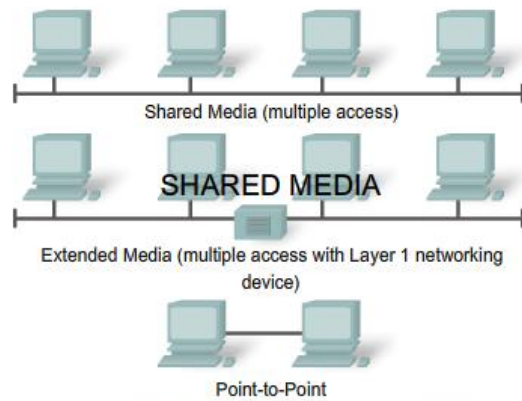


Ethernet

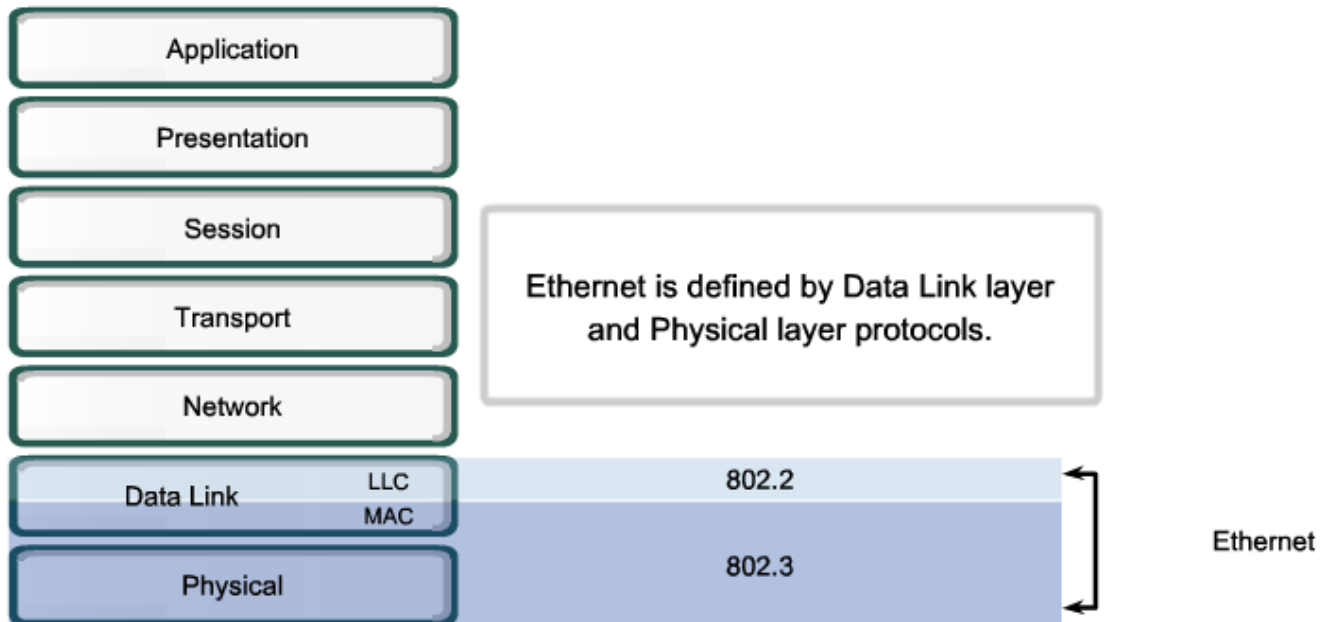
Introduction



Ethernet is the predominant LAN technology in use today.

Ethernet standards and Implementation

Ethernet



Ethernet- Layer1 and Layer2

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

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

Logical Link Control Sublayer	
802.3 Media Access Control	
Physical Signaling Sublayer	10BASE5 500m) 50 Ohm Coax N-Style
Physical Medium	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-ST (220-550m) MM Fiber SC
	1000BASE-LX (550-5000m) MM or SM Fiber SC

MAC-Getting the Data to the Media

MAC—Getting Data to the Media

MEDIA ACCESS CONTROL

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

Physical Implementation of Ethernet

Physical Devices Implementing Ethernet



UTP patch panels in a rack



Ethernet switches

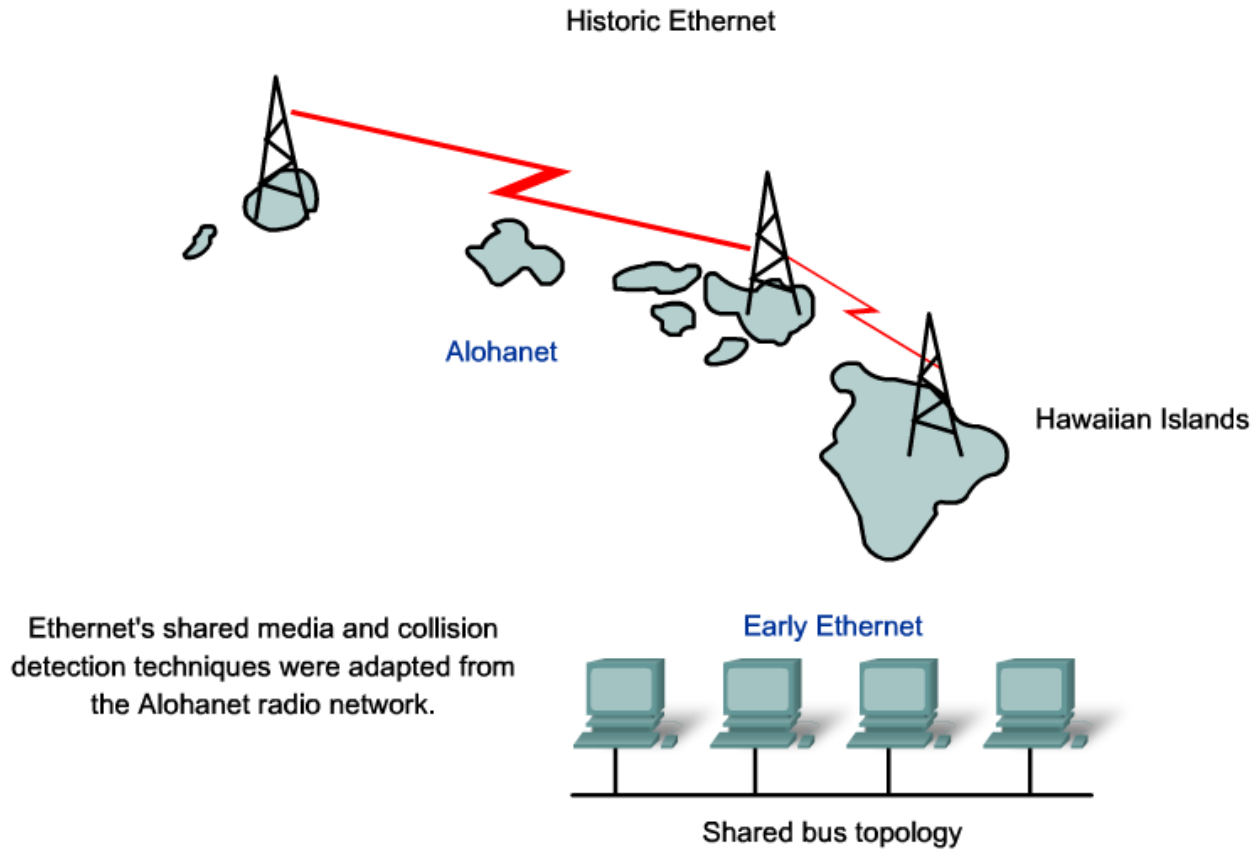


Ethernet fiber connectors



Ethernet switch

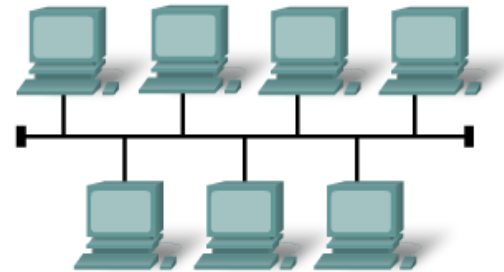
Historic Ethernet



Historic Ethernet...

Early Ethernet Media and Topology

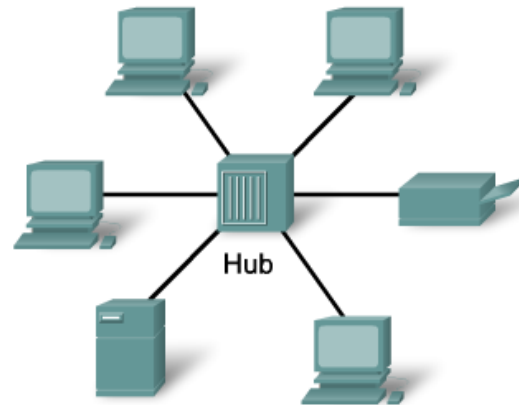
Topology
Physical: Bus
Logical: Multi-Access (Bus)



Migration to

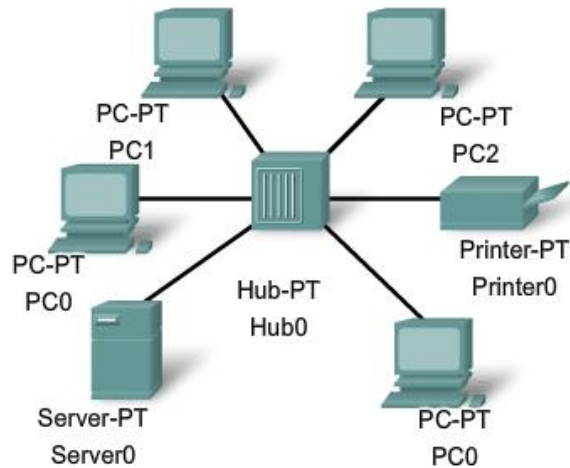


Topology
Physical: Star
Logical: Multi-Access (Bus)



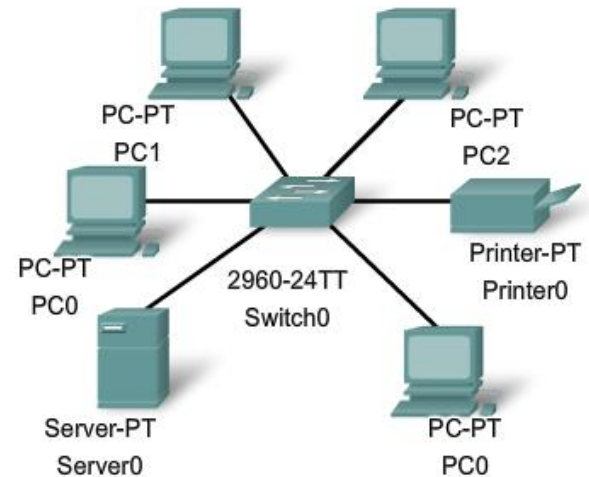
Ethernet Collision Management

Migration to Ethernet Switches



Hub-based

Migration to Ethernet Switches



Switch-based

Moving to 1 Gbps and beyond

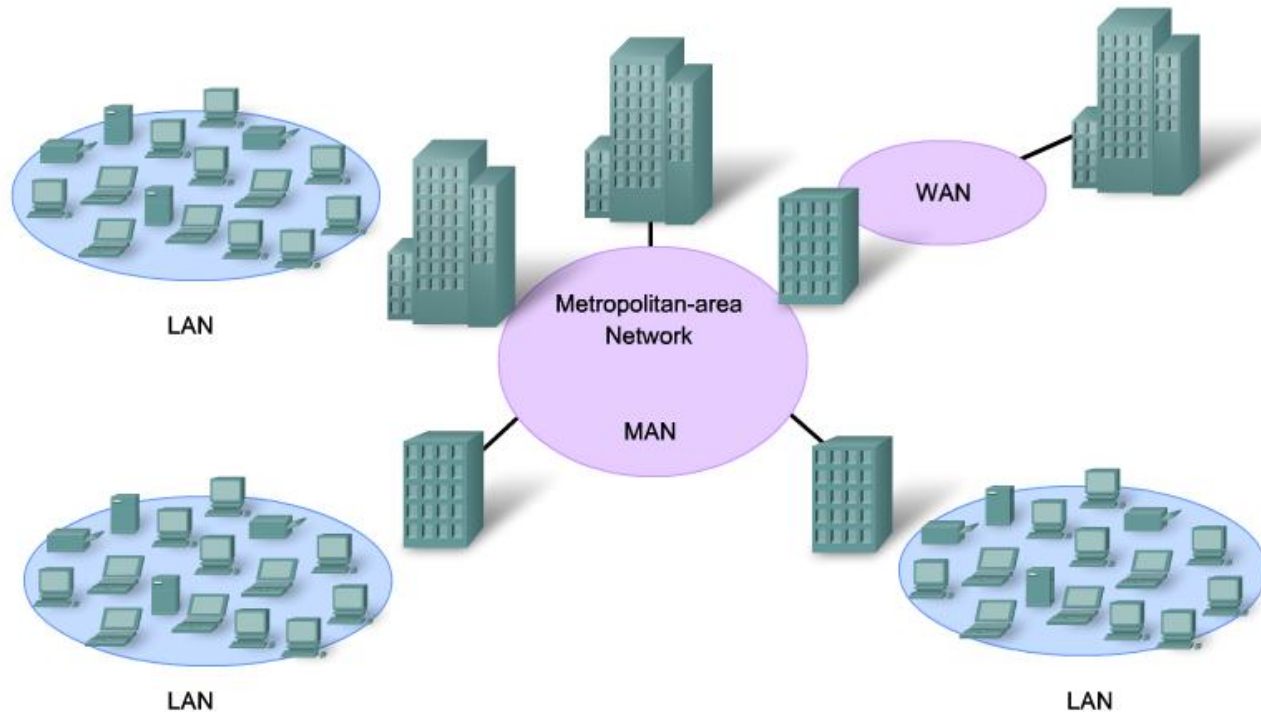
Moving Ethernet to 1 Gbps and Beyond



Moving to 1 Gbps and beyond...

Gigabit Ethernet

Gigabit Ethernet technology is applied beyond the enterprise LAN to MAN and WAN-based networks.



