ARP and RARP

CONTENTS

- **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 internetwork 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
- Examples
  48-bit MAC 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

- **Static mapping means creating a table that associates a logical address with a physical address.**
- This table is stored in each machine on the network. Each machine that knows, for example, the IP address of another machine but not its physical address can look it up in the table.
- This has some limitations because physical addresses may change in the following ways:
- **1. A machine could change its NIC, resulting in a new physical address.**
- **2. In some LANs, such as LocalTalk, the physical address changes every time the computer is turned on.**
- **3. A mobile computer can move from one physical network to another, resulting in a change in its physical address.**

- To implement these changes, a static mapping table must be updated periodically. This overhead could affect network performance.

DYNAMIC MAPPING

- In **dynamic mapping, each time a machine knows the logical address of another machine,** it can use a protocol to find the physical address.
- Two protocols have been designed to perform dynamic mapping:

- **Address Resolution Protocol (ARP) and**
- **Reverse Address Resolution Protocol (RARP).**

- **ARP maps a logical address to a physical address;**
- **RARP** maps a physical address to a logical address.

Figure 7-1

ARP and RARP

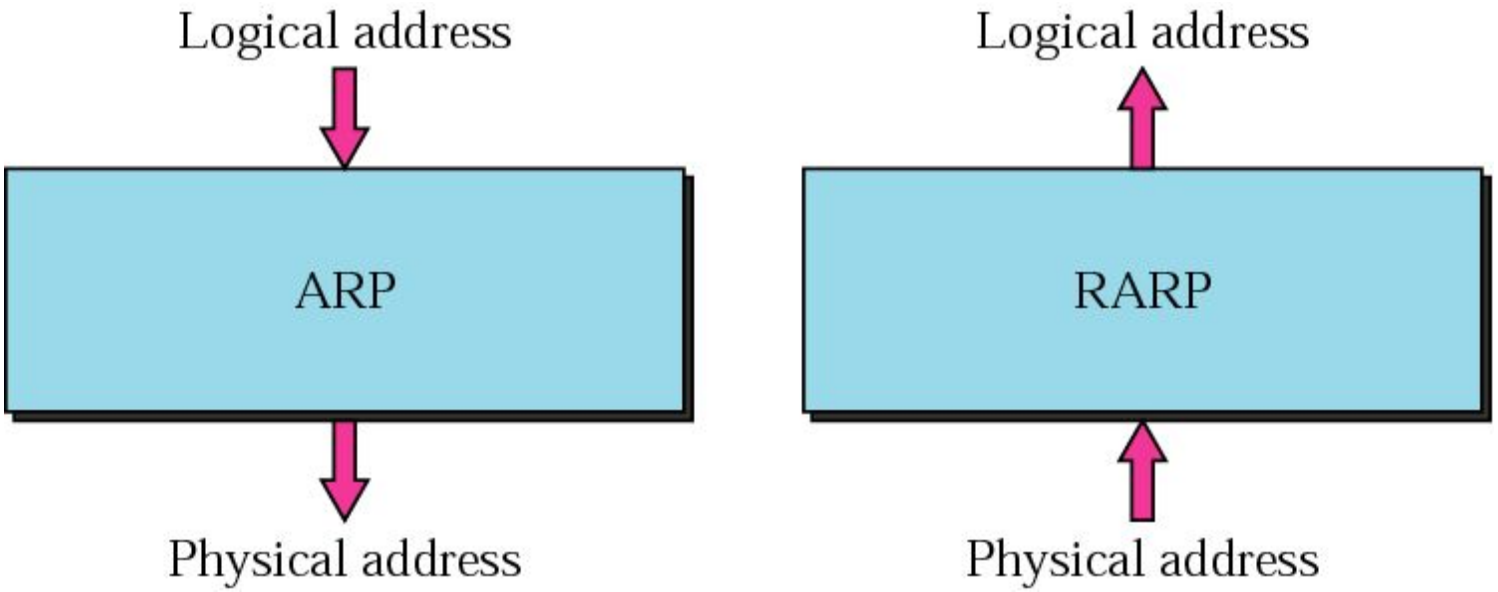
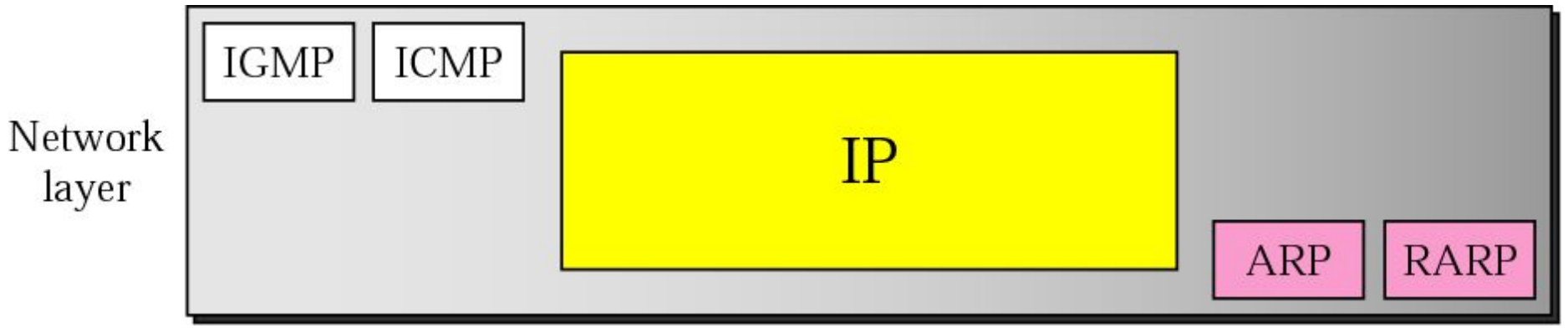


Figure 7-2

Position of ARP and RARP in TCP/IP protocol suite



7.1

A R P

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 IP address of the receiver

ARP Operation (Cont.)

- Then, ARP request message is broadcast by the physical layer
  - Received by every station on the physical network
- The intended recipient send back an ARP reply message
  - ARP reply message packet is ***unicast***

