

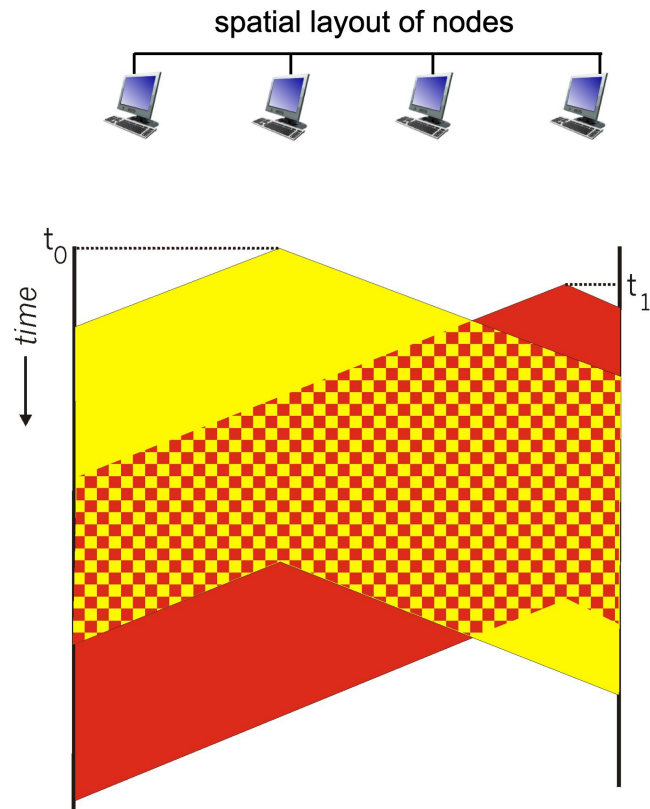
# Pure CSMA

collisions can still occur with carrier sensing:

- propagation delay means two nodes may not hear each other's just-started transmission

collision: entire packet transmission time wasted

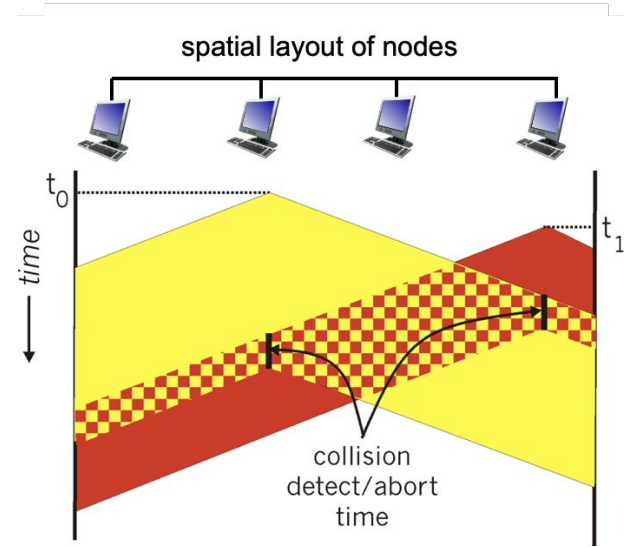
- distance & propagation delay play role in determining collision probability



# CSMA/CD

CSMA/CD reduces the amount of time wasted in collisions

- transmission aborted on collision detection



# Link Layer

1. What is a link?
2. How do we share a network medium?
3. How do we identify link adapters?
4. What is Ethernet?
5. How do we interconnect segments at the link layer?

Medium Access Control addresses

# MAC Addresses

identify the sender & receiver adapters

used on a link

are uniquely assigned

hard-coded into the adapter when built

use a flat space of 48 bits

allocated hierarchically

## MAC Addresses are Hierarchical

34 : 36 : 3b : d2 : 8a : 86

# The First 24 bits Represent the Vendor

34:36:3b:d2:8a:86

Apple, Inc.  
1 Infinite Loop  
Cupertino CA 95014  
US

see <http://standards-oui.ieee.org/oui/oui.txt>

# The Second 24 bits are Assigned by the Vendor to the Adapter

34:36:3b:d2:8a:86

assigned by Apple  
to my adapter



If all bits are Set, it's a **Broadcast** Address

`ff:ff:ff:ff:ff:ff`

enables to send a frame to  
*all* adapters on the link

**By Default, Adapters only Decapsulates Frames Addressed to the Local MAC or the Broadcast Address**

# By Default, Adapters only Decapsulates Frames Addressed to the Local MAC or the Broadcast Address

Workaround is **promiscuous** mode: enables to decapsulate everything, independently of the destination MAC