The Frame Encapsulation the Packet

Comparison of 802.3 and Ethernet 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						
8	6	6	2	46	4	
Preamble	Destination Address	Source Address	Type	Data	Frame Check Sequence	

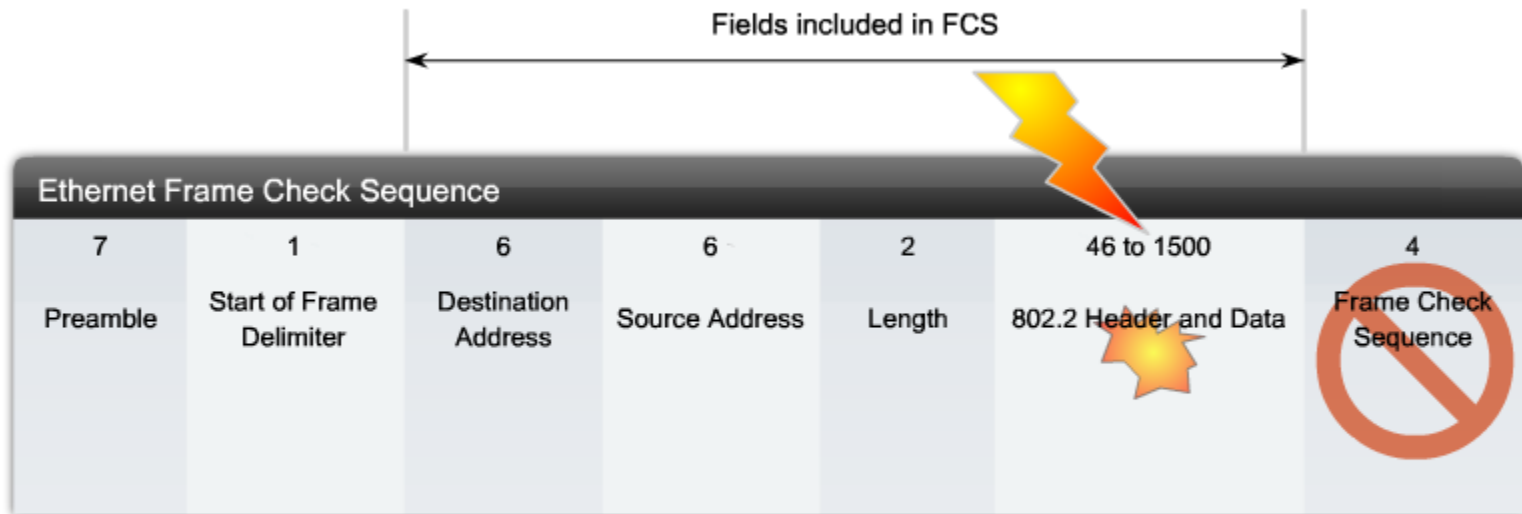
Field size in bytes

The Frame Encapsulation 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	802.2 Header and Data	Frame Check Sequence

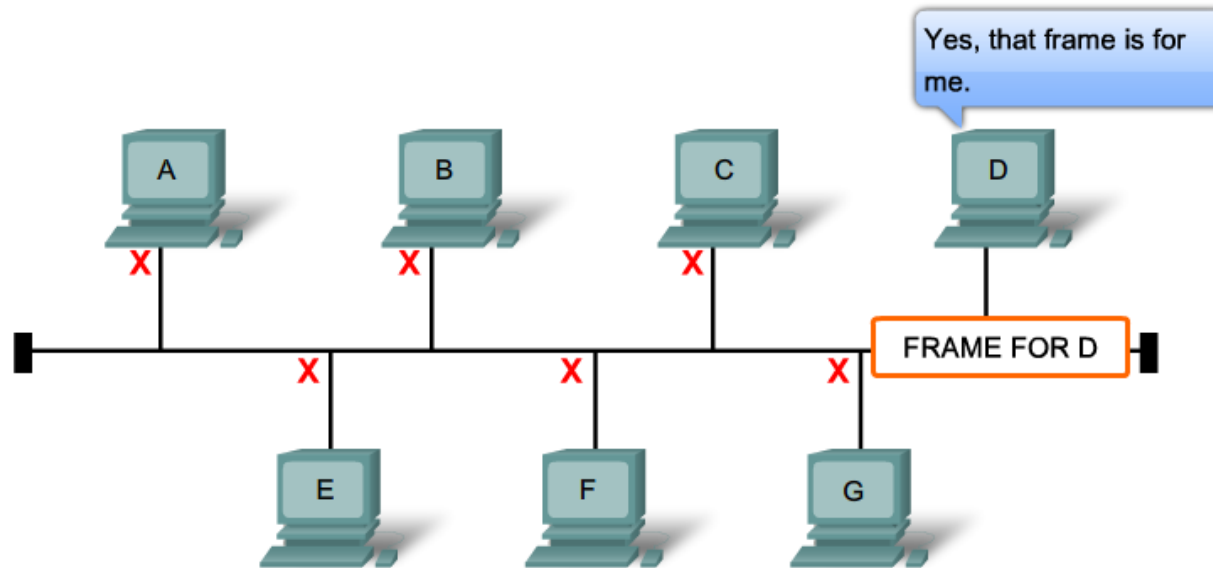
The Frame Encapsulation the Packet...



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.

The Ethernet Mac Address

The MAC Address—Addressing in Ethernet

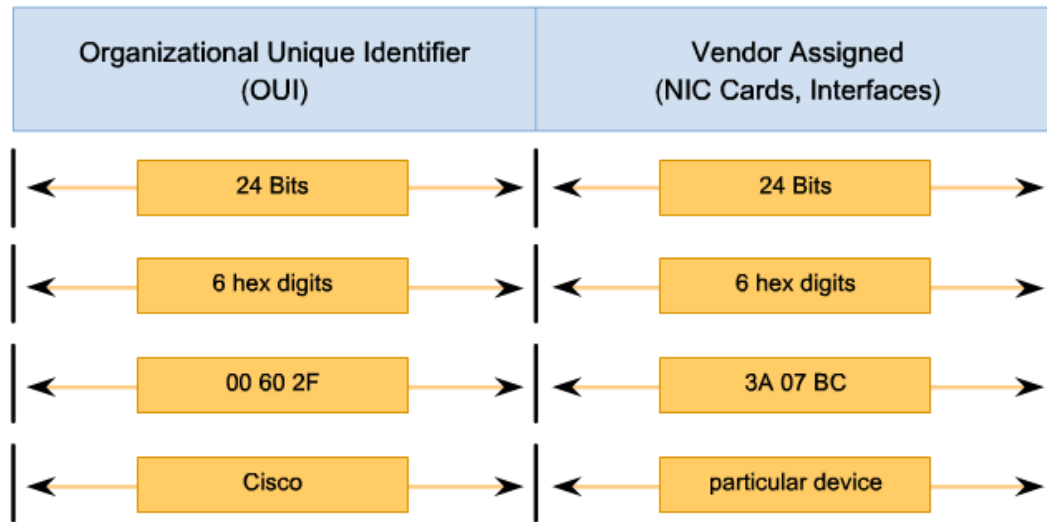


Shared Media (Multiple Access)

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

The Ethernet Mac Address...

The Ethernet MAC Address Structure



Different representations of MAC Addresses

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

Hexadecimal Numbering

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

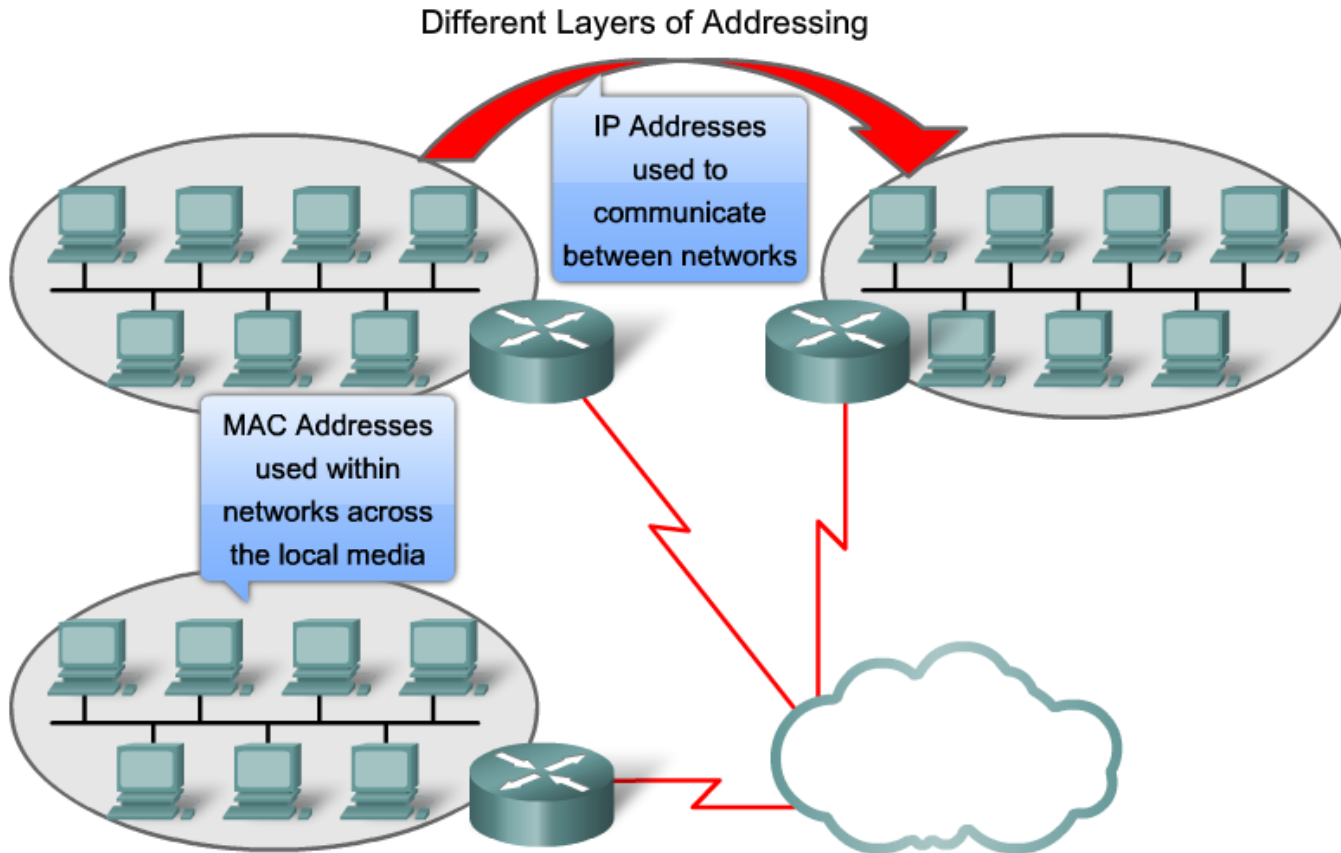
Hexadecimal Numbering...

Viewing the MAC Address

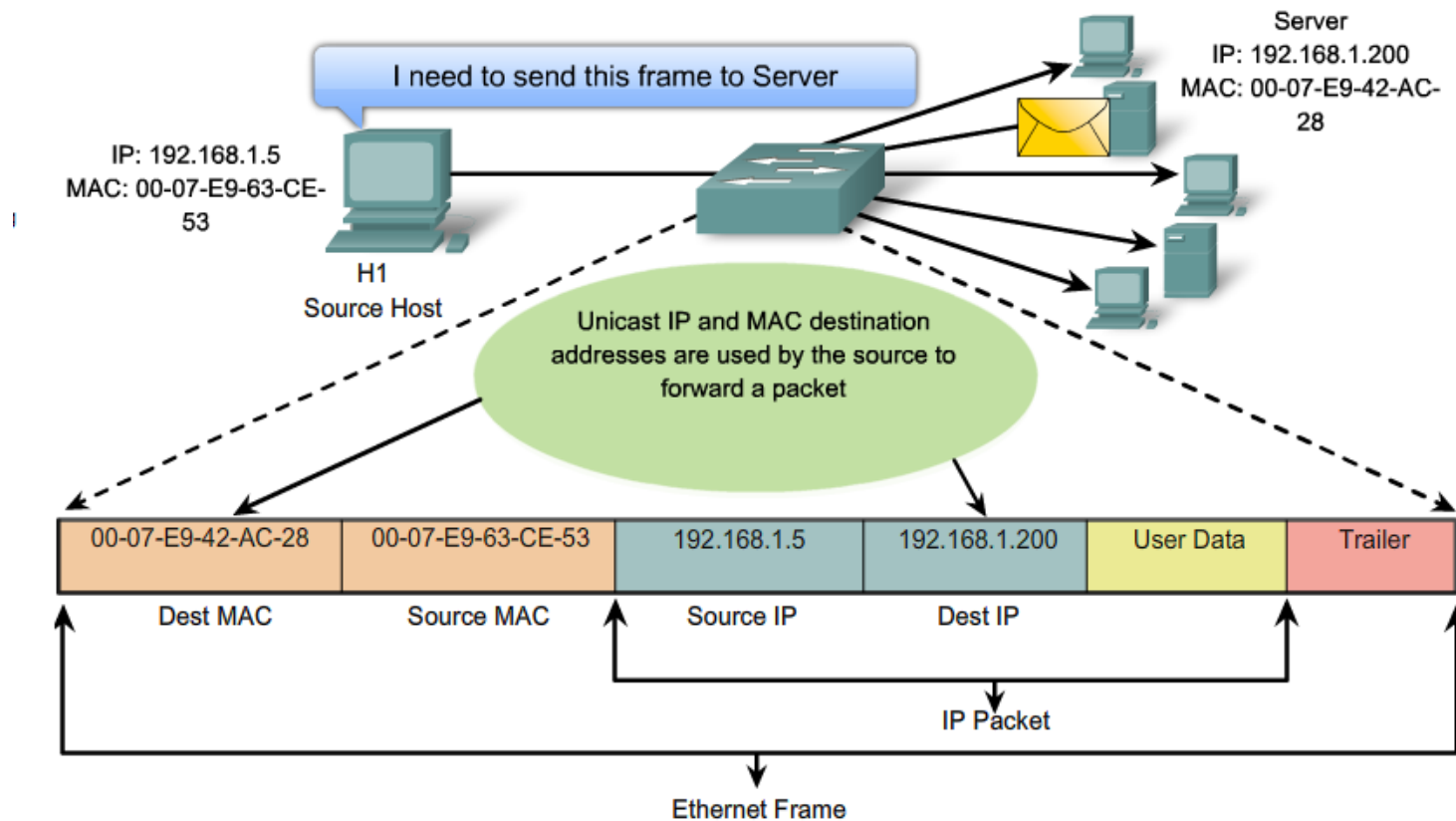
```
C:\>ipconfig /all
Ethernet adapter Network Connection:
    Connection-specific DNS Suffix: example.com
    Description . . . . . : Intel(R) PRO/Wireless 3945ABG Network
Connection
    Physical Address. . . . . : 00-18-DE-C7-F3-FB
    Dhcp Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . : 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:\>
```