Figure 7-3

ARP operation

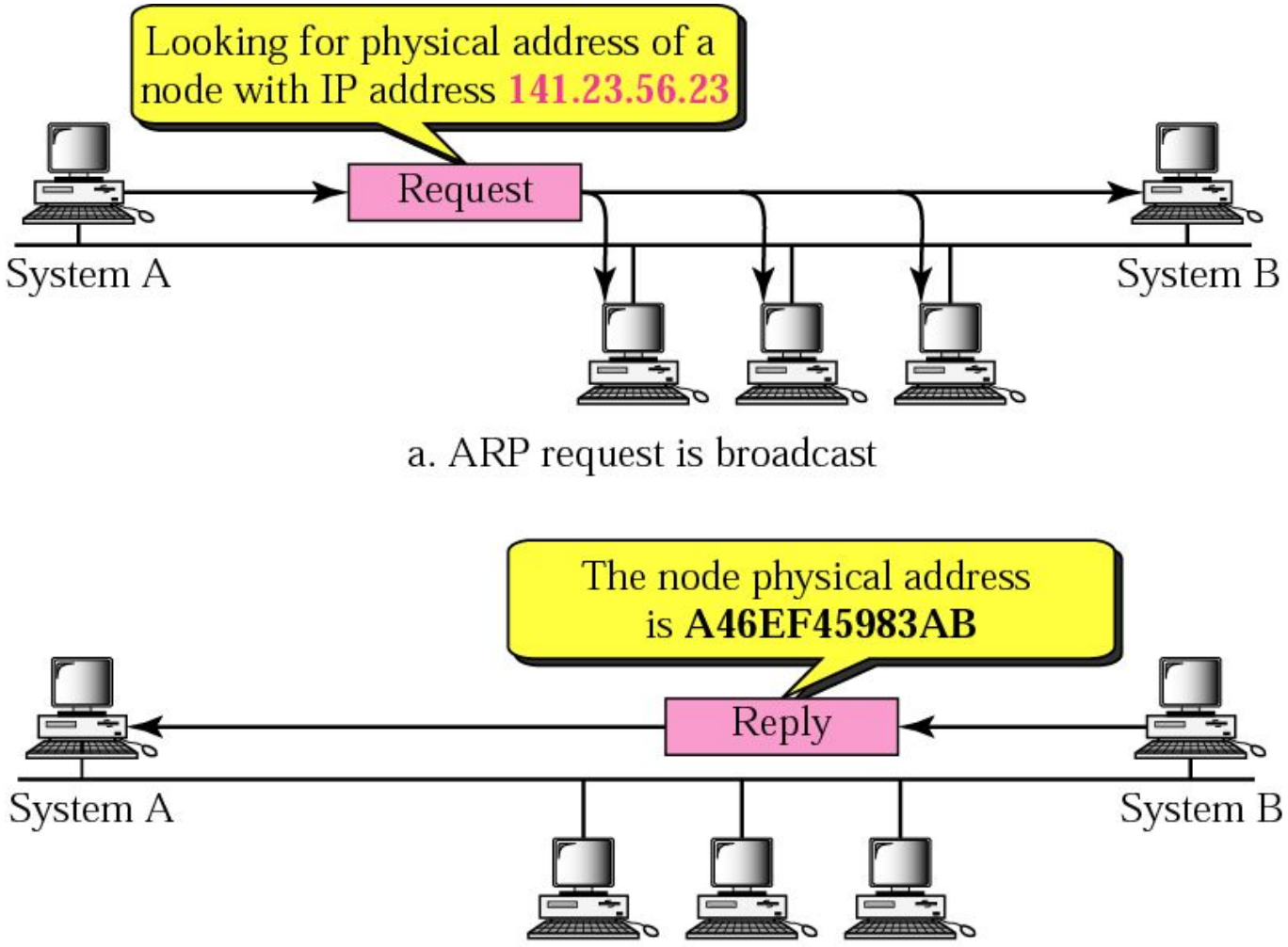
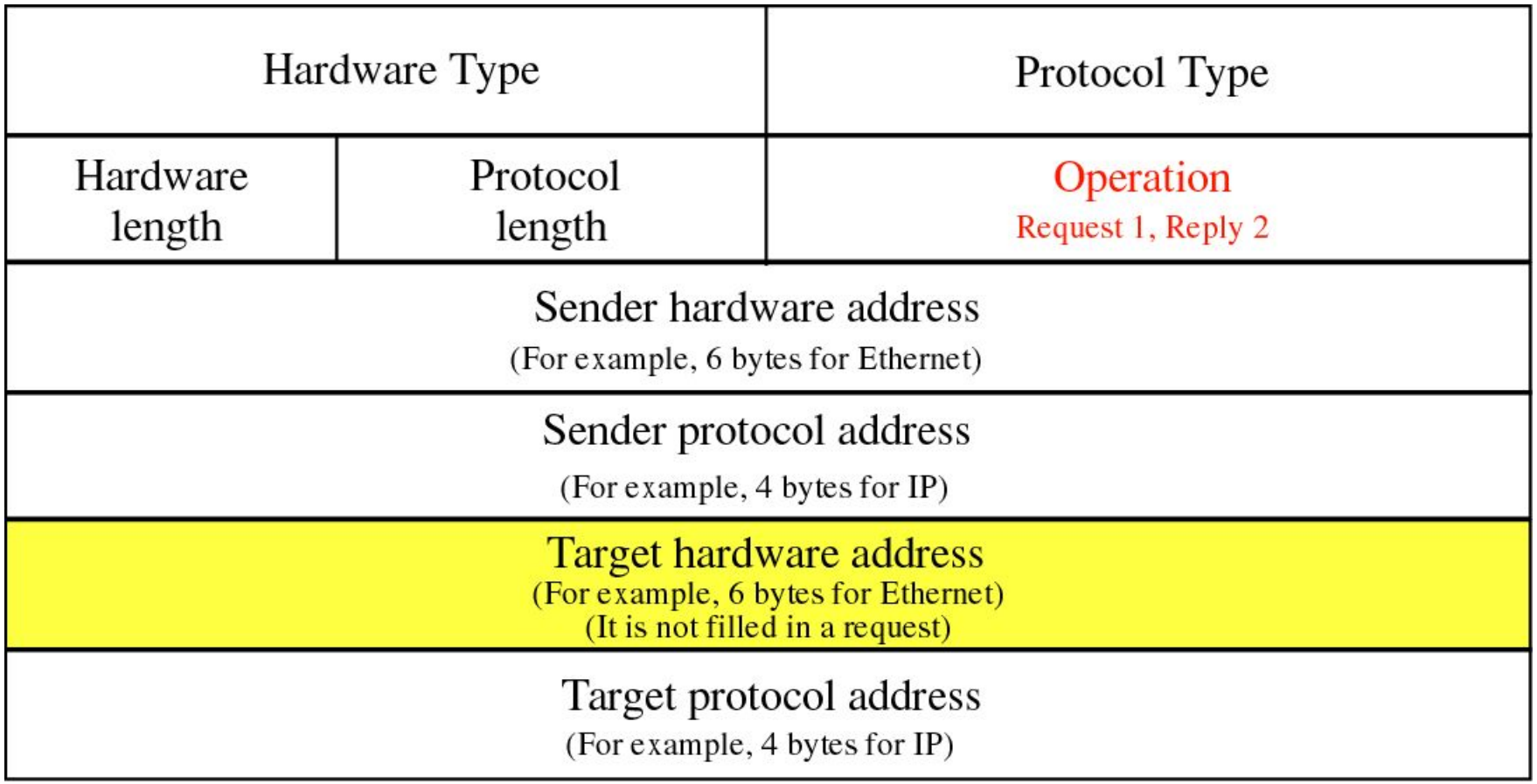


Figure 7-4

ARP packet



Packet Format

- HTYPE (Hardware type)
  - 16-bit field defining the underlying type of the network On which ARP is running.
    - Ethernet is given the type 1
    - ARP can be used on any physical network
- PTYPE (Protocol type)
  - 16-bit field defining the protocol

Packet Format (Cont.)