**Why Do We Need MAC Addresses (and not just use IPs)?**

# Why Do We Need MAC Addresses (and not just use IPs)?

Adapters must be identified during bootstrap  
need to talk to an adapter to give it an IP address

# Network Adapter Bootstrap

Two problems to solve:

1. Who am I?                      How do I acquire an IP address?
  
2. Who are you?                      Given an IP, how do I find which MAC to send to?

# Network Adapter Bootstrap

Two problems to solve:

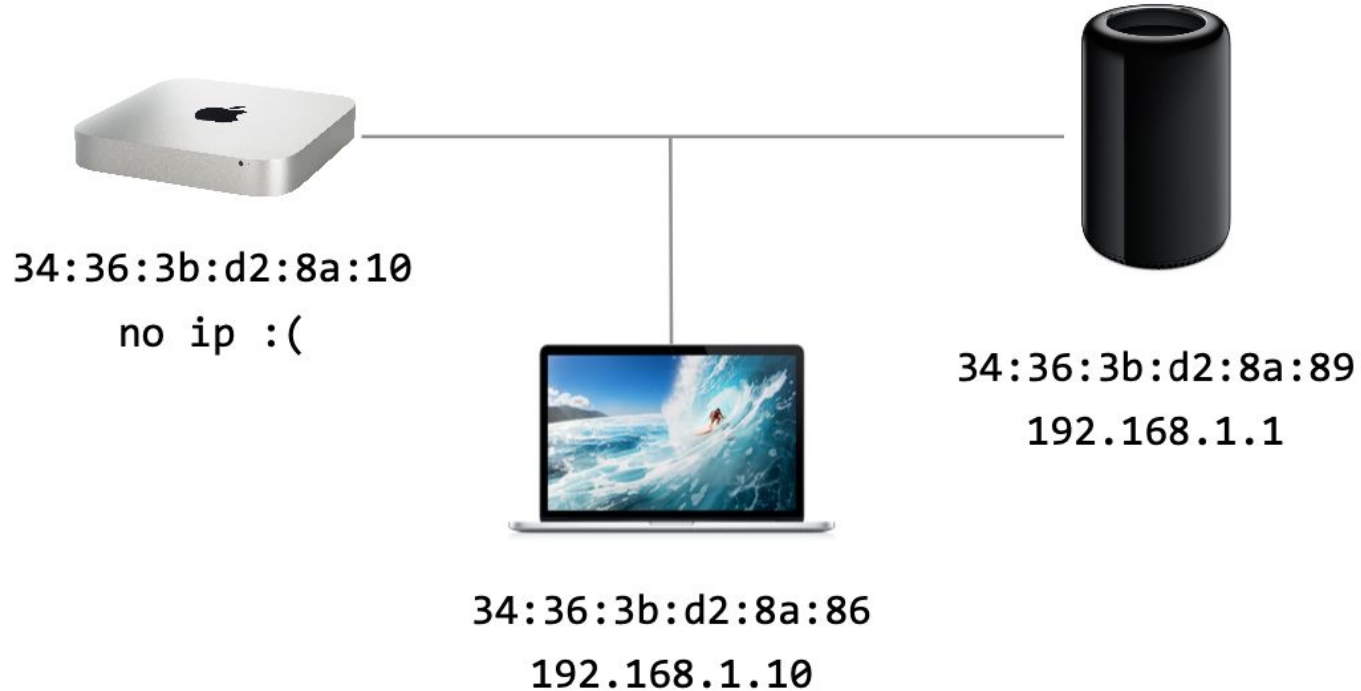
1. Who am I?                      How do I acquire an IP address?  
**Dynamic Host Configuration Protocol**
  
