ARP and RARP

Outline

- ARP
- ARP Package
- RARP

Logical Addresses

The hosts and routers are recognized at the network level by their *logical addresses*

- A **logical address is an internet address**
- Called a *logical address because it is usually* implemented in software.
- The logical addresses in the TCP/IP are called **IP address and are 32 bits long**

Physical Address

However, hosts/routers are recognized at the physical layer by their *physical address*

A **physical address is an local address**

Called a *physical address because it is usually* implemented in hardware

Example:
48-bit MAC (Media Access Control) addresses in Ethernet

Translation

- We need both the physical address and the logical address for packet delivery
- Thus, we need to be able to map a logical address to its corresponding physical address and vice versa
- Solutions:
  - ***Static mapping***
  - ***Dynamic mapping***

Static Mapping

- Create a table that associates a logical address with a physical address and store in each machine
- However, physical addresses may change
- A machine could change its NIC resulting in a new physical address
- In some LANs the physical address changes every time the computer is turned on
- A mobile station can move from one physical network to another, resulting in a change in its physical address

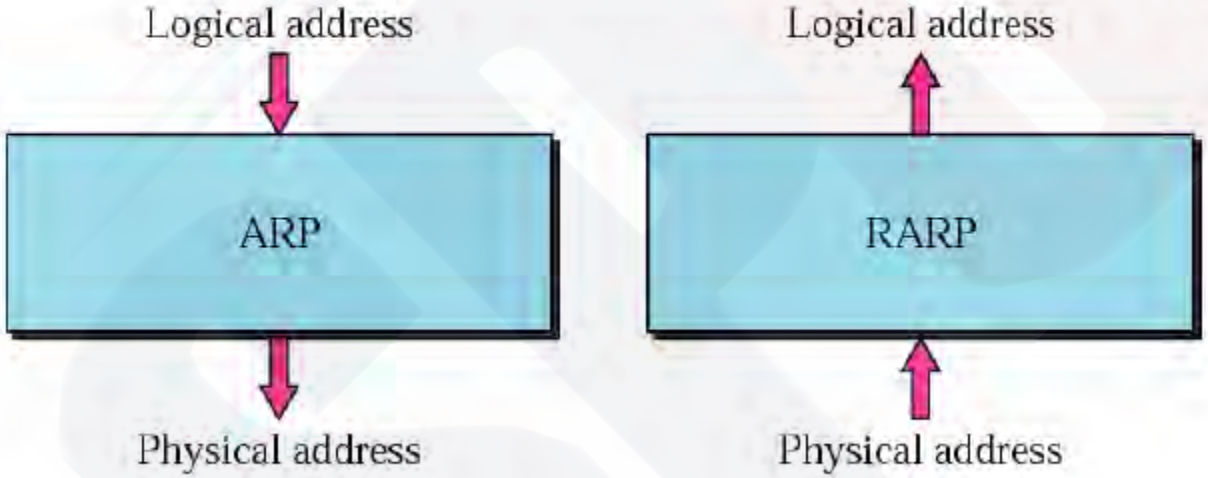
Dynamic Mapping

- Use a protocol to find another address
- **ARP**: Address Resolution Protocol

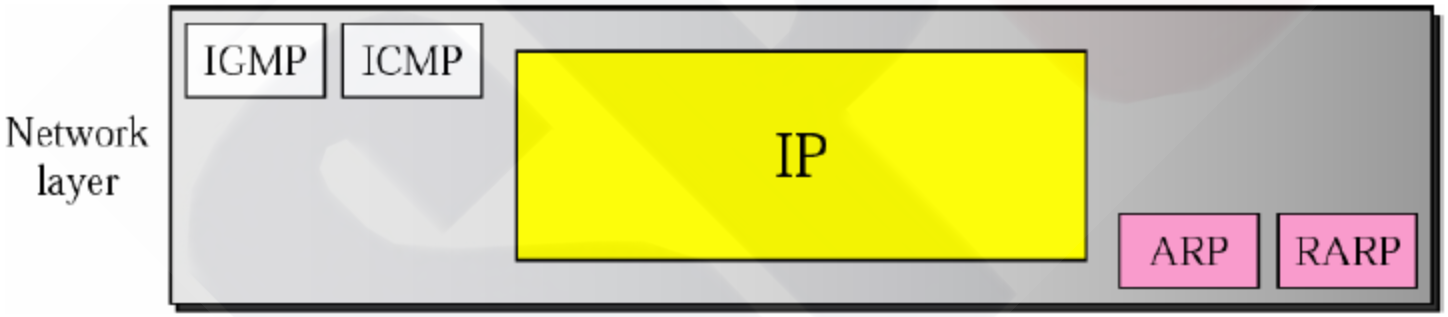
  Map a logical address to a physical address
- **RARP**: Reverse Address Resolution Protocol

  Map a physical address to a logical address

ARP and RARP


Logical address
ARP
Physical address
Logical address
RARP
Physical address

Position of ARP and RARP in TCP/IP Protocol Suite



ARP

ARP Operation

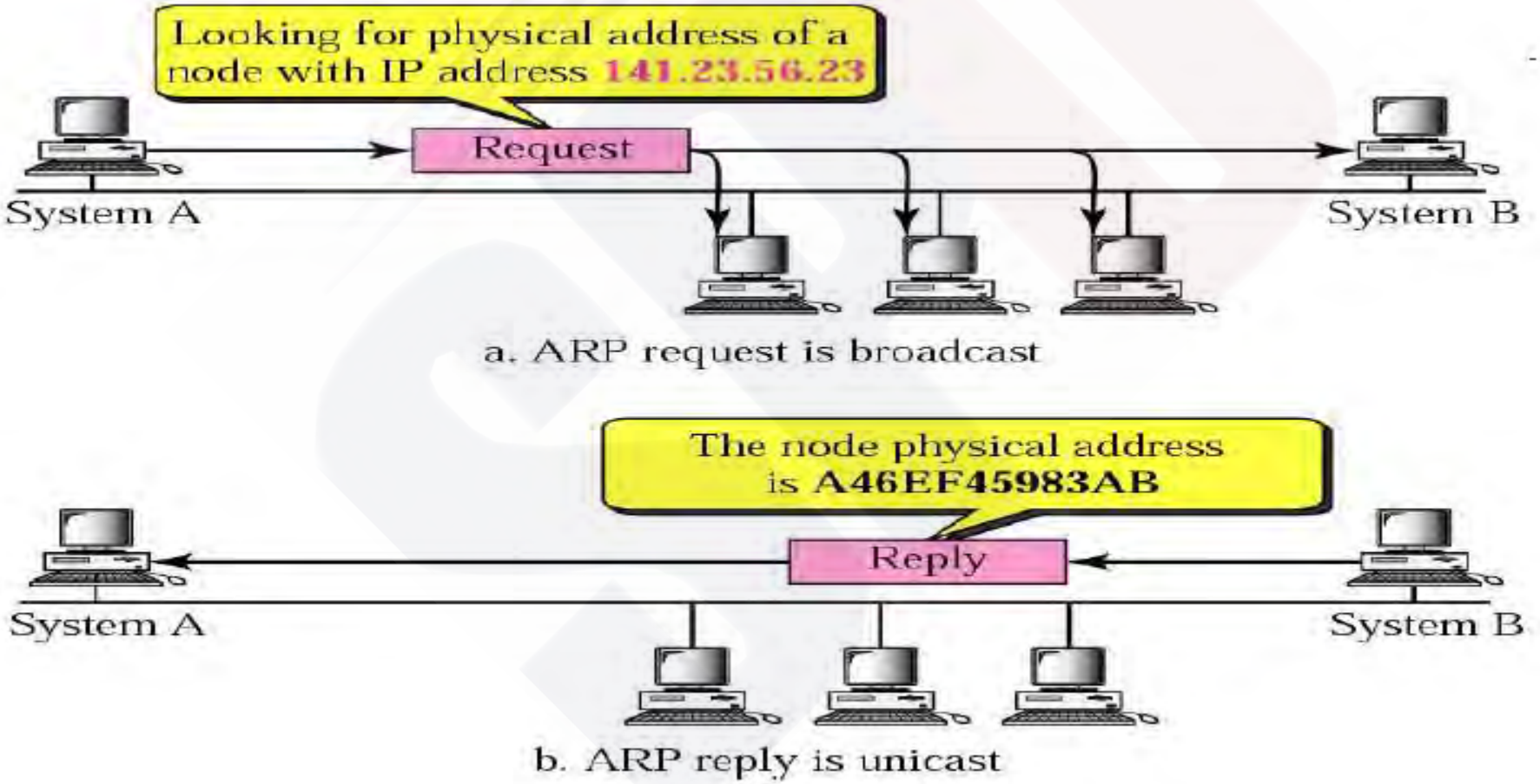
- To find the physical address of another host or router on its network
  - Send an ARP request message

- ARP request message
  - The physical address of the sender
  - The IP address of the sender
  - The physical address of the receiver is ***0s***
  - The IP address of the receiver

ARP Operation (Cont.)

- Then, ARP request message is broadcast by the physical layer
  - For example: in Ethernet, MAC header's destination address is all *1s (broadcast address)*
  - Received by every station on the physical network
- The intended recipient send back an ARP reply message
  - ARP reply message packet is ***unicast***

ARP Operation (Cont.)



ARP Packet

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)		

Packet Format

- **HTYPE** (Hardware type):
  - 16-bit field defining the underlying type of the network
    - Ethernet is given the type 1
    - ARP can be used on any physical network

- **PTYPE** (Protocol type)
  - 16-bit field defining the protocol
    - IPv4 is 0x(0800)
    - ARP can be used with any higher-level protocol
- **HLEN** (Hardware length)
  - 8-bit field defining the length of the physical address in bytes
    - Ethernet has the value of 6

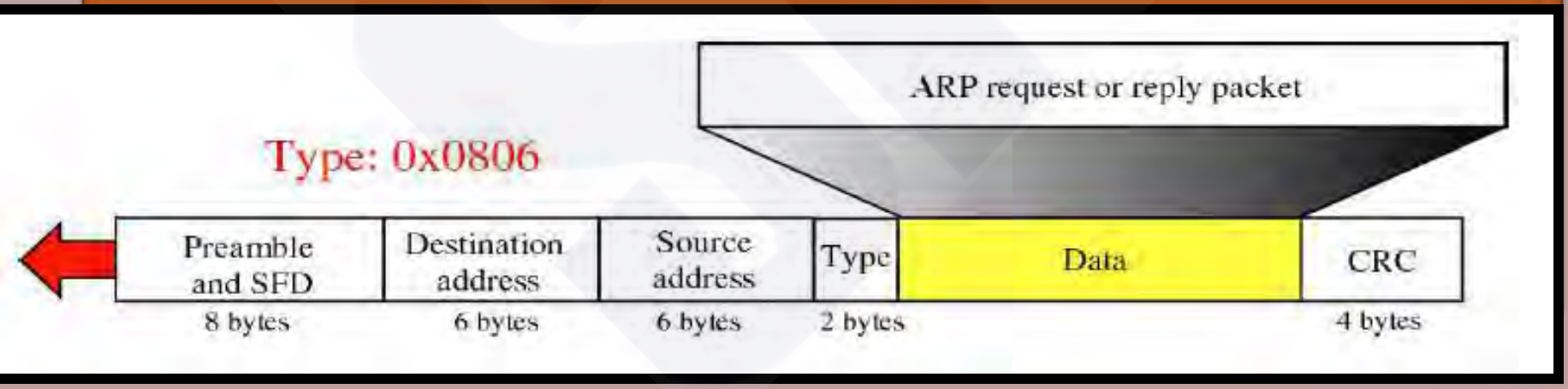
- **PLEN** (Protocol length)
  - 8-bit field defining the length of the logical address in bytes
    - IPv4 has the value of 4
- **OPER** (Operation)
  - 16-bit field defining the type of packet
    - (1) = ARP request, (2) = ARP reply

- **SHA** (Sender hardware address)
  - A variable-length field defining the physical address of the sender
- **SPA** (Sender protocol address)
  - A variable-length field defining the logical address of the sender

- **THA** (Target hardware address)
  - A variable-length field defining the physical address of the target
  - For an ARP request operation packet
    - ***This field is all 0s***
- **TPA** (Target protocol address)
  - A variable-length field defining the logical address of the target

Encapsulation of ARP Packet

- An ARP packet is encapsulated directly into a data link frame
- Type field indicates that the data carried by the frame is an ARP packet.



Operations

- The sender knows the target's IP address
- IP asks ARP to create an ARP request message:
  - The sender physical address
  - The sender IP address
  - The target physical address field is filled with 0s
  - The target IP address
- The message is passed to the data link layer to encapsulate in a data link frame
  - **Physical destination address is" *broadcast address"***

Operations (Cont.)

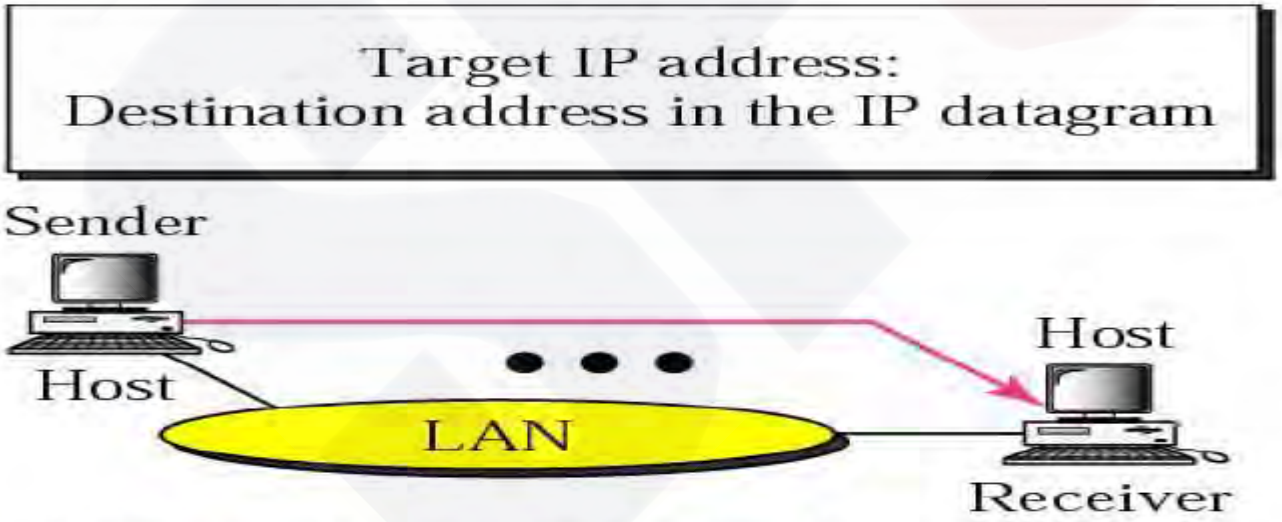
- Every host or routers receives the frame and since the destination address is broadcast, pass it to the ARP
  - All machines' ARP except the one targeted drop the Packet
- The target reply with an ARP reply message that contains its physical address and is unicast
- The sender receives the reply message and knows the target's physical address

Four Cases to Use ARP

- ***Case 1:***

  The sender is a host and wants to send a packet to another host on the same network

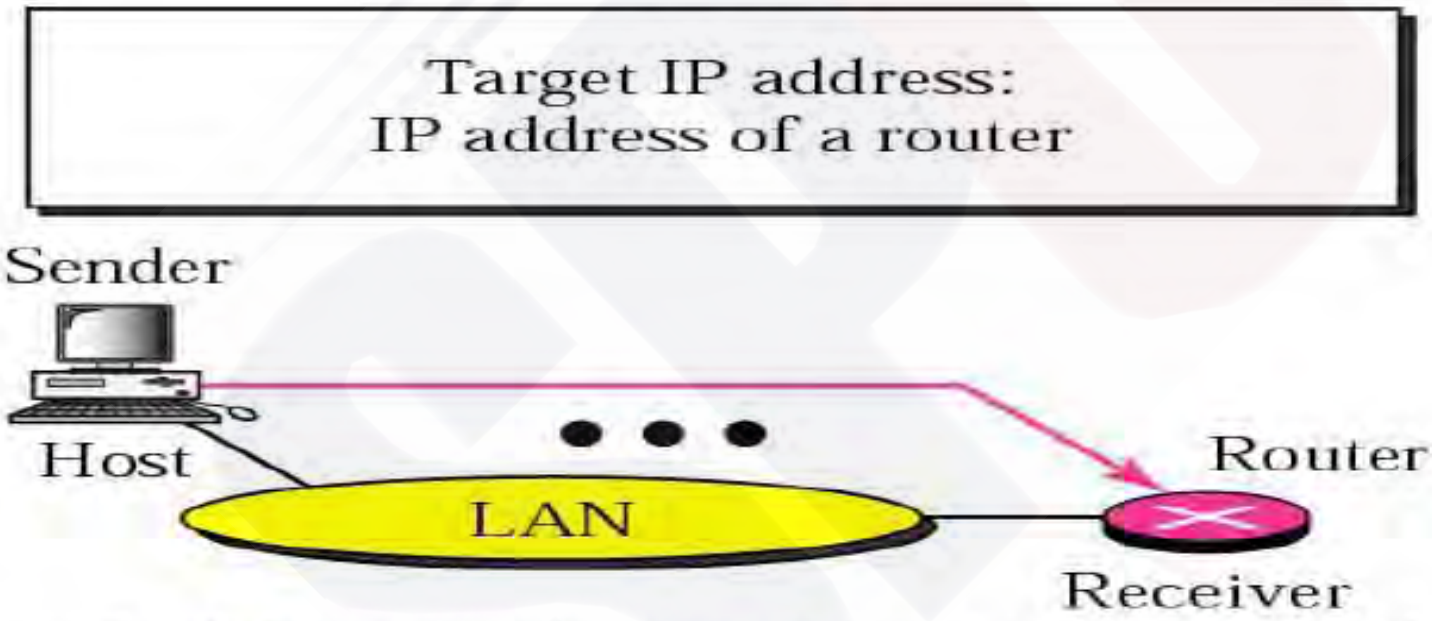
Use ARP to find another host's physical address