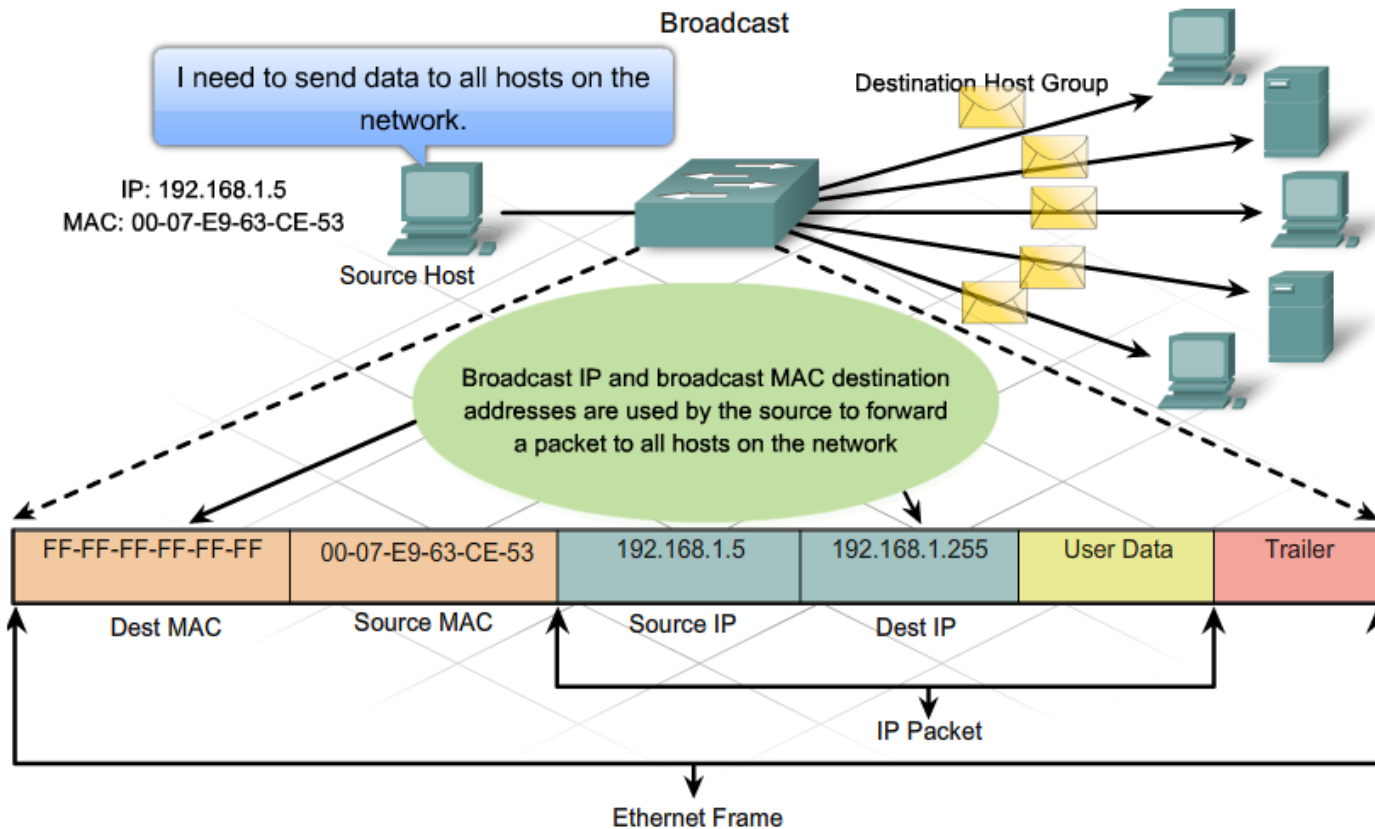
Another Layer Addressing



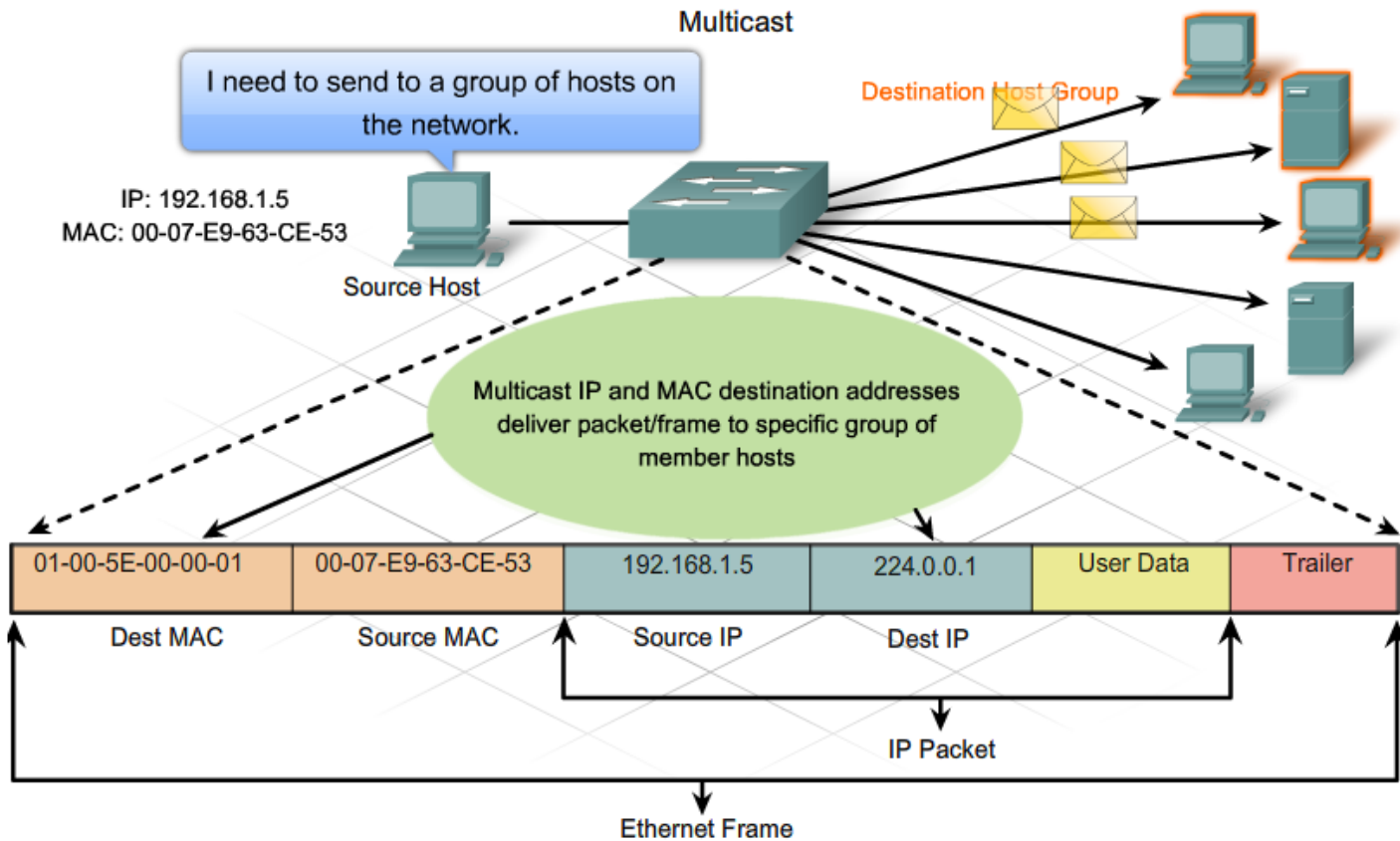
Unicast, Multicast, and Broadcast Communications....



Broadcast



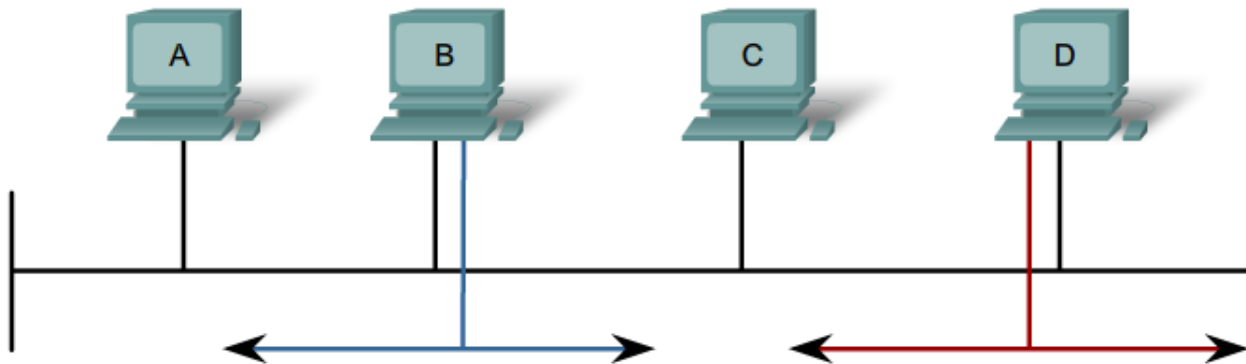
Multicast



Media Access Control in Ethernet

Media Access Control in Ethernet

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

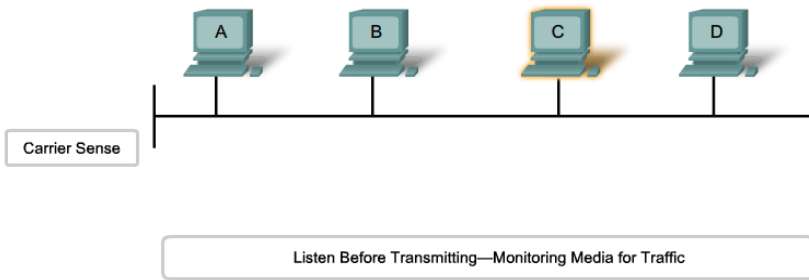


CSMA/CD controls access to the shared media. If there is a collision, it is detected and frames are retransmitted.

CSMA/CD the Process

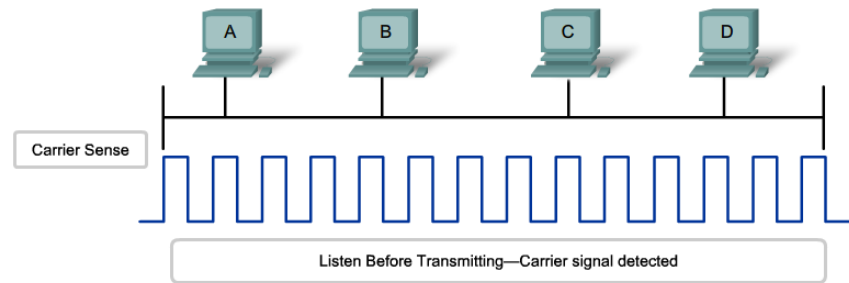
Media Access Control in Ethernet

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



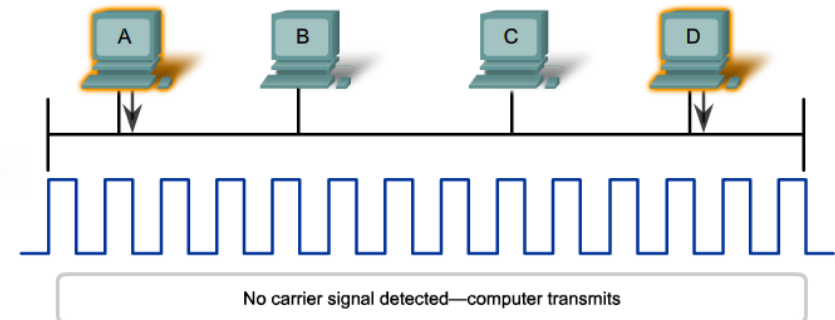
Media Access Control in Ethernet

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



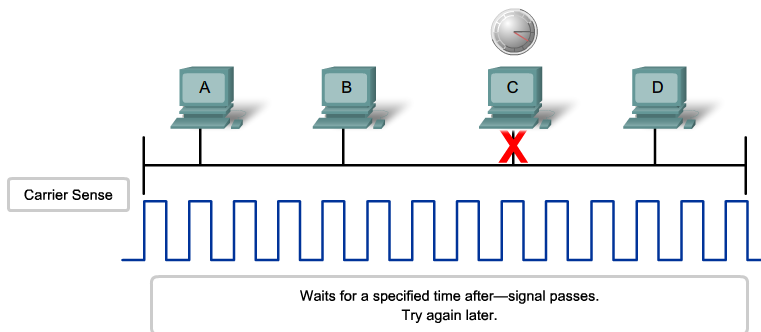
Media Access Control in Ethernet

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



Media Access Control in Ethernet

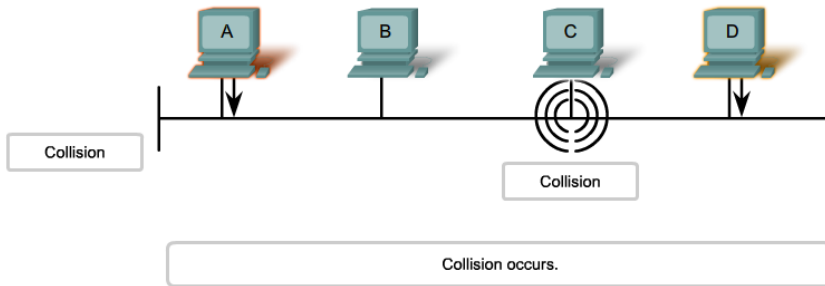
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)



CSMA/CD the Process...