2. Who are you?                      Given an IP, how do I find which MAC to send to?  
**Address Resolution Protocol**

# Functionally, Every Connected Device Requires an IP

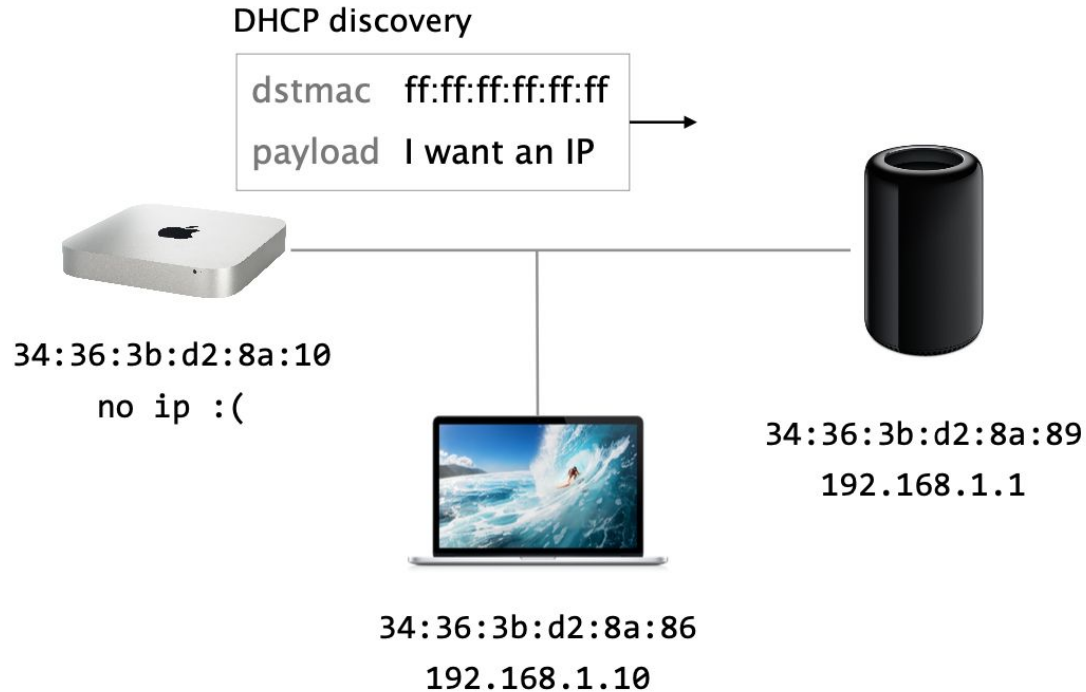




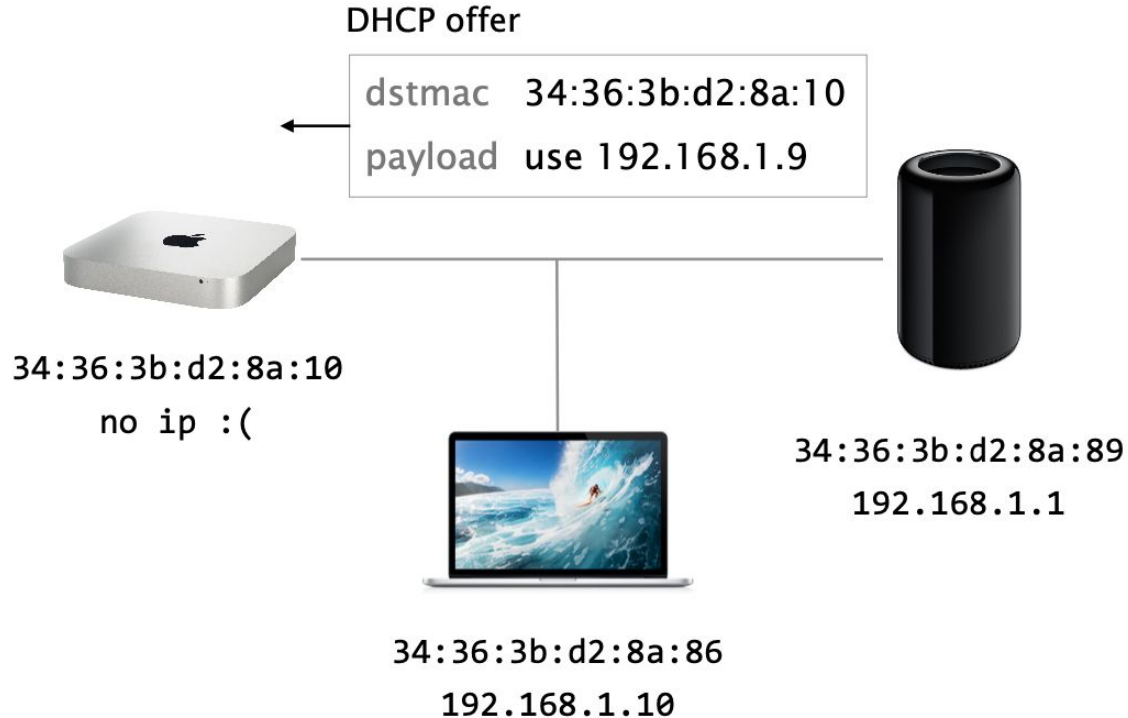