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

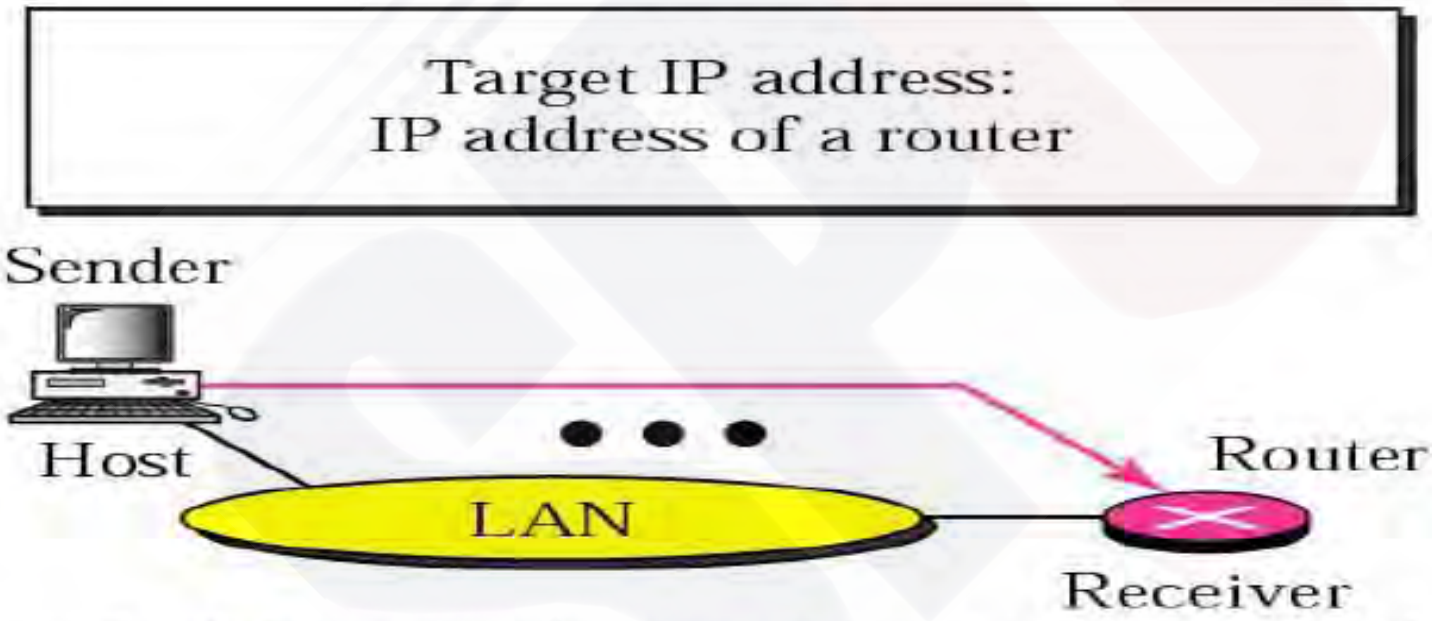
- ***Case 2:***

The sender is a host and wants to send a packet to another host on another network



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

- Sender looks at its routing table
- Find the IP address of the next hop (router) for this destination
- Use ARP to find the router's physical address



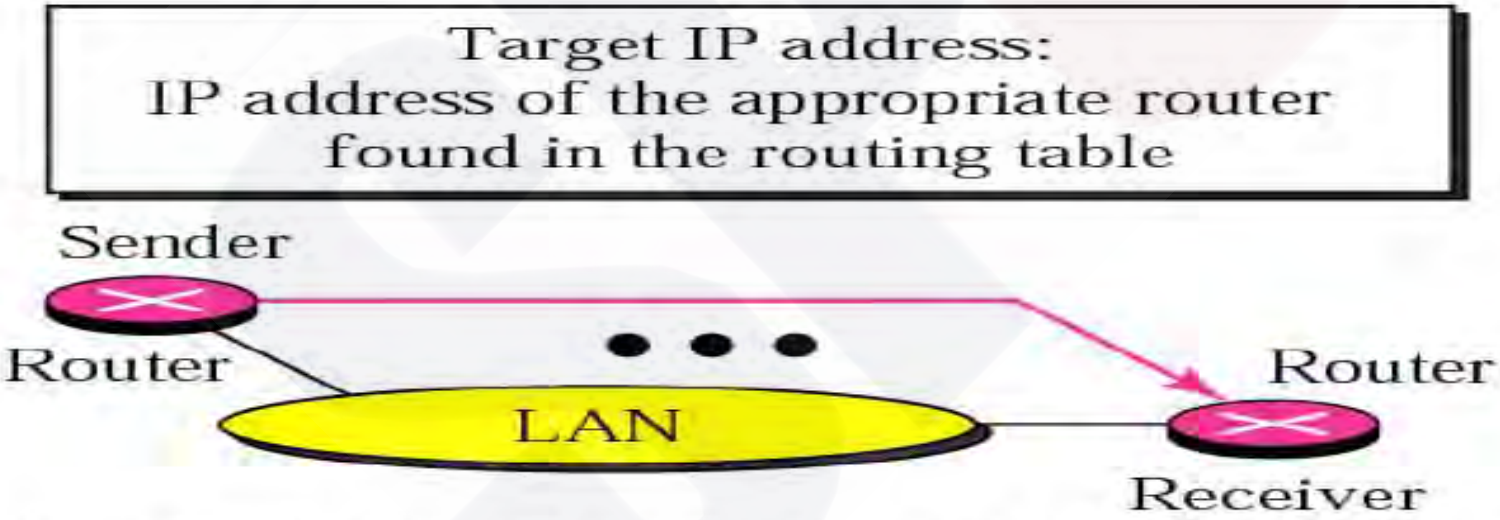
Case 2. A host wants to send a packet to another host on another network.
It must first be delivered to a router.

- ***Case 3:***

  the sender is a router and received a datagram

  destined for a host on another network

- Router check its routing table
- Find the IP address of the next router
- Use ARP to find the next router's physical address

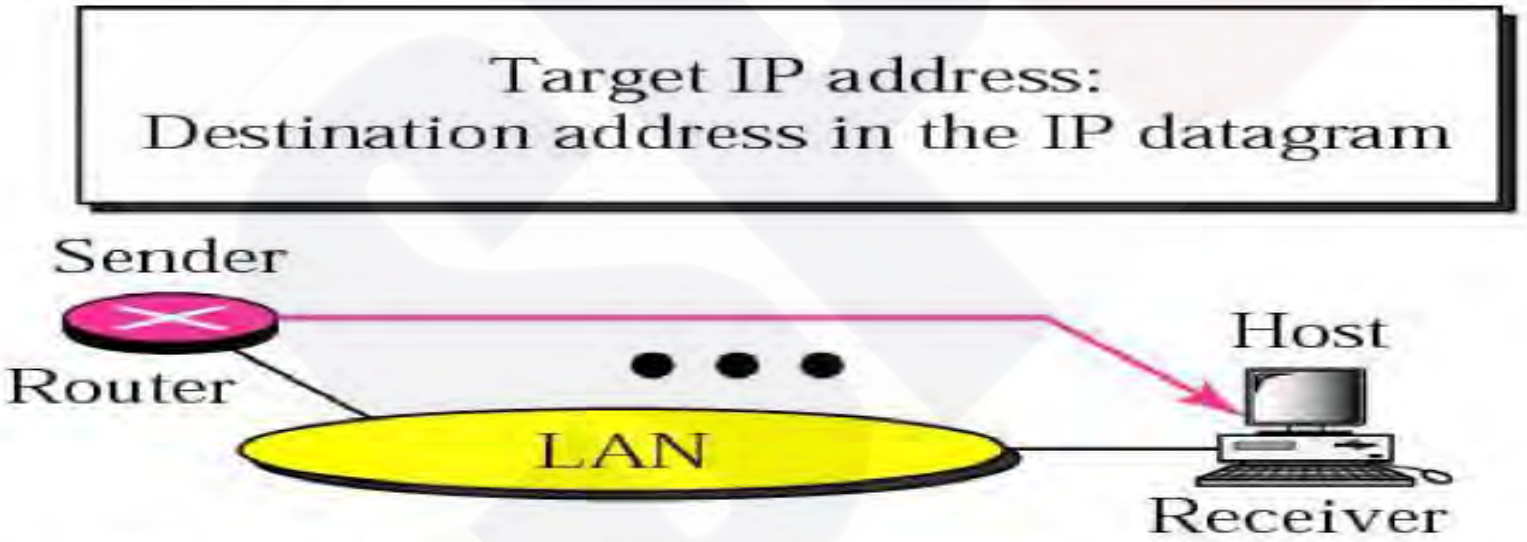


Case 3. A router receives a packet to be sent to a host on another network. It must first be delivered to the appropriate router.

- ***Case 4:***

  the sender is a router that has received a datagram destined for a host in the same network

Use ARP to find this host's physical address



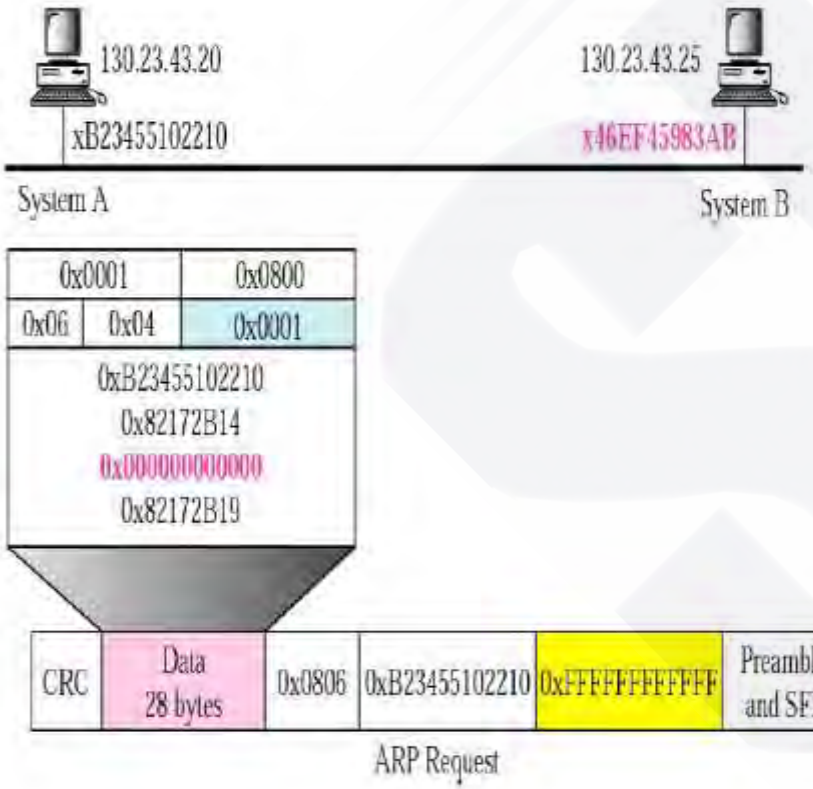
Case 4. A router receives a packet to be sent to a host on the same network.

Example 1

- A host with IP address 130.23.43.20 and physical address 0xB2:34:55:10:22:10
- Another host with IP address 130.23.43.25 and physical address 0xA4:6E:F4:59:83:AB.
- The two hosts are on the same Ethernet Network
- **Show the ARP request and reply packets encapsulated in Ethernet frames**

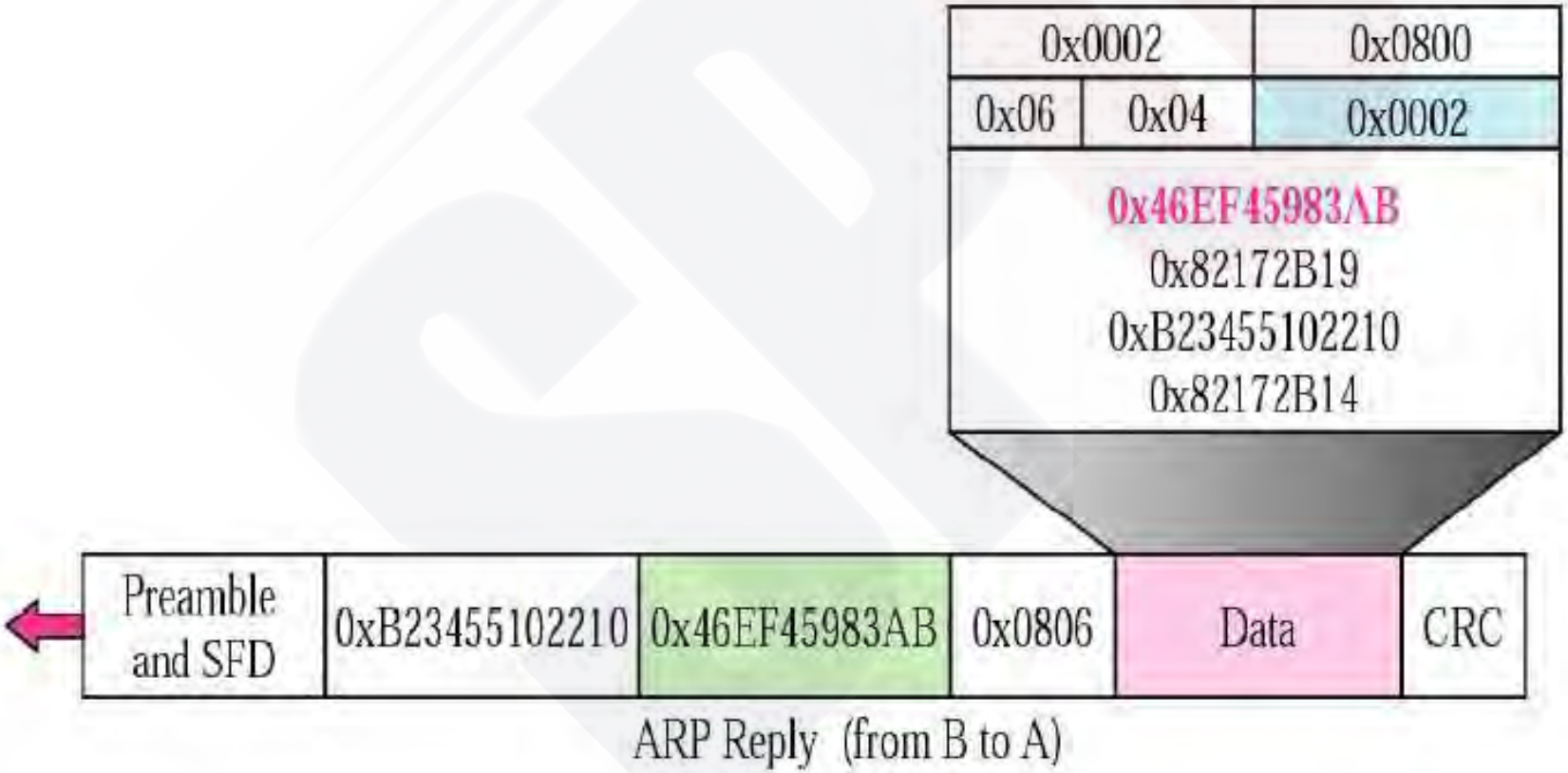
Solution

Request:



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)		

reply:


0x0002
0x0800
0x06
0x04
0x0002
0x46EF45983AB
0x82172B19
0xB23455102210
0x82172B14
Preamble and SFD
0xB23455102210
0x46EF45983AB
0x0806
Data
CRC
ARP Reply (from B to A)

examples

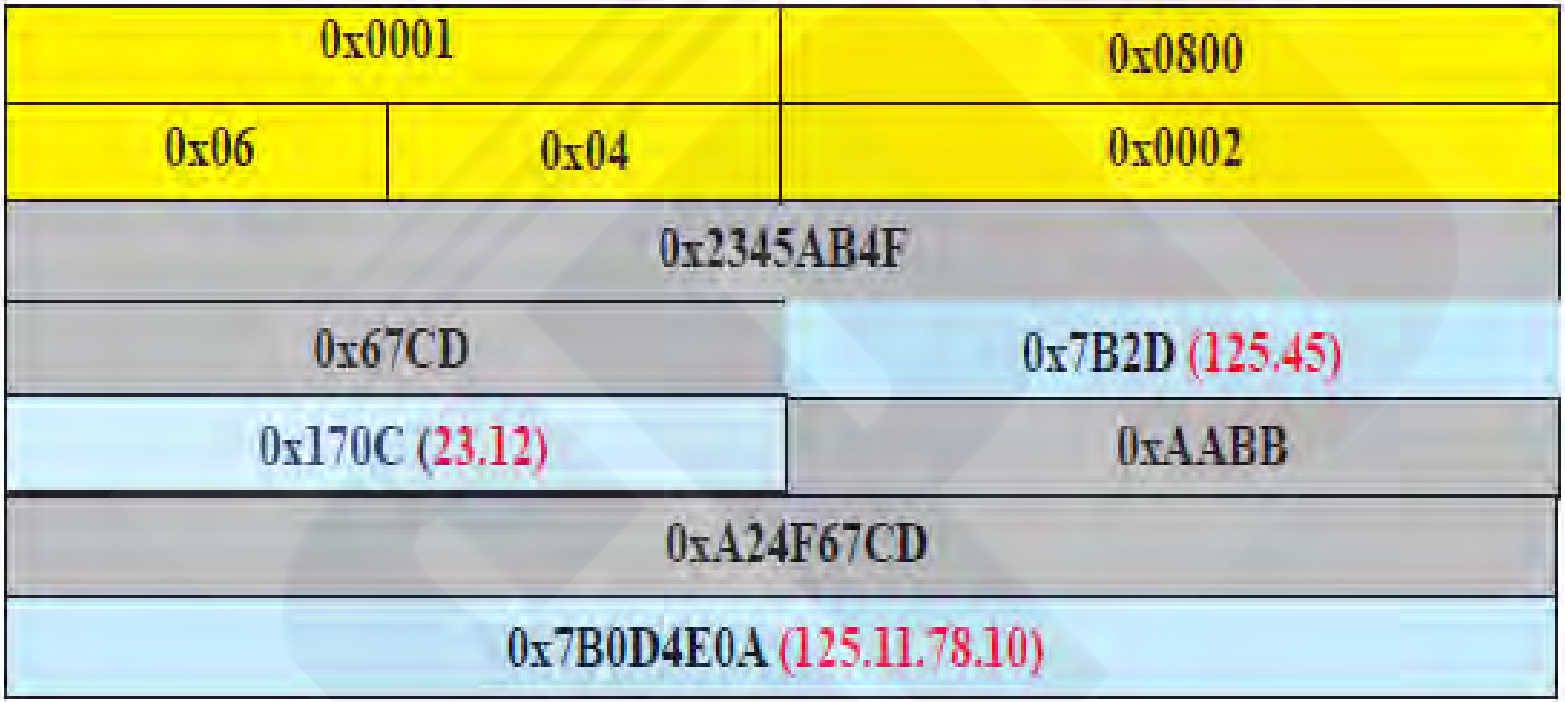
A router with IPv4 address (125.45.23.12) and Ethernet physical address 23: 45 : AB: 4F : 67: CD has received a packet for a host destination with IP address (125.11.78.10). Show the entries in the ARP request packet sent by the router. Assume no sub-netting

0x0001		0x0800
0x06	0x04	0x0001
0x2345AB4F		
0x67CD		0x7B2D (125.45)
0x170C (23.12)		0x0000
0x00000000		
0x7B0D4E0A (125.11.78.10)		

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)		

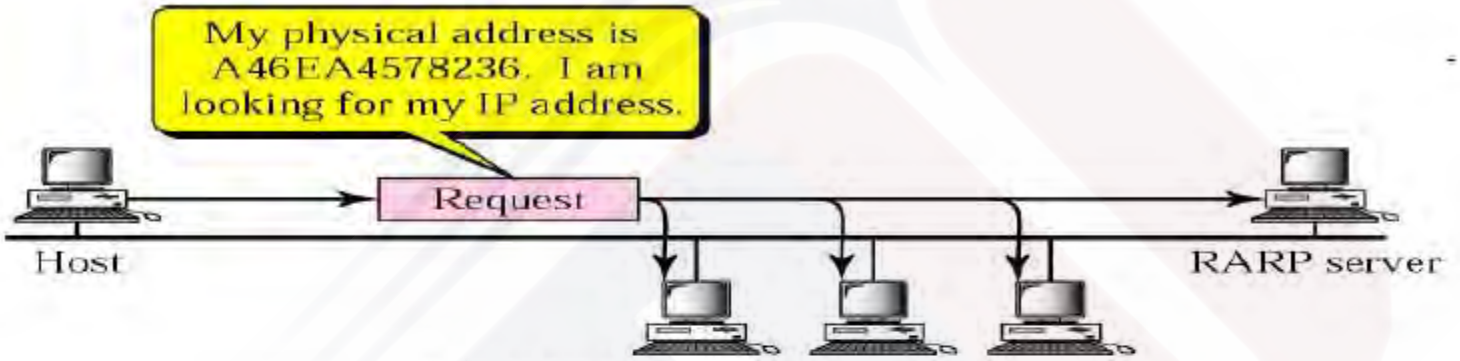
0x0001		0x0800
0x06	0x04	0x0001
0x2345AB4F		
0x67CD		0x7B2D (125.45)
0x170C (23.12)		0x0000
0x00000000		
0x7B0D4E0A (125.11.78.10)		

Show the entries in the ARP packet sent in response

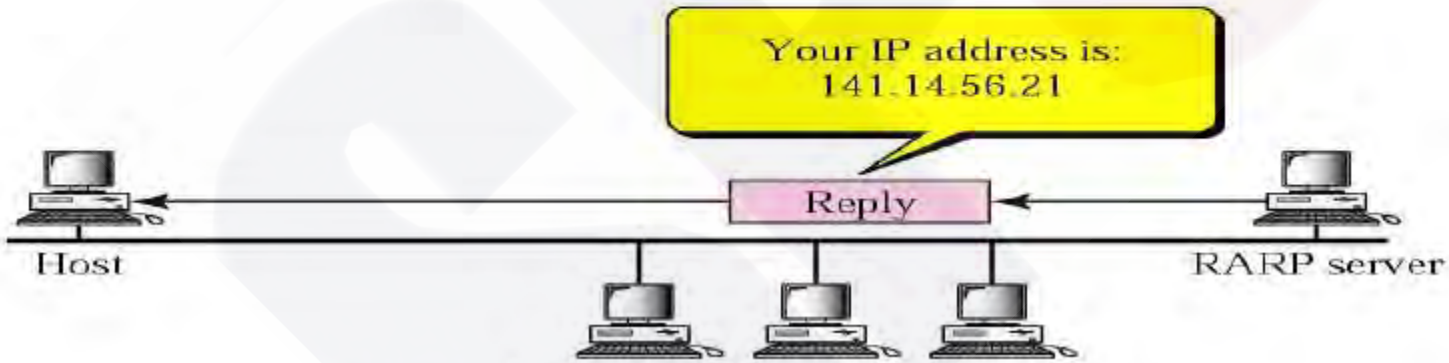


RARP

- A diskless machine is usually booted from ROM
- It cannot include the IP address
  - IP address are assigned by the network Administrator
- Obtain its logical address by the physical address using the RARP protocol



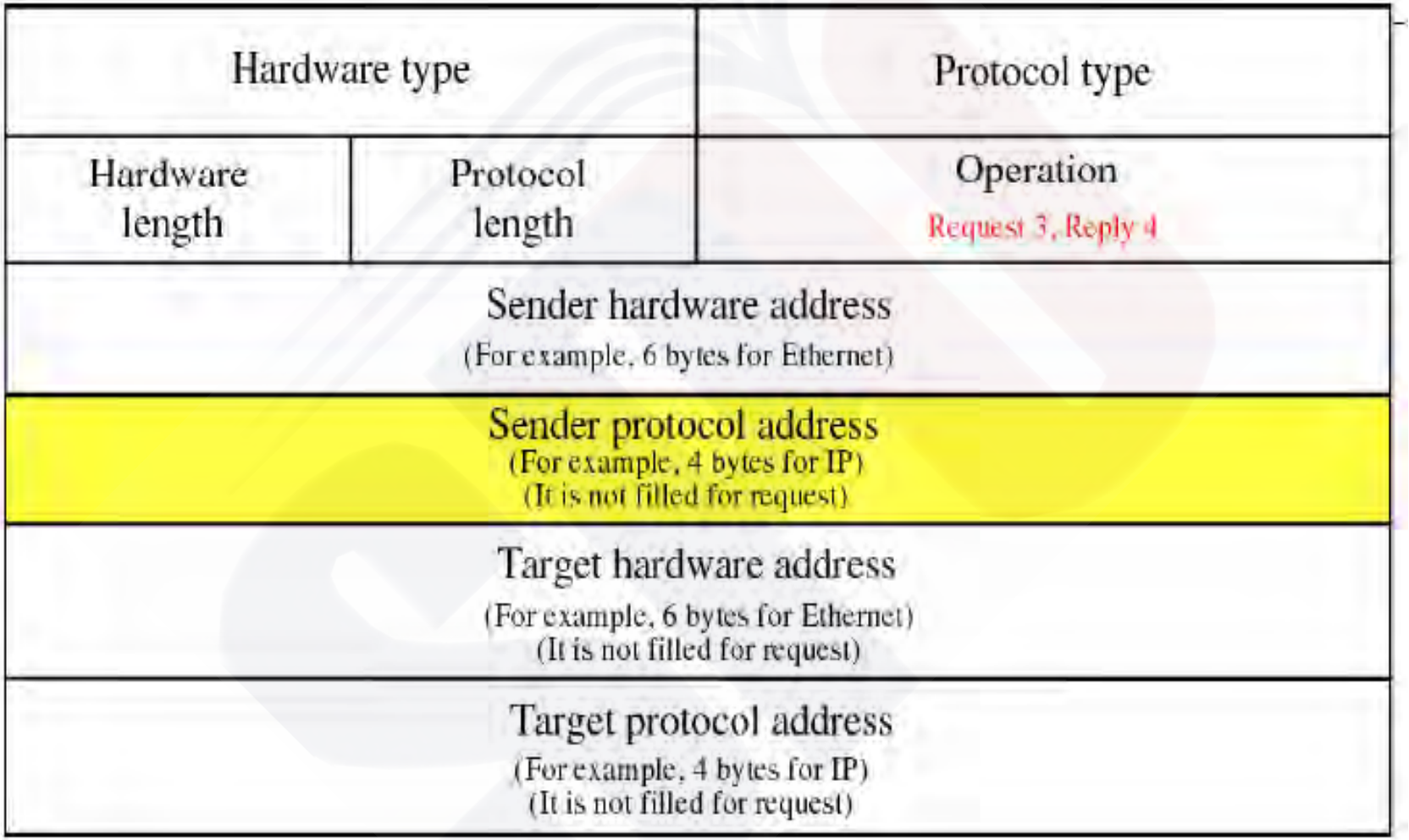
a. RARP request is broadcast



b. RARP reply is unicast

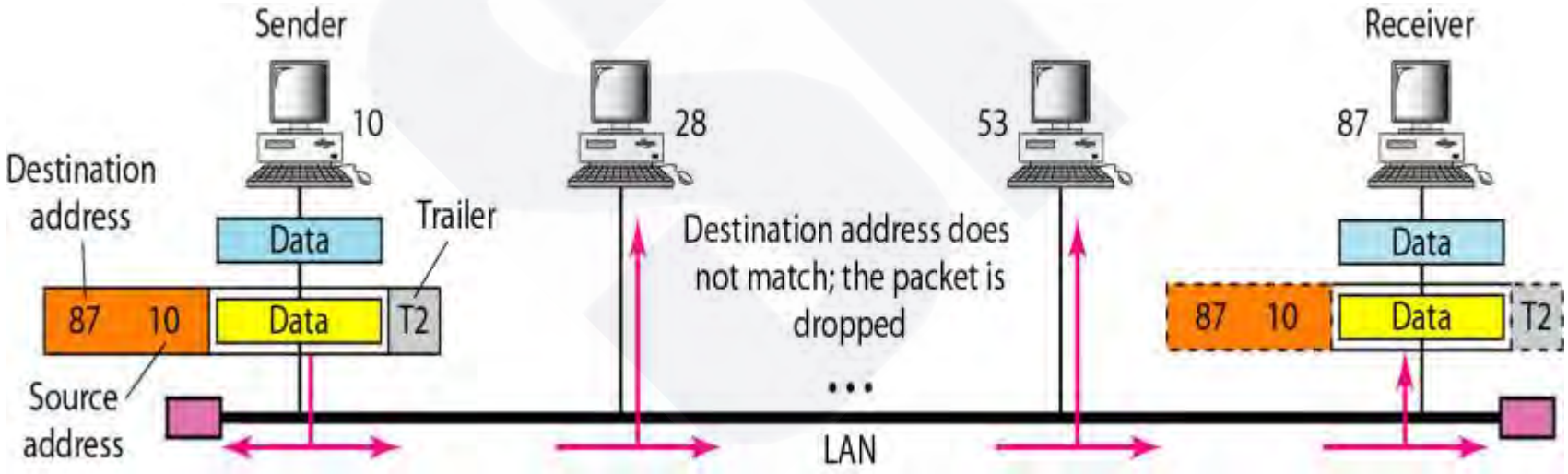
Packet Format

- The format of the RARP packet is the same as the ARP packet
- Except that the operation field is
  - Three for RARP request message
  - Four for RARP reply message


Hardware type
Protocol type
Hardware length
Protocol length
Operation
Request 3, Reply 4
Sender hardware address
(For example, 6 bytes for Ethernet)
Sender protocol address
(For example, 4 bytes for IP)
(It is not filled for request)
Target hardware address
(For example, 6 bytes for Ethernet)
(It is not filled for request)
Target protocol address
(For example, 4 bytes for IP)
(It is not filled for request)

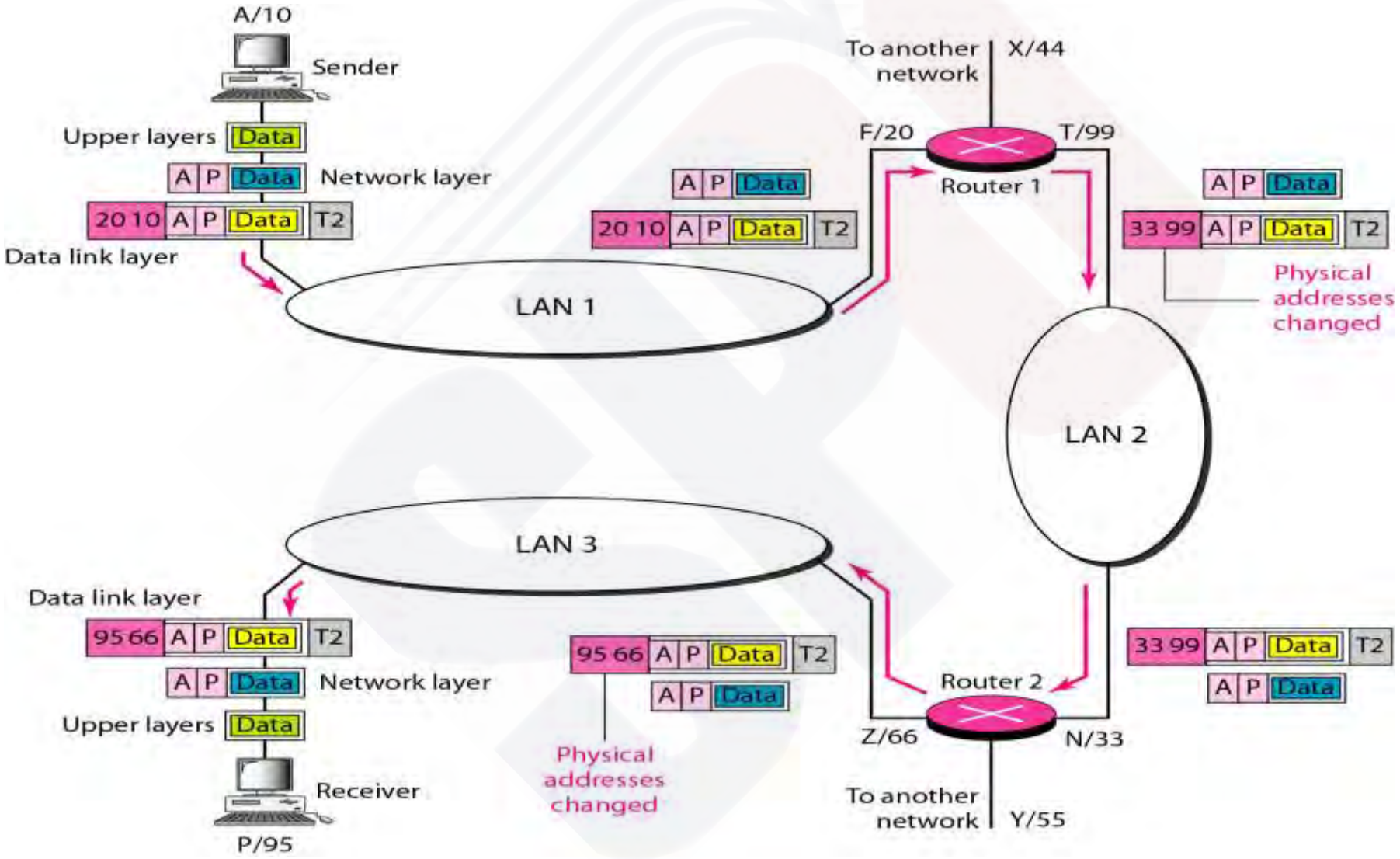
Example

- In Figure : a node with physical address 10 sends a frame to a node with physical address 87.
- The two nodes are connected by a link (bus topology LAN).
- As the figure shows, the computer with physical address 10 is the sender, and the computer with physical address 87 is the receiver.



Example 2.3

- Figure shows a part of an internet with two routers connecting three LANs.
- Each device (computer or router) has a pair of addresses (logical and physical) for each connection.
- In this case, each computer is connected to only one link and therefore has only one pair of addresses.
- Each router, however, is connected to three networks (only two are shown in the figure).
- So each router has three pairs of addresses, one for each connection.


A/10
Sender
Upper layers
Data
A P Data
Network layer
20 10 A P Data T2
Data link layer
LAN 1
To another network
X/44
F/20
T/99
Router 1
A P Data
20 10 A P Data T2
A P Data
33 99 A P Data T2
Physical addresses changed
LAN 2
LAN 3
Data link layer
95 66 A P Data T2
A P Data
Network layer
Upper layers
Data
Receiver
P/95
95 66 A P Data T2
A P Data
Physical addresses changed
Router 2
Z/66
N/33
33 99 A P Data T2
A P Data
To another network
Y/55