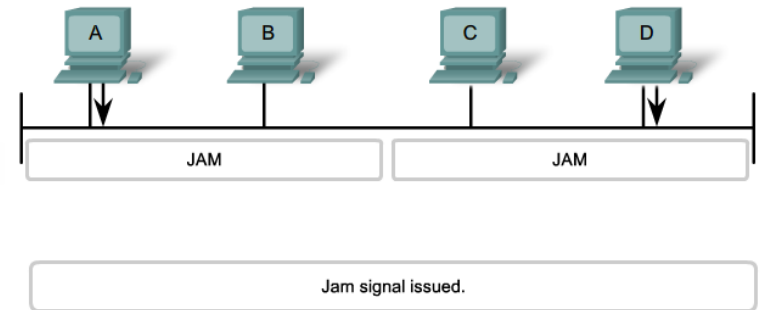
Media Access Control in Ethernet

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



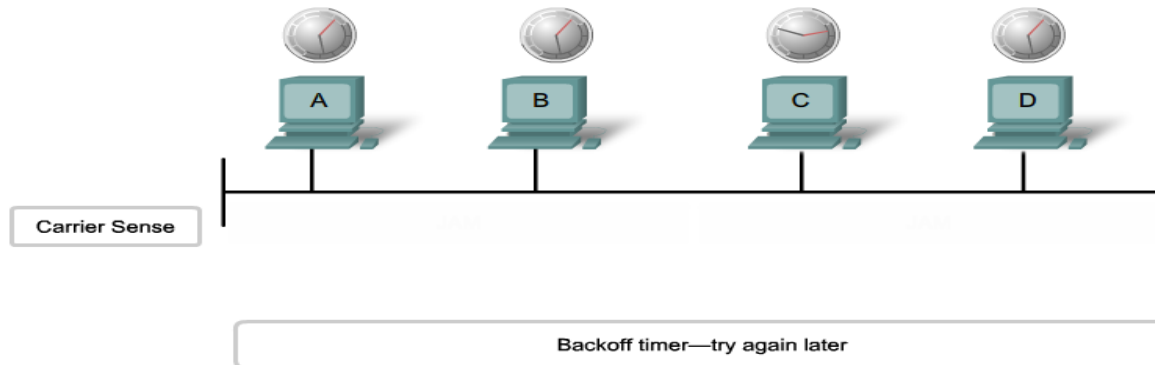
Media Access Control in Ethernet

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



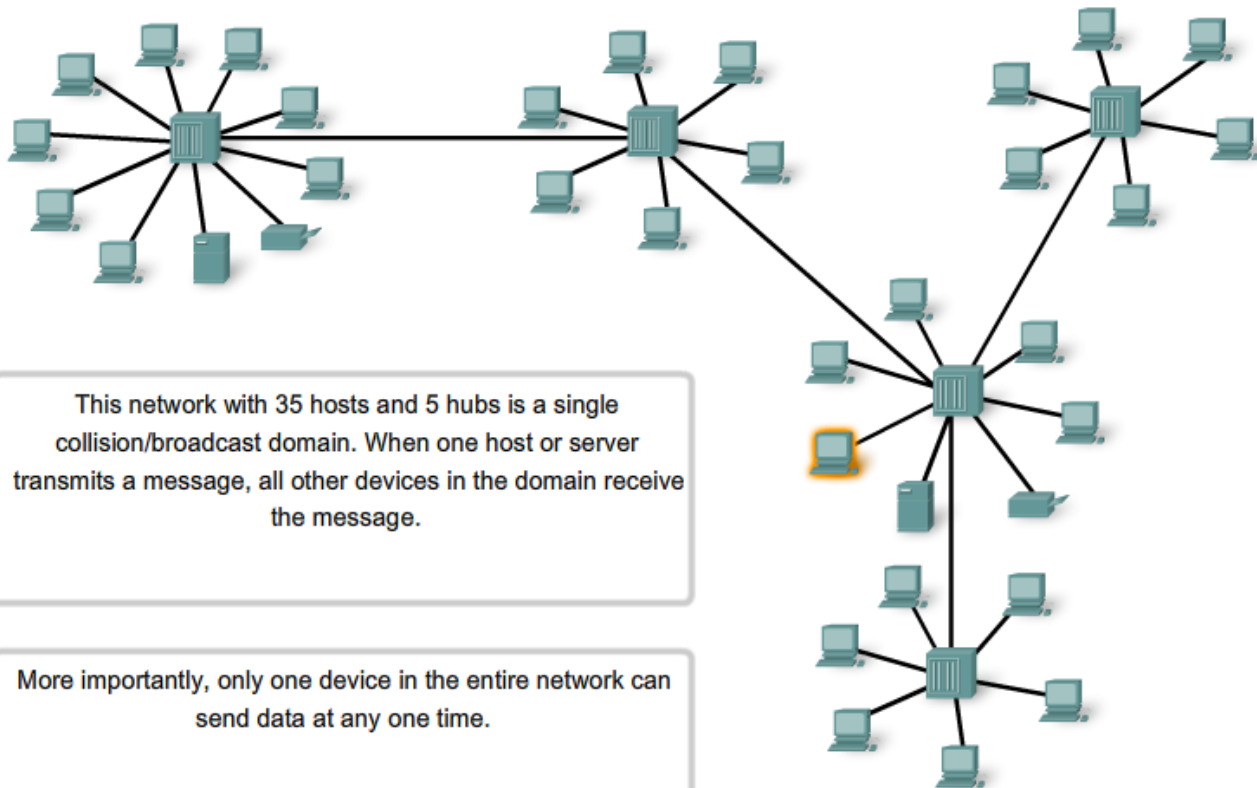
Media Access Control in Ethernet

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



Hubs and Collision Domains

Using hubs in extended star topologies can create large collision domains

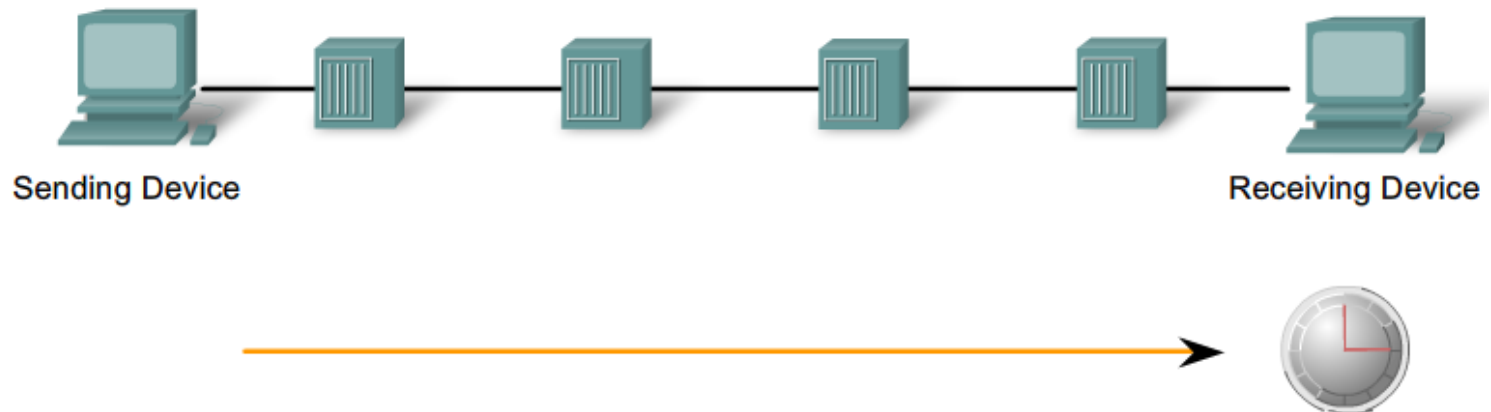


This network with 35 hosts and 5 hubs is a single collision/broadcast domain. When one host or server transmits a message, all other devices in the domain receive the message.

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

Ethernet Timing

Ethernet Delay (Latency)



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

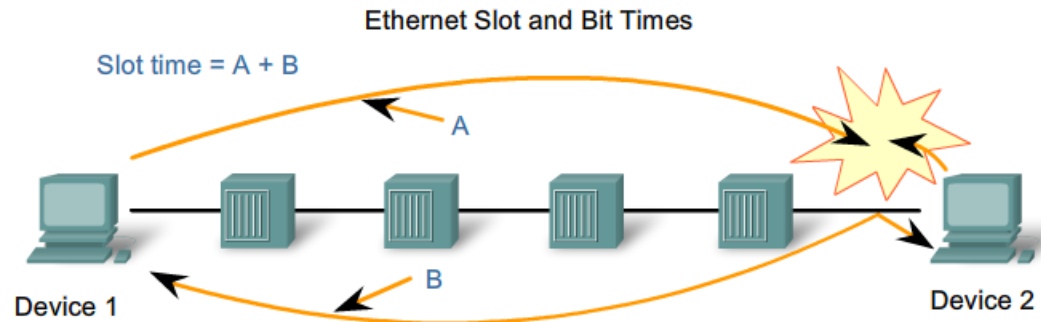
Ethernet Timing...

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.

Ethernet Timing...



Speed	Slot Time	Time Interval
10 Mbps	512 bit time	51.2 μ s
100 Mbps	512 bit time	5.12 μ s
1 Gbps	4096 bit time	4.096 μ s
10 Gbps	not applicable	not applicable

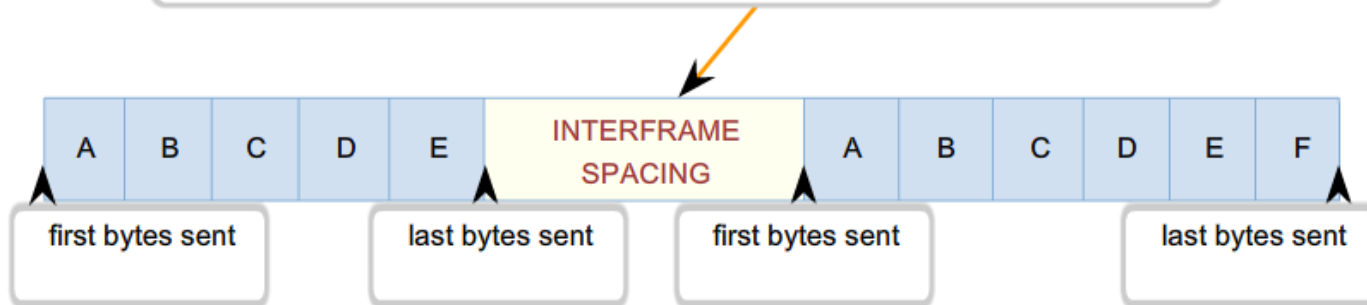
Ethernet Speed	Bit time
10 Mbps	100 ns
100 Mbps	10 ns
1000 Mbps = 1 Gbps	1 ns
10,000 Mbps = 10 Gbps	.1 ns

Interframe Spacing and Back off

Ethernet Interframe Spacing

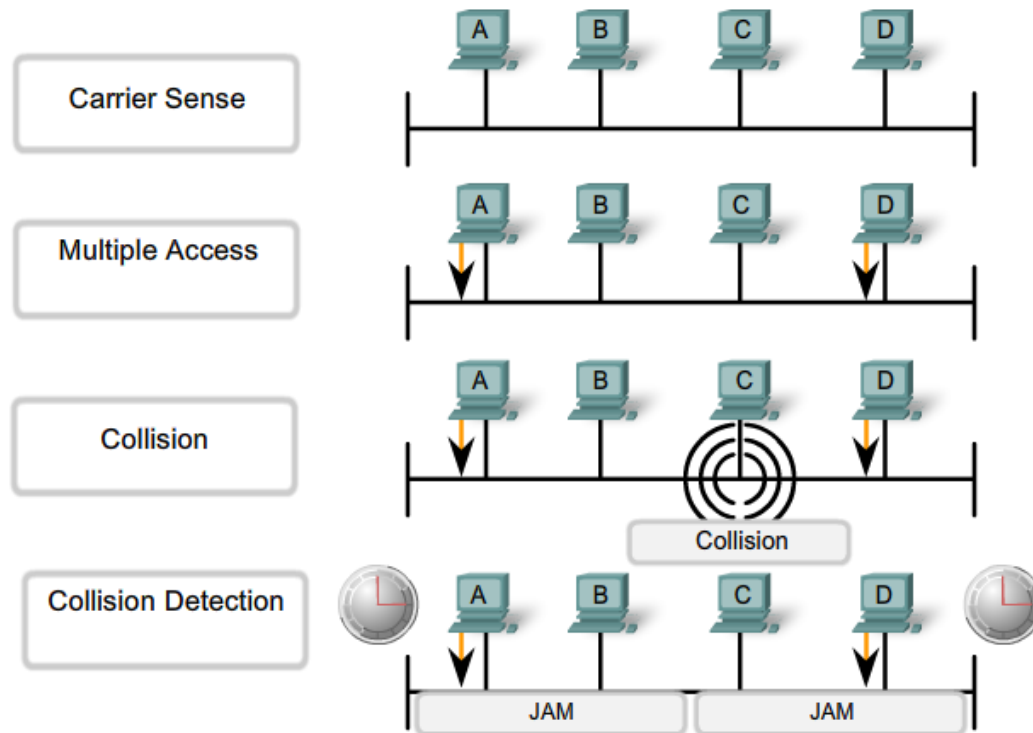
Speed	Interframe Spacing	Time Required
10 Mbps	96 bit time	9.6 μ s
100 Mbps	96 bit time	0.96 μ s
1 Gbps	96 bit time	0.096 μ s
10 Gbps	96 bit time	0.0096 μ s

Interframe time reduces as Ethernet speed increases



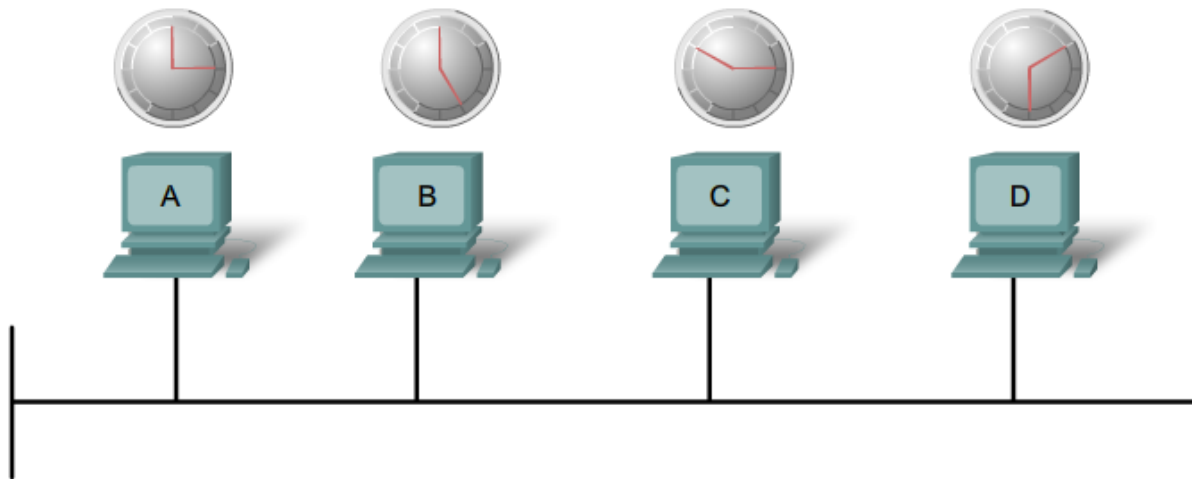
Interframe Spacing and Back off...

Stations detecting a collision send a jam signal.



Interframe Spacing and Back off...

Backoff Timing



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.

Ethernet Physical Layer

Types of Ethernet

Types of Ethernet	Bandwidth	Cable Type	Duplex	Maximum Distance
10Base-5	10 Mbps	Thicknet Coaxial	Half	500 m
10Base-2	10 Mbps	Thinnet Coaxial	Half	185 m
10Base-T	10 Mbps	Cat3/Cat5 UTP	Half	100 m
100Base-T	100 Mbps	Cat5 UTP	Half	100 m
100Base-TX	200 Mbps	Cat5 UTP	Full	100 m
100Base-FX	100 Mbits	Multimode Fiber	Half	400 m
100Base-FX	200 Mbps	Multimode Fiber	Full	2 km
1000Base-T	1 Gbps	Cat 5e UTP	Full	100 m
1000Base-TX	1 Gbps	Cat 6 UTP	Full	100 m
1000Base-SX	1 Gbps	Multimode Fiber	Full	550 m
1000Base-LX	1 Gbps	Single-Mode Fiber	Full	5 km
10GBase-CX4	10 Gbps	Twinaxial	Full	15 m
10GBase-T	10 Gbps	Cat6a/Cat7 UTP	Full	100 m
10GBase-LX4	10 Gbps	Multimode Fiber	Full	300 m
10GBase-LX4	10 Gbps	Single-mode Fiber	Full	10 km

10 and 100 Mbps Ethernet

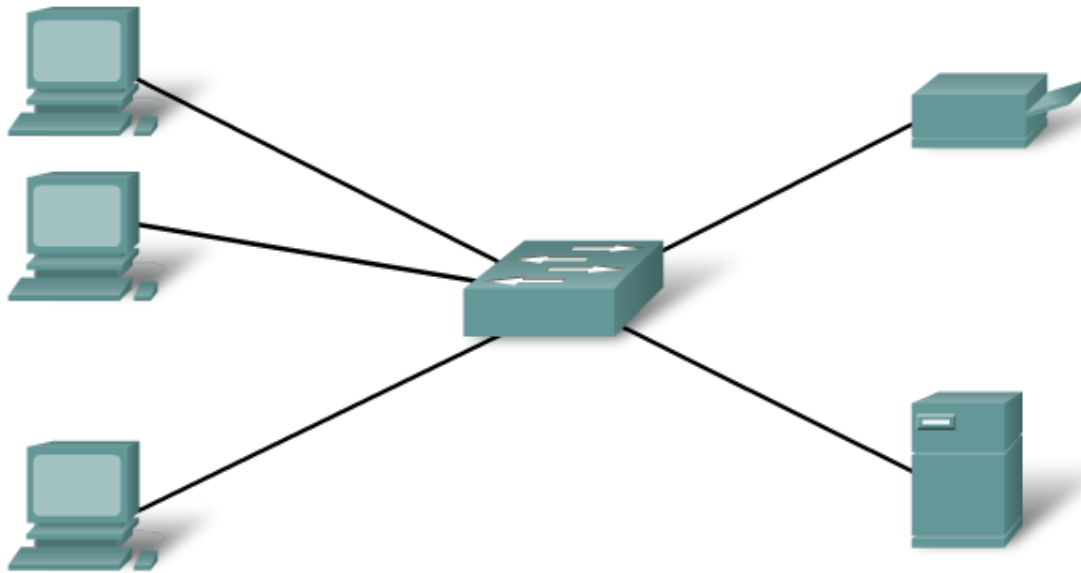
10Base-T Ethernet RJ-45 Pinouts



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

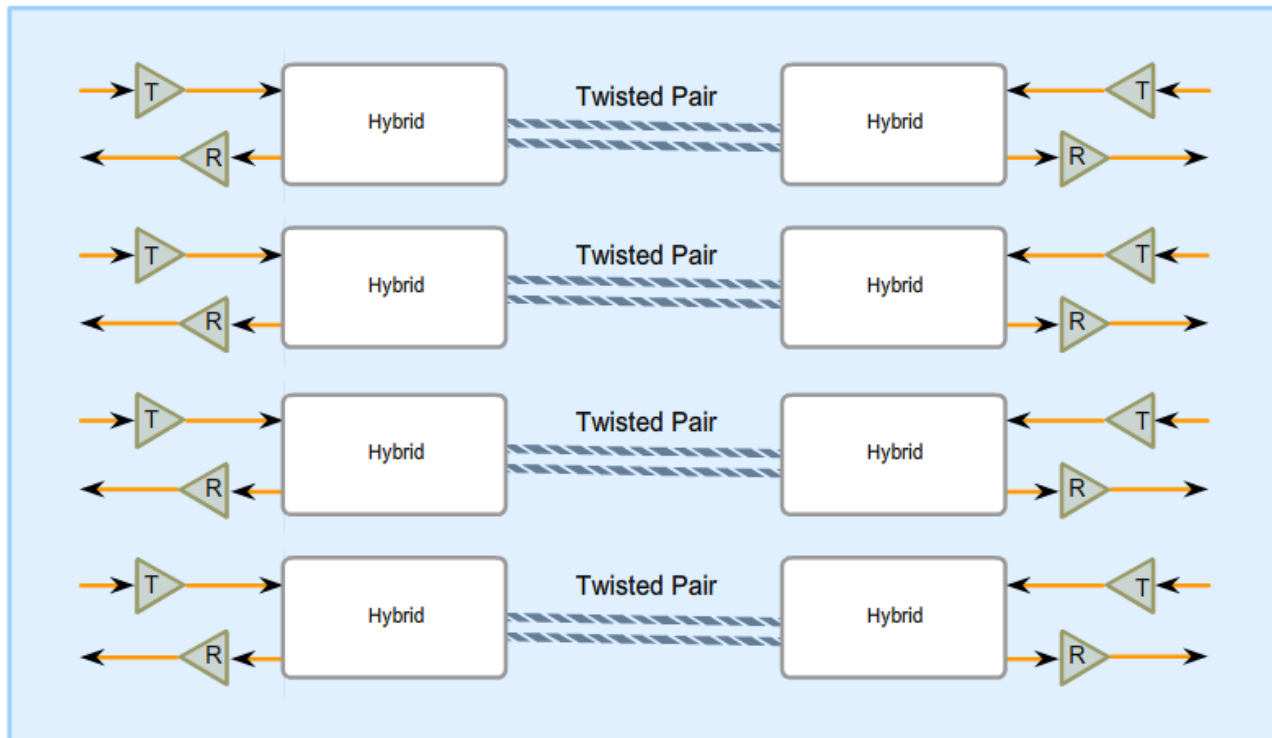
10 and 100 Mbps Ethernet...

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



1000 Mbps - Gigabit Ethernet

1000BASE-T Circuitry



1000 Mbps - Gigabit 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

Hubs and Switches

Poor Performance of Hub-based LANs

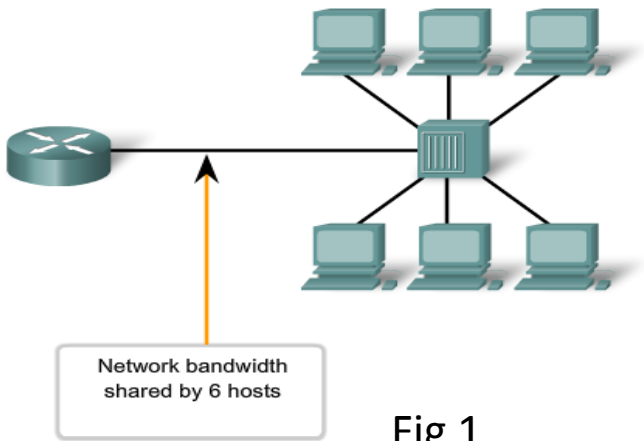


Fig 1

Poor Performance of Hub-based LANs

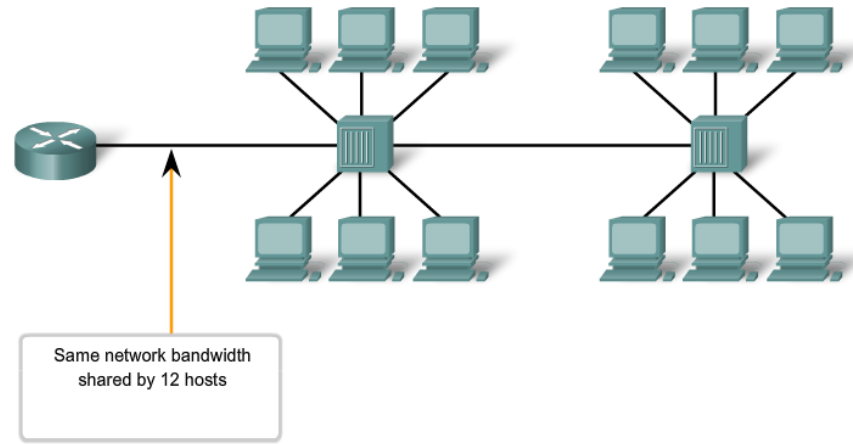


Fig 2

Poor Performance of Hub-based LANs

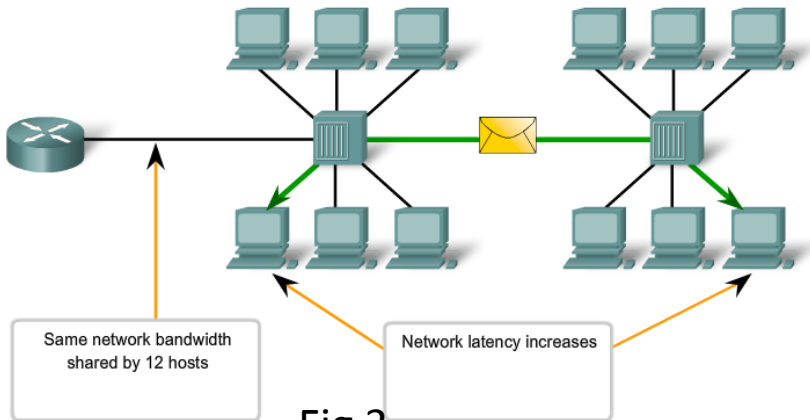


Fig 3

Poor Performance of Hub-based LANs

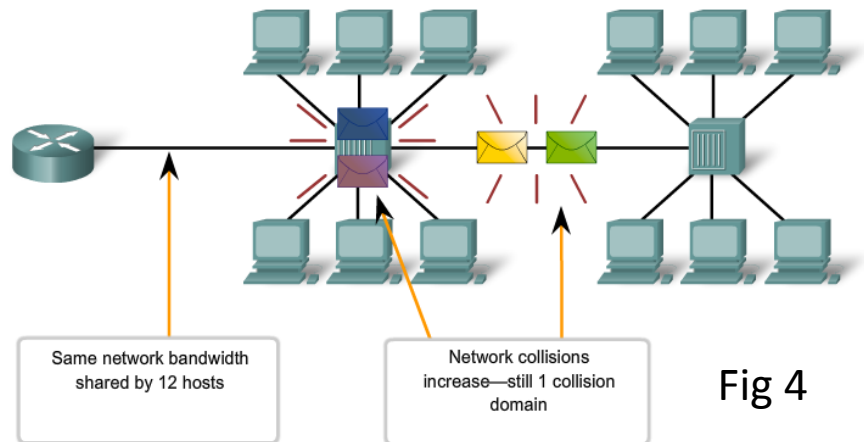
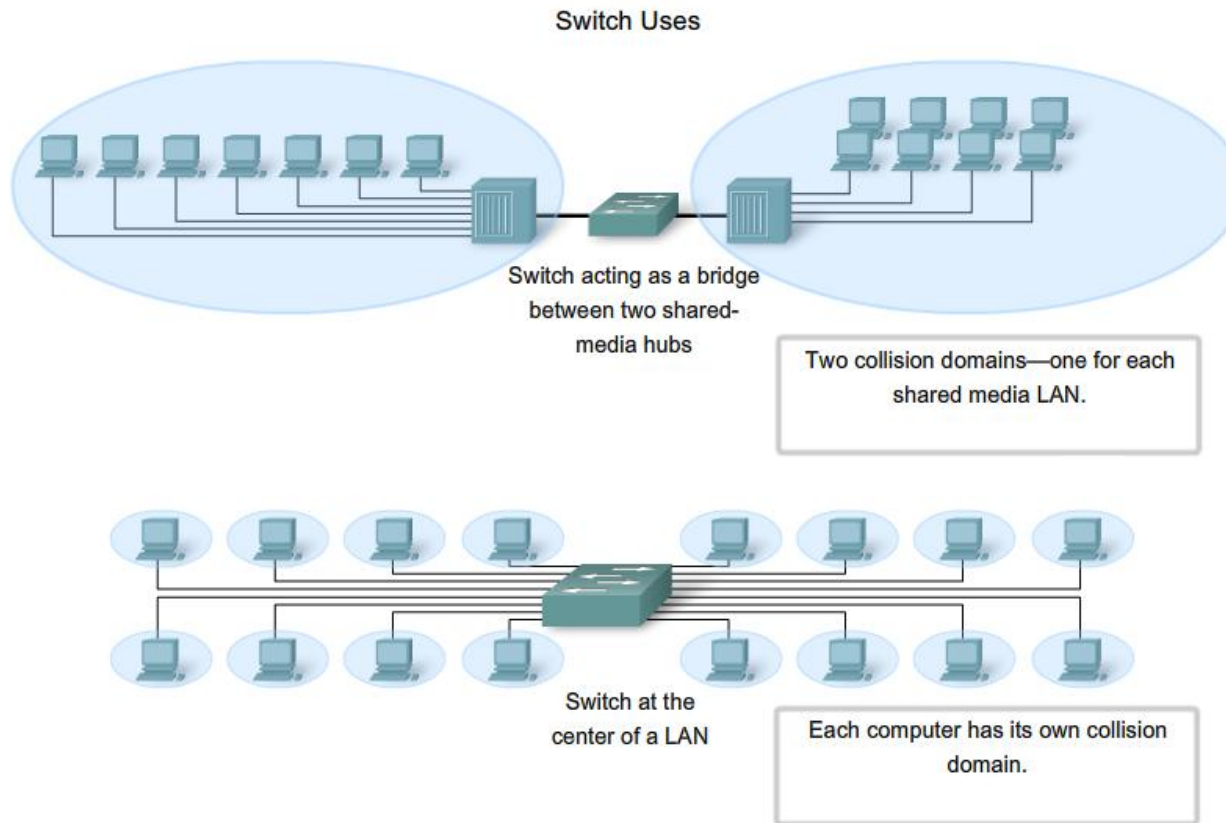


Fig 4

Ethernet Using Switches



Ethernet Using Switches...

Features of Switch-based LANs

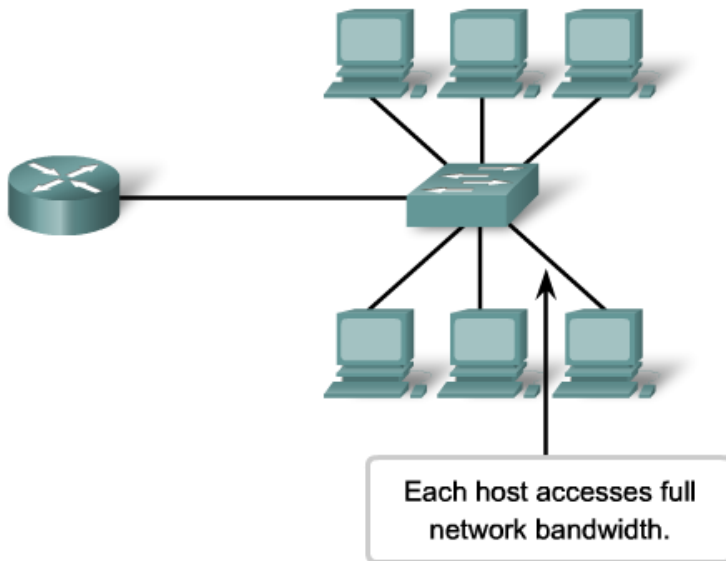


Fig 1

Features of Switch-based LANs

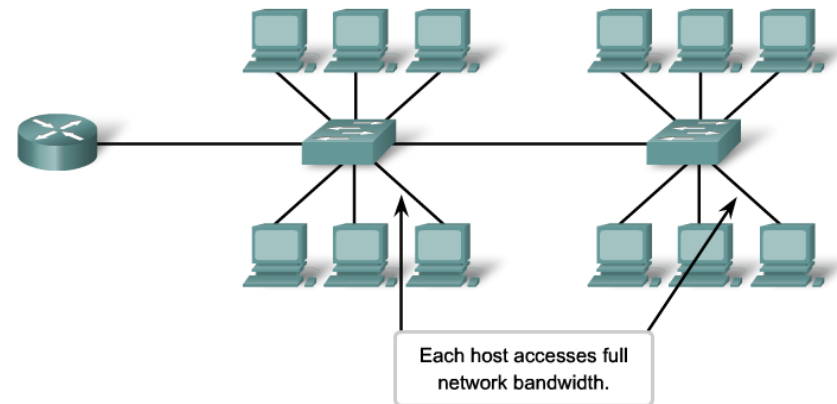


Fig 2

Ethernet Using Switches...

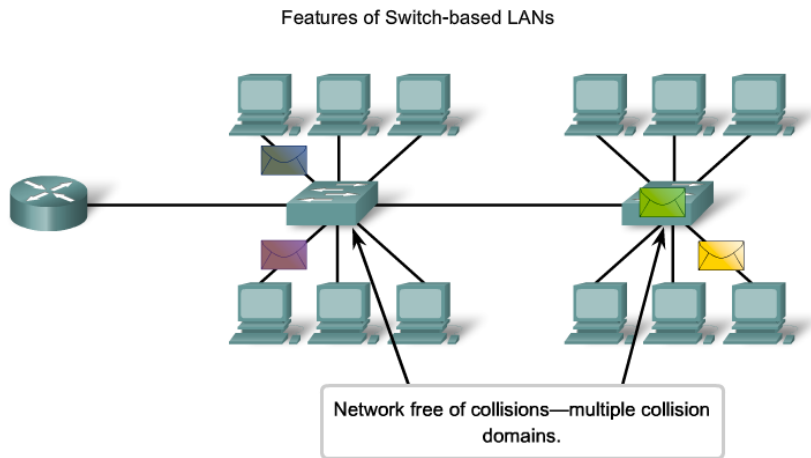


Fig 3

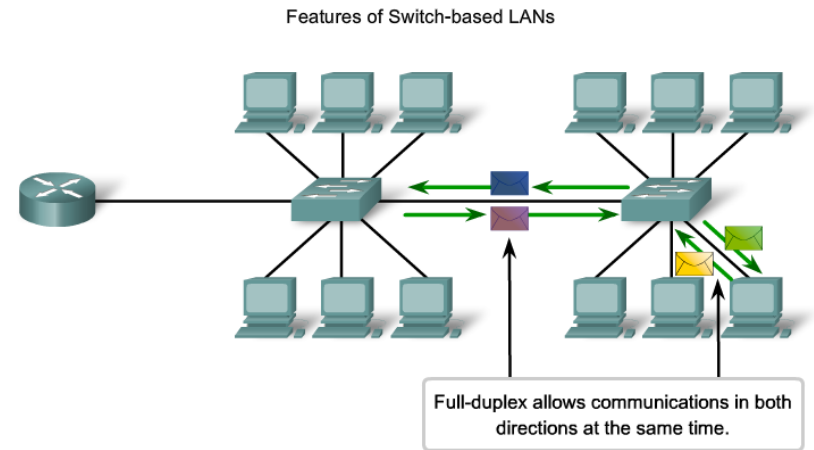
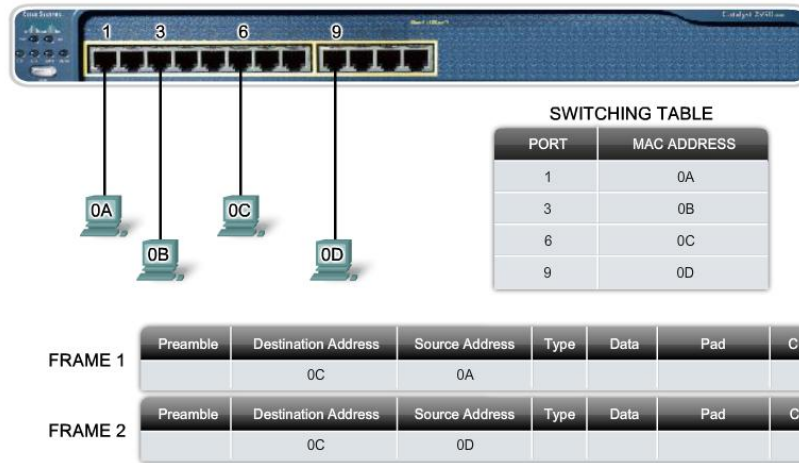


