Network Layer: Address Mapping, Error Reporting

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ADDRESS MAPPING

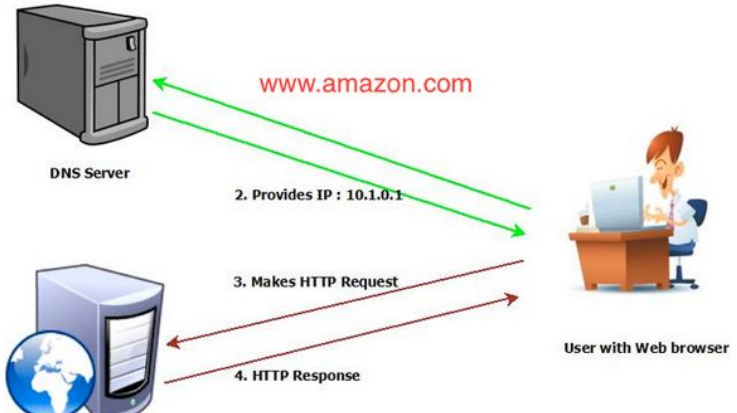
Types of Addresses in Internet

- **Media Access Control (MAC)** addresses in the network access layer
  - Associated with network interface card (NIC)
  - 48 bits
- **IP addresses** for the network layer
  - 32 bits for IPv4, and 128 bits for IPv6
  - E.g. 192.168.10.10
- **IP addresses + ports** for the transport layer
  - E.g: 192.168.10.10:80
- **Domain names** for the application layer
  - E.g: www.google.com

Logical Address and Physical Address

ARP: Address Resolution Protocol (logical to physical address)

- Logical address for a given URL(Uniform Resource Locator) can be obtained by DNS (Domain Name System)
- The MAC layer needs physical address.
- ARP helps to obtain physical address.



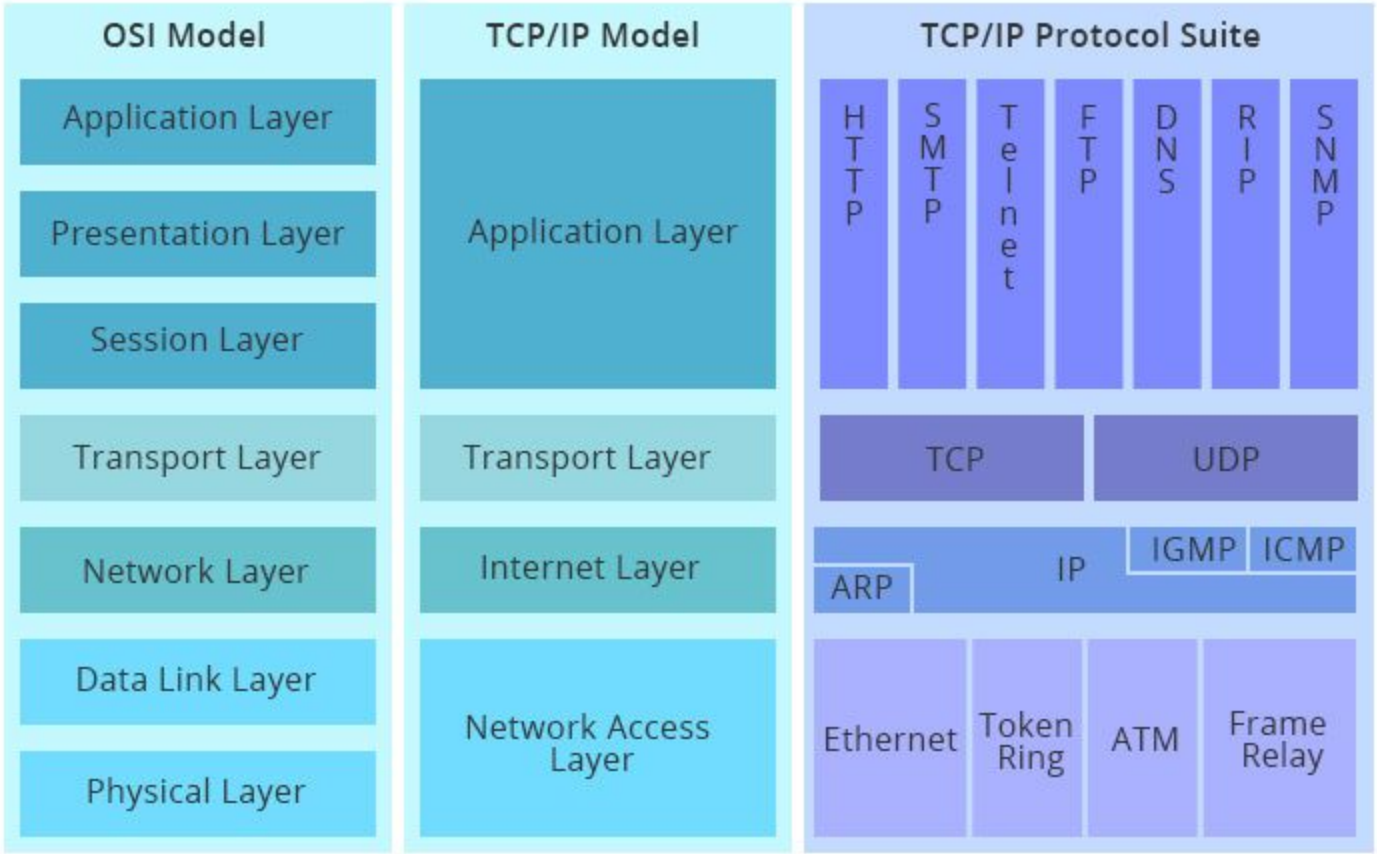
What is the use of MAC address?

Computers need MAC addresses!

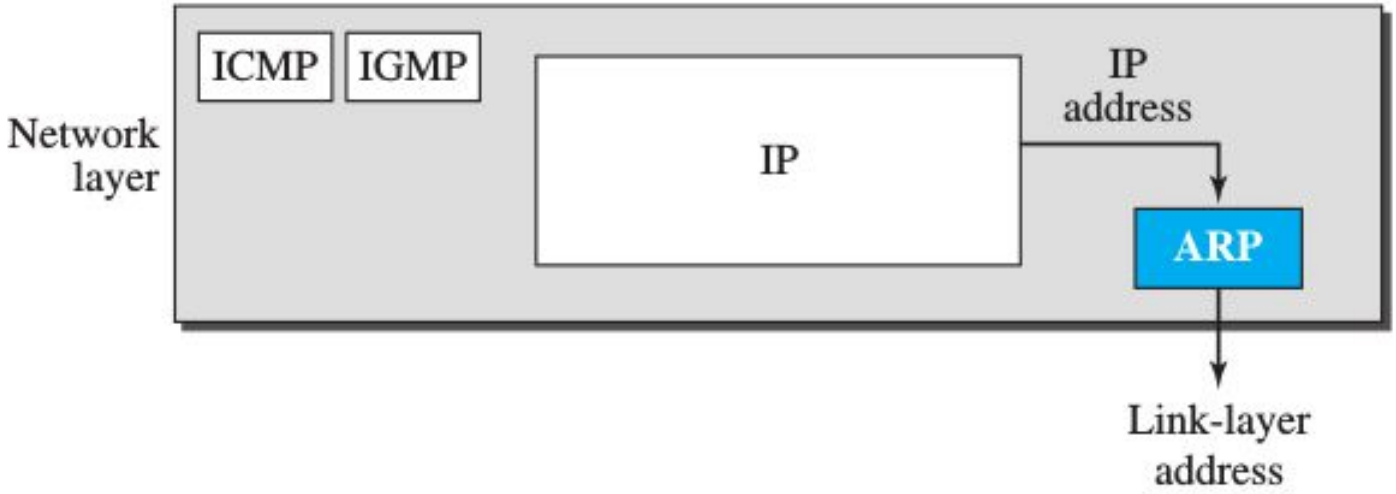
Physical layer needs physical address to know where the IP packet physically be sent.