- 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

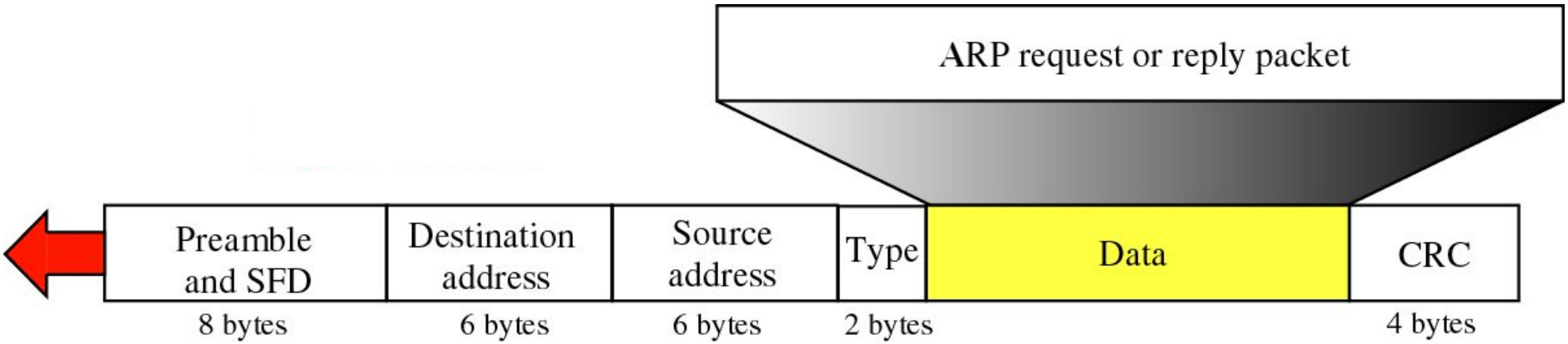
Packet Format (Cont.)

- 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

Packet Format (Cont.)

- 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

- The preamble consists of a 56-bit (seven-byte) pattern of alternating 1 and 0 bits, allowing devices on the network to easily synchronize their receiver clocks, providing bit-level synchronization.
- It is followed by the SFD to mark a new incoming frame.
- The SFD is the eight-bit (one-byte) value that marks the end of the preamble, which is the first field of an Ethernet packet, and indicates the beginning of the Ethernet frame. The SFD is designed to break the bit pattern of the preamble and signal the start of the actual frame

Operation

- 7 steps involved in the process::
- The sender knows the IP address of the target.
- IP asks ARP to create an ARP request message,

✔ sender physical address,

✔ the sender IP address,

✔ the target IP address.

The target physical address field is filled with 0s.

- The message is passed to the data link layer where it is encapsulated in a frame using the physical address of the sender as the source address and the physical broadcast address as the destination address.

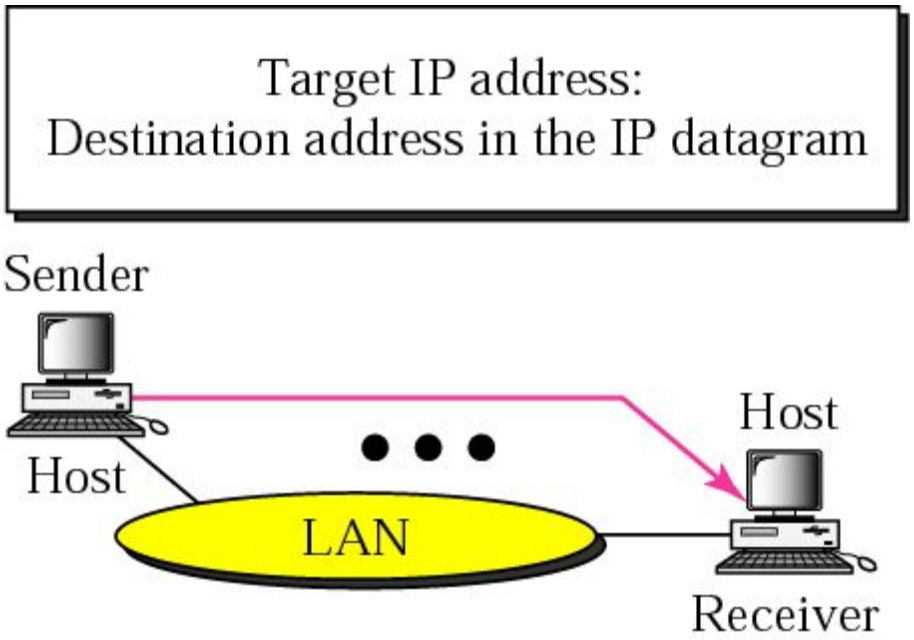
- Every host or router receives the frame. Because the frame contains a broadcast destination address, all stations remove the message and pass it to ARP. All machines except the one targeted drop the packet. The target machine recognizes the IP address.
- The target machine replies with an ARP reply message that contains its physical address. The message is unicast.
- The sender receives the reply message. It now knows the physical address of the target machine
- The IP datagram, which carries data for the target machine, is now encapsulated in a frame and is unicast to the destination

