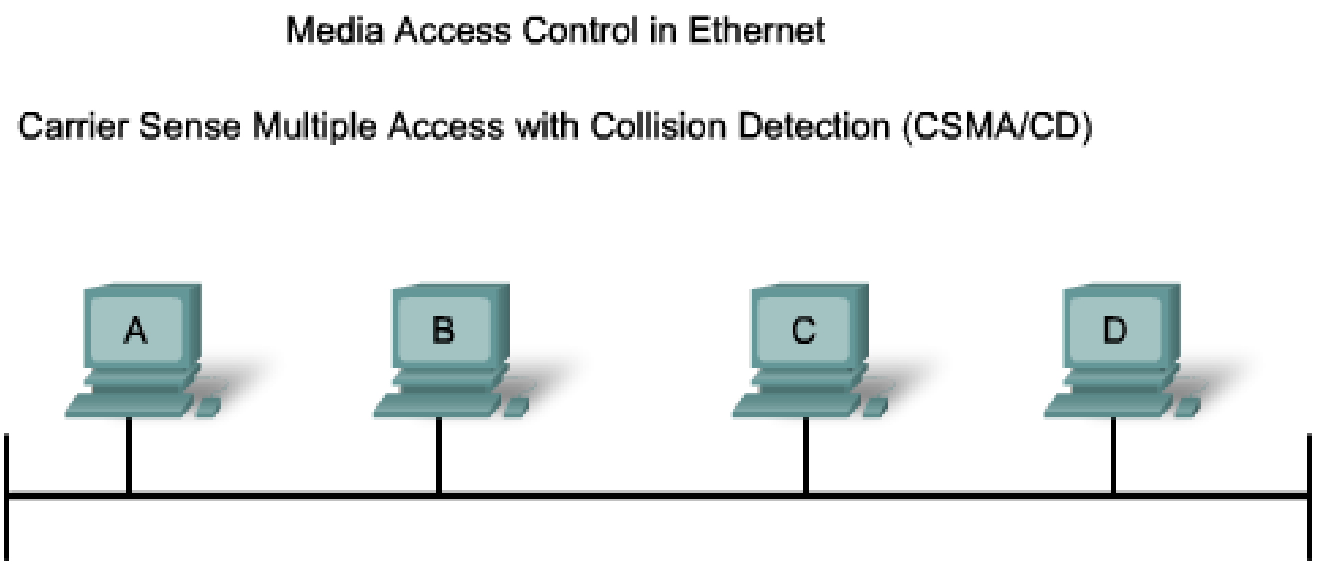
- Listen before transmitting
- If a signal is detected, wait
- If no traffic detected, transmit
- After message is sent return to listening mode

Multiple Access

- Latency on the network may prevent each device from detecting a collision
- Multiple devices may then transmit

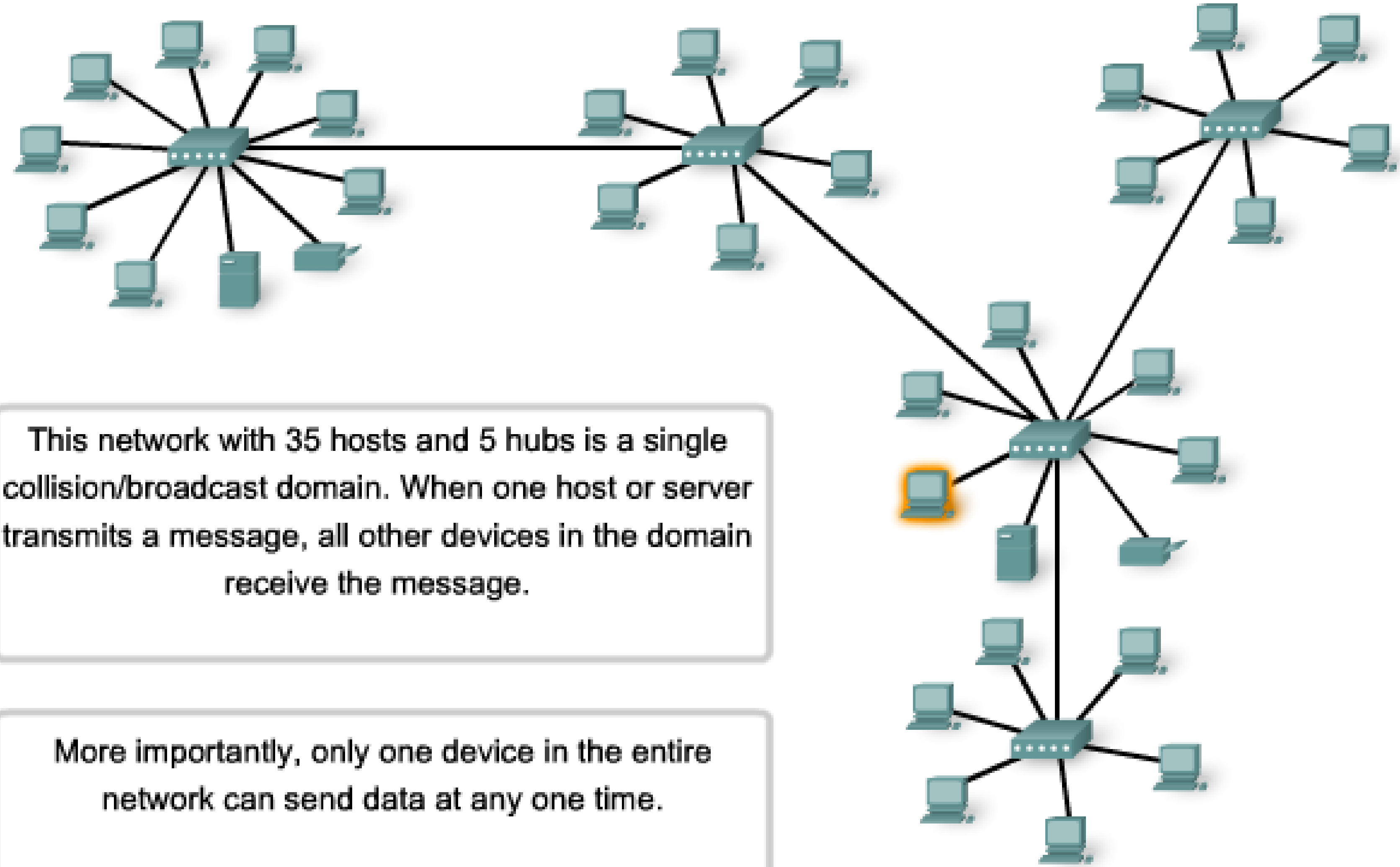
Collision Domain

- Data is destroyed
- Live voltage increases
- Cards send a jam signal
- Network cards back-off and wait



9.4.2 CSMA/CD Process

Using hubs in extended star topologies can create large collision domains



This network with 35 hosts and 5 hubs is a single collision/broadcast domain. When one host or server transmits a message, all other devices in the domain receive the message.

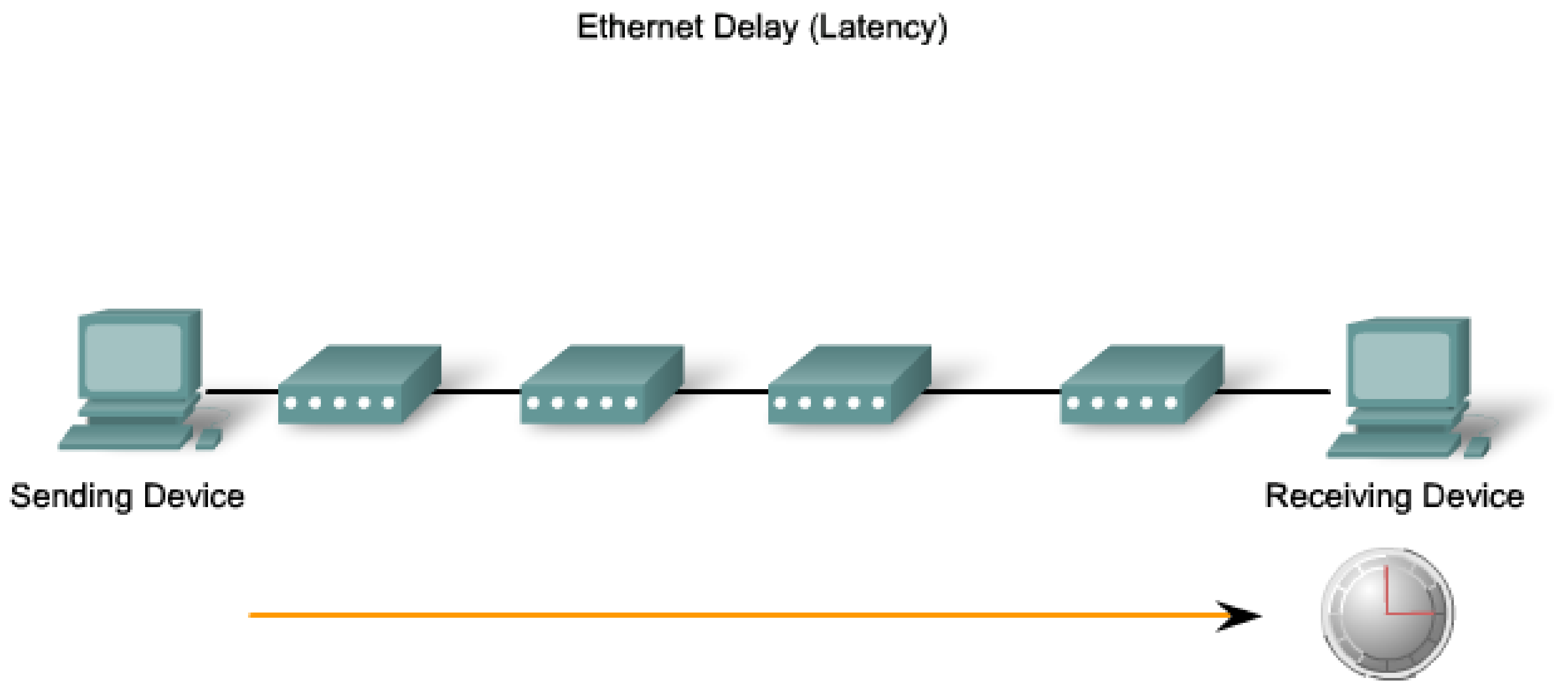
More importantly, only one device in the entire network can send data at any one time.