Two types of mapping from IP to MAC address:

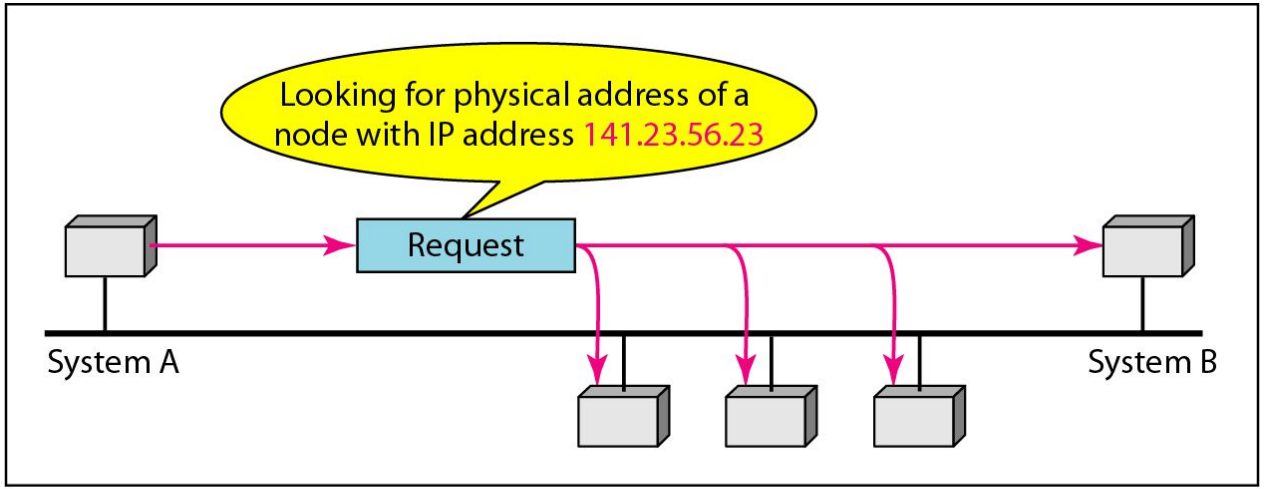
- **Static Mapping**
  - A table with logical to physical address mapping is stored in every machine in the network.
- **Dynamic Mapping**
  - If a host knows logical or physical address it can find the mapping using ARP or RARP protocols.


OSI Model
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer
TCP/IP Model
Application Layer
Transport Layer
Internet Layer
Network Access Layer
TCP/IP Protocol Suite
HTTP
SMTP
Telnet
FTP
DNS
RIP
SNMP
TCP
UDP
IP
IGMP
ICMP
ARP
Ethernet
Token Ring
ATM
Frame Relay