Four Different Cases

The following are four different cases in which the services of ARP can be used

Figure 7-6:a

Four cases using ARP



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

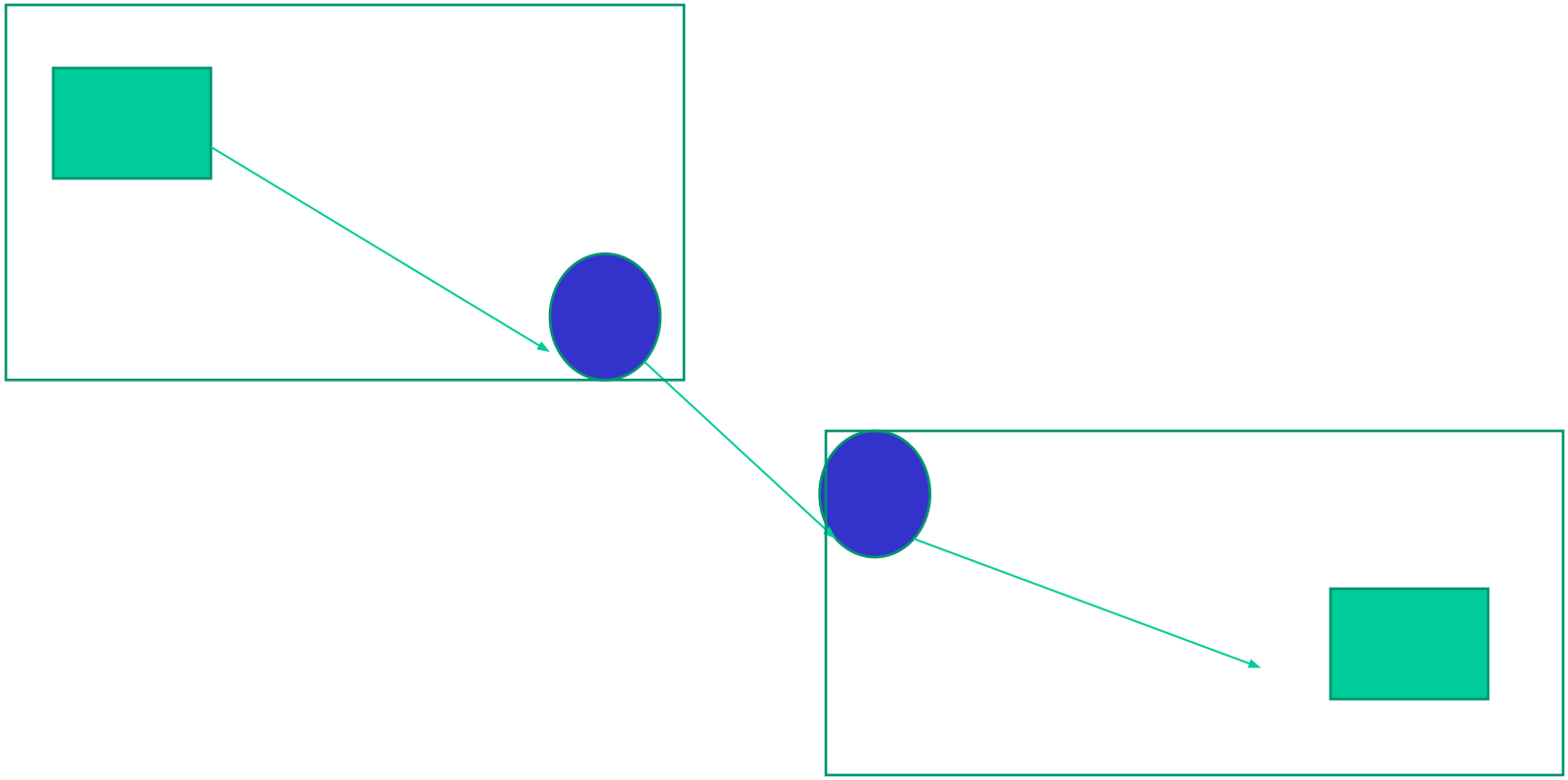
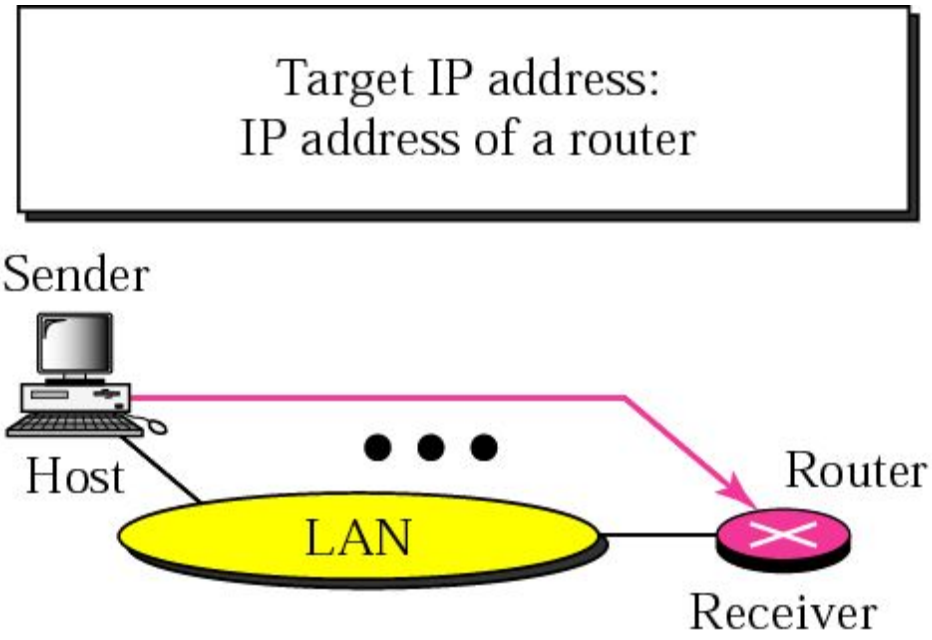


Figure 7-6:b

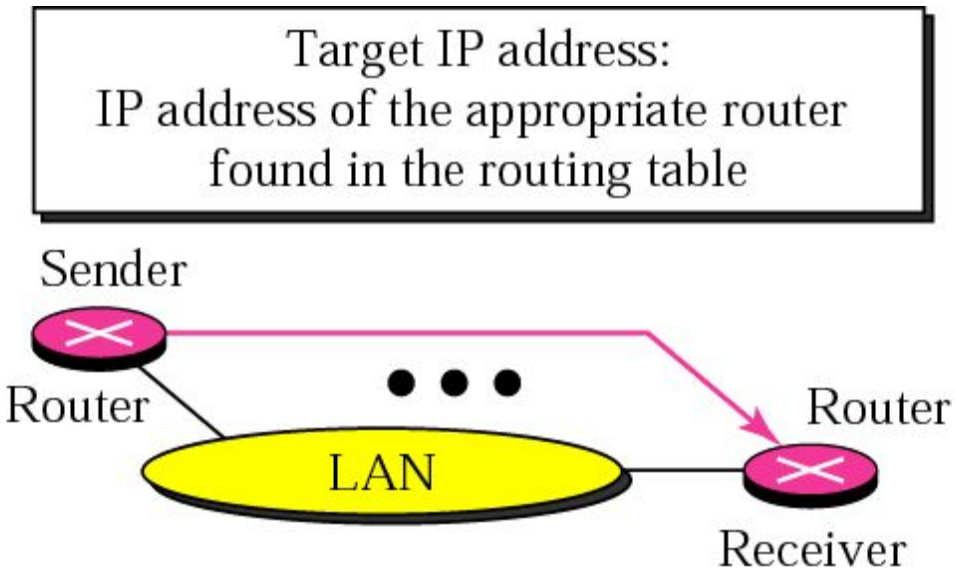
Four cases using ARP



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

Figure 7-6:c

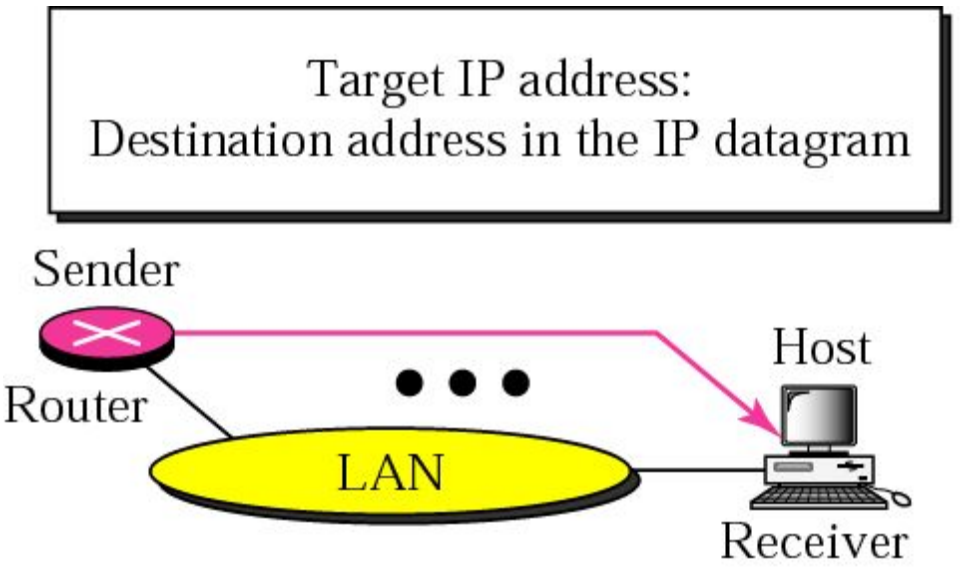
Four cases using ARP



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.

