




# Chapter 5: Ethernet

Introduction to Networks v5.1



## Chapter Outline

- 5.0 Introduction
- 5.1 Ethernet Protocol
- 5.2 LAN Switches
- 5.3 Address Resolution Protocol
- 5.4 Summary



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## Section 5.1: Ethernet Protocol

Upon completion of this section, you should be able to:

- Explain how the Ethernet sublayers are related to the frame fields.
- Describe the Ethernet MAC address.

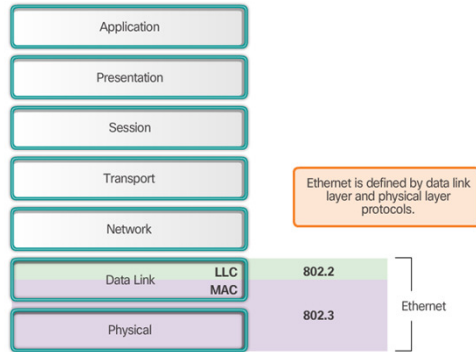
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## Topic 5.1.1: Ethernet Frame



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## Ethernet Encapsulation



## Ethernet Encapsulation (cont.)

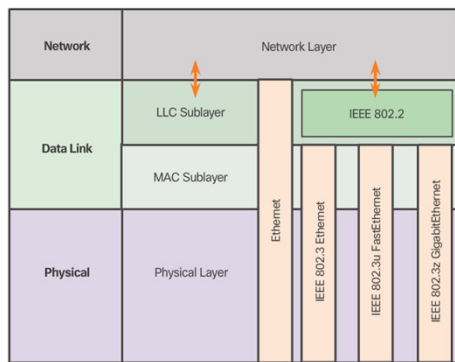
Ethernet

- Most widely used LAN technology
- Operates in the data link layer and the physical layer
- Family of networking technologies that are defined in the IEEE 802.2 and 802.3 standards
- Supports data bandwidths of 10, 100, 1000, 10,000, 40,000, and 100,000 Mbps (100 Gbps)

Ethernet standards

- Define Layer 2 protocols and Layer 1 technologies
- Two separate sub layers of the data link layer to operate - Logical link control (LLC) and the MAC sublayers

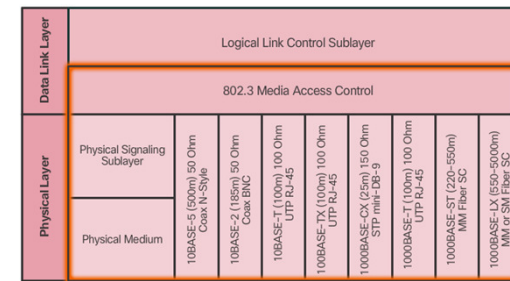
## Ethernet Encapsulation(cont.)



## Mac Sublayer

Primary responsibilities:

- Data encapsulation
- Media access control



## Ethernet Evolution

Ethernet II Frame Structure and Field Size

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

## Ethernet II Frame Fields

- Minimum Ethernet frame size is 64 bytes (Collision Frame or Runt)
- Maximum Ethernet frame size is 1518 bytes (Jumbo or Baby Giant)



## Topic 5.1.2: Ethernet MAC Address



## MAC Address and Hexadecimal

### 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

## MAC Address and Hexadecimal (cont.)

**Hexadecimal Numbering**  
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

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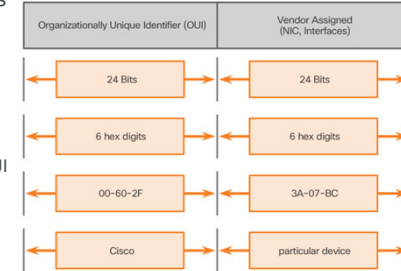
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## MAC Address: Ethernet Identity

• Layer 2 Ethernet MAC address is a 48-bit binary value expressed as 12 hexadecimal digits.

• IEEE requires a vendor to follow two simple rules:

Must use that vendor's assigned OUI as the first three bytes.  
All MAC addresses with the same OUI must be assigned a unique value in the last three bytes.



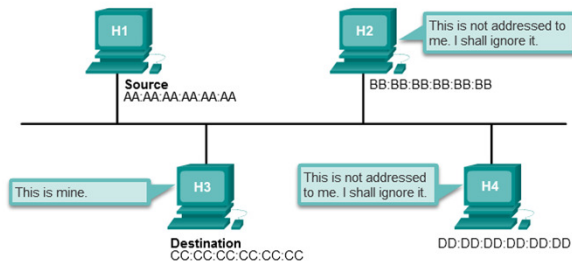
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## Frame Processing

**Frame Forwarding**

Destination Address	Source Address	Data
CC:CC:CC:CC:CC:CC	AA:AA:AA:AA:AA:AA	Encapsulated data
Frame Addressing		



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## Frame Processing (cont.)

- The 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, the device discards the frame.
- If there is a match, the NIC passes the frame up the OSI layers, where the de-encapsulation process takes place.

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## MAC Address Representations

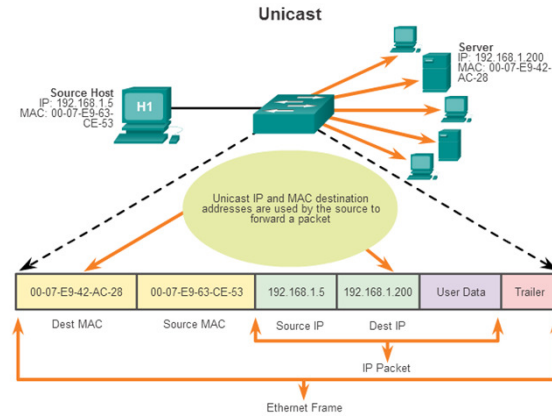
- With Dashes 00-60-2F-3A-07-BC
- With Colons 00:60:2F:3A:07:BC
- With Periods 0060.2F3A.07BC

```
C:\> ipconfig/all

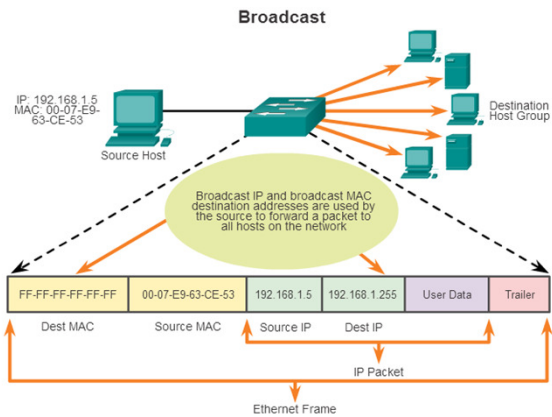
Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix  . : example.com
    Description . . . . . : Intel(R) Gigabit Network Connection
    Physical Address. . . . . : 00-18-DE-DD-A7-B2
    DHCP Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . : Yes
    Link-local IPv6 Address . . . . . : fe80::449f:c2:de06:ebad%10 (Preferred)
    IPv4 Address. . . . . : 10.10.10.2 (Preferred)
    Subnet Mask . . . . . : 255.255.255.0
    Lease Obtained. . . . . : Monday, June 01, 2015 11:19:48 AM
    Lease Expires . . . . . : Thursday, June 04, 2015 11:19:49 PM
    Default Gateway . . . . . : 10.10.10.1
    DHCP Server . . . . . : 10.10.10.1
    DNS Servers . . . . . : 10.10.10.1
```

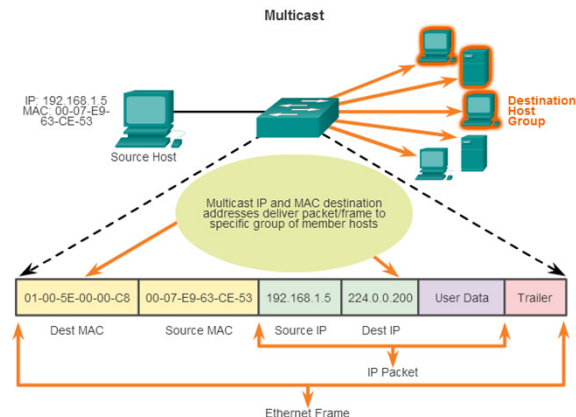
## Unicast MAC Address



## Broadcast MAC Address



## Multicast MAC Address



## Section 5.2: LAN Switches

Upon completion of this section, you should be able to:

- Explain how a switch operates.
- Explain how a switch builds its MAC address table and forwards frames.
- Describe switch forwarding methods.
- Describe the types of port settings available for Layer 2 switches.

### Topic 5.2.1: MAC Address Table

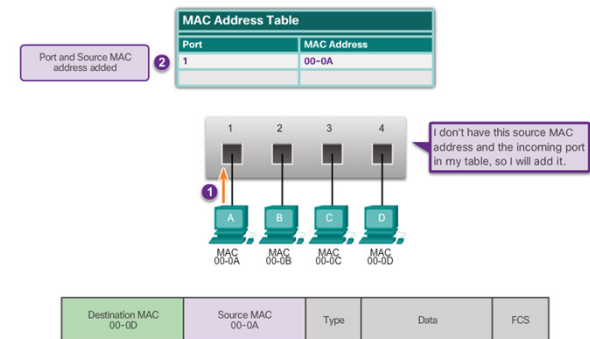


## Switch Fundamentals

- An Ethernet Switch is a Layer 2 device.
- It uses MAC addresses to make forwarding decisions.
- The MAC address table is sometimes referred to as a content addressable memory (CAM) table.