# DHCP



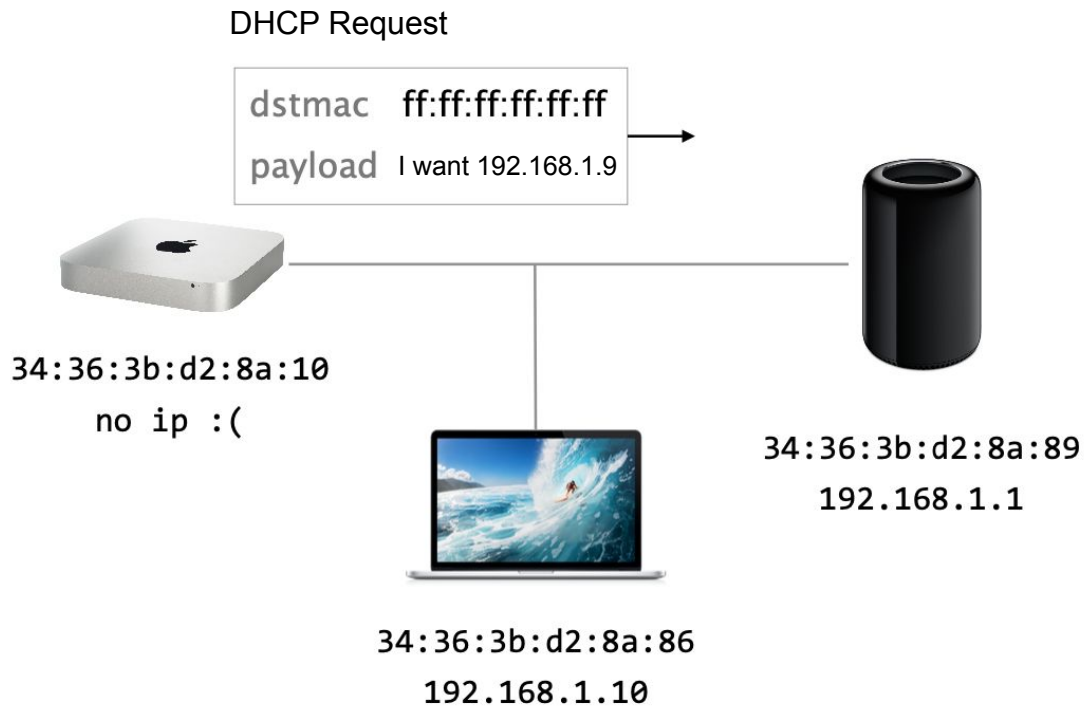
# DHCP Discovery “Is there a DHCP Server out there?” using the Broadcast Address



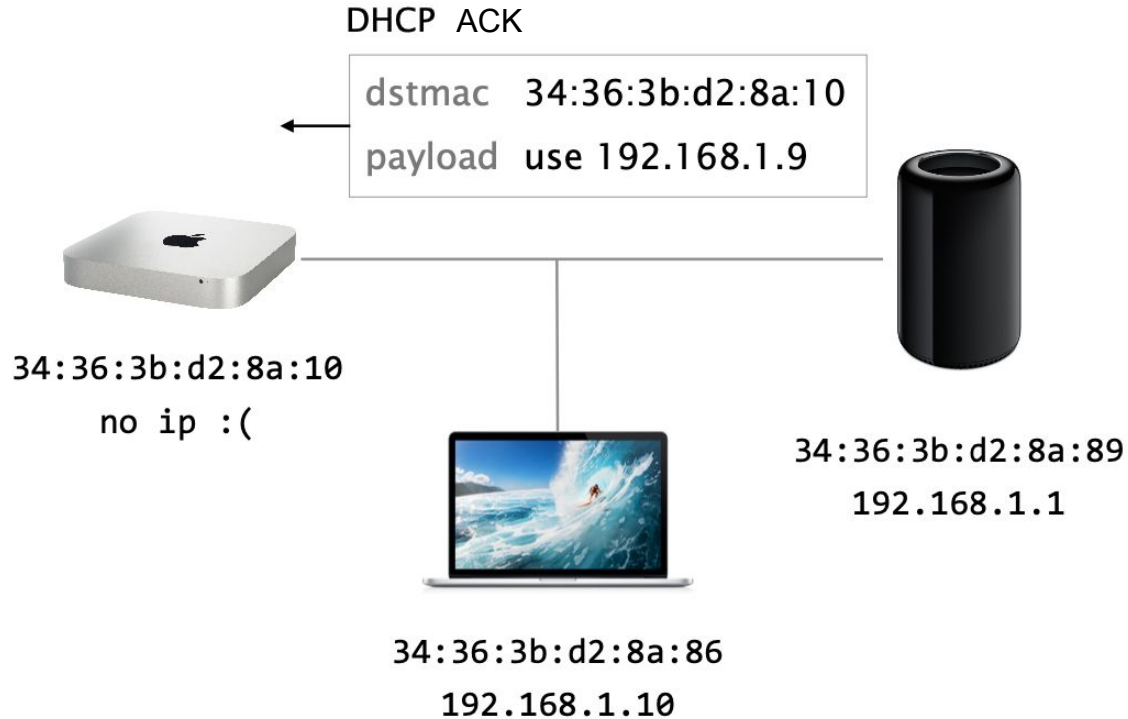
# DHCP - Server (if there is one) Answers With an Offer