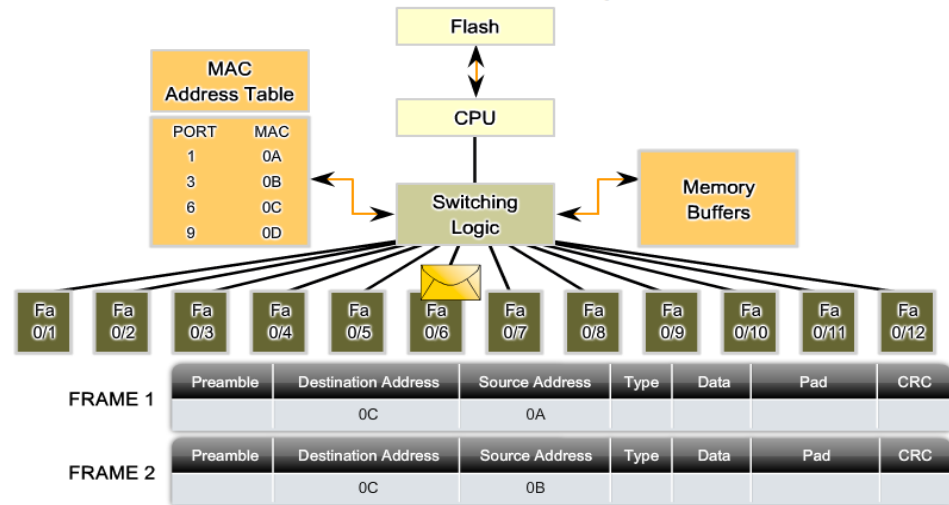
Fig4

Switch-Selective Forwarding

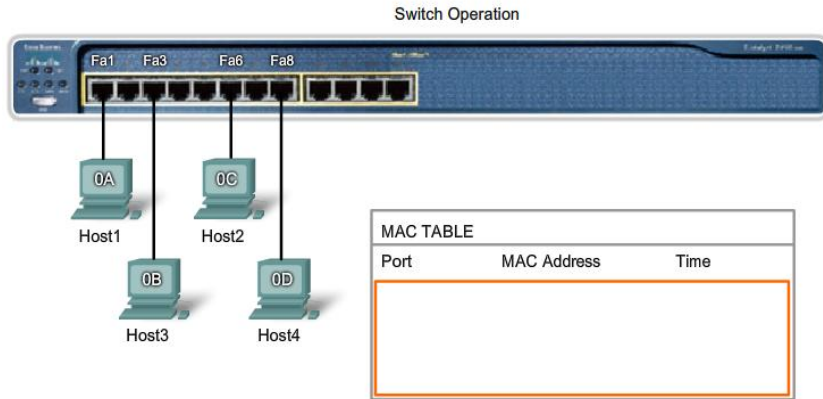
Switches - Selective Forwarding



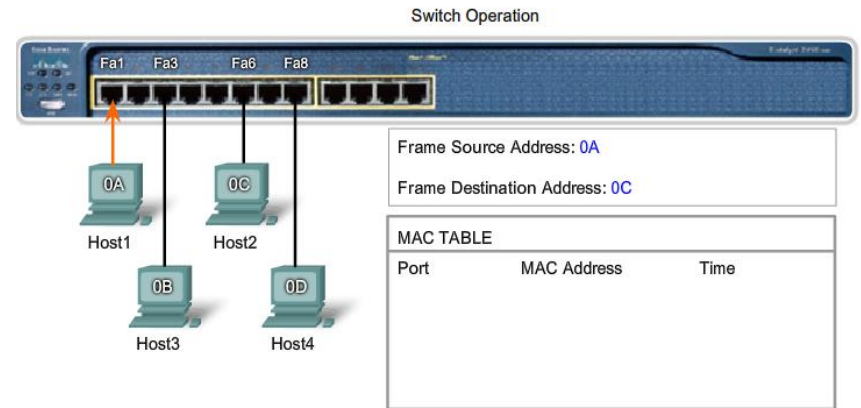
Switches - Selective Forwarding



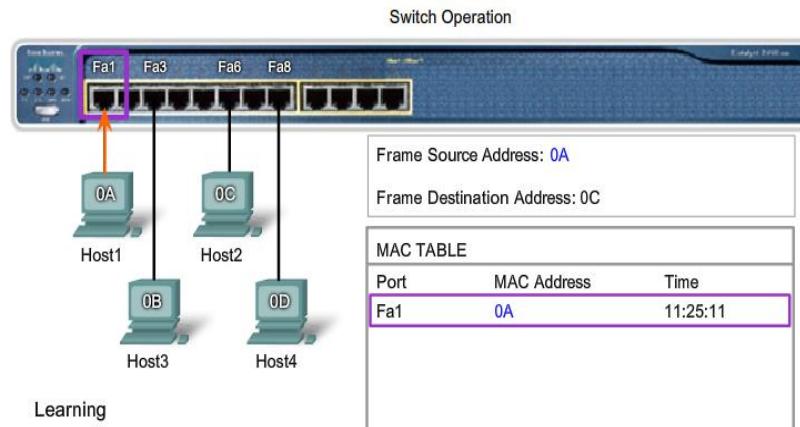
Switch Operation



Upon initialization of the switch, the MAC address table is empty.



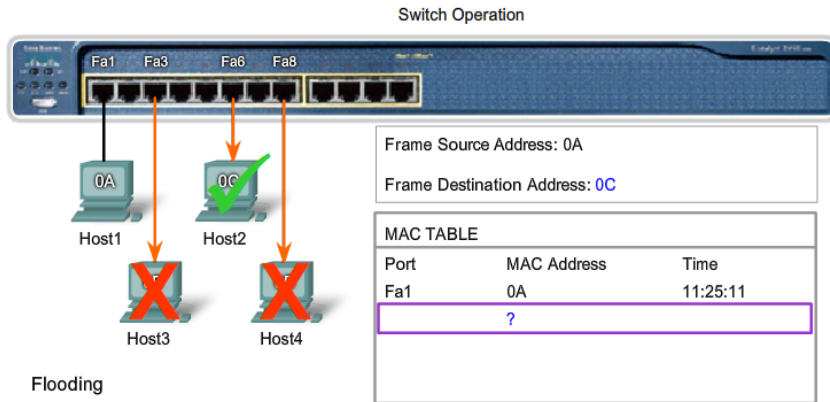
Host1 sends data to Host2. The frame sent contains both a source MAC address and a destination MAC address.



Learning

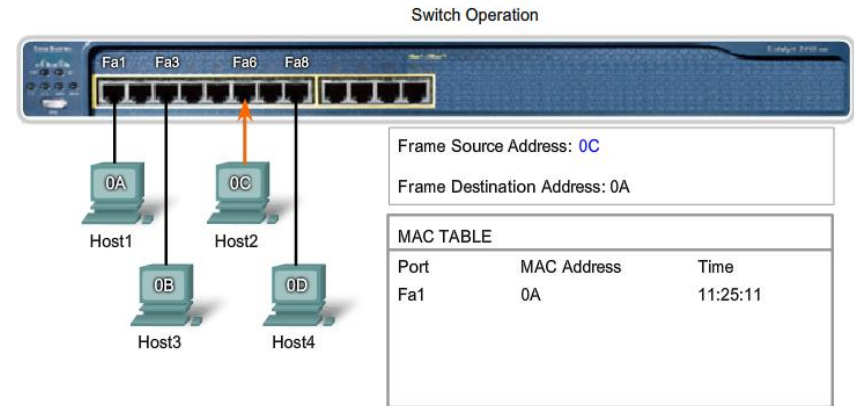
The switch reads the source MAC address, 0A, from the frame received on port Fa1 and stores it in the MAC address table for use in the forwarding of frames to Host1.

Switch Operation...



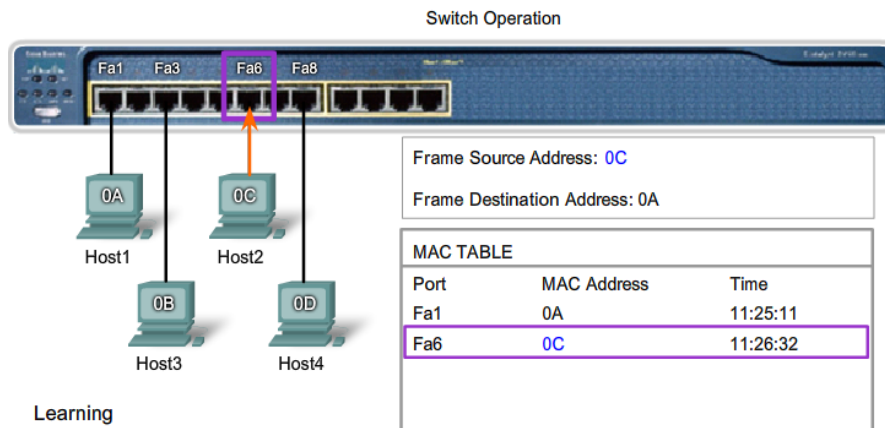
Flooding

The destination MAC address, 0C, is not in the MAC Table. The switch floods the frame out all ports except port Fa1, the port for the sender. Host3 and Host4 receive the frame, but the address in the frame does not match their MAC address. They drop the frame. The destination MAC address in the frame matches Host2 and it accepts the frame.



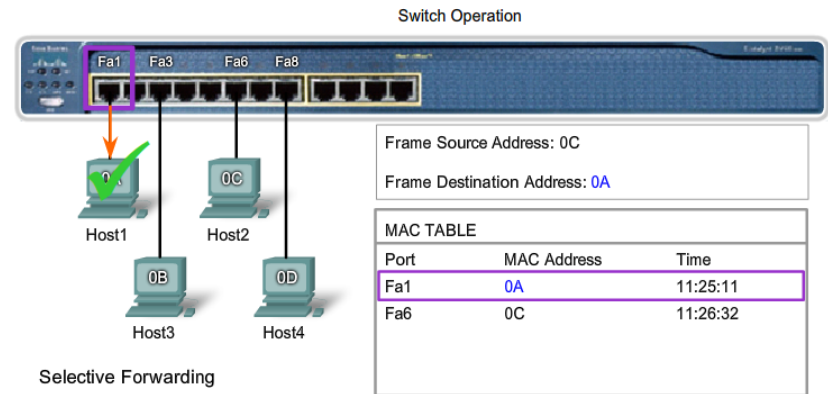
Host2 sends a frame to Host1 containing a reply. The source address in the frame is the MAC address of Host2. The destination address in the frame matches the MAC address for Host1.

Switch Operation...



Learning

The switch reads the source MAC address, 0C, from the frame received on port Fa6, and stores it in the MAC address table for use in the forwarding of frames to Host2.



Selective Forwarding

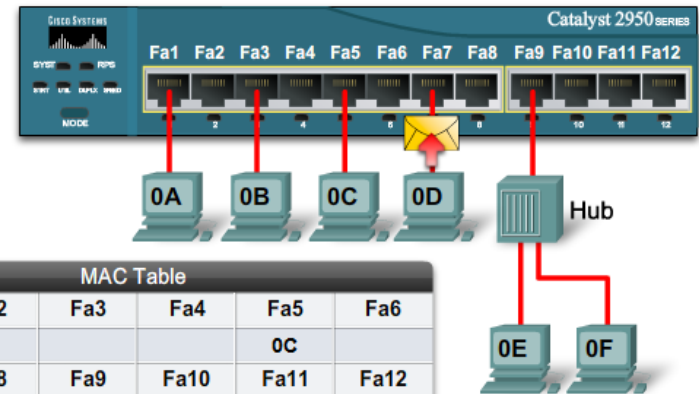
The destination MAC address, 0A, is in the MAC address table. The switch selectively forwards the frame out port Fa1 only. The destination MAC address in the frame matches the MAC address for Host1. Host1 accepts the frame.

Activity 1

Activity

Determine how the switch forwards a frame based on the Source MAC and Destination MAC addresses and information in the switch MAC table.

Answer the questions below using the information provided.



Preamble	Destination MAC	Source MAC	Length Type	Encapsulated Data	End of frame
	0B	0D			

Fa1	Fa2	Fa3	Fa4	Fa5	Fa6
				0C	
Fa7	Fa8	Fa9	Fa10	Fa11	Fa12
0D		0E 0F			

1. Where will the switch forward the frame?

- Fa1 Fa4 Fa7 Fa10
 Fa2 Fa5 Fa8 Fa11
 Fa3 Fa6 Fa9 Fa12

2. When the switch forwards the frame, which statement(s) are true?

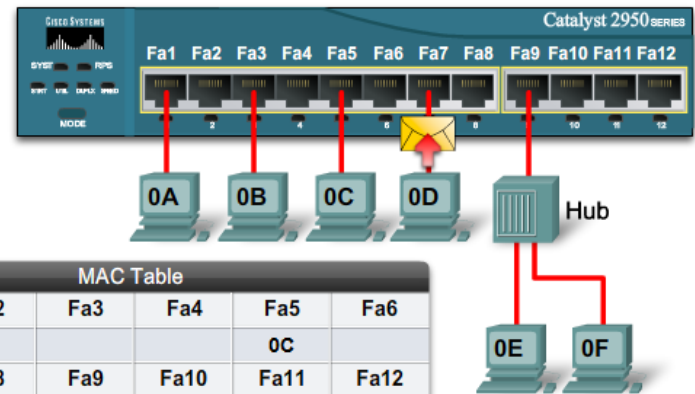
- Switch adds the source MAC address to the MAC table.
 Frame is a broadcast frame and will be forwarded to all ports.
 Frame is a unicast frame and will be sent to specific port only.
 Frame is a unicast frame and will be flooded to all ports.
 Frame is a unicast frame but it will be dropped at the switch.

Answer

Activity

Determine how the switch forwards a frame based on the Source MAC and Destination MAC addresses and information in the switch MAC table.

Answer the questions below using the information provided.



Preamble	Destination MAC	Source MAC	Length Type	Encapsulated Data	End of frame
	0B	0D			

Fa1	Fa2	Fa3	Fa4	Fa5	Fa6
				0C	
Fa7	Fa8	Fa9	Fa10	Fa11	Fa12
0D		0E 0F			

1. Where will the switch forward the frame?

- | | | | |
|---|---|---|-------------------------------|
| <input checked="" type="checkbox"/> Fa1 | <input type="checkbox"/> Fa4 | <input type="checkbox"/> Fa7 | <input type="checkbox"/> Fa10 |
| <input type="checkbox"/> Fa2 | <input checked="" type="checkbox"/> Fa5 | <input type="checkbox"/> Fa8 | <input type="checkbox"/> Fa11 |
| <input checked="" type="checkbox"/> Fa3 | <input type="checkbox"/> Fa6 | <input checked="" type="checkbox"/> Fa9 | <input type="checkbox"/> Fa12 |

2. When the switch forwards the frame, which statement(s) are true?

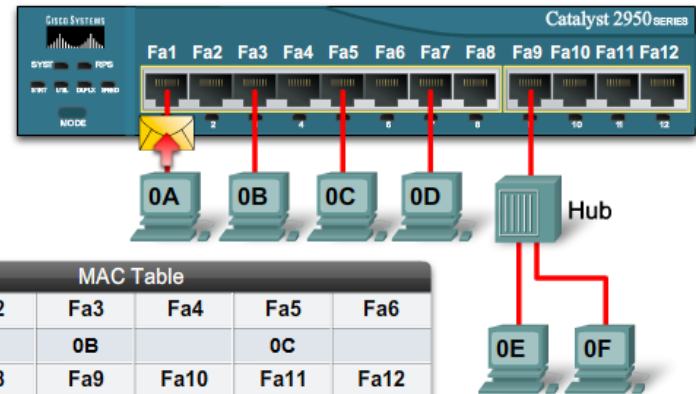
- Switch adds the source MAC address to the MAC table.
- Frame is a broadcast frame and will be forwarded to all ports.
- Frame is a unicast frame and will be sent to specific port only.
- Frame is a unicast frame and will be flooded to all ports.
- Frame is a unicast frame but it will be dropped at the switch.

Activity 2

Activity

Determine how the switch forwards a frame based on the Source MAC and Destination MAC addresses and information in the switch MAC table.

Answer the questions below using the information provided.



Preamble	Destination MAC	Source MAC	Length	Type	Encapsulated Data	End of frame
	0B	0A				

MAC Table					
Fa1	Fa2	Fa3	Fa4	Fa5	Fa6
0A		0B		0C	
Fa7	Fa8	Fa9	Fa10	Fa11	Fa12

1. Where will the switch forward the frame?

- | | | | |
|------------------------------|------------------------------|------------------------------|-------------------------------|
| <input type="checkbox"/> Fa1 | <input type="checkbox"/> Fa4 | <input type="checkbox"/> Fa7 | <input type="checkbox"/> Fa10 |
| <input type="checkbox"/> Fa2 | <input type="checkbox"/> Fa5 | <input type="checkbox"/> Fa8 | <input type="checkbox"/> Fa11 |
| <input type="checkbox"/> Fa3 | <input type="checkbox"/> Fa6 | <input type="checkbox"/> Fa9 | <input type="checkbox"/> Fa12 |

2. When the switch forwards the frame, which statement(s) are true?

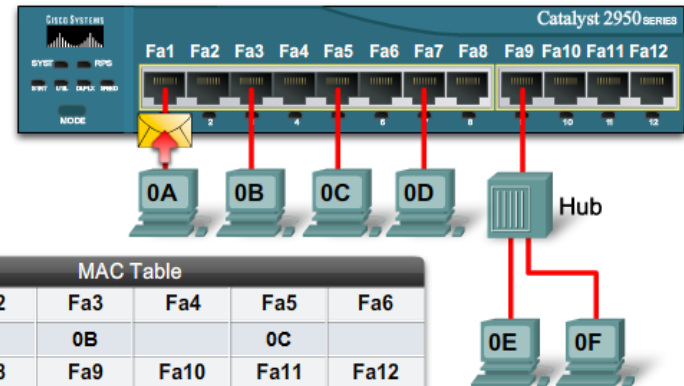
- Switch adds the source MAC address to the MAC table.
- Frame is a broadcast frame and will be forwarded to all ports.
- Frame is a unicast frame and will be sent to specific port only.
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Answer

Activity

Determine how the switch forwards a frame based on the Source MAC and Destination MAC addresses and information in the switch MAC table.

Answer the questions below using the information provided.



Preamble	Destination MAC	Source MAC	Length Type	Encapsulated Data	End of frame
	0B	0A			

Fa1	Fa2	Fa3	Fa4	Fa5	Fa6
0A		0B		0C	
Fa7	Fa8	Fa9	Fa10	Fa11	Fa12

1. Where will the switch forward the frame?

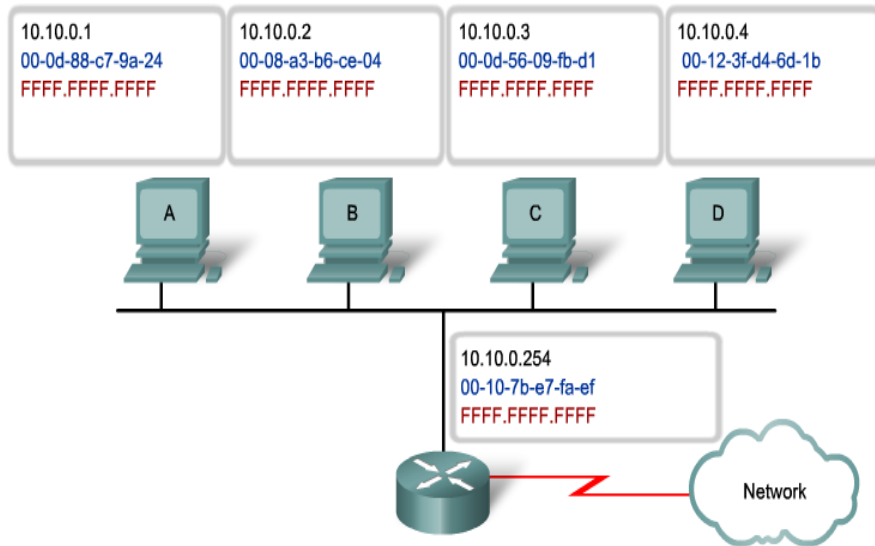
- | | | | |
|---|------------------------------|------------------------------|-------------------------------|
| <input type="checkbox"/> Fa1 | <input type="checkbox"/> Fa4 | <input type="checkbox"/> Fa7 | <input type="checkbox"/> Fa10 |
| <input type="checkbox"/> Fa2 | <input type="checkbox"/> Fa5 | <input type="checkbox"/> Fa8 | <input type="checkbox"/> Fa11 |
| <input checked="" type="checkbox"/> Fa3 | <input type="checkbox"/> Fa6 | <input type="checkbox"/> Fa9 | <input type="checkbox"/> Fa12 |

2. When the switch forwards the frame, which statement(s) are true?

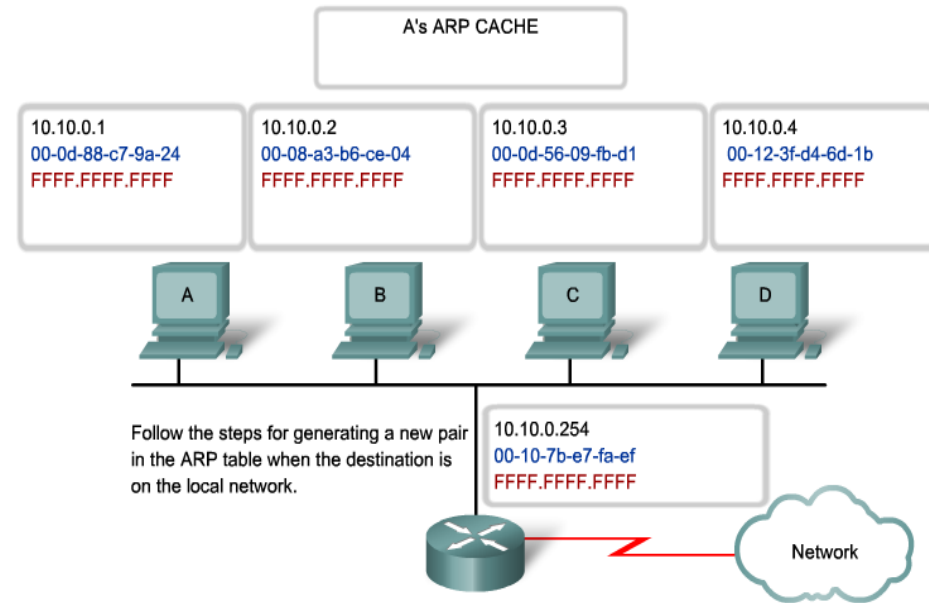
- Switch adds the source MAC address to the MAC table.
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- Frame is a unicast frame and will be flooded to all ports.
- Frame is a unicast frame but it will be dropped at the switch.

ARP Process-Mapping IP to MAC Addresses

The ARP Process — Mapping Addresses

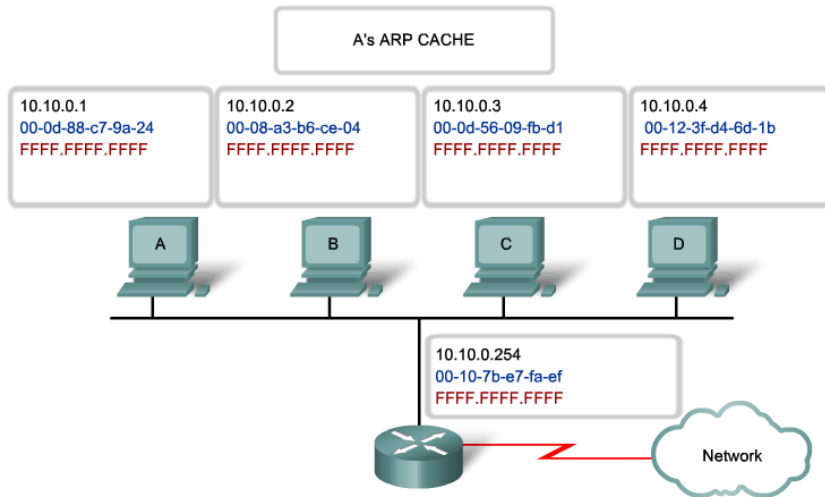


The ARP Process — Mapping Addresses

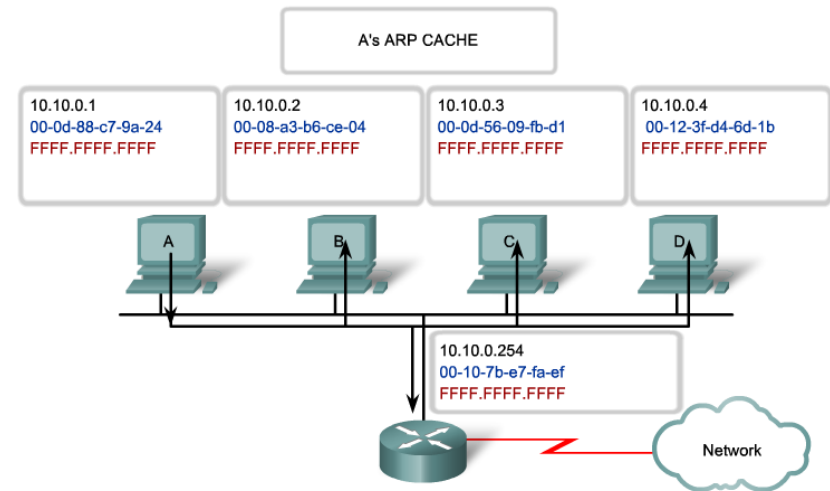


ARP Process ...

The ARP Process — No ARP Entry

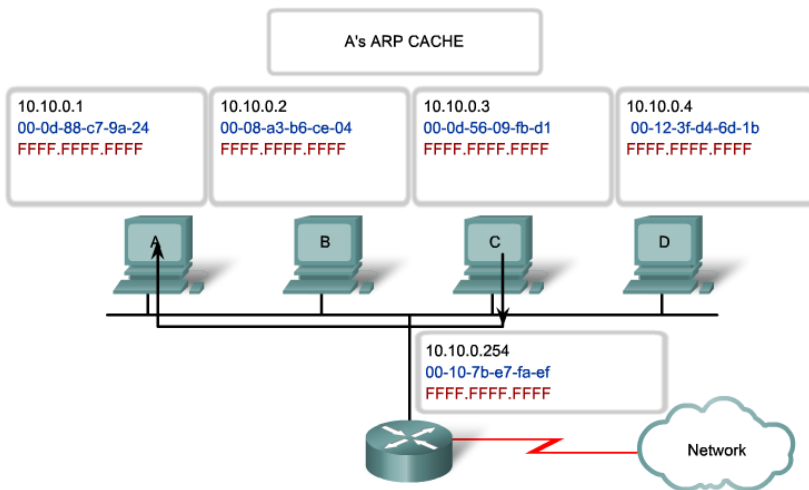


The ARP Process — Broadcast ARP Request to Devices

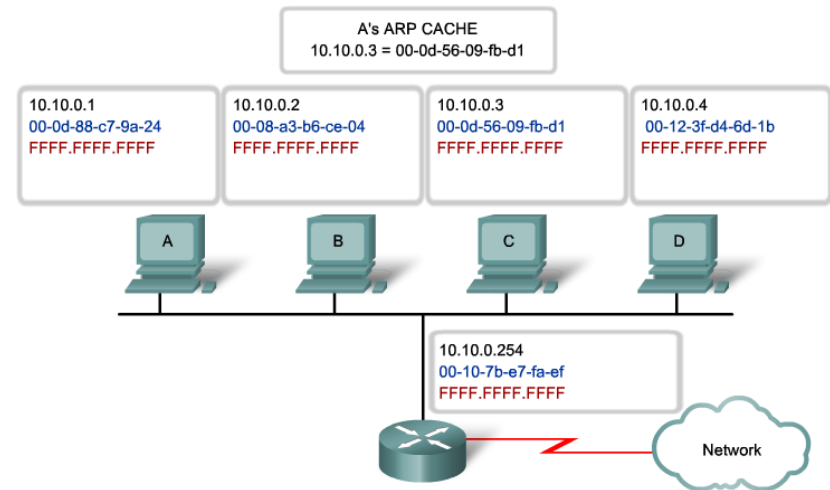


ARP Process ...

The ARP Process — Unicast ARP Reply with MAC Address

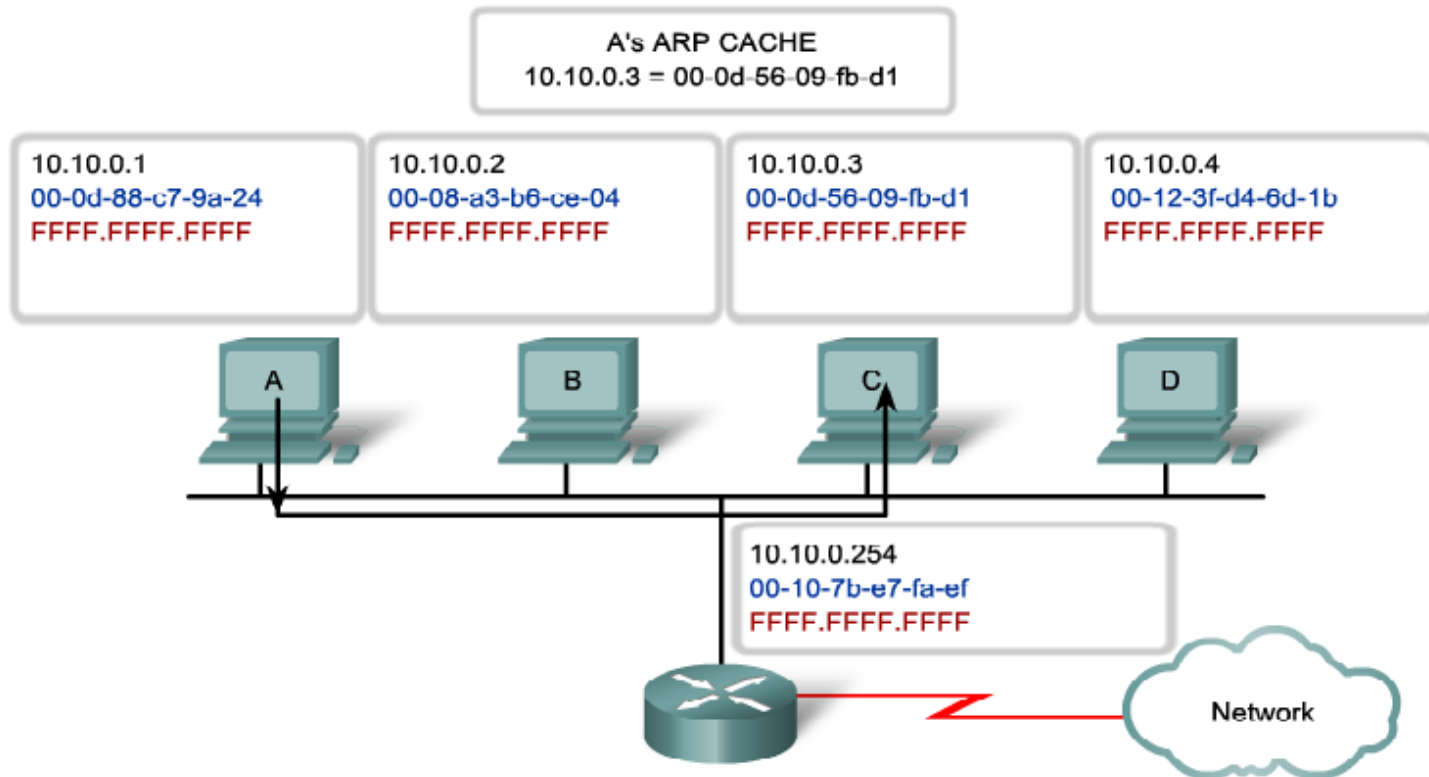


The ARP Process — IP and MAC Addresses Stored in ARP Cache



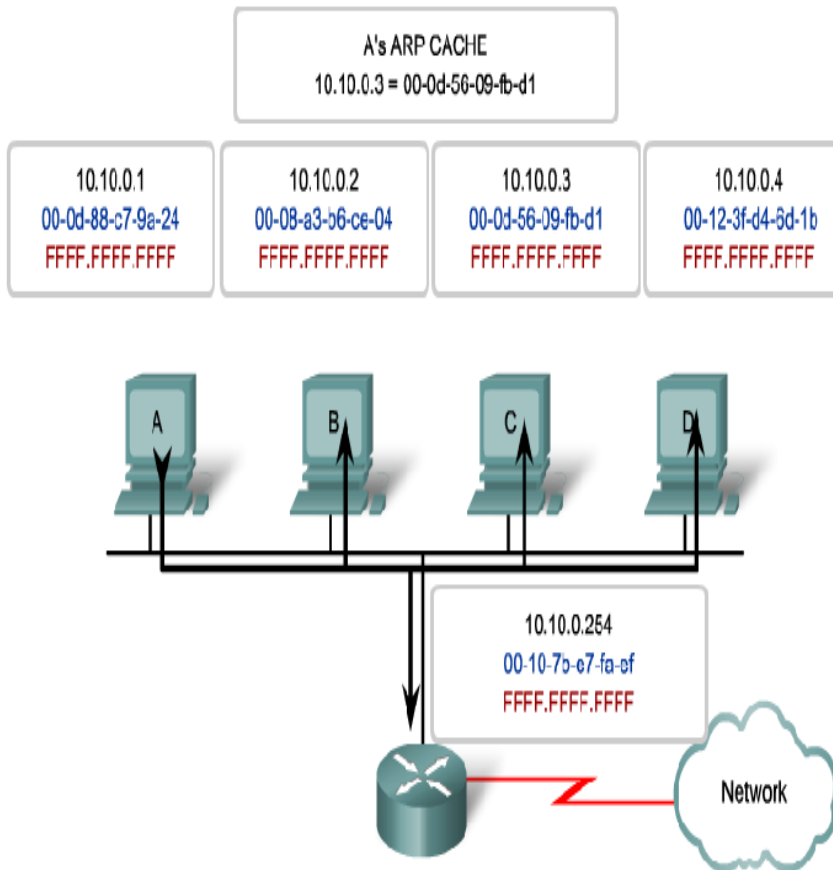
ARP Process ...

The ARP Process — ARP Entry Enables Frame to be Sent

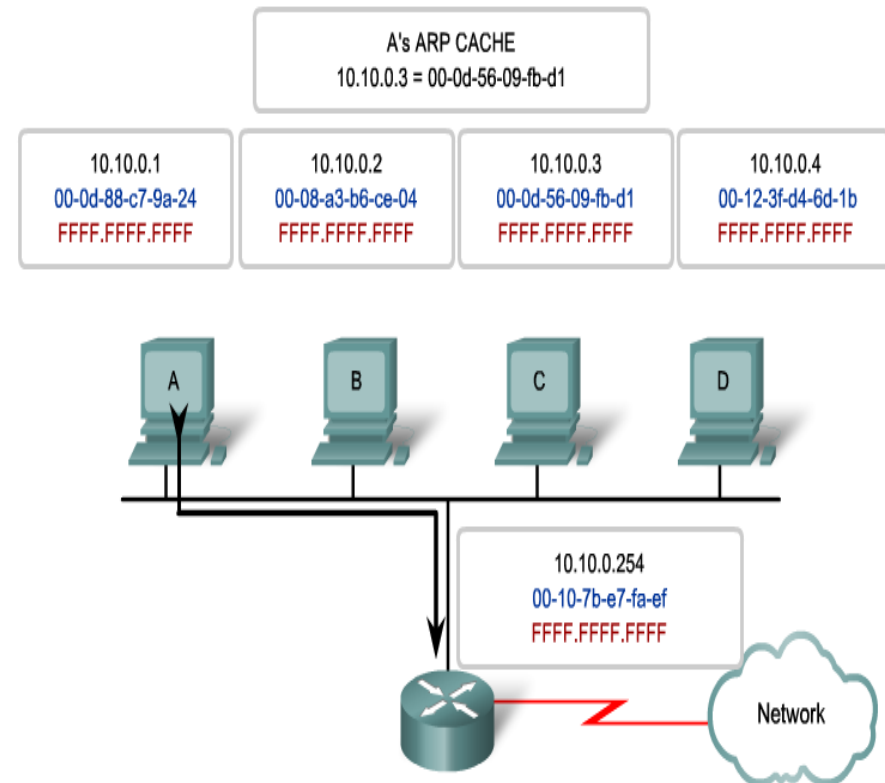


ARP Process- destination outside the local Network

ARP—Broadcast ARP Request to Devices

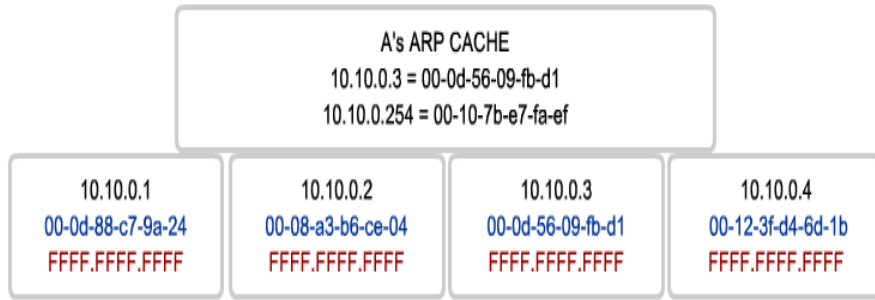


ARP—Reply with MAC Address of Gateway

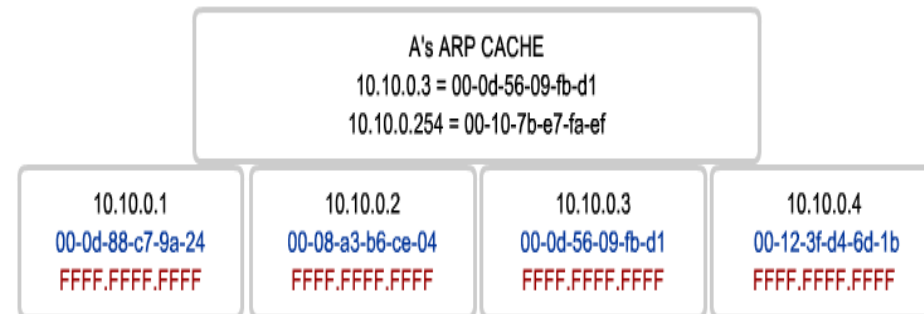


ARP Process- destination outside the local Network...

The ARP Process—IP and MAC Addresses Stored in ARP Cache

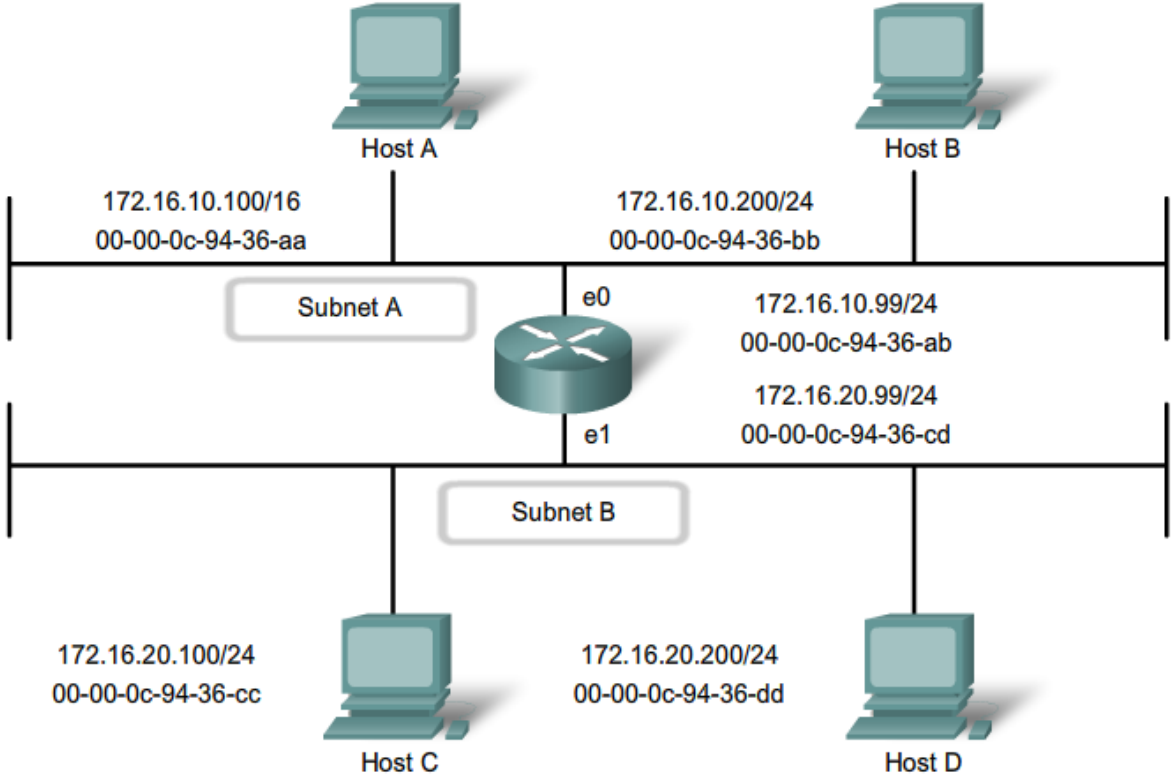


The ARP Process—ARP Entry Enables Frame to be Sent



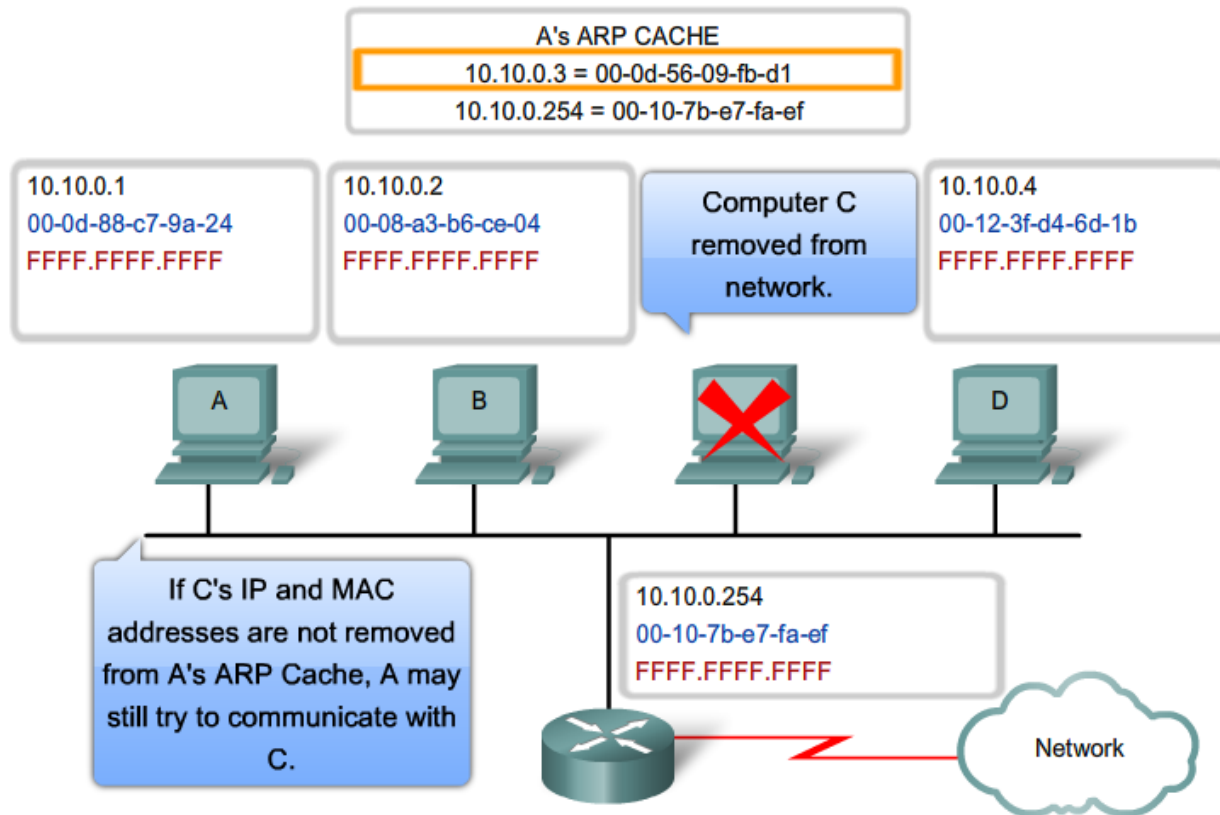
Proxy ARP

Proxy ARP Allows Router to Respond for Remote Host



Removing Address Mapping

The ARP Process - Removing Address Mappings

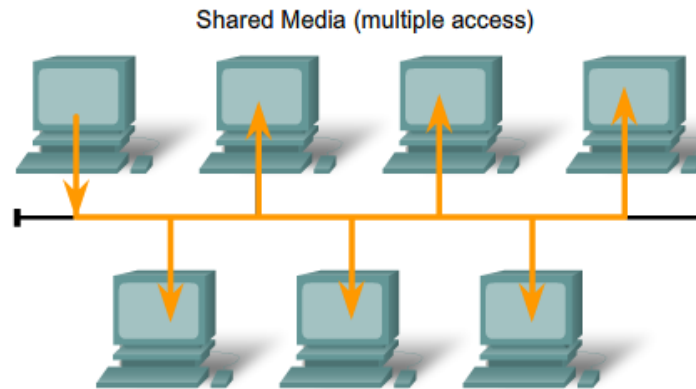


ARP Issues

ARP Issues:

- Broadcasts, overhead on the Media
- Security

ARP broadcasts can flood the local media.



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

The end