## Learning MAC Addresses

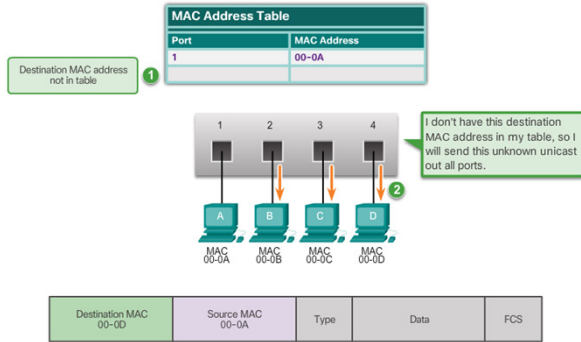
Learn: Examine Source MAC Address



MAC addresses are shortened for demonstration purposes.

## Learning MAC Addresses (cont.)

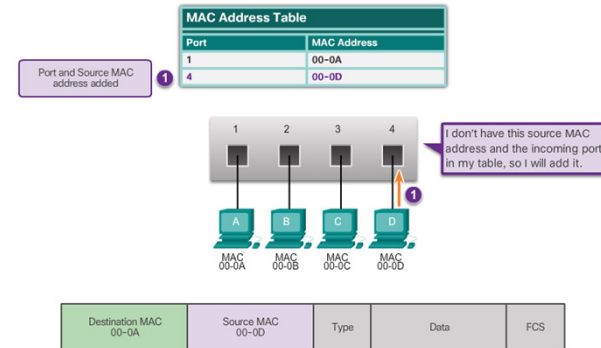
Forward: Examine Destination MAC Address



MAC addresses are shortened for demonstration purposes.

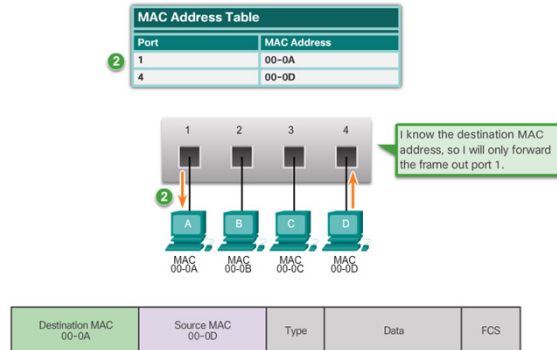
## Filtering Frames

PC-D sends a frame back to PC-A and the switch learns PC-D's MAC address.



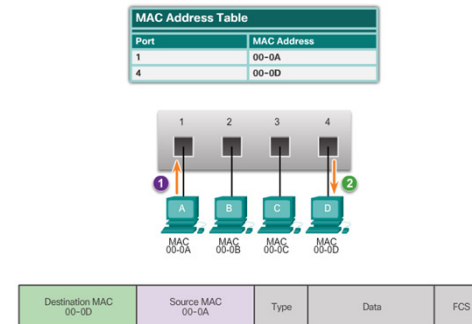
## Filtering Frames (cont.)

Since the Switch MAC Address table contains PC-A's MAC Address, it sends the frame out only port 1.



## Filtering Frames (cont.)

PC-A sends another frame to PC-D. The switch's table now contains PC-D's MAC address, so it sends the frame out only port 4.



## Video Demonstration - MAC Address Tables on Connected Switches

- A switch can have multiple MAC addresses associated with a single port.
- This occurs when the switch is connected to another switch.
- See **VIDEO DEMONSTRATION**

## Video Demonstration - Sending a Frame to the Default Gateway

- When a device has an IP address that is on a remote network, the Ethernet frame cannot be sent directly to the destination device.
- The Ethernet frame is sent to the MAC address of the default gateway, which is the router.
- See **VIDEO DEMONSTRATION**

## Topic 5.2.2: Switch Forwarding Methods



## 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.



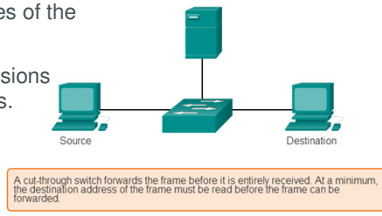
## Cut-Through Switching

Fast-forward switching:

- Lowest level of latency immediately forwards a packet after reading the destination address.
- Typical cut-through method of switching.

Fragment-free switching:

- Switch stores the first 64 bytes of the frame before forwarding.
- Most network errors and collisions occur during the first 64 bytes.



## Memory Buffering on Switches

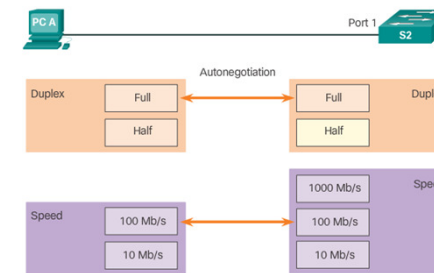
Port-based memory	In port-based memory buffering, frames are stored in queues that are linked to specific incoming and outgoing ports.
Shared memory	Shared memory buffering deposits all frames into a common memory buffer, which all the ports on the switch share.

## Topic 5.2.3: Switch Port Settings



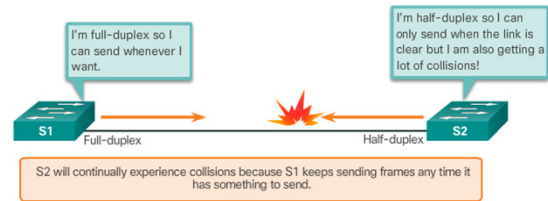
## Duplex and Speed Settings

- Full-duplex – Both ends of the connection can send and receive simultaneously.
- Half-duplex – Only one end of the connection can send at a time.



## Duplex and Speed Settings (cont.)

A common cause of performance issues on 10/100 Mb/s Ethernet links is when one port on the link operates at half-duplex and the other on full-duplex.

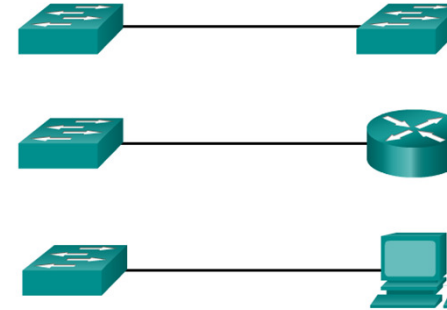


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## Auto-MDIX

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



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## Section 5.3: Address Resolution Protocol

Upon completion of this section, you should be able to:

- Compare the roles of the MAC address and the IP address.
- Describe the purpose of ARP.
- Explain how ARP requests impact network and host performance.

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### Topic 5.3.1: MAC and IP



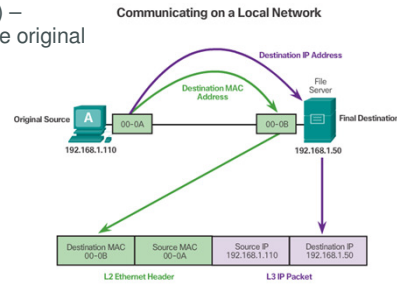
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## Destination on the Same Network

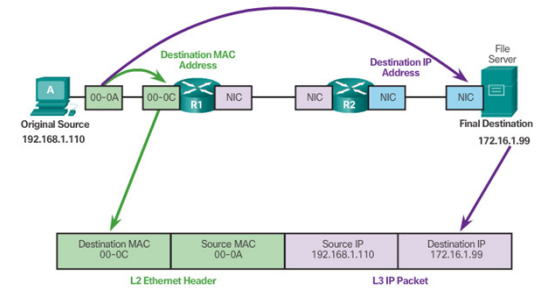
There are two primary addresses assigned to a device on an Ethernet LAN:

- Physical address (the MAC address) – Used for Ethernet NIC to Ethernet NIC communications on the same network.
- Logical address (the IP address) – Used to send the packet from the original source to the final destination.



## Destination on a Remote Network

Communicating to a Remote Network



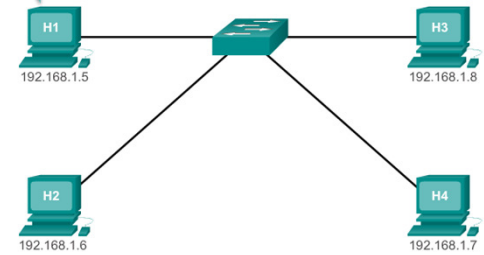
MAC addresses are shortened for demonstration purposes.

## Topic 5.3.2: ARP



## Introduction to ARP

I need to send information to 192.168.1.7, but I only have the IP address. I don't know the MAC address of the device that has that IP.



## ARP Functions

### ARP Table

- Used to find the MAC address that is mapped to the destination IPv4 address.
- If the destination IPv4 address is on the same network as the source IPv4, the device will search the ARP table for the destination IPv4 address.
- If the destination IPv4 address is on a different network, the device will search for the IPv4 address of the default gateway.
- If the device locates the IPv4 address, its corresponding MAC address is used as the destination MAC address in the frame.
- If no entry is found, then an ARP request is sent.

## ARP Request

- Sent when a device needs a MAC address associated with an IPv4 address, and it does not have an entry in its ARP table.
- The ARP request message includes:
  - Target IPv4 address – This is the IPv4 address that requires a corresponding MAC address.
  - Target MAC address – This is the unknown MAC address and will be empty in the ARP request message.
- The ARP request is encapsulated in an Ethernet frame using the following header information:
  - Destination MAC address – This is a broadcast address requiring all Ethernet NICs on the LAN to accept and process the ARP request.
  - Source MAC address – This is the sender's MAC address.
  - Type – ARP messages have a type field of 0x806.
- **See VIDEO DEMONSTRATION**

## ARP Reply

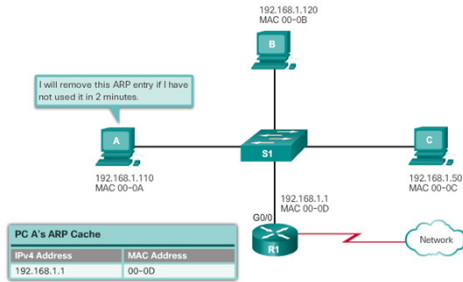
- The device with the target IPv4 address in the ARP request will respond with an ARP reply. The ARP reply message includes:
  - Sender's IPv4 address – This is the IPv4 address of the sender, the device whose MAC address was requested.
  - Sender's MAC address – This is the MAC address of the sender, the MAC address needed by the sender of the ARP request.
- The ARP reply is encapsulated in an Ethernet frame using the following header information:
  - Destination MAC address – This is the MAC address of the sender.
  - Source MAC address – This is the sender of the ARP reply's MAC address.
  - Type – ARP messages have a type field of 0x806.
- **See VIDEO DEMONSTRATION**

## Video Demonstration – ARP Role in Remote Communication

- When the destination IPv4 address is not on the same network as the source IPv4 address, the source device needs to send the frame to its default gateway.
- The source checks its ARP table for an entry with the IPv4 address of the default gateway.
- If there is not an entry, it uses the ARP process to determine the MAC address of the default gateway.
- **See VIDEO DEMONSTRATION**

## Removing Entries from an ARP Table

- ARP cache timer removes ARP entries that have not been used for a specified period of time.
- Commands may also be used to manually remove all or some of the entries in the ARP table.



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## ARP Tables on Networking Devices

### Router ARP Table

```
Router# show ip arp
```

Protocol	Address	Age (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

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## ARP Tables on Networking Devices (cont.)

### Host ARP Table

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

Interface	Internet Address	Physical Address	Type
Interface: 192.168.1.67 --- 0xa	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-ec	static
	255.255.255.255	ff-ff-ff-ff-ff-ff	static
Interface: 10.82.253.91 --- 0x10	10.82.253.92	64-0f-29-0d-36-91	dynamic
	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-ec	static
	255.255.255.255	ff-ff-ff-ff-ff-ff	static

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## Topic 5.3.3: ARP Issues

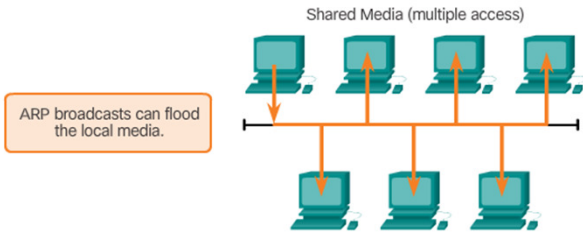


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## ARP Broadcasts

All devices powered on at the same time

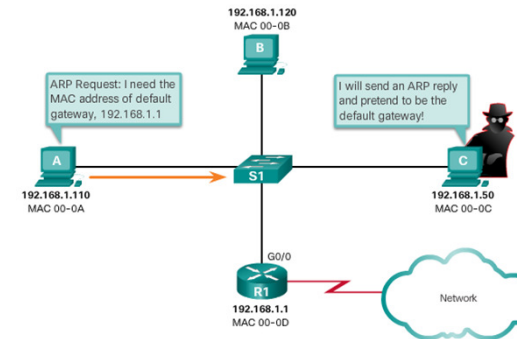


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## ARP Spoofing

All Devices Powered On at the Same Time



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## Section 5.4: Summary

Chapter Objectives:

- Explain the operation of Ethernet.
- Explain how a switch operates.
- Explain how the address resolution protocol enables communication on a network.

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Thank you.



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