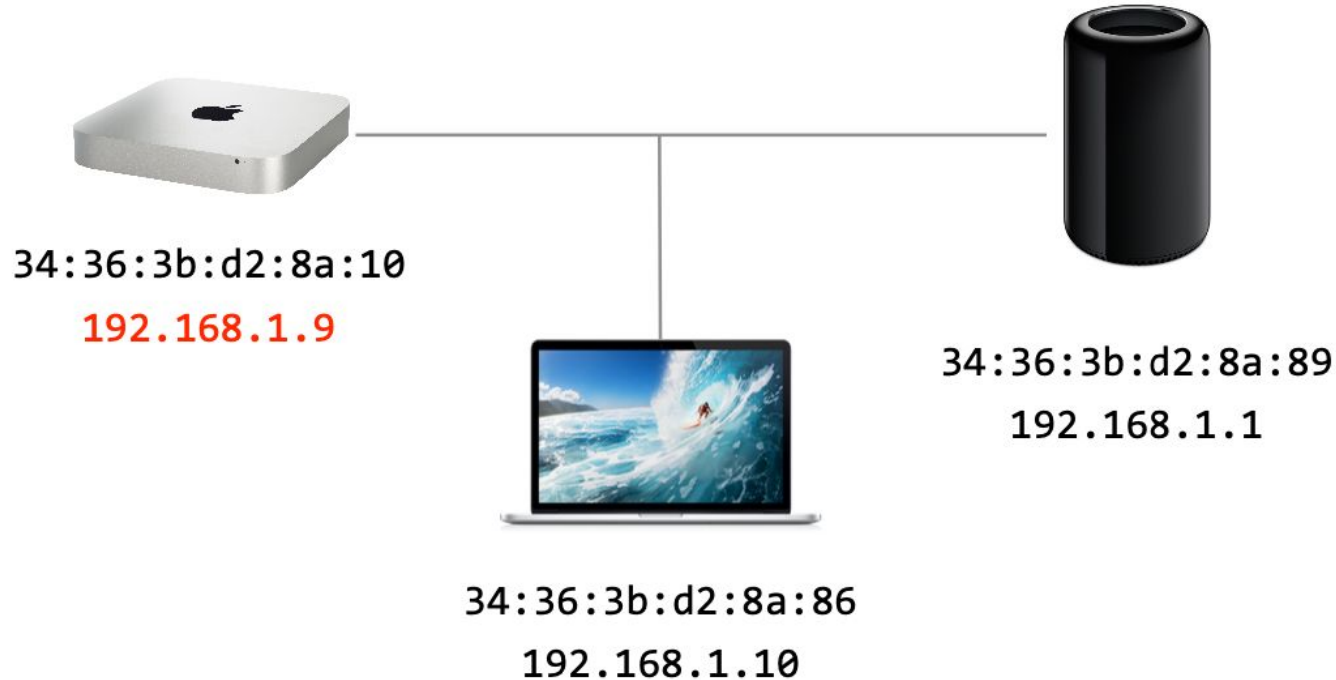
# DHCP Request “Can I have this IP?” using the Broadcast Address



# DHCP - Server Answers With an Acknowledgement



# DHCP - Client Now Has an IP for the Lifetime of the Lease



# DHCP

Download the pcap from [https://teaching.pschmitt.net/EE449\\_Spring2023/exercises/dhcp.pcap](https://teaching.pschmitt.net/EE449_Spring2023/exercises/dhcp.pcap)

1. Are DHCP messages sent over UDP or TCP?
2. What is the link-layer (e.g., Ethernet) address of the host?
3. What values in the DHCP discover message differentiate this message from the DHCP request message?
4. What is the value of the Transaction-ID in each of the first four (Discover/Offer/Request/ACK) DHCP messages? What is the purpose of the Transaction-ID field?
5. A host uses DHCP to obtain an IP address, among other things. But a host's IP address is not confirmed until the end of the four-message exchange. If the IP address is not set until the end of the four-message exchange, then what values are used in the IP datagrams in the four-message exchange?
6. What is the IP address of the DHCP server?
7. What IP address is the DHCP server offering to your host in the DHCP Offer message? Indicate which DHCP message contains the offered DHCP address.
8. Explain the purpose of the lease time. How long is the lease time in your experiment?

# DHCP

Download the pcap from [https://teaching.pschmitt.net/EE449\\_Spring2023/exercises/dhcp.pcap](https://teaching.pschmitt.net/EE449_Spring2023/exercises/dhcp.pcap)

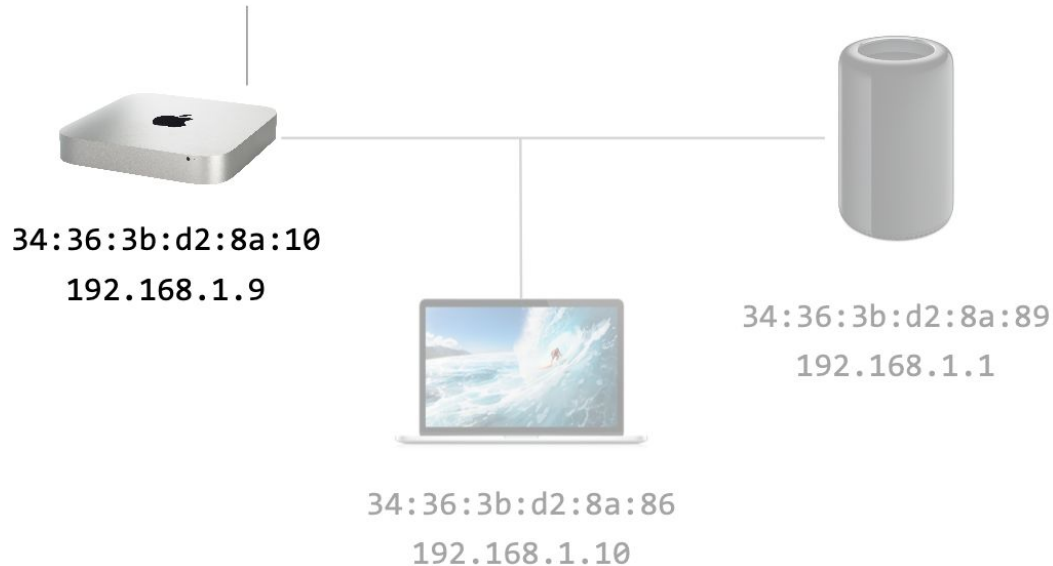
1. Are DHCP messages sent over UDP or TCP?  
UDP ports 67 and 68
2. What is the link-layer (e.g., Ethernet) address of the host?  
bc:d0:74:1a:75:19
3. What values in the DHCP discover message differentiate this message from the DHCP request message?  
Message type, Requested IP Address, DHCP Server, IP address lease time
4. What is the value of the Transaction-ID in each of the first four (Discover/Offer/Request/ACK) DHCP messages? What is the purpose of the Transaction-ID field?  
0x9e03d8c2
5. A host uses DHCP to obtain an IP address, among other things. But a host's IP address is not confirmed until the end of the four-message exchange. If the IP address is not set until the end of the four-message exchange, then what values are used in the IP datagrams in the four-message exchange?  
0.0.0.0->255.255.255.255; 192.168.86.1->192.168.86.123; 0.0.0.0->255.255.255.255; 192.168.86.1->192.168.86.123
6. What is the IP address of the DHCP server?  
192.168.86.1
7. What IP address is the DHCP server offering to your host in the DHCP Offer message? Indicate which DHCP message contains the offered DHCP address.  
192.168.86.123 in the offer
8. Explain the purpose of the lease time. How long is the lease time in your experiment?  
The lease time is how long the server will hold the IP out of the pool from other potential users. Lease time is one day



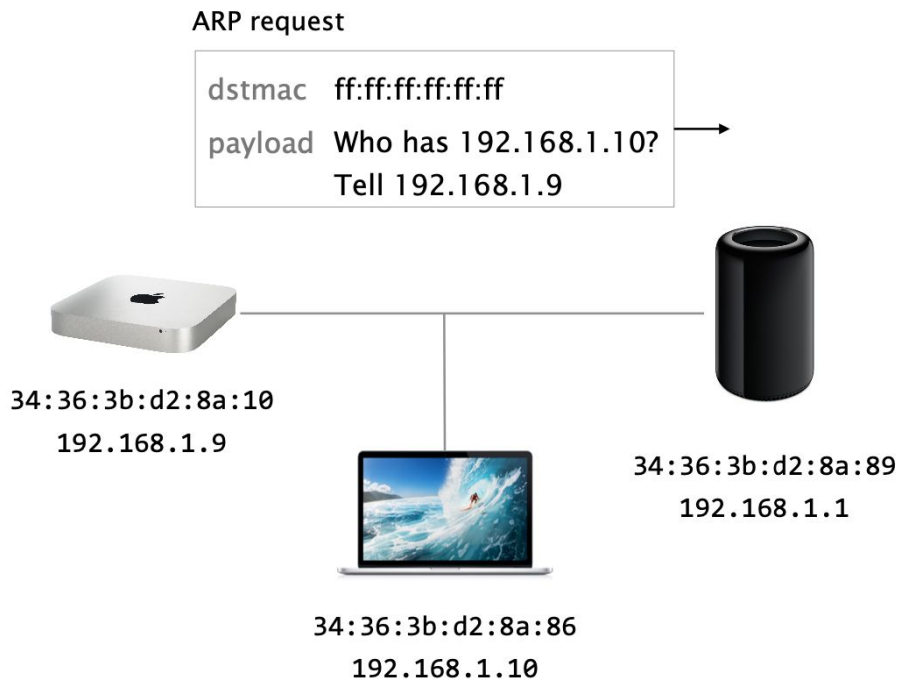
# Address Resolution Protocol (ARP) Enables Hosts to Discover MACs Associated with IPs

I want to send an IP packet  
to 192.168.1.10?

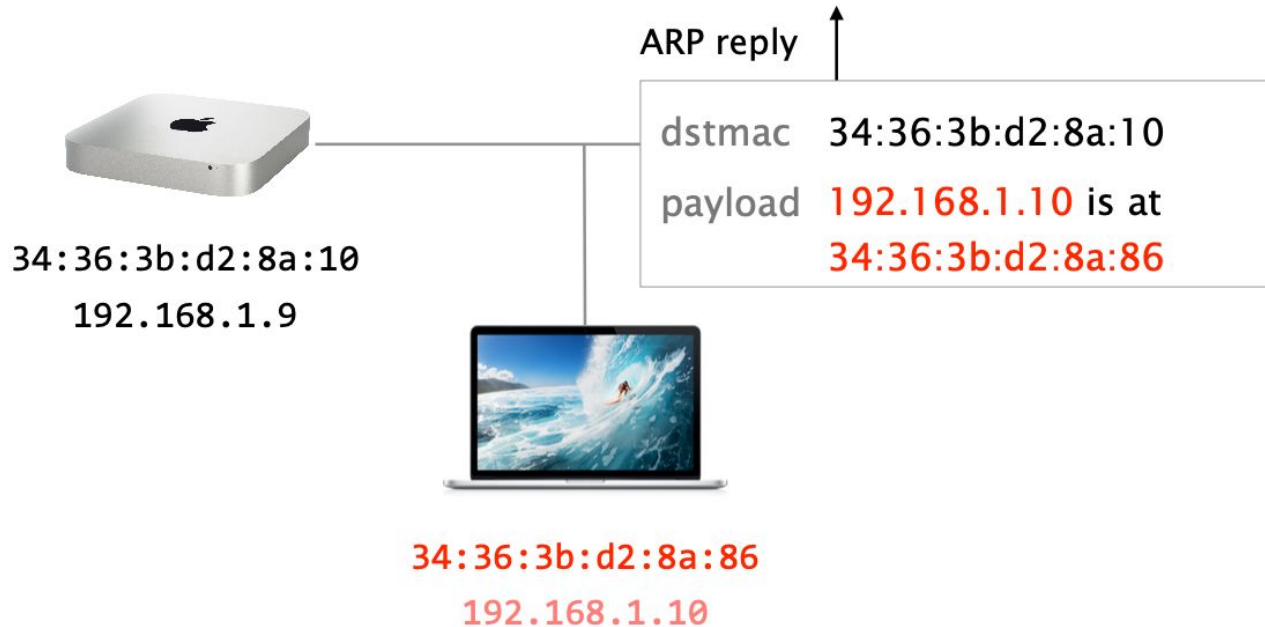
What destination MAC do I use?!



# Address Resolution Protocol (ARP) Enables Hosts to Discover MACs Associated with IPs



# Address Resolution Protocol (ARP) Enables Hosts to Discover MACs Associated with IPs



# Address Resolution Protocol (ARP) Enables Hosts to Discover MACs Associated with IPs

ARP table

192.168.1.10	34:36:3b:d2:8a:86
...	...



34:36:3b:d2:8a:10  
192.168.1.9



34:36:3b:d2:8a:86  
192.168.1.10



34:36:3b:d2:8a:89  
192.168.1.1

# ARP

ARP is stateless

- Hosts will automatically cache any ARP replies they receive, regardless of whether network hosts requested them.
- Even ARP entries that have not yet expired will be overwritten when a new ARP reply packet is received.
- There is no method in the ARP protocol by which a host can authenticate the peer from which the packet originated.
  - Allows **ARP spoofing**

# ARP

Download the pcap from [https://teaching.pschmitt.net/EE449\\_Spring2023/exercises/arp.pcap](https://teaching.pschmitt.net/EE449_Spring2023/exercises/arp.pcap)

1. What are the hexadecimal values for the source and destination addresses in the Ethernet frame containing the ARP request message?
2. Where in the ARP request does the “question” appear – the Ethernet address of the machine whose corresponding IP address is being queried?
3. Where in the ARP message does the “answer” to the earlier ARP request appear – the IP address of the machine having the Ethernet address whose corresponding IP address is being queried?
4. What would happen if, when you manually added an entry to the ARP table, you entered the correct IP address, but the wrong Ethernet address for that remote interface?

# ARP

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1. What are the hexadecimal values for the source and destination addresses in the Ethernet frame containing the ARP request message?  
**Src: bc:d0:74:1a:75:19, Dst: ff:ff:ff:ff:ff:ff**
2. Where in the ARP request does the “question” appear – the Ethernet address of the machine whose corresponding IP address is being queried?  
**Target IP address**
3. Where in the ARP message does the “answer” to the earlier ARP request appear – the IP address of the machine having the Ethernet address whose corresponding IP address is being queried?  
**Sender MAC Address**
4. What would happen if, when you manually added an entry to the ARP table, you entered the correct IP address, but the wrong Ethernet address for that remote interface?  
**The frames for that IP destination would be addressed using the ARP table entry, no NIC would process the frame (because it wouldn't match them)**

# DHCP + ARP

The three hosts Bob, Alice and Eve are all connected to the same network, which has a DHCP server.

Bob just connected to the network and wants to send important IP packets to Alice. Bob only knows the IP address of Alice (192.168.1.35) and his laptop is not yet configured with an IP address.

Question: Explain all the steps that are necessary such that Bob's computer can finally send packets to Alice.



SRC MAC	DST MAC	Message Type	Message Content



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Question: Explain all the steps that are necessary such that Bob's computer can finally send packets to Alice.



SRC MAC	DST MAC	Message Type	Message Content
44:36:3b:12:ba:12	ff:ff:ff:ff:ff:ff	DHCP discovery	I need an IP address
34:36:3b:d2:8a:89	44:36:3b:12:ba:12	DHCP offer	use 192.168.1.37
44:36:3b:12:ba:12	ff:ff:ff:ff:ff:ff	ARP request	Who has 192.168.1.35 Tell 192.168.1.37
34:36:3b:d2:8a:10	44:36:3b:12:ba:12	ARP reply	192.168.1.35 is at 34:36:3b:d2:8a:10