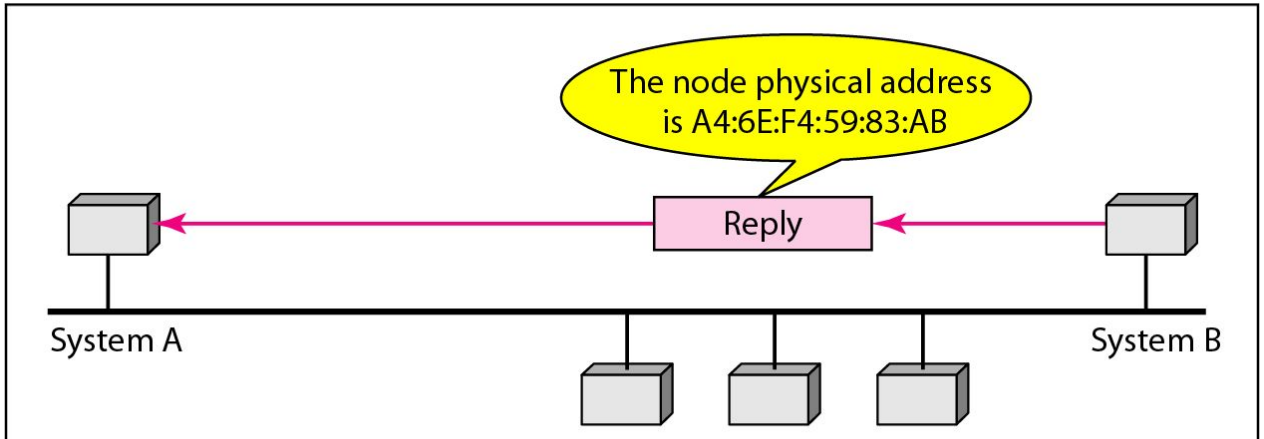
ARP is a Network Layer Protocol



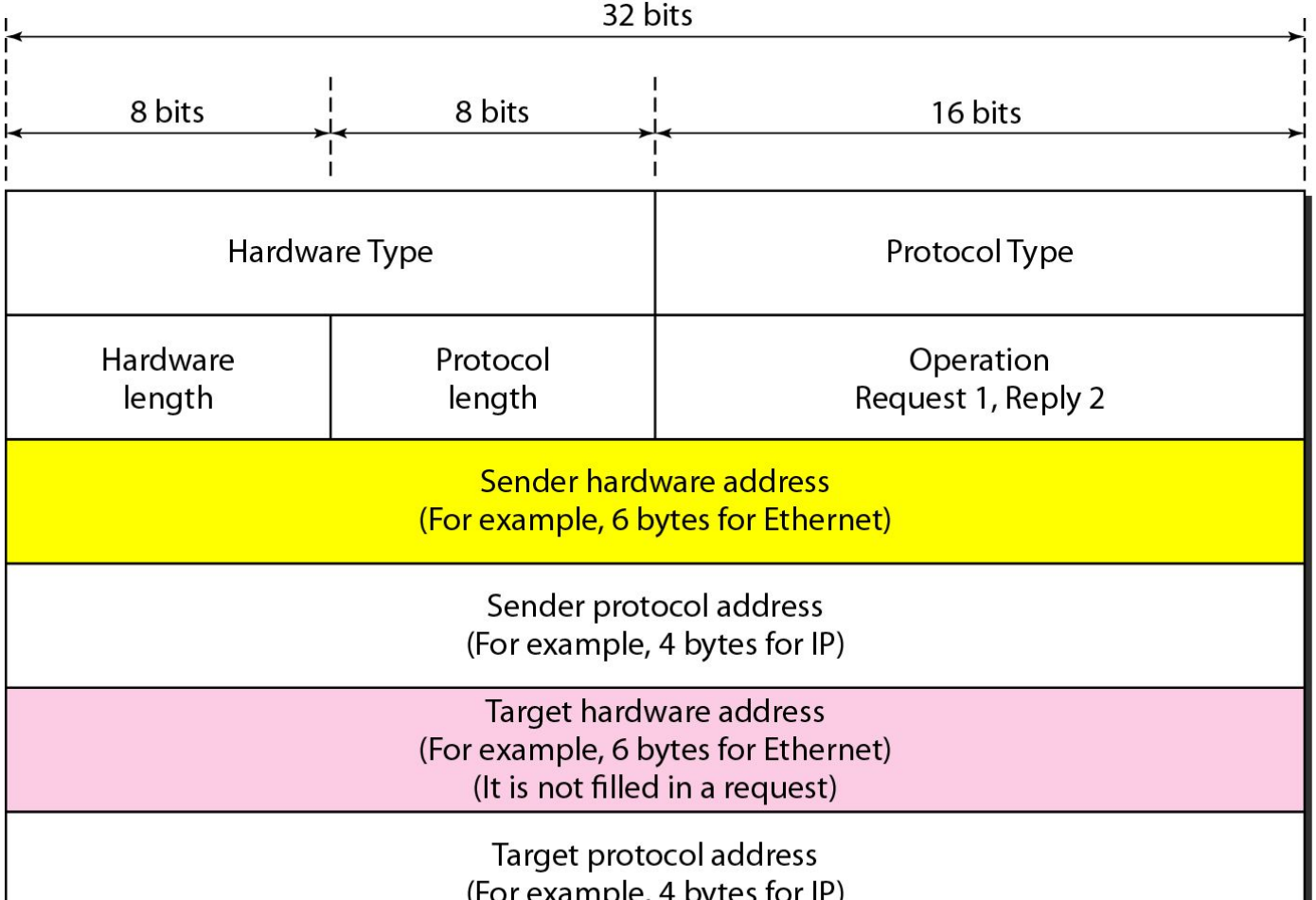
ARP Operation



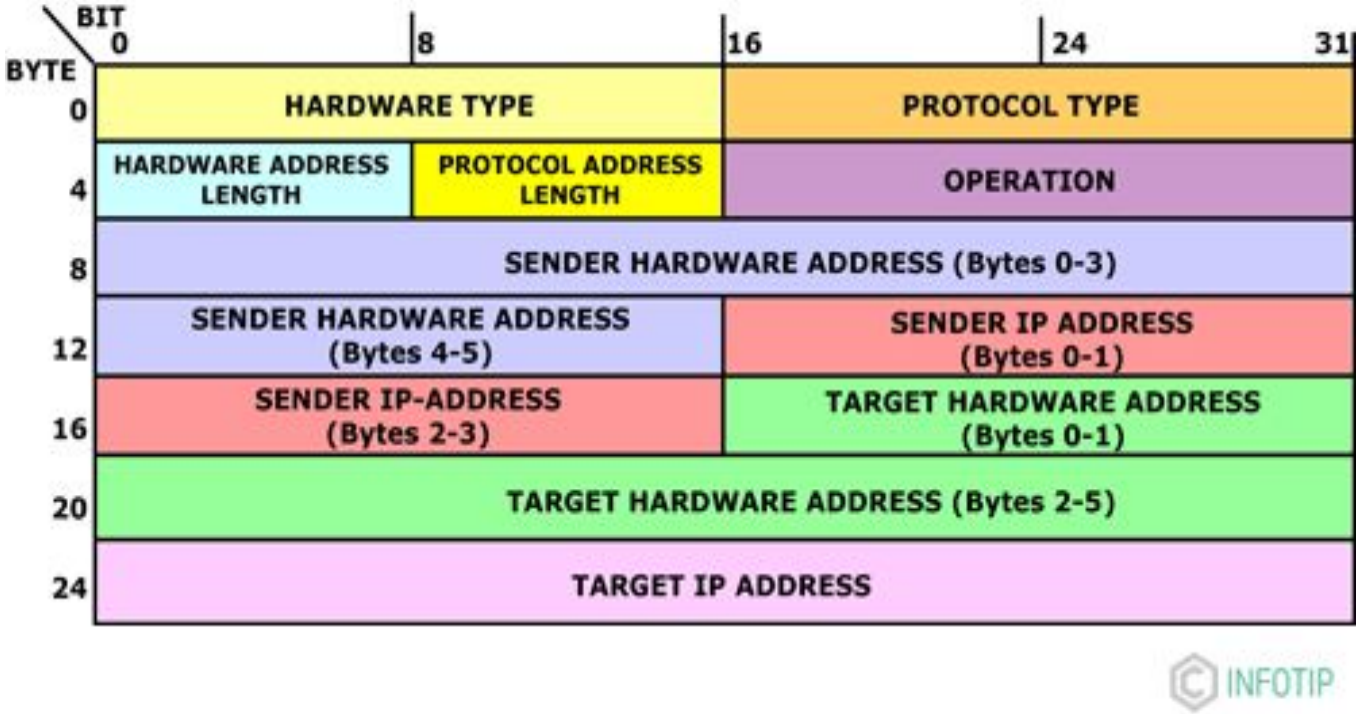
a. ARP request is broadcast



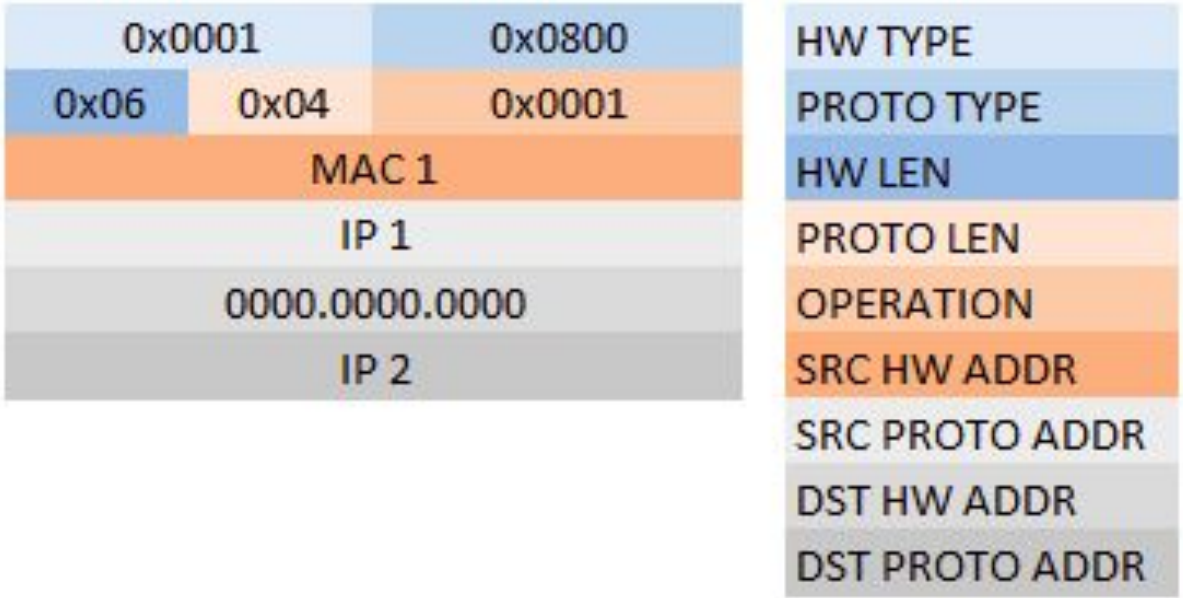
ARP Packet:


32 bits
8 bits
8 bits
16 bits
Hardware Type
Protocol Type
Hardware length
Protocol length
Operation Request 1, Reply 2
Sender hardware address (For example, 6 bytes for Ethernet)
Sender protocol address (For example, 4 bytes for IP)
Target hardware address (For example, 6 bytes for Ethernet) (It is not filled in a request)
Target protocol address (For example, 4 bytes for IP)

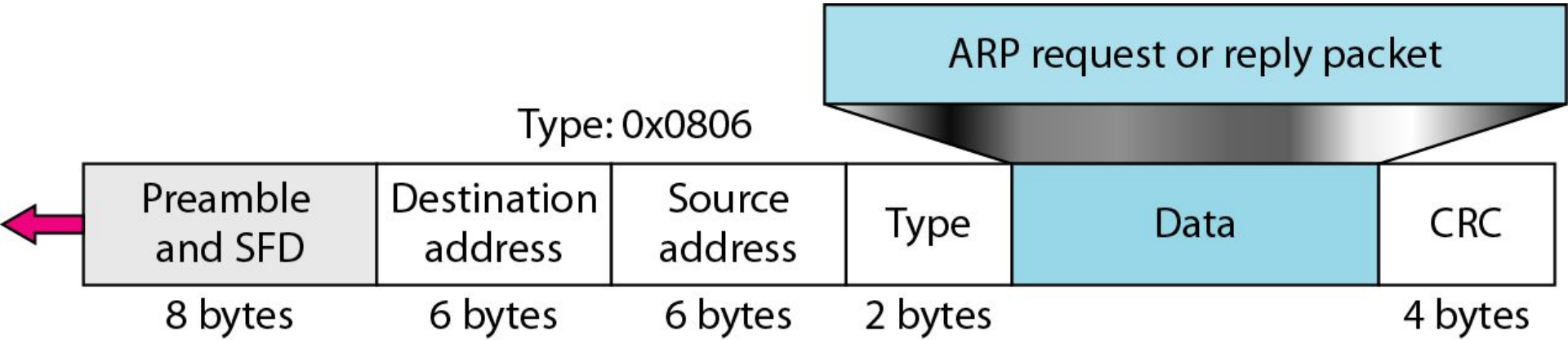
Actual Packet Format:



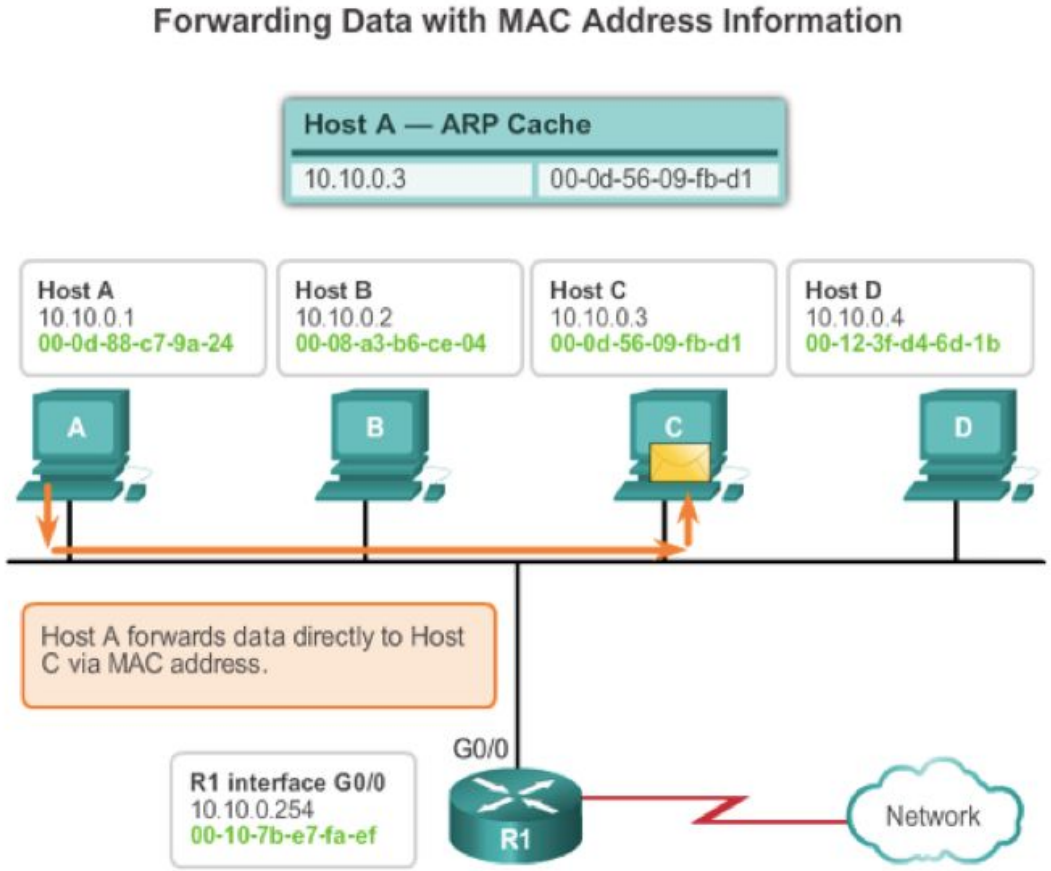
Example:

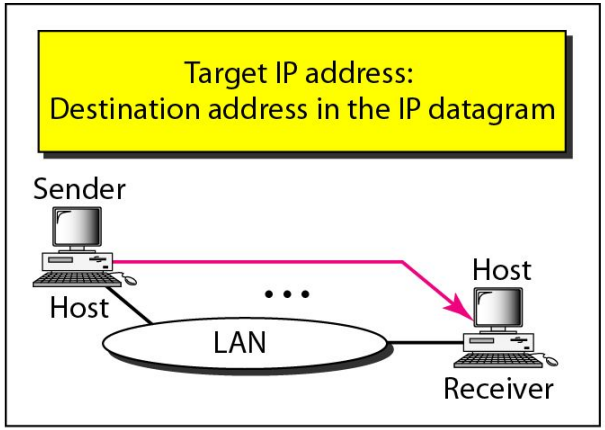

0x0001
0x0800
0x06
0x04
0x0001
MAC 1
IP 1
0000.0000.0000
IP 2
HW TYPE
PROTO TYPE
HW LEN
PROTO LEN
OPERATION
SRC HW ADDR
SRC PROTO ADDR
DST HW ADDR
DST PROTO ADDR

Encapsulation of ARP Packet

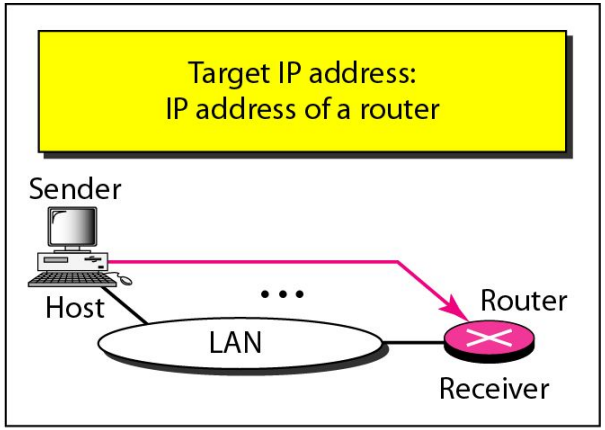


The ARP Process – Communicating Locallv

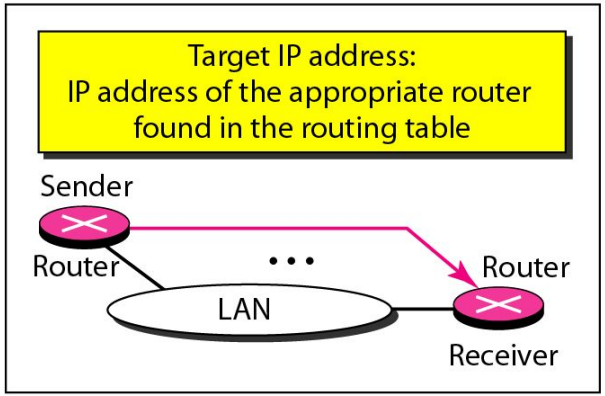




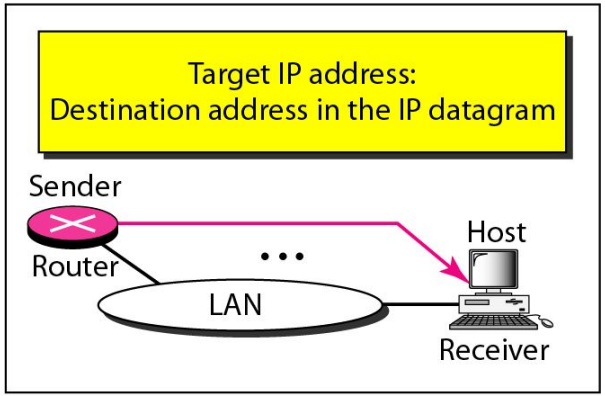
Case 1. A host has a packet to send to another host on the same network.