Figure 7-6:d

Four cases using ARP

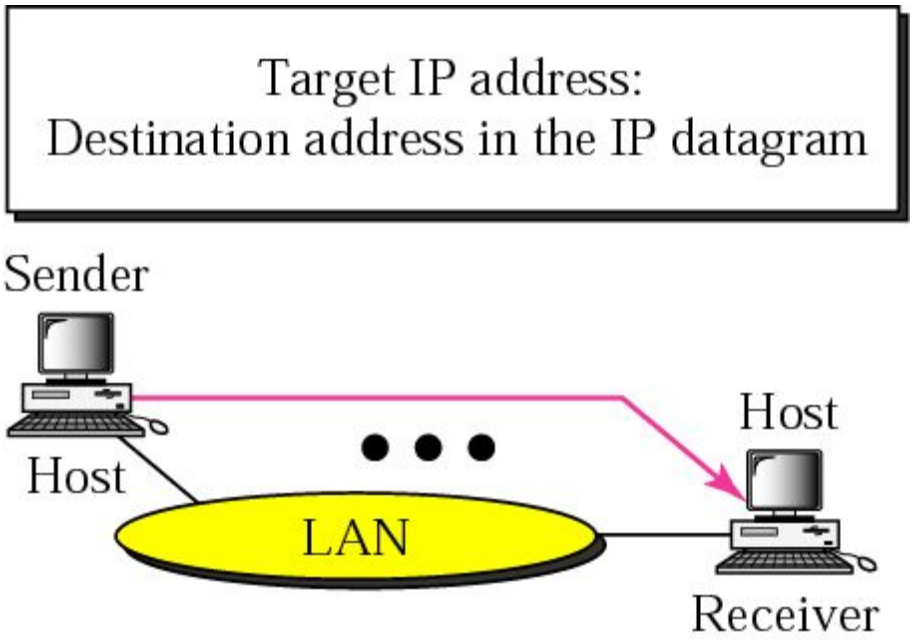


Case 4. A router receives a packet to be sent to a host on the same network.

- **Case 1: The sender is a host and wants to send a packet to another host on the same network.**
- In this case, the logical address that must be mapped to a physical address is the destination IP address in the datagram header.

Figure 7-6:a

Four cases using ARP

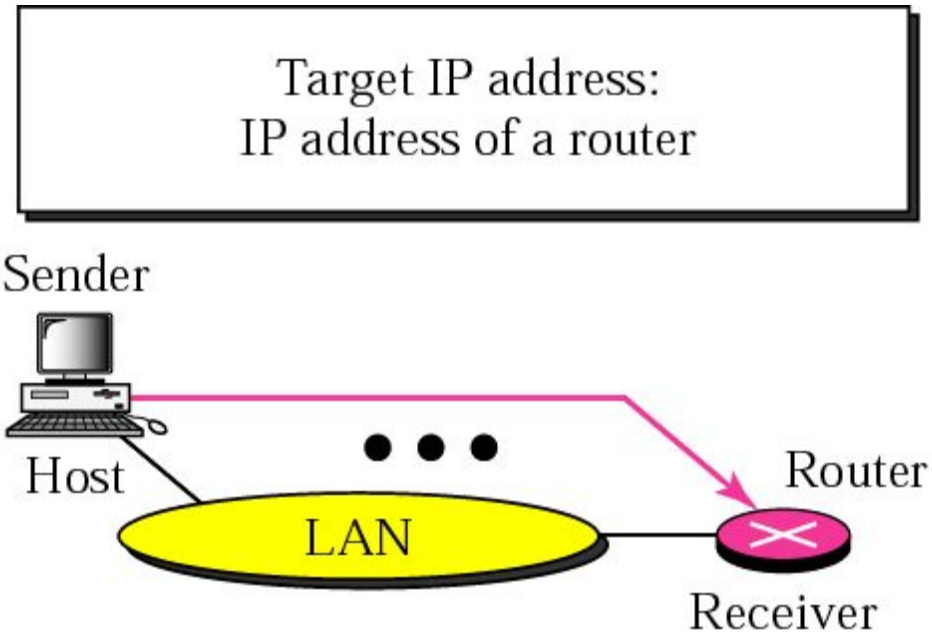


Case 1. A host has a packet to send to another host on the same network.

- **Case 2: The sender is a host and wants to send a packet to another host on another network.**
- In this case, the host looks at its routing table and finds the IP address of the next hop (router) for this destination.
- The IP address of the router becomes the logical address that must be mapped to a physical address.

Figure 7-6:b

Four cases using ARP

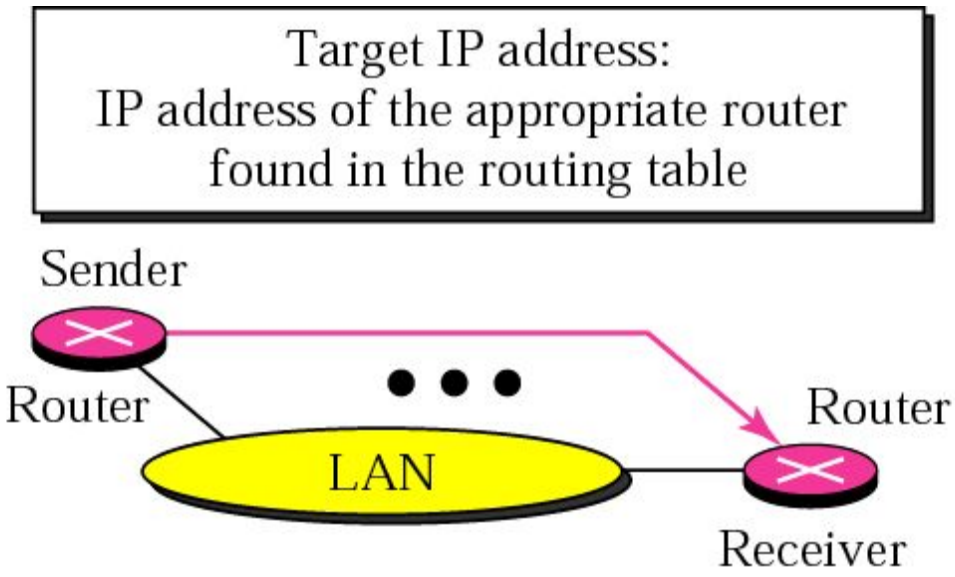


Case 2. A host wants to send a packet to another host on another network. It must first be delivered to a router.