9.4.2 CSMA/CD Process

Packet Tracer Exploration:

Observing the Effects of Collisions in a Shared Media Environment

9.4.3 Ethernet Timing



An Ethernet frame takes a measurable time to travel from the sending device to the receiver. Each intermediary device contributes to the overall latency.

9.4.3 Ethernet Timing

Frame Synchronization for Asynchronous Communications

Field Names				
A	B	C	D	E
Start Frame Field	Address Field	Type/Length Field	Data Field	FCS Field

10 Mbps and slower Ethernet use the first 64 bits of the frame Preamble to synchronize the receiver.

Speeds of 10 Mbps and slower are asynchronous

Throughput of 100 Mbps and higher are synchronous.

Slot Time

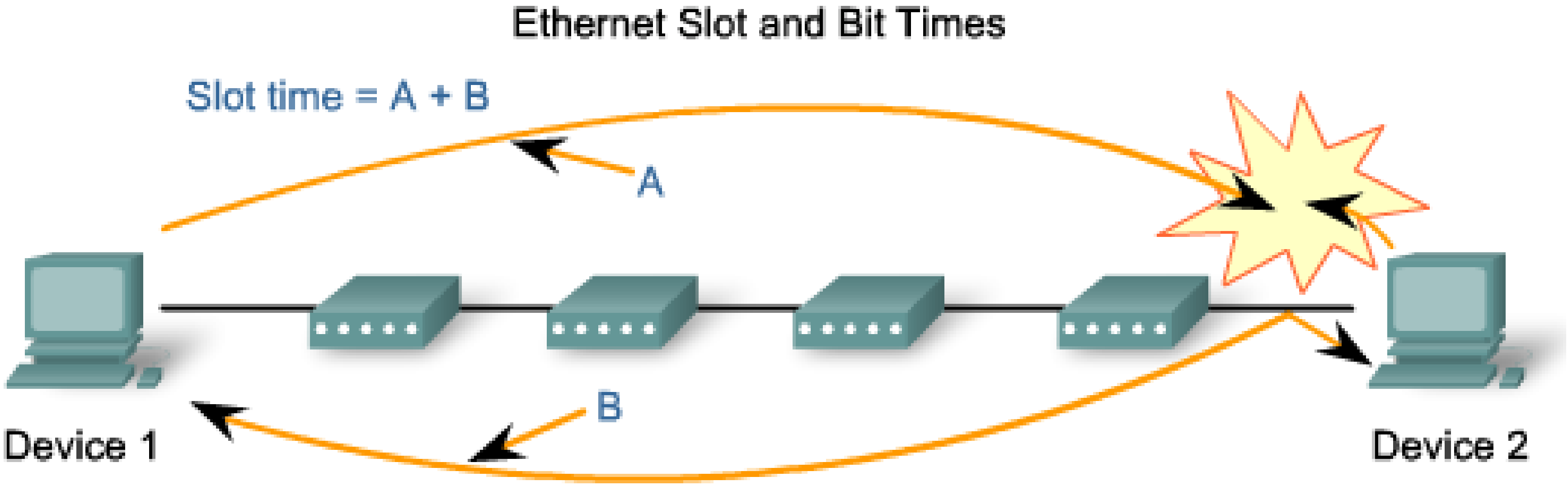
SLOT TIME

The length of time that a transmitting station waits before attempting to retransmit following a collision.

Slot time is calculated assuming maximum cable lengths on the largest legal network architecture.

The minimum spacing between two non-colliding frames is also called the interframe spacing. This is measured from the last bit of the FCS field of the first frame to the first bit of the preamble of the second frame

9.4.3 Ethernet Timing



The period of time required for a bit to be placed and sensed on the media is called the **bit time**.

The longer the cable the longer the bit time
(time it takes the receiving device to sense bits from sending computer)

For CSMA/CD Ethernet to operate, the sending device must become aware of a collision before it has completed transmission of the entire packet

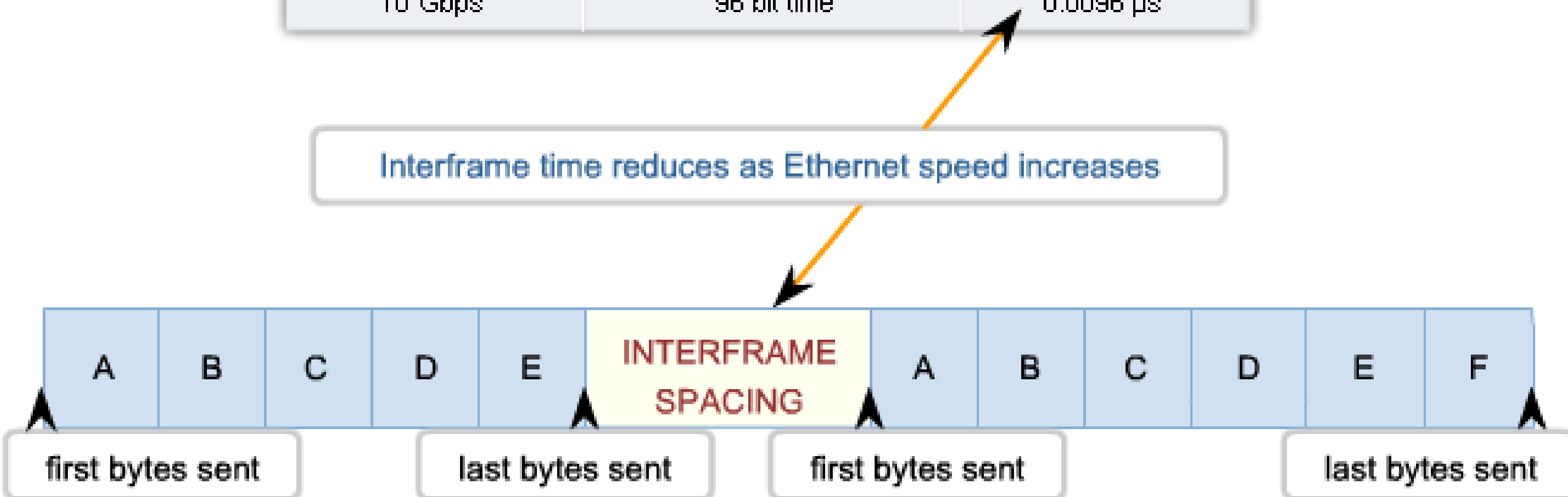
Slot time for 10- and 100-Mbps Ethernet is 512 bit times, or 64 octets. Slot time for 1000-Mbps Ethernet is 4096 bit times, or 512 octets.

The 512-bit slot time establishes the minimum size of an Ethernet frame as 64 bytes. Any frame less than 64 bytes in length is considered a "runt frame"

9.4.4 Interframe Spacing

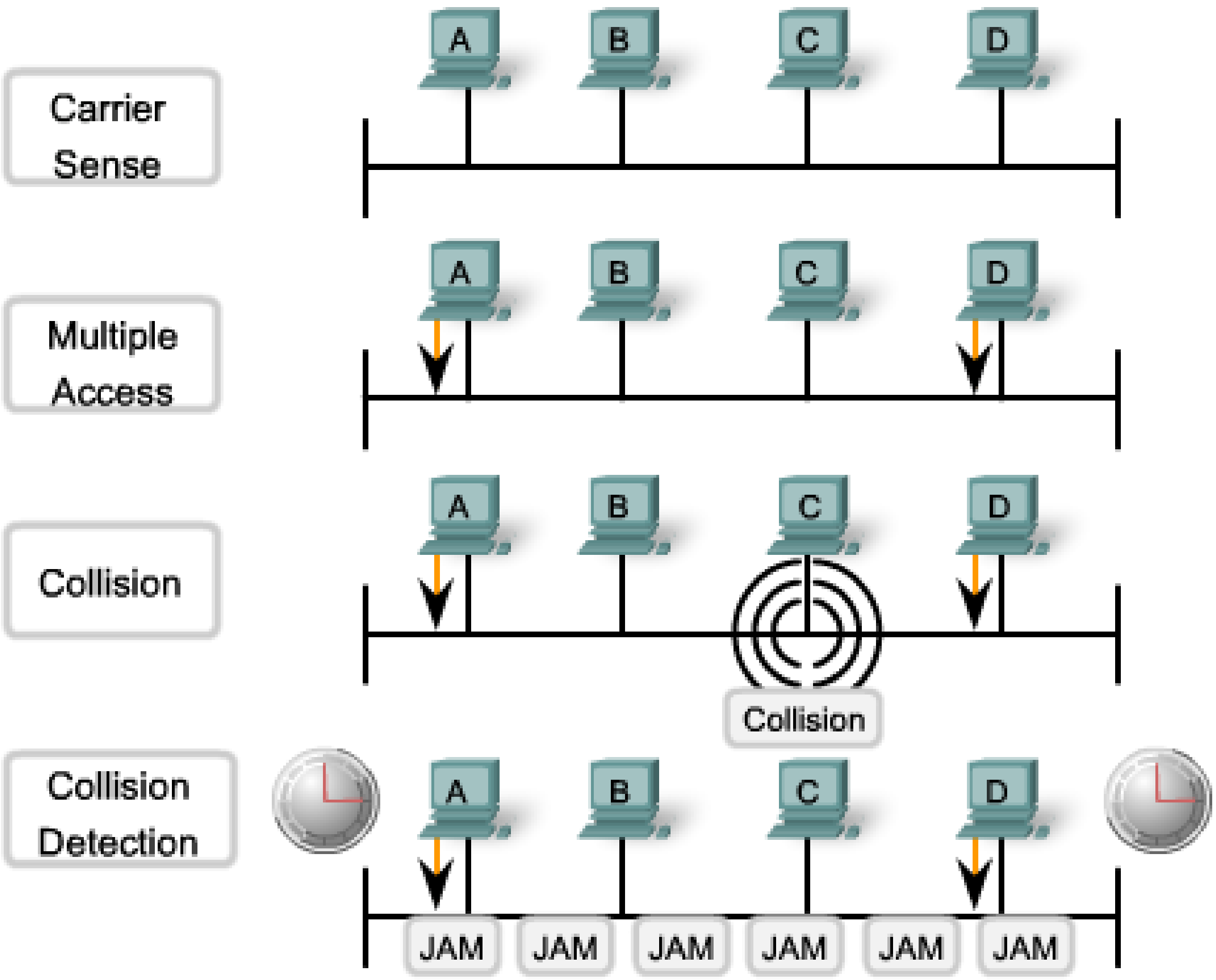
Ethernet Interframe Spacing

Speed	Interframe Spacing	Time Required
10 Mbps	96 bit time	9.6 µs
100 Mbps	96 bit time	0.96 µs
1 Gbps	96 bit time	0.096 µs
10 Gbps	96 bit time	0.0096 µs