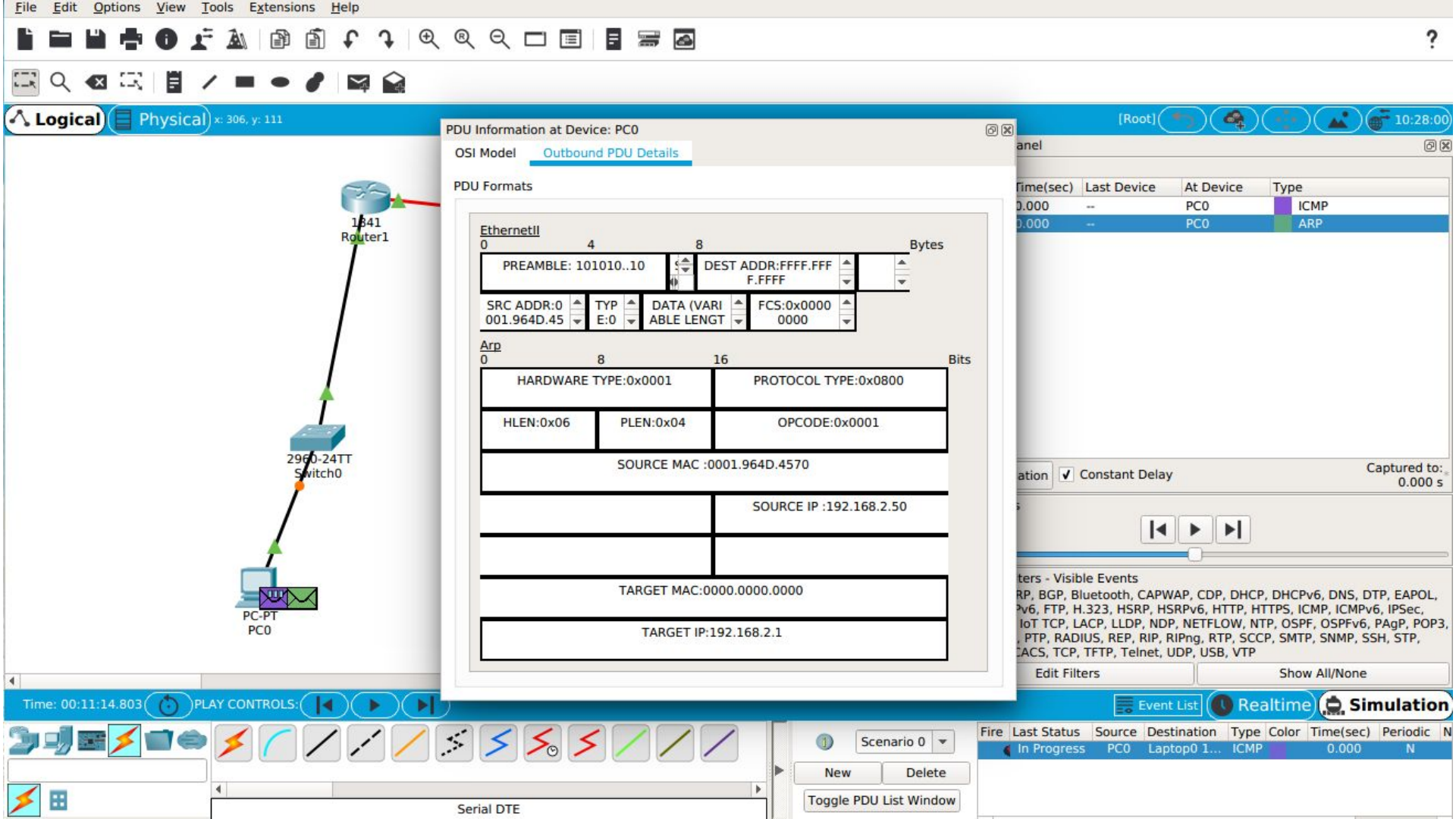
Case 2. A host wants to send a packet to another host on another network. It must first be delivered to a router.



Case 3. A router receives a packet to be sent to a host on another network. It must first



Case 4. A router receives a packet to be sent to a host on the same network.


File Edit Options View Tools Extensions Help
Logical
Physical
x: 306, y: 111
[Root]
10:28:00
PDU Information at Device: PC0
OSI Model
Outbound PDU Details
PDU Formats
EthernetII
0
4
8
Bytes
PREAMBLE: 101010..10
DEST ADDR:FFFF.FFFF.FFFF
SRC ADDR:0001.964D.45
TYPE:0
DATA (VARIABLE LENGT
FCS:0x00000000
Arp
0
8
16
Bits
HARDWARE TYPE:0x0001
PROTOCOL TYPE:0x0800
HLEN:0x06
PLEN:0x04
OPCODE:0x0001
SOURCE MAC :0001.964D.4570
SOURCE IP :192.168.2.50
TARGET MAC:0000.0000.0000
TARGET IP:192.168.2.1
1841
Router1
2960-24TT
Switch0
PC-PT
PC0
Time(sec)
Last Device
At Device
Type
0.000
PC0
ICMP
ARP
Constant Delay
Captured to:
0.000 s
Edit Filters
Show All/None
Time: 00:11:14.803
PLAY CONTROLS:
Event List
Realtime
Simulation
Scenario 0
New
Delete
Toggle PDU List Window
Fire
Last Status
Source
Destination
Type
Color
Time(sec)
Periodic
In Progress
PC0
ICMP
0.000
N
Serial DTE

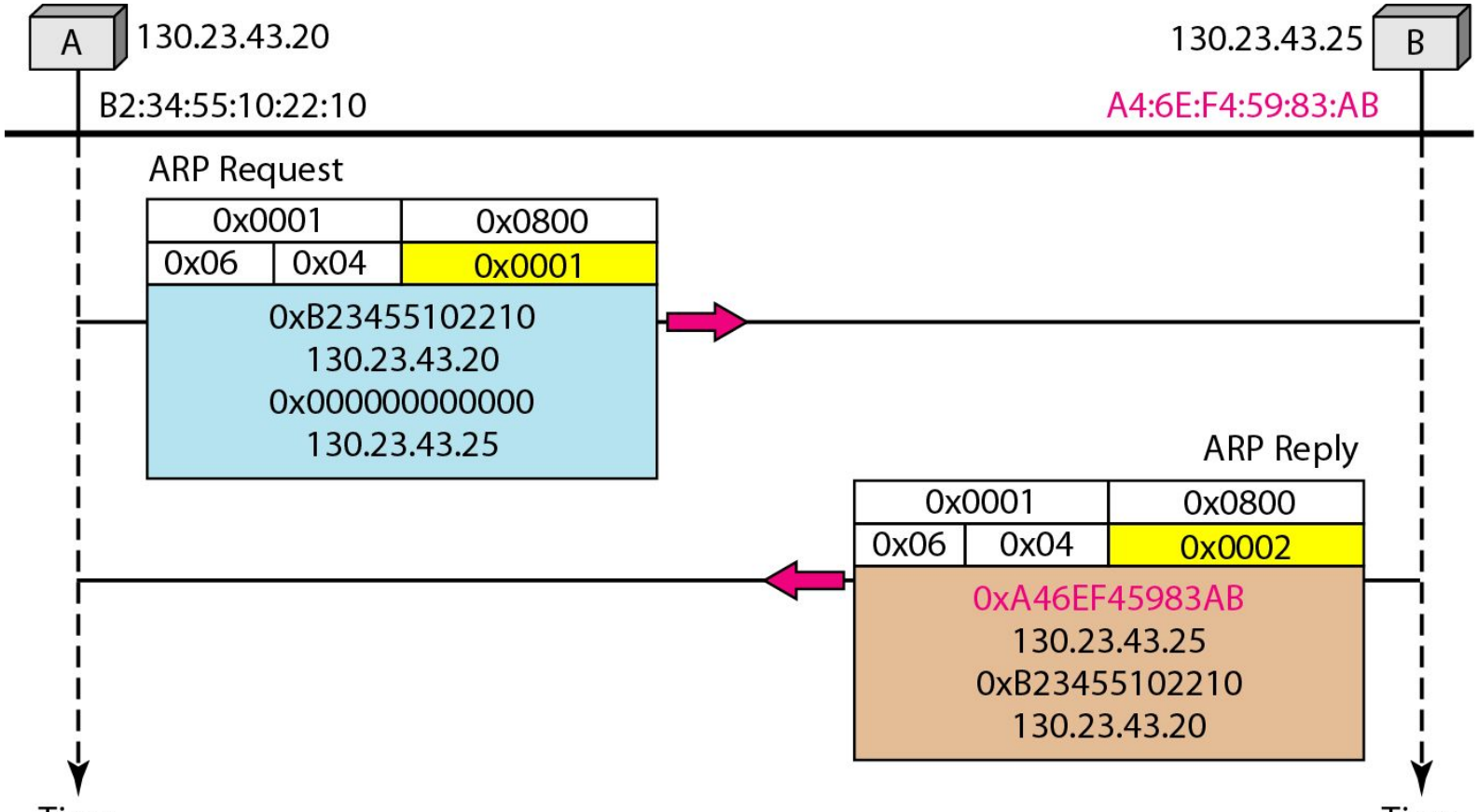
Problem:

A host with IP address 130.23.43.20 and physical address B2:34:55:10:22:10 has a packet to send to another host with IP address 130.23.43.25 and physical address A4:6E:F4:59:83:AB. The two hosts are on the same Ethernet network. Show the ARP request and reply packets encapsulated in Ethernet frames.