- **Case 3: The sender is a router that has received a datagram destined for a host on another network**.
- It checks its routing table and finds the IP address of the next router.
- The IP address of the next router becomes the logical address that must be mapped to a physical address.

Figure 7-6:c

Four cases using ARP

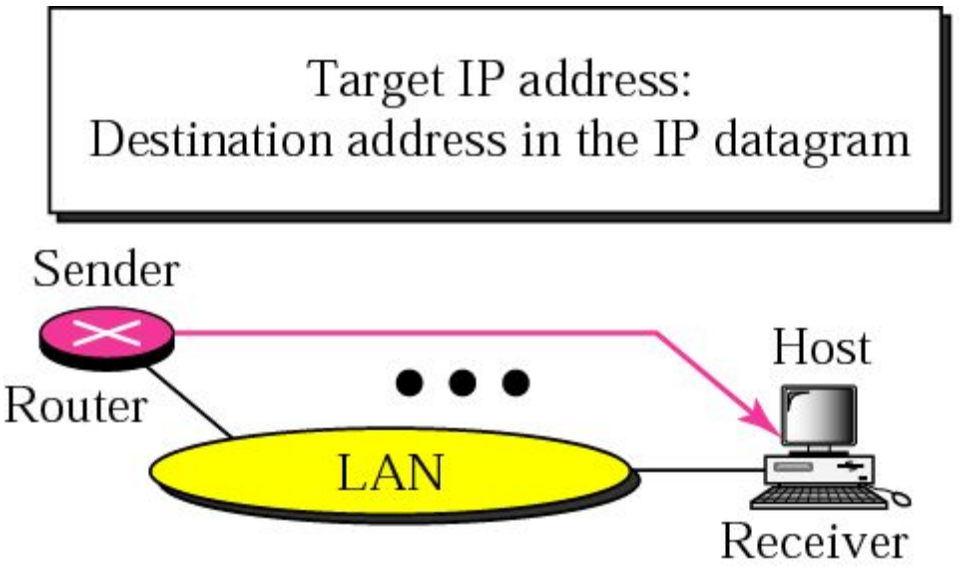


Case 3. A router receives a packet to be sent to a host on another network. It must first be delivered to the appropriate router.

- **Case 4: The sender is a router that has received a datagram destined for a host in the same network.**
- The destination IP address of the datagram becomes the logical address that must be mapped to a physical address.

Figure 7-6:d

Four cases using ARP



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

Note

An ARP request is broadcast;

an ARP reply is unicast.

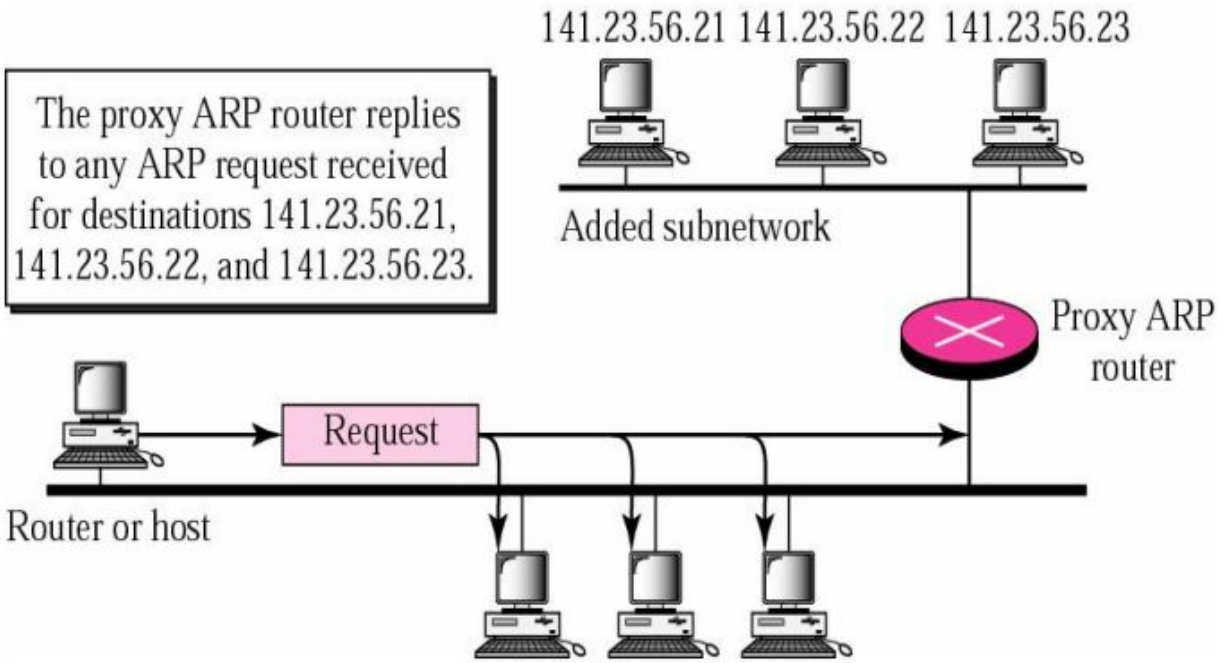
Proxy ARP

- Used to create a subnetting effect
- A router running a proxy ARP
  - Its ARP acts on behalf of a set of hosts
  - If it receives an ARP request message looking for the address of one of these host
    - The router sends an ARP reply announcing its own hardware (physical) address
  - After the router receives the actual IP packet
    - It sends the packet to the appropriate host or router