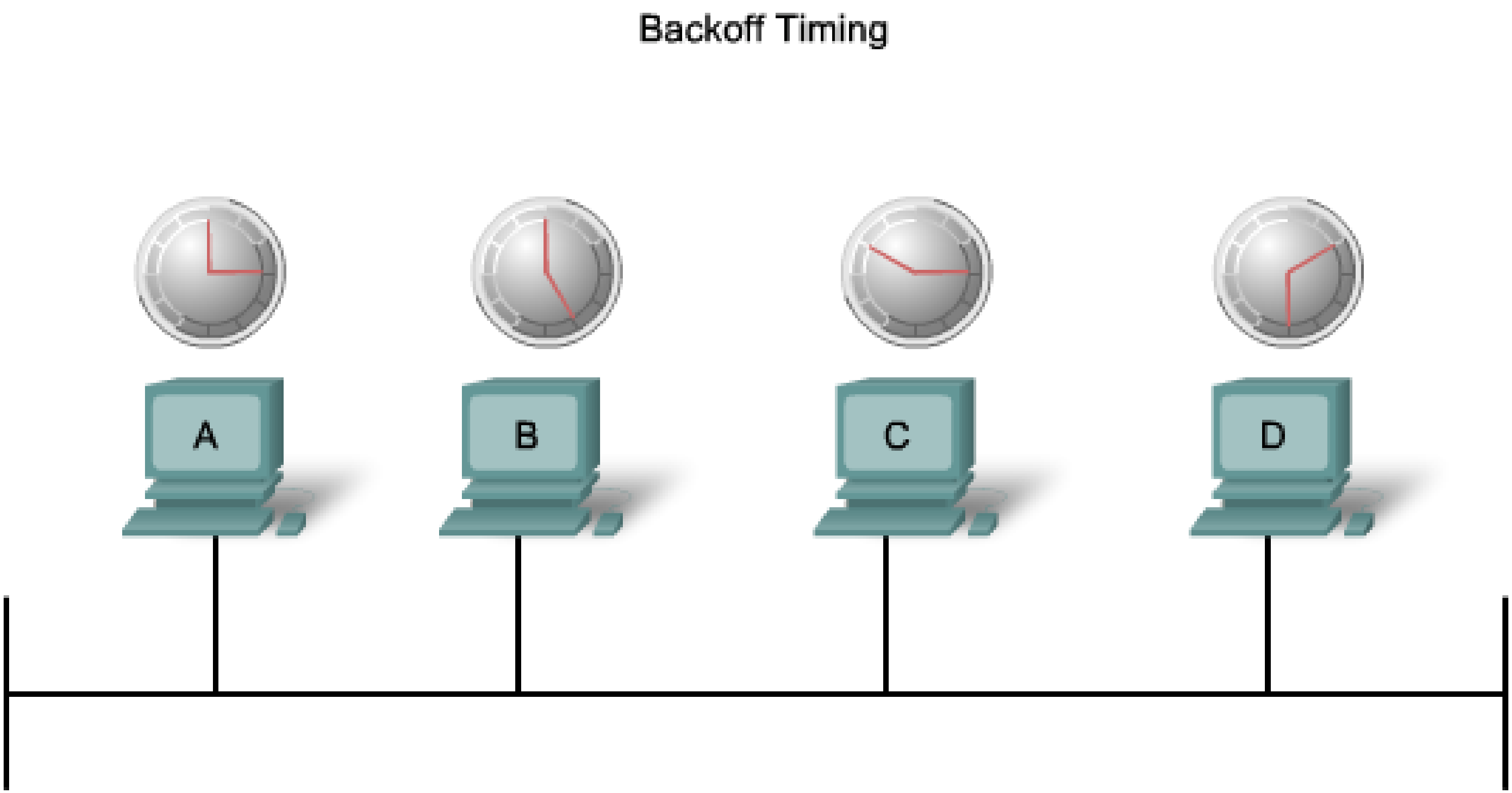


9.4.4 Interframe Spacing and Back-off

Stations detecting a collision send a jam signal.



9.4.4 Interframe Spacing and Back-off



After a Jam signal is received, all stations cease transmission and each waits a random time period—set by the back off timer—before trying to send another frame.

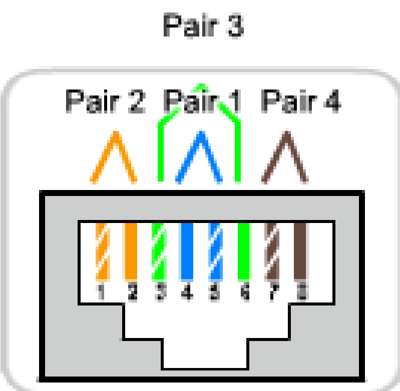
9.5.1 Overview of Ethernet Physical Layer

Types of Ethernet

Ethernet Type	Bandwidth	Cable Type	Duplex	Maximum Distance
10Base-5	10 Mbps	Thicknet Coaxial	Half	500 m
10Base-2	10 Mbps	Thinnet Coaxial	Half	185 m
100Base-TX	10 Mbps	Cat3/Cat5 UTP	Half	100 m
100Base-TX	100 Mbps	Cat5 UTP	Half	100 m
100Base-FX	200 Mbps	Cat5 UTP	Full	100 m
100Base-FX	100 Mbps	Multimode Fiber	Half	400 m
1000Base-T	200 Mbps	Multimode Fiber	Full	2 km
1000Base-TX	1 Gbps	Cat5e UTP	Full	100 m
1000Base-SX	1 Gbps	Cat6 UTP	Full	100 m
1000Base-LX	1 Gbps	Multimode Fiber	Full	550 m
10GBase-CX4	1 Gbps	Single-Mode Fiber	Full	2 km
10GBase-T	10 Gbps	Twin-axial	Full	100 m
10GBase-LX4	10 Gbps	Cat6a/Cat7 UTP	Full	100 m
10GBase-LX4	10 Gbps	Multimode Fiber	Full	300 m
10 Mbps	10 Gbps	Single-Mode Fiber	Full	10 km

9.5.2 10 and 100 Mbps Ethernet

10Base-T Ethernet RJ-45 Pinouts

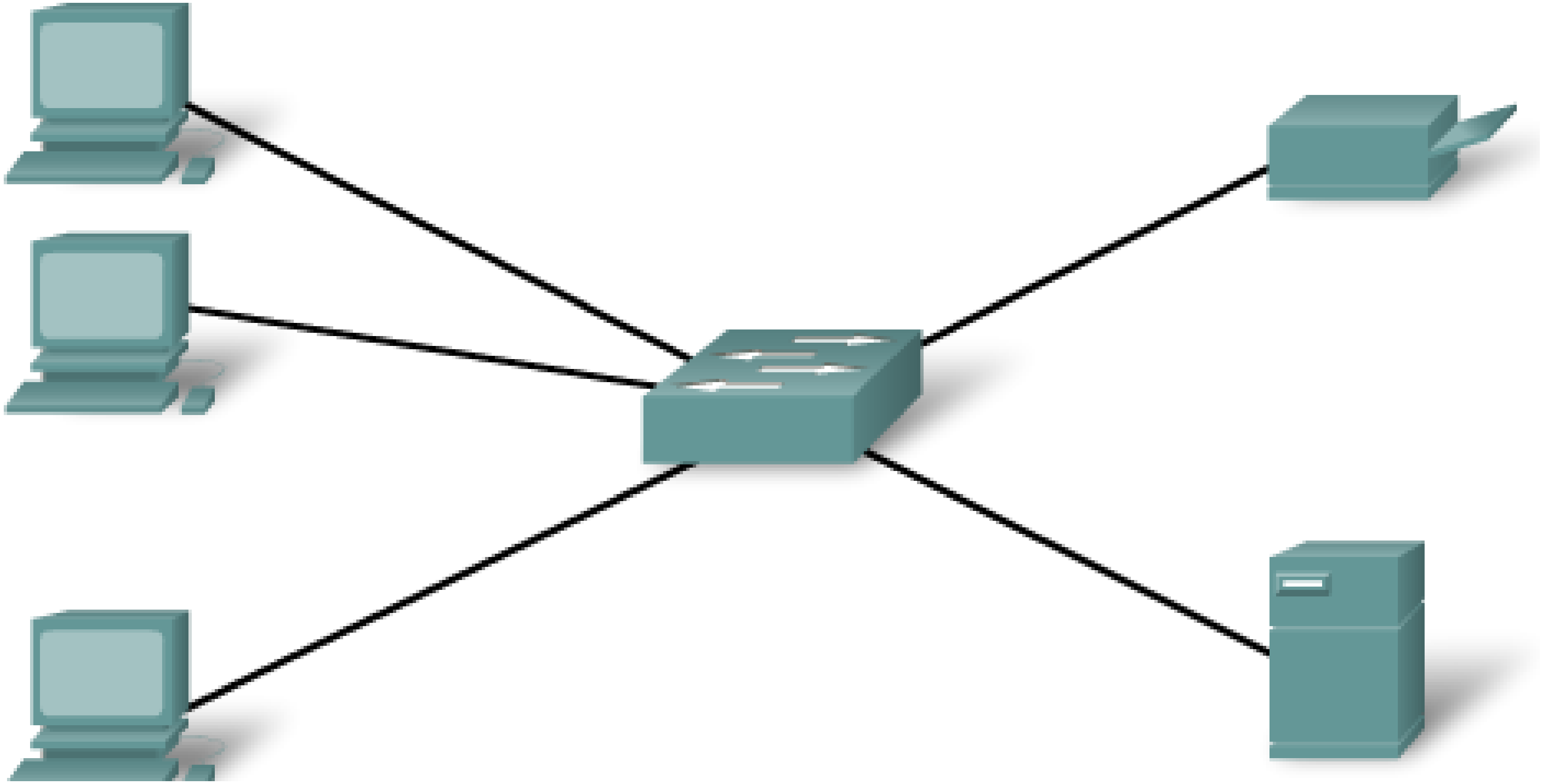


RJ-45 Connectors

Pin Number	Signal
1	TD+ (Transmit Data, positive-going differential signal)
2	TD- (Transmit Data, negative-going differential signal)
3	RD+ (Receive Data, positive-going differential signal)
4	Unused
5	Unused
6	RD- (Receive Data, negative-going differential signal)
7	Unused
8	Unused

9.5.2 10 and 100 Mbps Ethernet

Star Topology Used with 10BASE-T and 100BASE-TX Ethernet



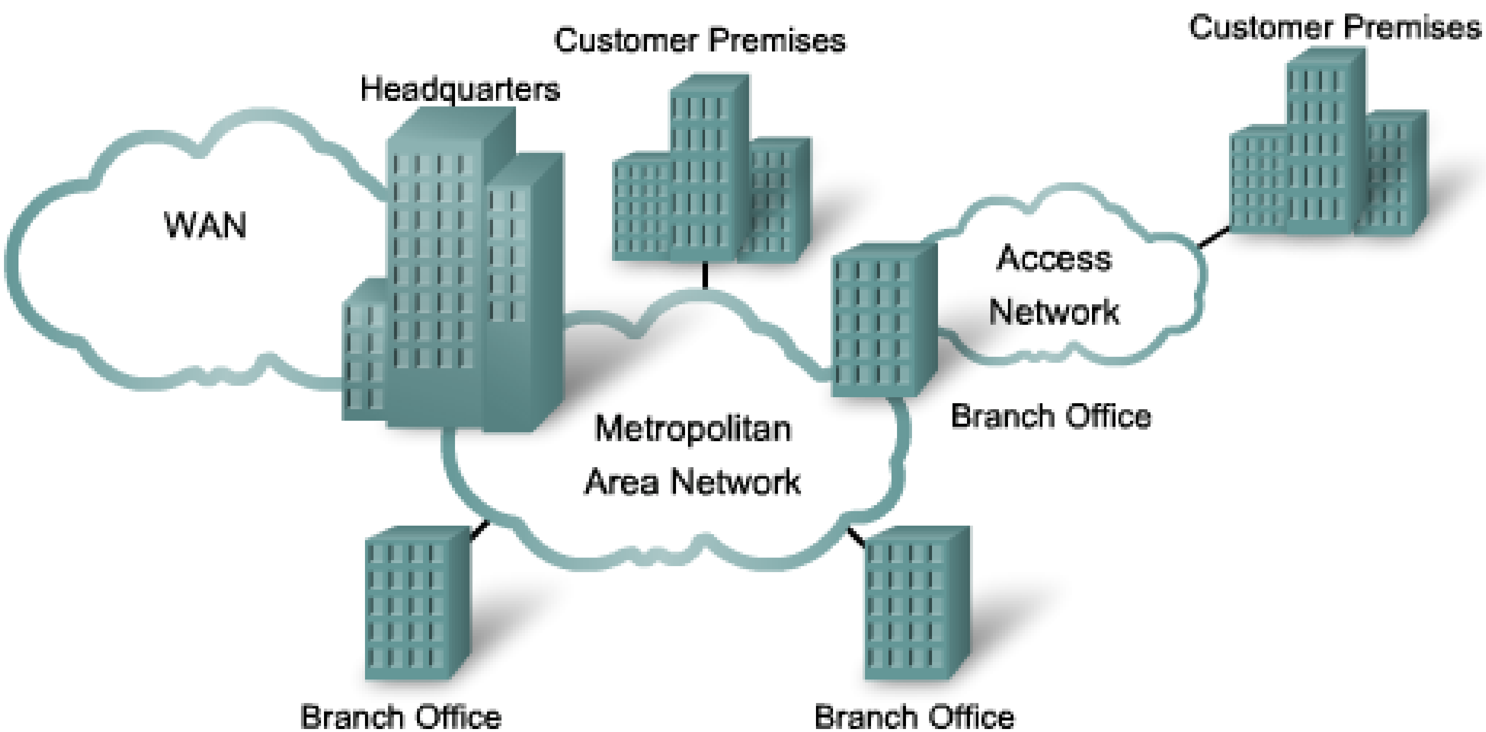
9.5.3 1000 Mbps Ethernet

1000Base-X Fiber Link Support		
Link Configuration	1000Base-SX (850 nm Wavelength)	1000Base-LX (1300 nm Wavelength)
125/62.5 µm multimode optical fiber	Supported	Supported
125/50 µm multimode optical fiber	Supported	Supported
125/10 µm single mode optical fiber	Not supported	Supported

The fiber versions of Gigabit Ethernet - 1000BASE-SX and 1000BASE-LX - offer the following advantages over UTP: noise immunity, small physical size, and increased unrepeated distances and bandwidth.

9.5.4 Ethernet Future Options

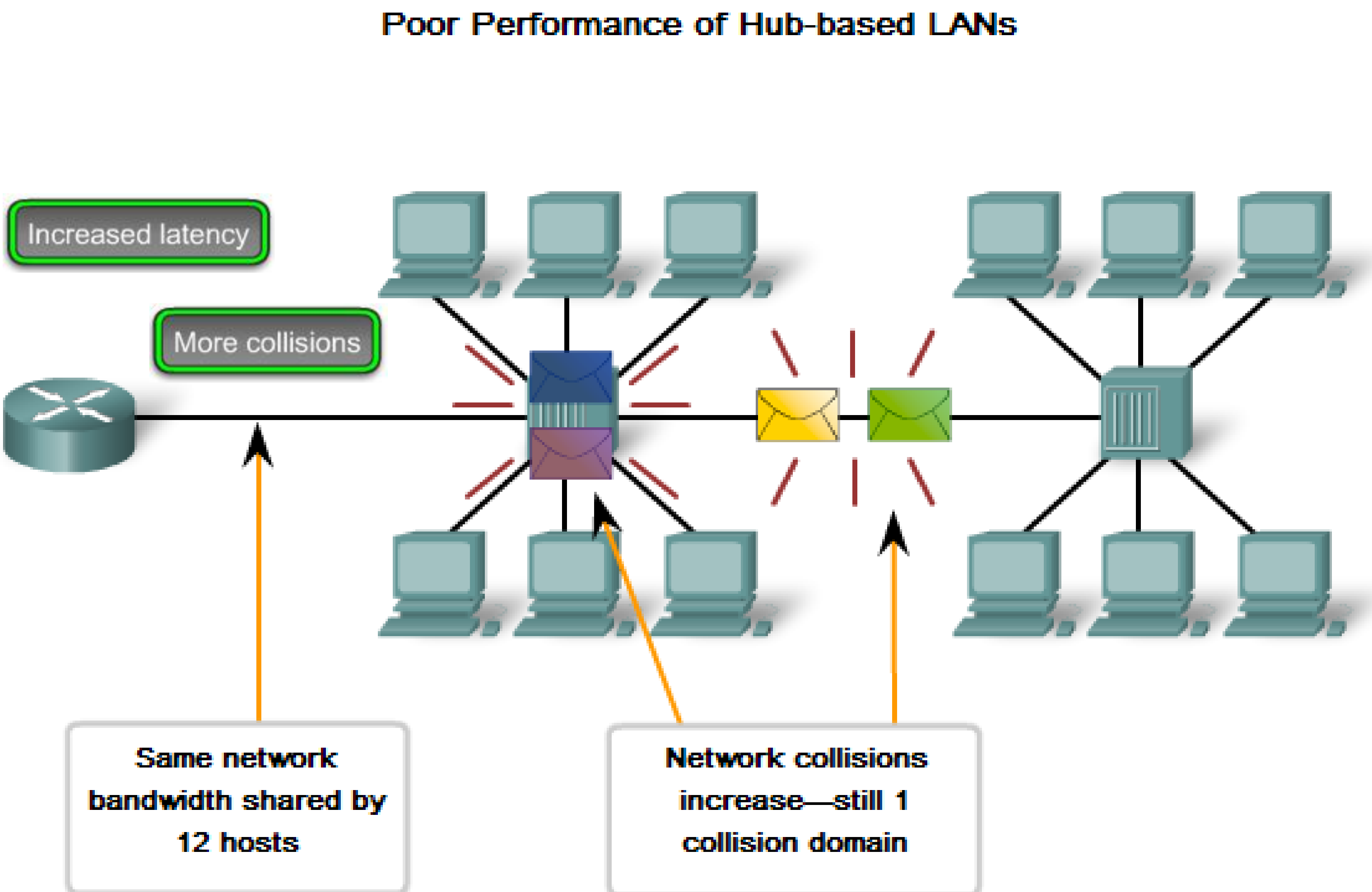
The common Ethernet frame can be applied to different network types



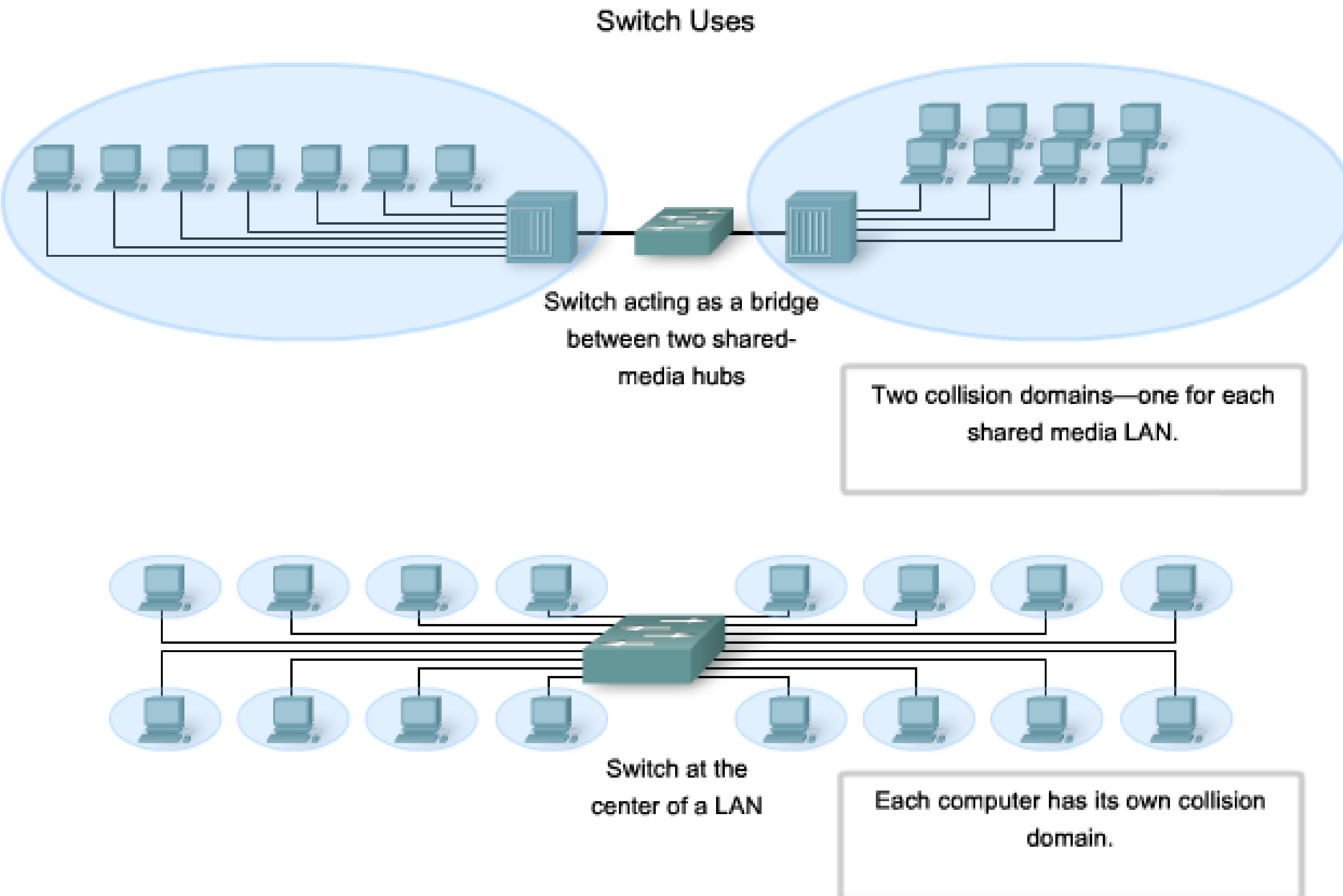
Ethernet

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

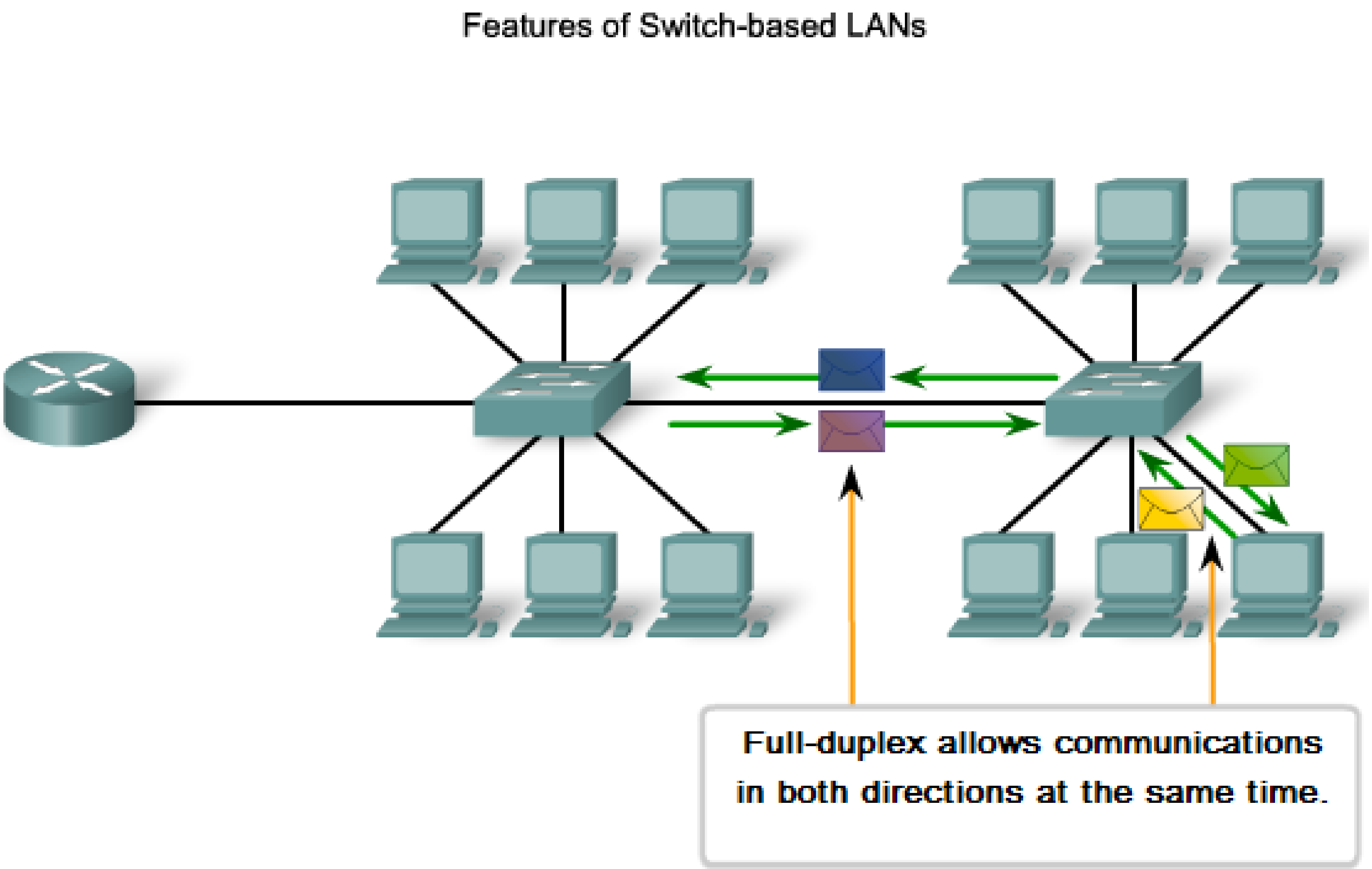
9.6.1 Legacy Ethernet Using Hubs



9.6.2 Ethernet – Using Switches

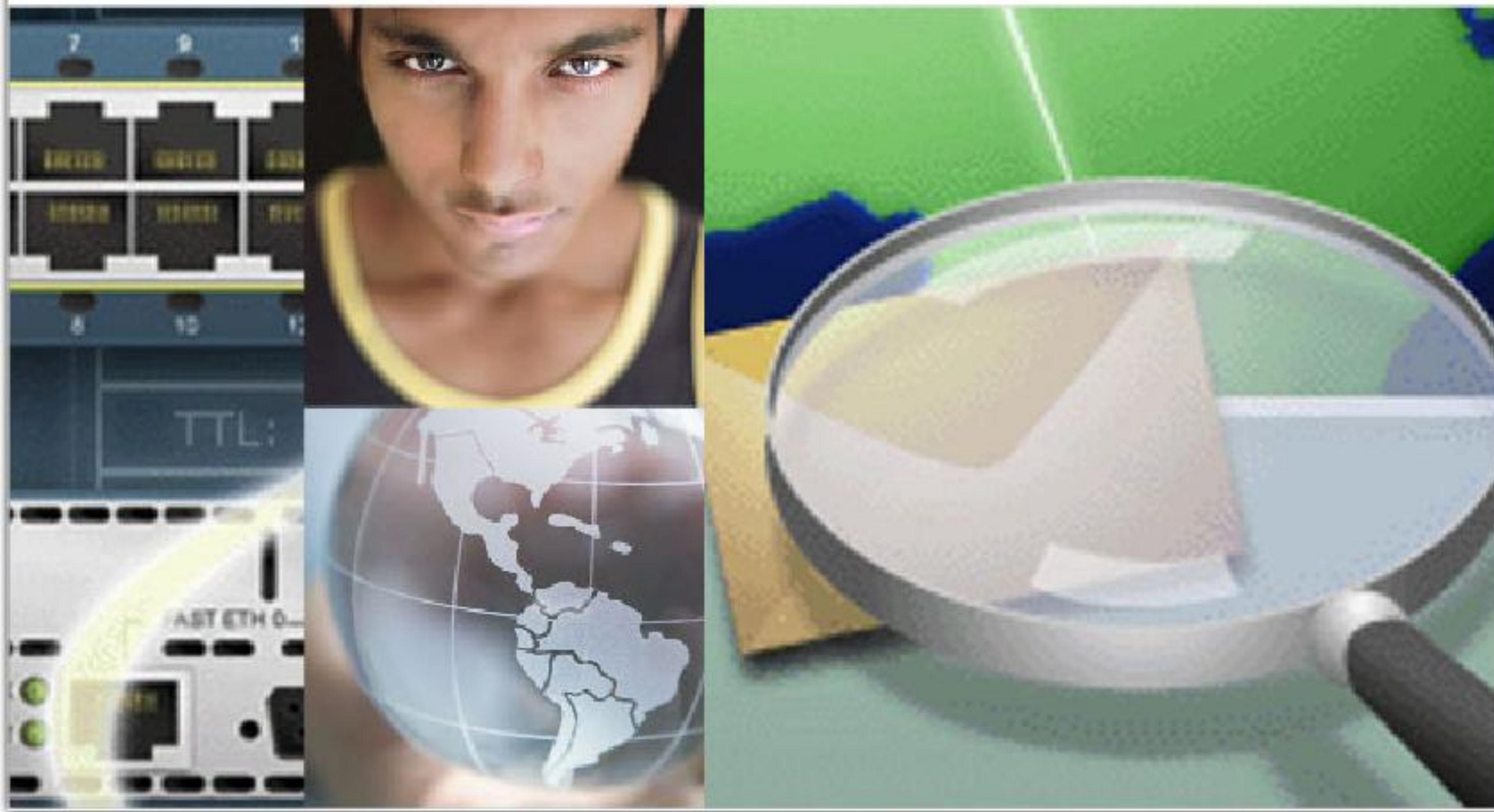


9.6.2 Ethernet – Using Switches



9.6.2 Ethernet – Using Switches

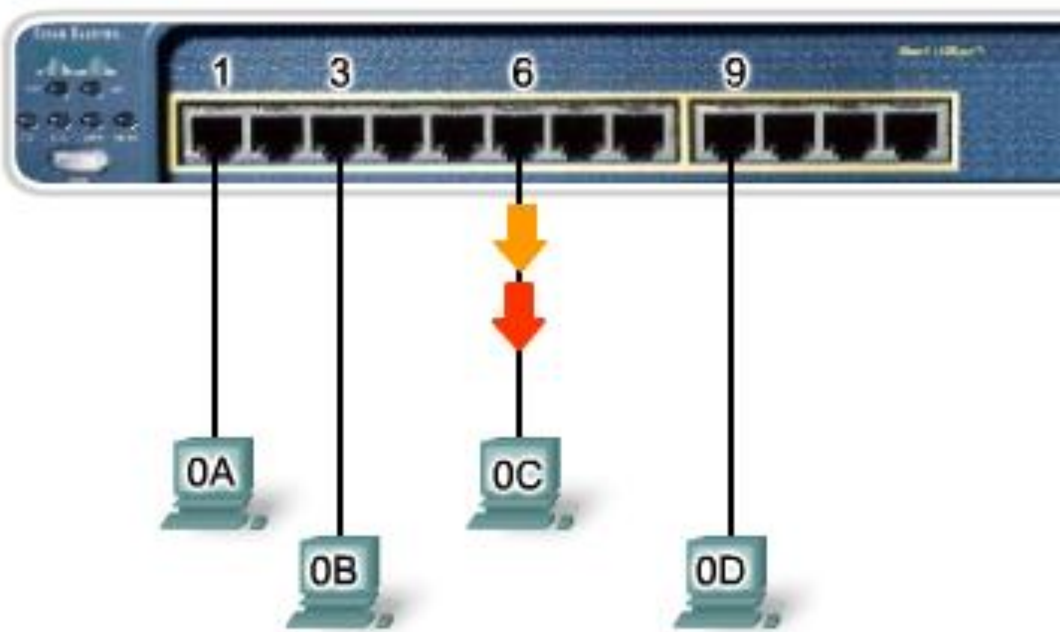
Packet Tracer Exploration:
From Hubs to Switches



9.6.3 Switches – Selective Forwarding

Switches are sometimes called Bridges

Switches - Selective Forwarding



SWITCHING TABLE

PORT	MAC ADDRESS
1	0A
3	0B
6	0C
9	0D

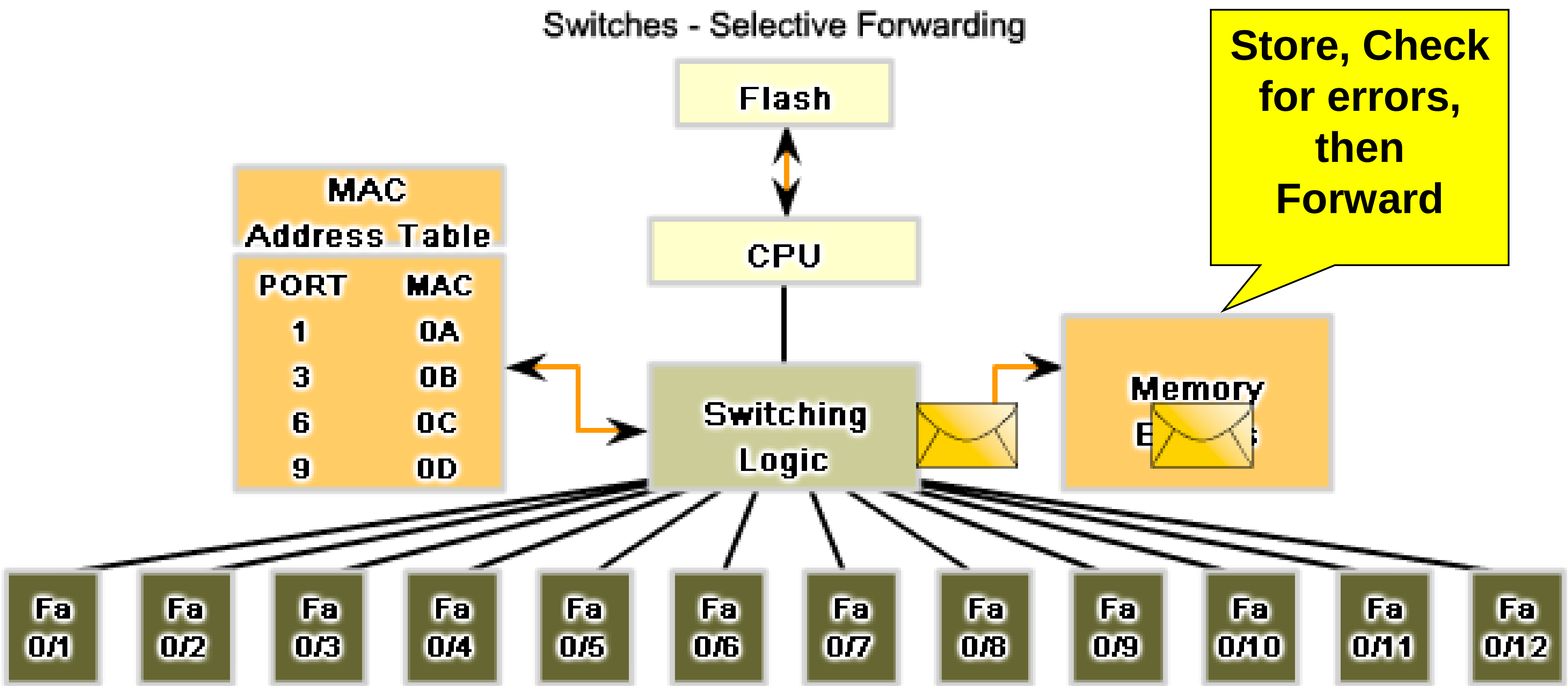
FRAME 1

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	0C	0A				

FRAME 2

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	0C	0D				

9.6.3 Switches – Selective Forwarding



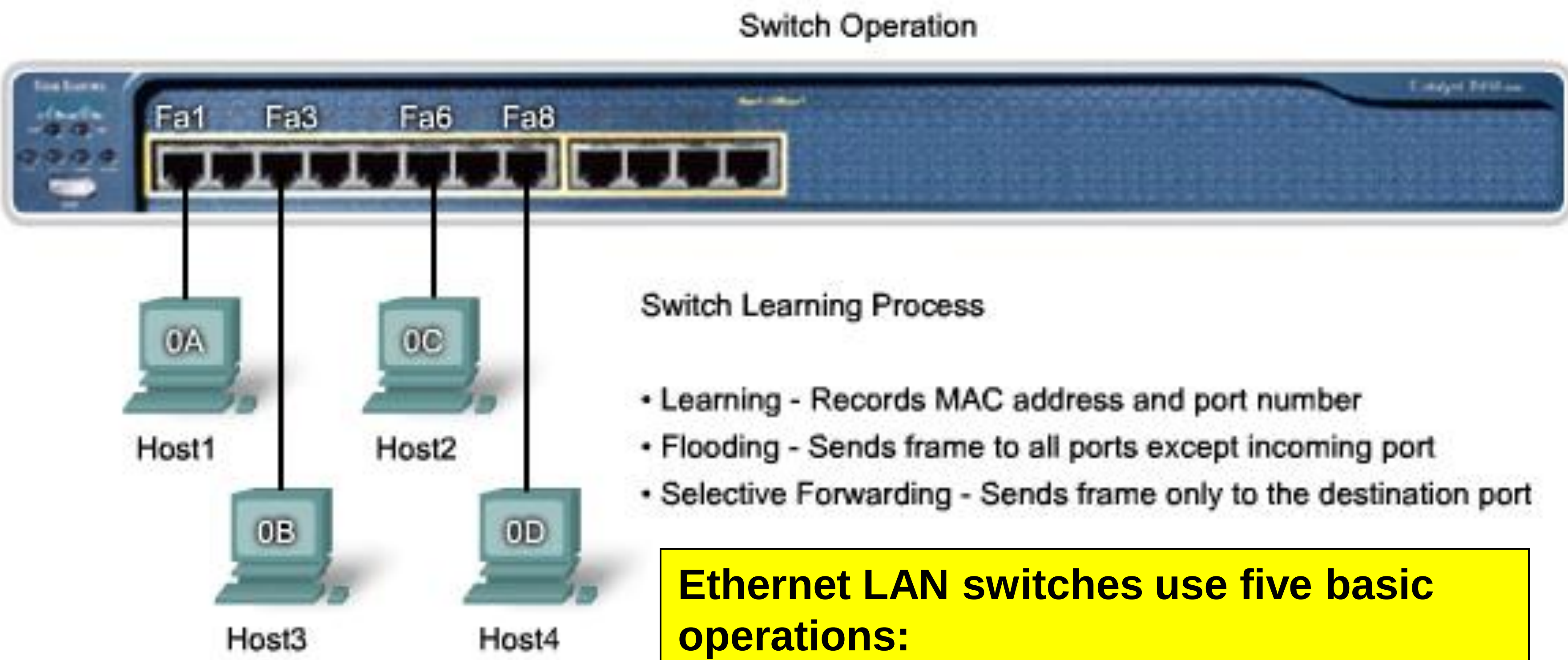
FRAME 1

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	0C	0A				

FRAME 2

Preamble	Destination Address	Source Address	Type	Data	Pad	CRC
	0C	0B				

9.6.3 Switches – Selective Forwarding

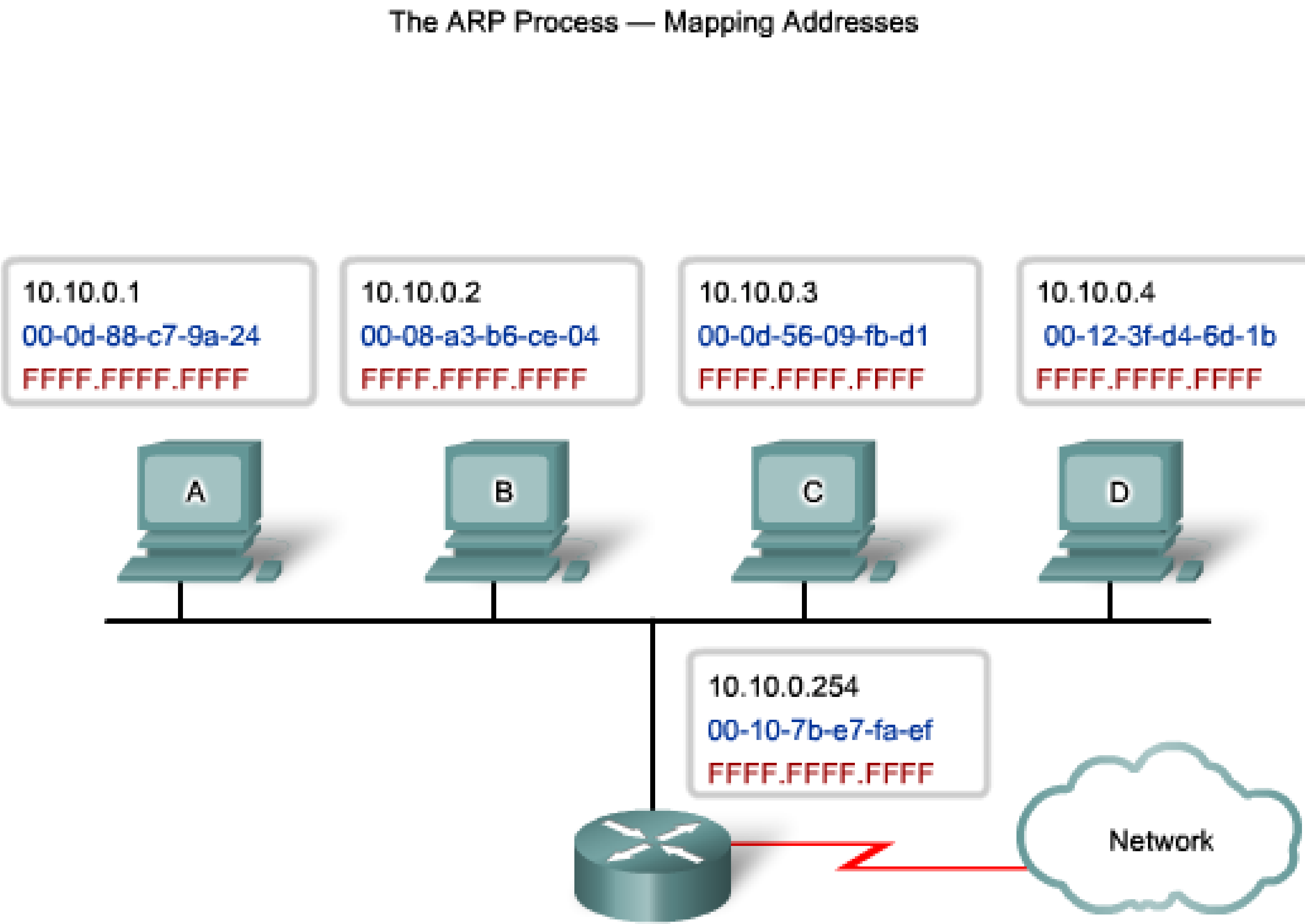


Ethernet LAN switches use five basic operations:

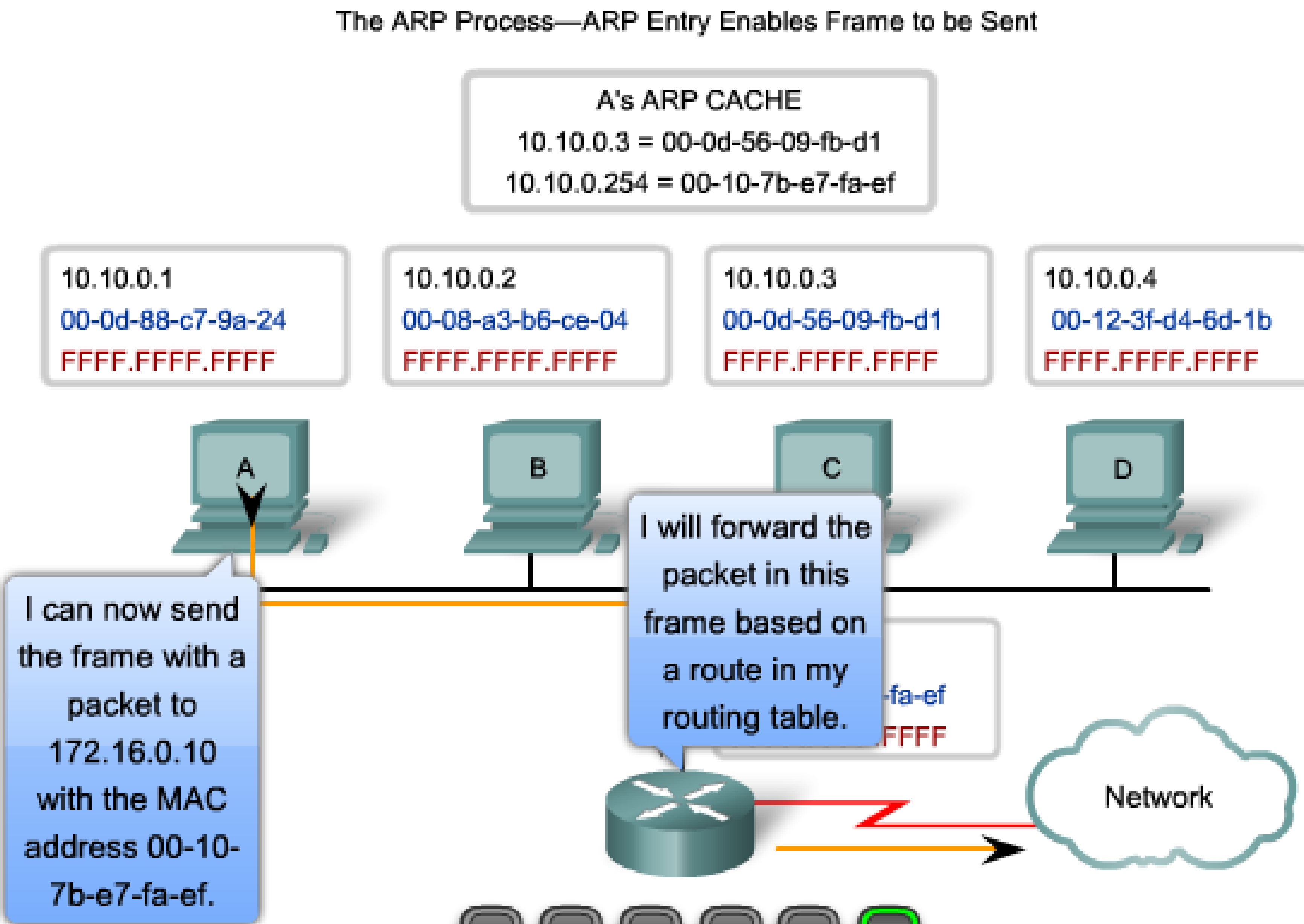
Learning
Aging
Flooding
Selective Forwarding
Filtering

Packet Tracer Exploration:
Switch Operation

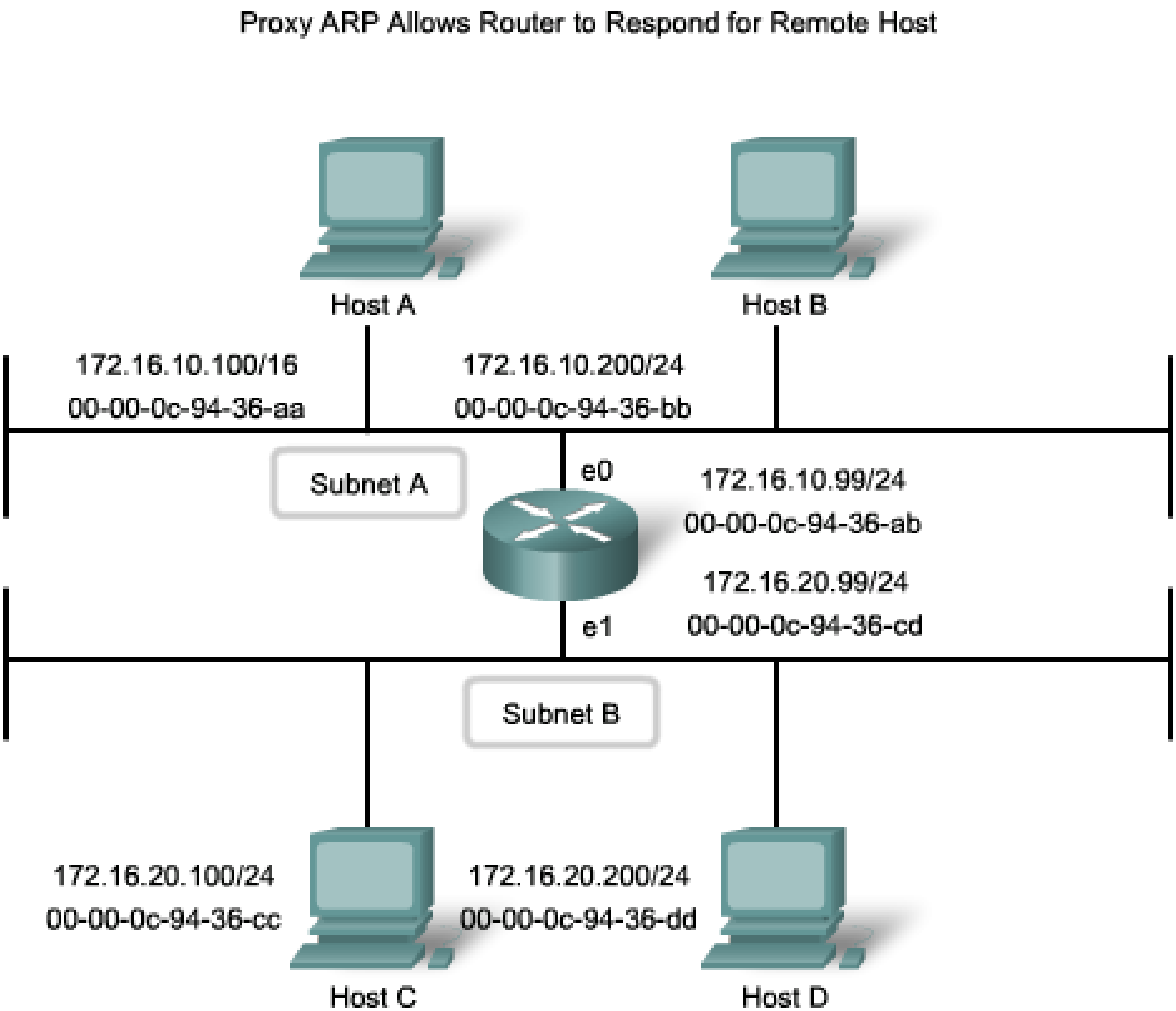
9.7.1 The ARP Process – Mapping IP to MAC Addresses



9.7.2 The ARP Process – Destination Outside the Local Network

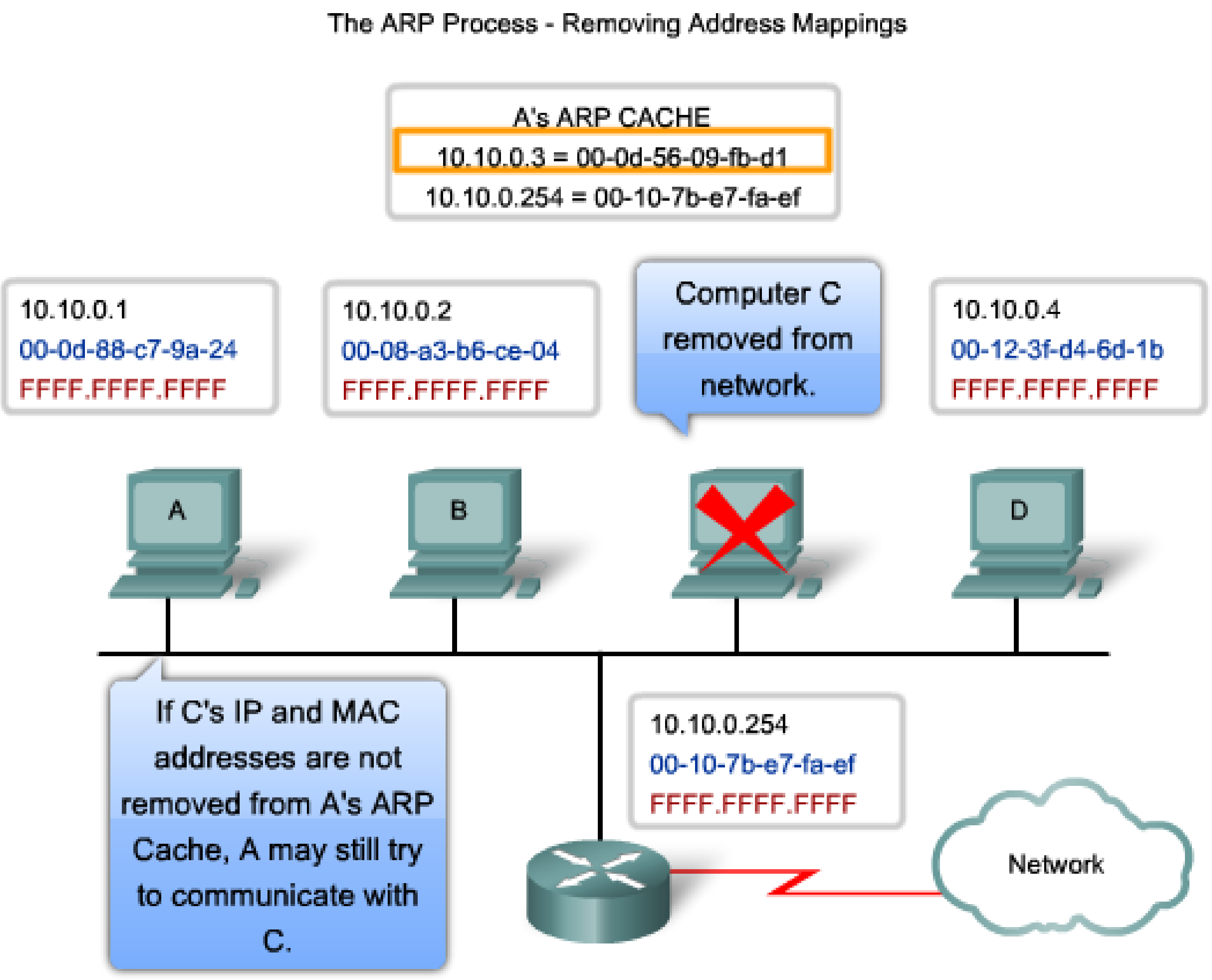


9.7.2 The ARP Process – Destination Outside the Local Network



As shown in the figure, Host A has been improperly configured with a /16 subnet mask. This host believes that it is directly connected to all of the 172.16.0.0 /16 network instead of to the 172.16.10.0 /24 subnet

9.7.3 The ARP Process – Removing the Mappings



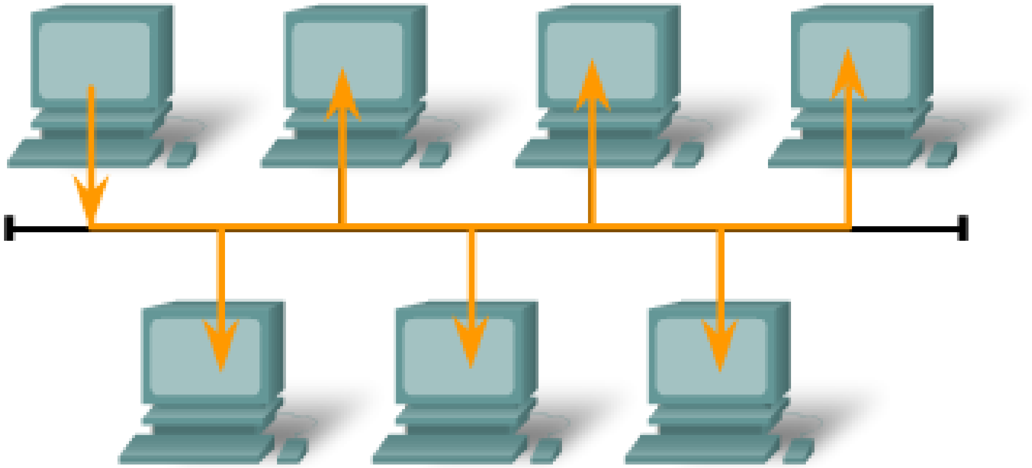
9.7.4 ARP Broadcast Issues

ARP Issues:

- Broadcasts, overhead on the Media
- Security

ARP broadcasts can flood the local media.

Shared Media (multiple access)



A false ARP message can provide an incorrect MAC address that will then hijack frames using that address (called a spoof).

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

9.9.1 Summary and Review

In this chapter, you learned to:

- Identify the basic characteristics of network media used in Ethernet.
- Describe the Physical and Data Link layer features of Ethernet.
- Describe the function and characteristics of the media access control method used by Ethernet protocol.
- Explain the importance of Layer 2 addressing used for data transmission and determine how the different types of addressing impacts network operation and performance.
- Compare and contrast the application and benefits of using Ethernet switches in a LAN as opposed to using hubs.
- Explain the ARP process.