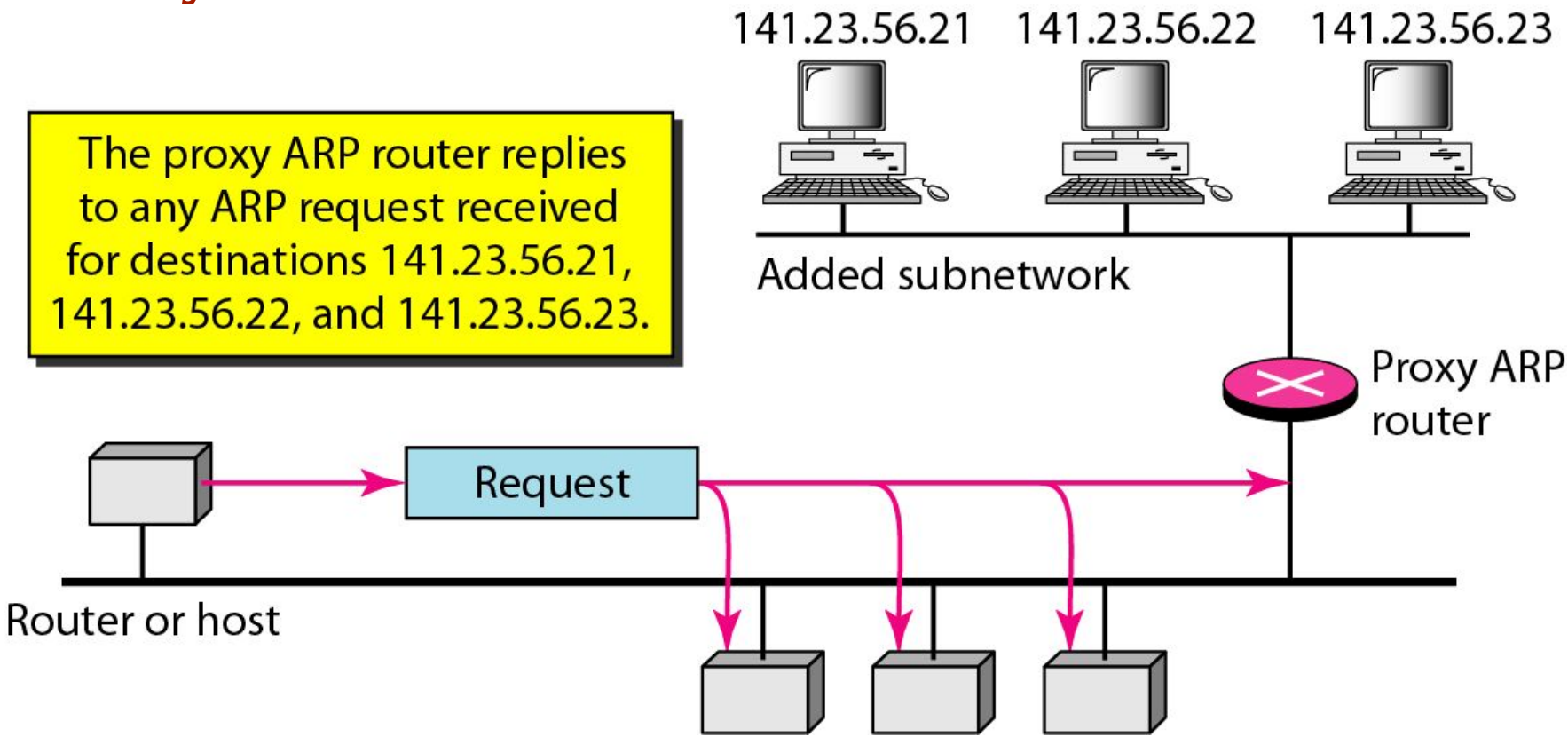
Solution:

Figure 1 shows the ARP request and reply packets. Note that the ARP data field in this case is 28 bytes, and that the individual addresses do not fit in the 4-byte boundary. That is why we do not show the regular 4-byte boundaries for these addresses.

Figure 1:


A
130.23.43.20
B2:34:55:10:22:10
130.23.43.25
B
A4:6E:F4:59:83:AB
ARP Request
0x0001
0x0800
0x06
0x04
0x0001
0xB23455102210
130.23.43.20
0x000000000000
130.23.43.25
ARP Reply
0x0001
0x0800
0x06
0x04
0x0002
0xA46EF45983AB
130.23.43.25
0xB23455102210
130.23.43.20

Proxy ARP


141.23.56.21
141.23.56.22
141.23.56.23
The proxy ARP router replies to any ARP request received for destinations 141.23.56.21, 141.23.56.22, and 141.23.56.23.
Added subnetwork
Proxy ARP router
Request
Router or host

Mapping of Physical Address to Logical Address:

- Consider two scenarios:
  - Diskless Workstation or Unavailability of memory to store IP and MAC address at a host.
  - Shortage of IP addresses
- Protocols to Map Physical address to IP address:
  - RARP : Reverse Address Resolution Protocol
  - BOOTP : Bootstrap Protocol
  - DHCP : Dynamic Host Configuration Protocol

RARP : Reverse Address Resolution Protocol

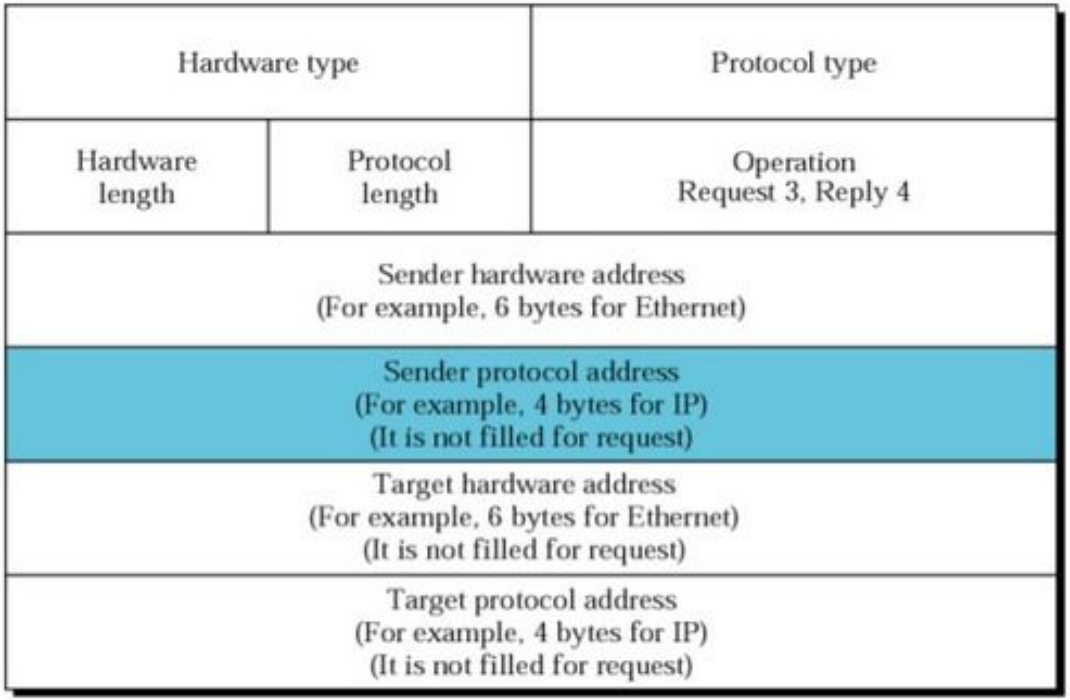
a. RARP request is broadcast

b. RARP reply is unicast

RARP:

- Network Layer Protocol
- Drawback:
  - Each RARP servers need to maintain a large database of static mappings of MAC to IP addresses.
  - RARP servers provide IP addresses but not Gateway, DNS addresses and subnet masks.
- Thus it is made obsolete by BOOTP and DHCP protocols.