Figure 7-8

Proxy ARP

Proxy ARP



7.2

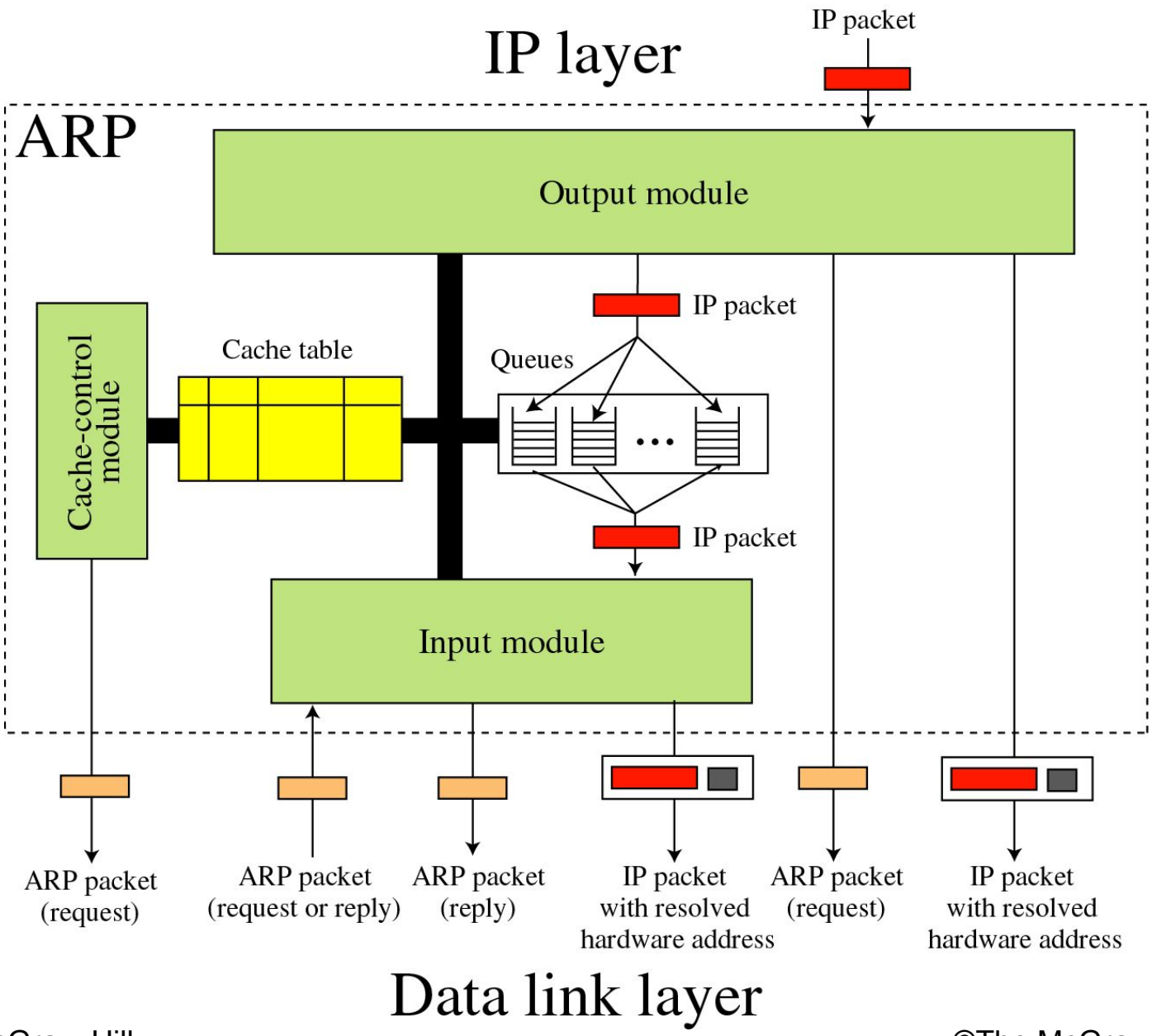
ARP PACKAGE

ARP Package

- Five components in an ARP package
  - A cache table
  - Queues
  - An output module
  - An input module
  - A cache-control module

Figure 7-9

ARP components



Cache Table

- Inefficient to use ARP to each datagram destined for the same host or router
  - Introduce the cache table

- Cache table: an array of entries that contains the following's entries

Content of a Cache Table Entry

- State: This column shows the state of the entry.
  - FREE: the time-to-live for this entry has expired
  - PENDING: a request for this entry has been sent, but the reply has not yet been received
  - RESOLVED: the entry is complete and valid
- Hardware type
- Protocol type
- Hardware length
- Protocol length
  - Above fields are all the same as in the ARP packet

- Interface number:

  A router can be connected to different networks, each with a different interface number.

Content of a Cache Table Entry (Cont.)

- Queue number: ARP uses numbered queues to enqueue the packet waiting for address resolution
- Attempts: the number of times an ARP request is sent out for this entry
- Time-out: the lifetime of an entry in seconds
- Hardware address: the destination hardware address
- Protocol address: the destination IP address

Queues

- ARP package maintains a set of queues to hold the IP packets while ARP tries to resolve the hardware address
- Packets for the same destination are usually enqueued in the same queue
- The output module sends unsolved packets into the queue
- The input module removes a packet from the queue and sends it, with the resolved physical address, to data link layer for transmission

Output Module

- Wait for an IP packet
- Check the cache table if receiving a IP packet
  - If found and state = RESOLVED
    - Passed to the data link layer for transmission
  - If found and state = PENDING
    - Send packet to this queue and wait
  - If not found
    - Create an entry with state = PENDING
    - Create a queue and enqueue this packet
    - Send an ARP request

Input Module

- Wait until an ARP packet (request or reply) arrives and check the cache table
  - If found state = PENDING
    - Copy the target hardware address in the packet
    - Change the state to RESOLVED
    - Set the value of TIME-OUT for this entry
    - Dequeue the packets from the corresponding queue and set them to the data link layer

Input Module (Cont.)

- If found and state = RESOLVED

Already resolved he target hardware address

It then deques the packet and delivers them to data link layer for transmission.

- If not found
  - Create a new entry and adds it to the table
- If the packet is a request
- Send an ARP reply

Cache-Control Module

- Maintain the cache table by periodically check the cache table, entry by entry
- If state is PENDING
  - Increment the value of attempts by 1
  - If (attempts greater than maximum)
    - Change the state to FREE and Destroy the corresponding queue
  - Else
    - Send an ARP request

Cache-Control Module (Cont.)

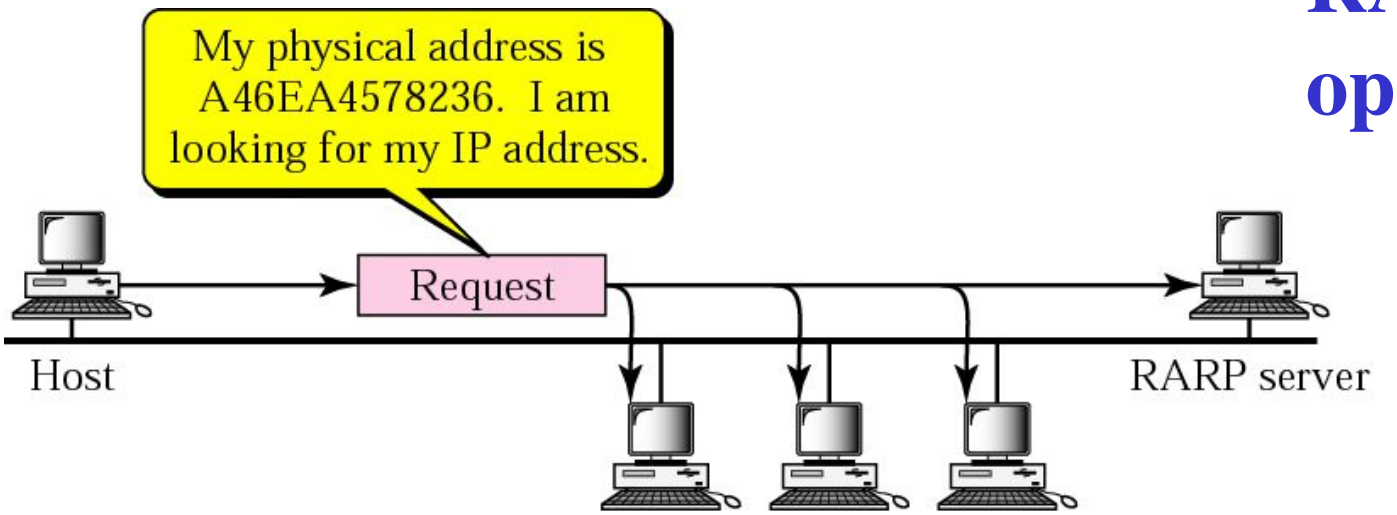
- If state is RESOLVED
  - Decrement the value of time-out by the value of elapsed time
  - If (time-out <= 0)
    - Change the state to FREE
    - Destroy the corresponding queue
- If state is FREE
  - Continue to the next entry

7.3

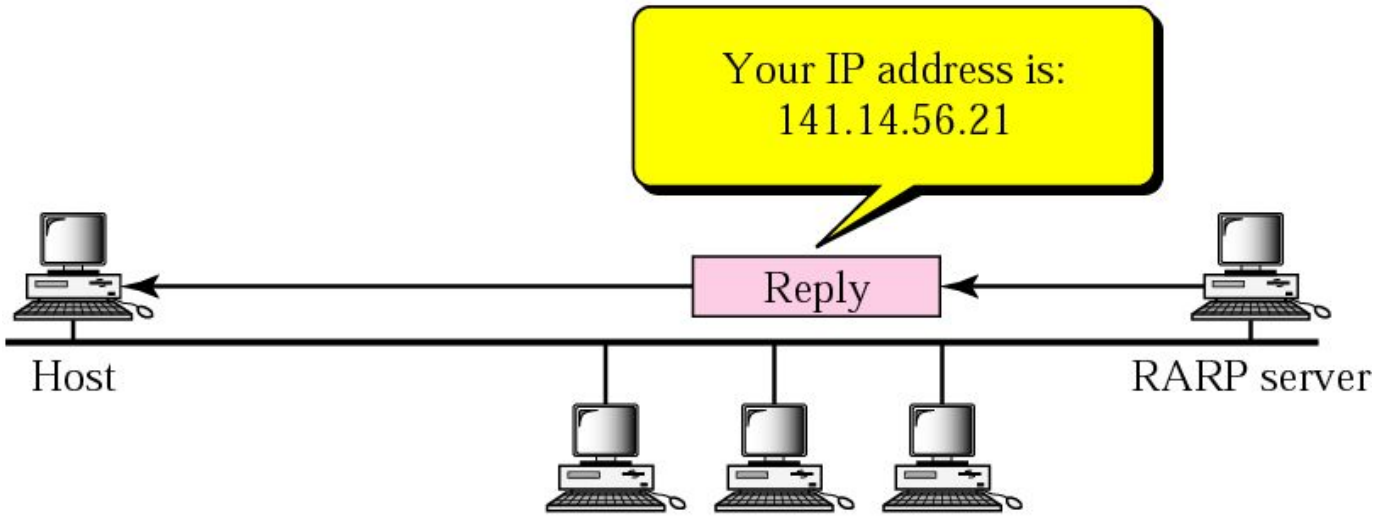
RARP

Figure 7-10

RARP operation



a. RARP request is broadcast



b. RARP reply is unicast

Note

The RARP request packets are broadcast; the RARP reply packets are unicast.

Figure 7-11

RARP packet

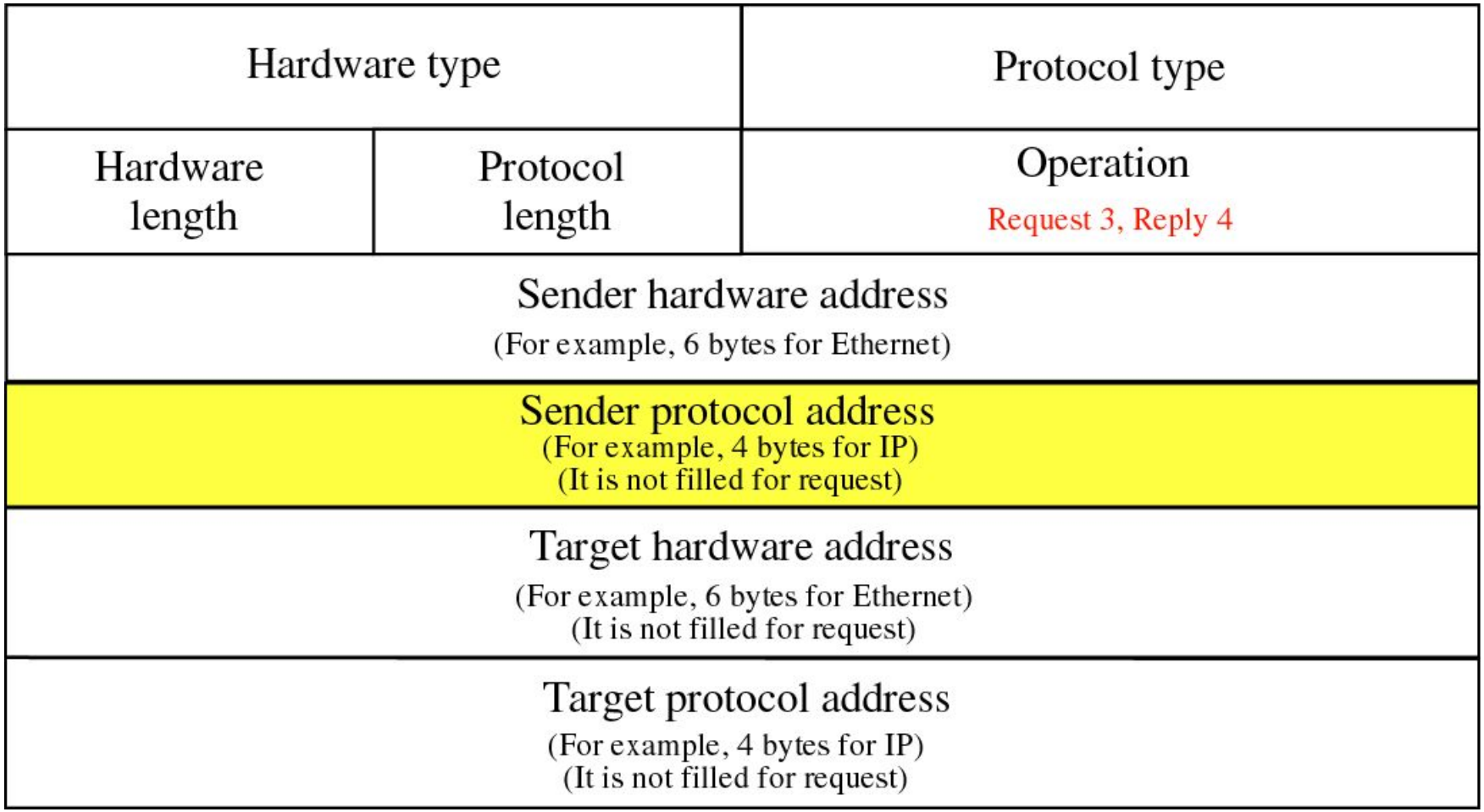


Figure 7-12

Encapsulation of RARP packet