RARP Packet Format:



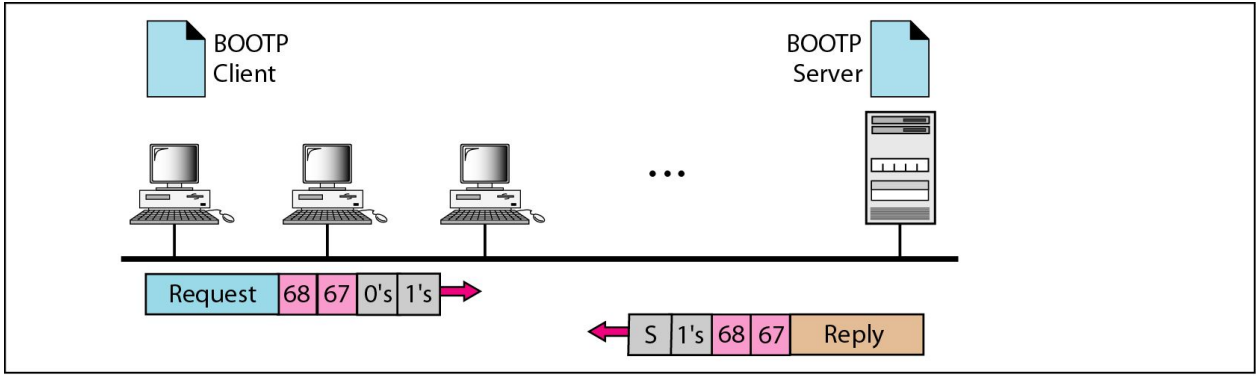
BOOTP : Bootstrap Protocol

- Application Layer Protocol
- BOOTP messages are encapsulated in a UDP packet.
- UDP packet is encapsulated in IP Packet.
- What about the Source and Destination IP addresses?
  - Source address all 0's
  - Destination address all 1's
- Advantage over RARP:
  - BOOTP client and server can be in different networks.

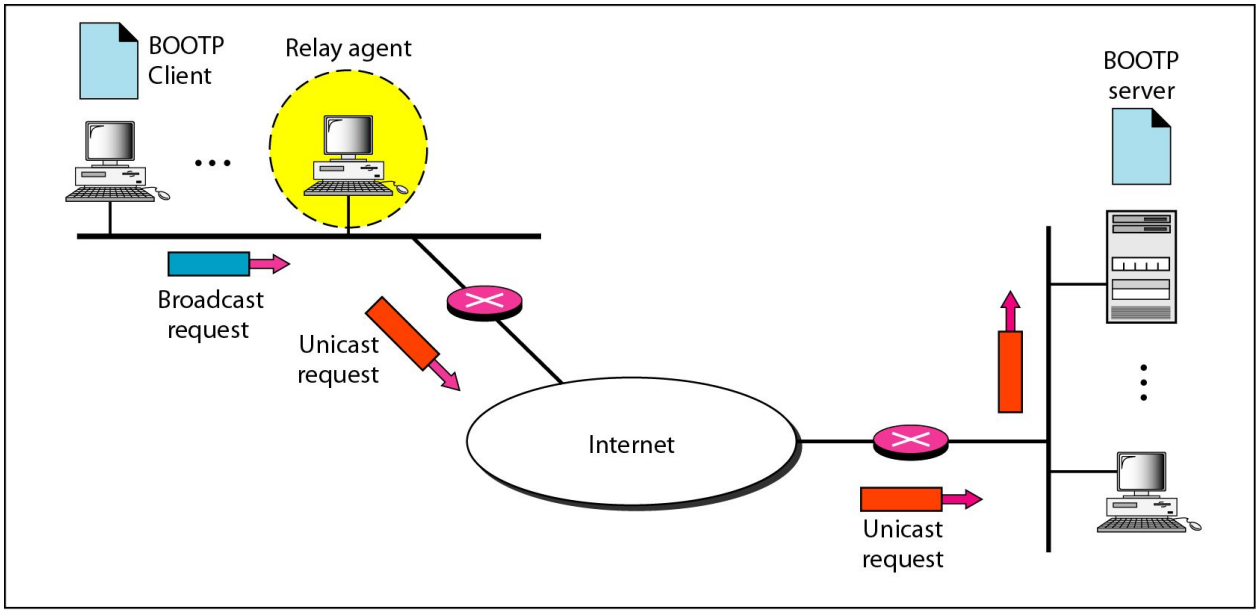
BOOTP

- Problem:
  - The BOOTP request is broadcast. It cannot pass through routers.
- Solution:
  - Make use of Relay Agents.

Example:



a. Client and server on the same network

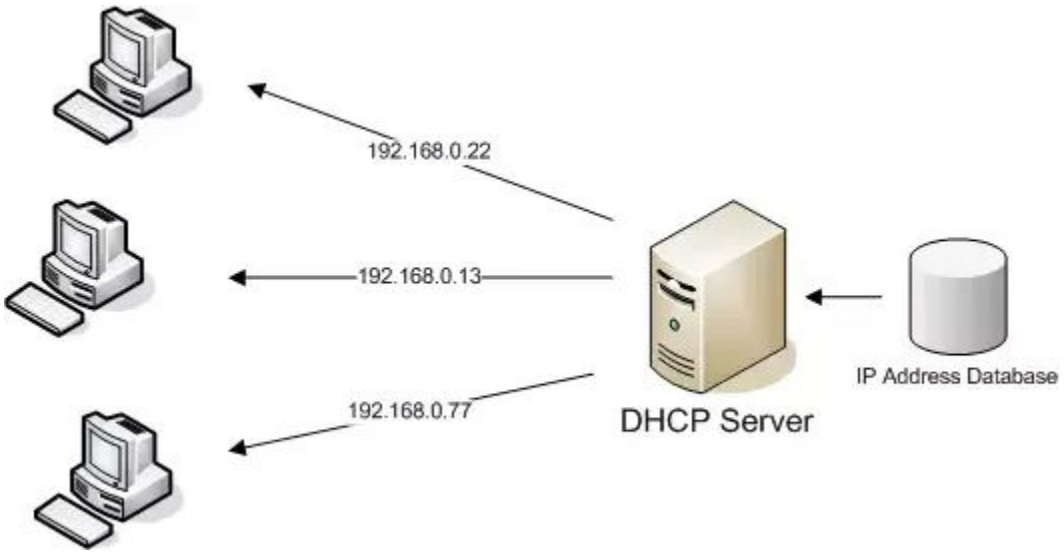


DHCP : Dynamic Host Configuration Protocol

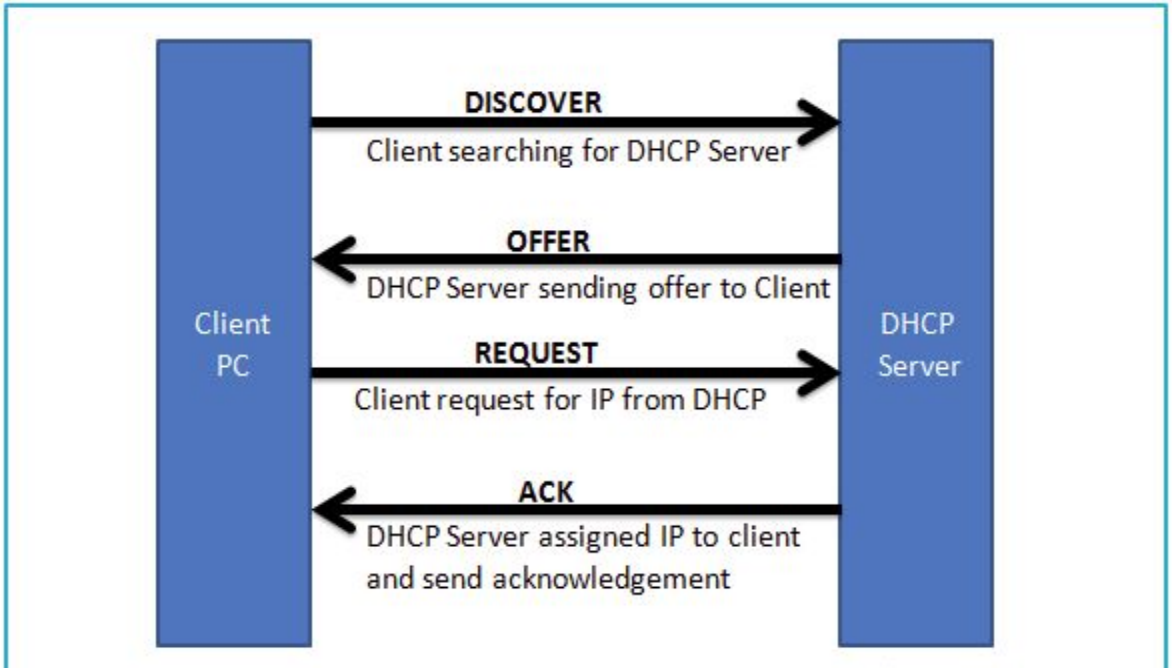
- Static address allocation: Similar to BOOTP
- Dynamic address allocation:
  - DHCP client request for the address
  - DHCP server checks static database. If an entry is present , return static address.
  - If no entry in static database, then selects address from a pool and returns it.
  - The DHCP assigns the address on basis of lease for specific interval of time.

DHCP:

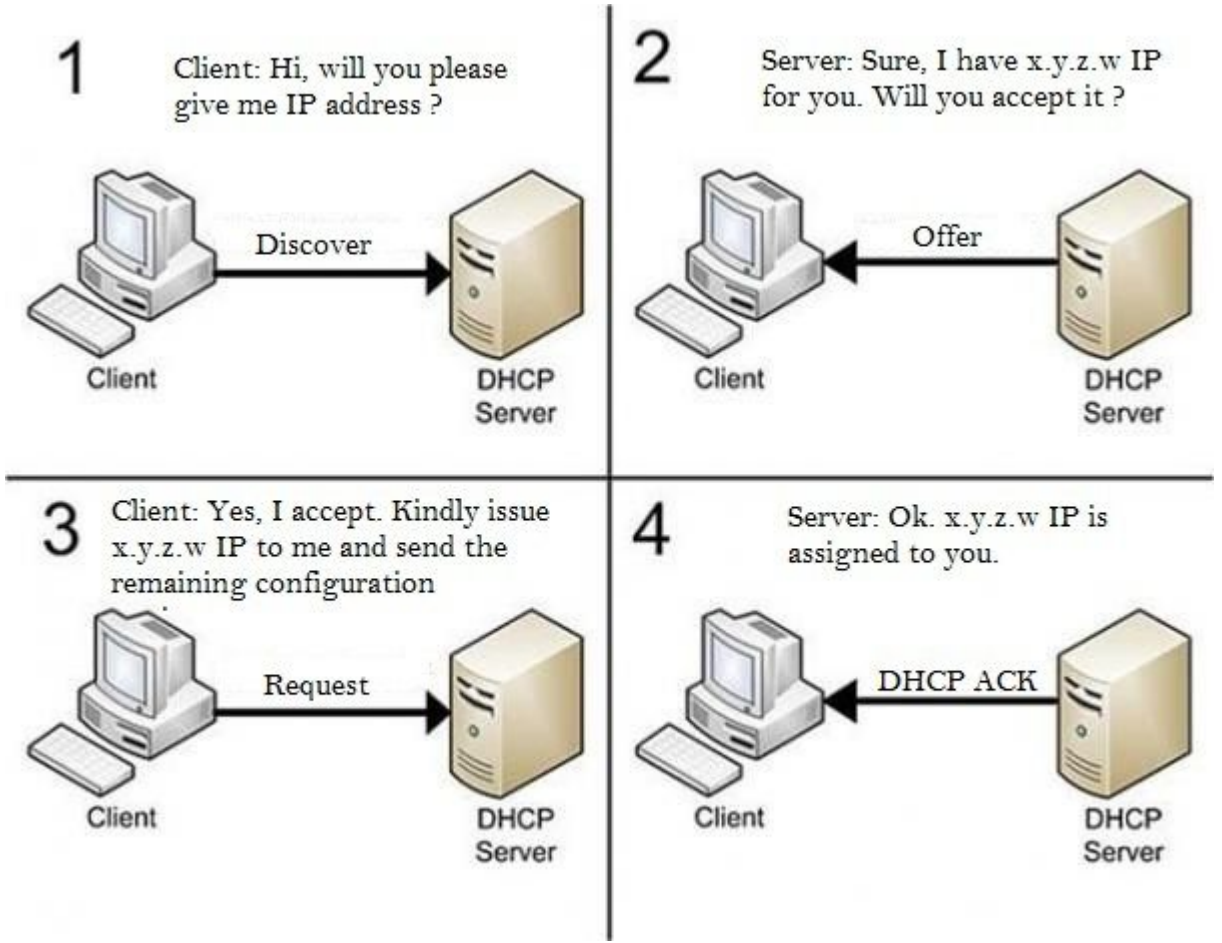
- DHCP provides static and dynamic address allocation that can be manual or automatic.



DHCP : DORA Process

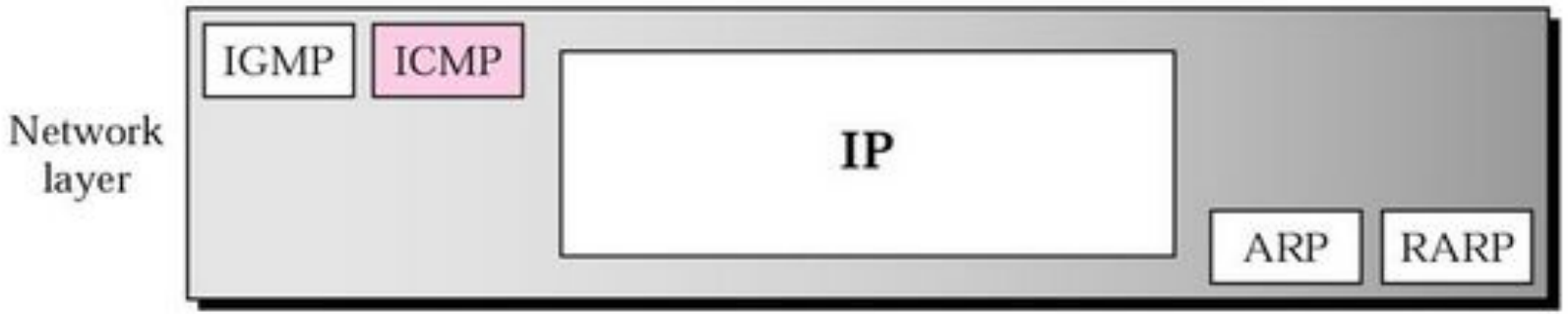


Example:


1
Client: Hi, will you please give me IP address ?
Discover
Client
DHCP Server
2
Server: Sure, I have x.y.z.w IP for you. Will you accept it ?
Offer
Client
DHCP Server
3
Client: Yes, I accept. Kindly issue x.y.z.w IP to me and send the remaining configuration
Request
Client
DHCP Server
4
Server: Ok. x.y.z.w IP is assigned to you.
DHCP ACK
Client
DHCP Server

ERROR REPORTING

ICMP : Internet Control Message Protocol



ICMP:

- The IP protocol has no **error-reporting or error-correcting mechanism.**
- The IP protocol also lacks a mechanism for host and management queries.
- The **Internet Control Message Protocol (ICMP)** has been designed to compensate for the above two deficiencies.
- It is a companion to the IP protocol.

Two types of ICMP Messages:

- Error Reporting
- Query

NOTE:

ICMP always reports error messages to the original source.

Error-Reporting Messages: