Address Resolution Protocol (ARP)

MAC and IP

- There are two primary addresses assigned to a device on an Ethernet LAN:
  - **Layer 2 physical address (the MAC address)** – Used for NIC to NIC communications on the same Ethernet network.
  - Communicating options-Unicast,Broadcast and multicast
  - **XX-XX-XX-XX-XX-XX (48 BITS ,6 Bytes each)**
  - **Vendor (OVI)-NIC 00-10-7b-3a-92-3c**
  - **01-00-5e-00-00-16 (Multicast)**
  - **Layer 3 logical address (the IP address)** – Used to send the packet from the source device to the destination device.

What is ARP?

- ARP is a protocol for providing address mapping functionality.

- Maps a Logical address (Layer 3 address) to a physical address (Layer 2 address)

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ADDRESS MAPPING

1. **The delivery of a packet to a host or a router requires two levels of addressing: *logical* and *physical*.**

2. **We need to be able to map a logical address to its corresponding physical address and vice versa.**

3. **These can be done using either *static* or *dynamic* mapping.**

8-2 ADDRESS MAPPING

- **Anytime a host or a router has an IP datagram to send to another host or router, it has the logical (IP) address of the receiver.**
- **But the IP datagram must be encapsulated in a frame to be able to pass through the physical network.**
- **This means that the sender needs the physical address of the receiver.**
- **A mapping corresponds a logical address to a physical address.**
- **ARP accepts a logical address from the IP protocol, maps the address to the corresponding physical address and pass it to the data link layer.**

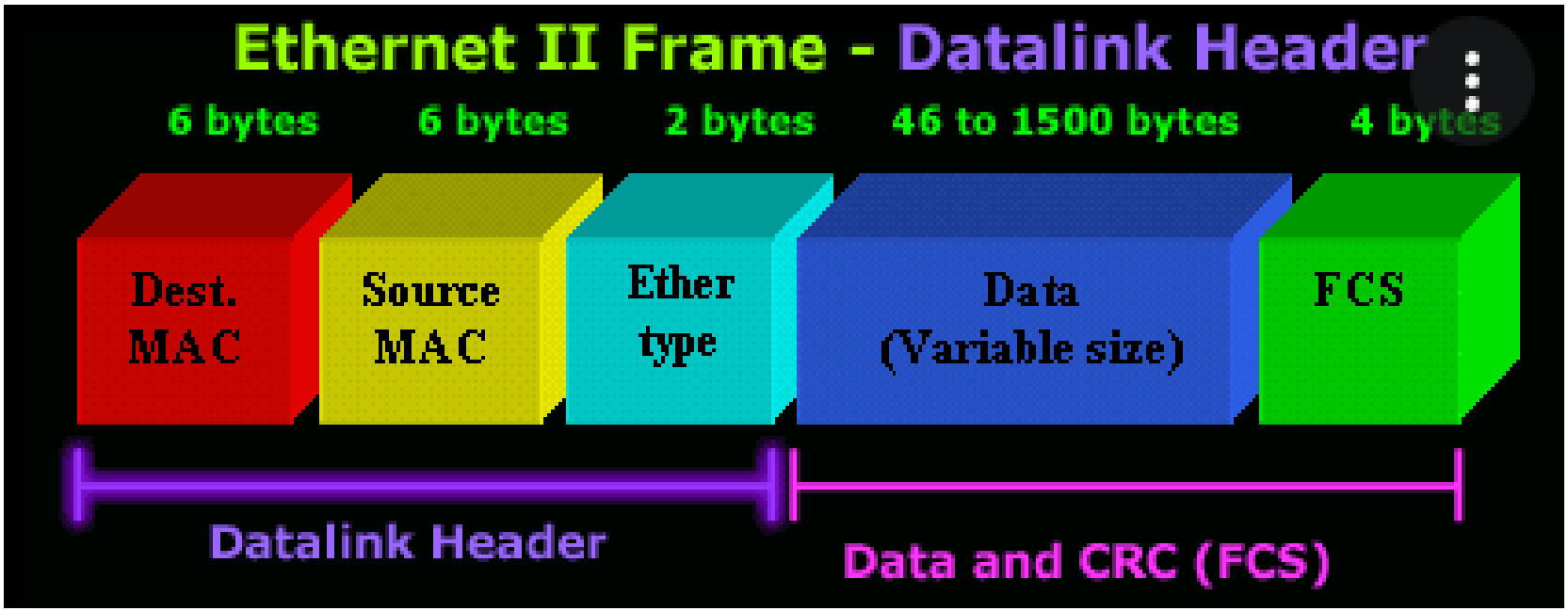
Why MAC needed?

- Local communication in a LAN, will use physical address (MAC in Ethernet) and not logical address(IP address)
- When a host in a network wants to communicate with host in another network, it uses IP address
- ARP maps an IP address into its corresponding MAC
- The purpose for creating such a mapping is: **a packet's L2 header can be properly populated to deliver a packet to the next NIC in the path between two end points**

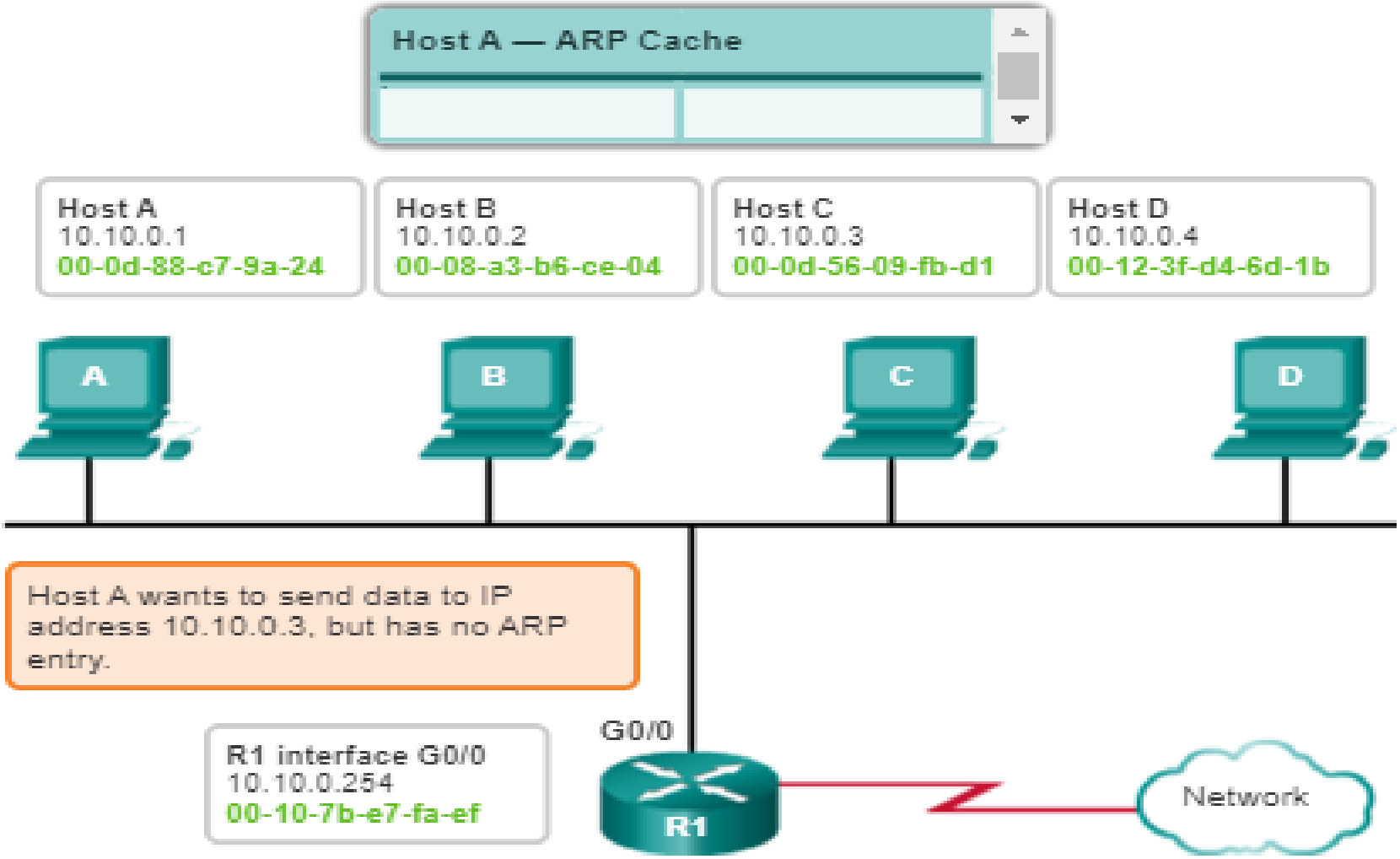
Why MAC needed?

- Every device/host with IP address uses a ARP table internally.
- Use command “ARP –a”
- ARP table has static (manually added) and dynamic entries (ARP program adds)
- ARP cache table has timeout period after which all entries are lost

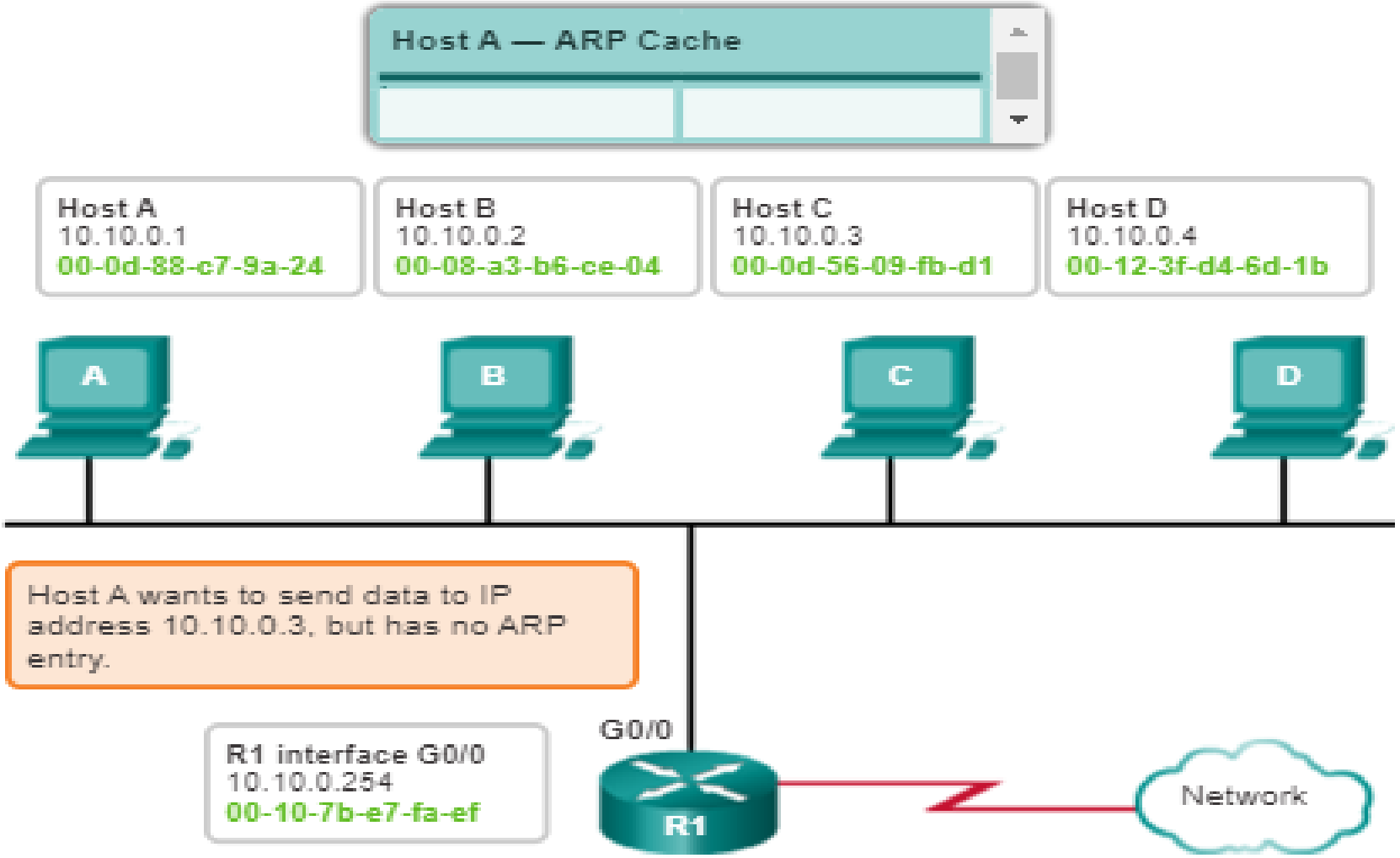
Ethernet Header



(i)Destination on the same LAN



(i)Destination on remote LAN

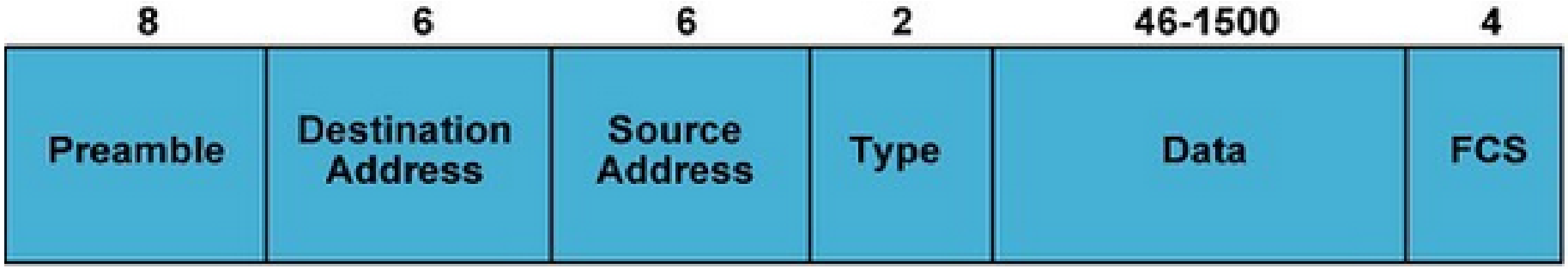


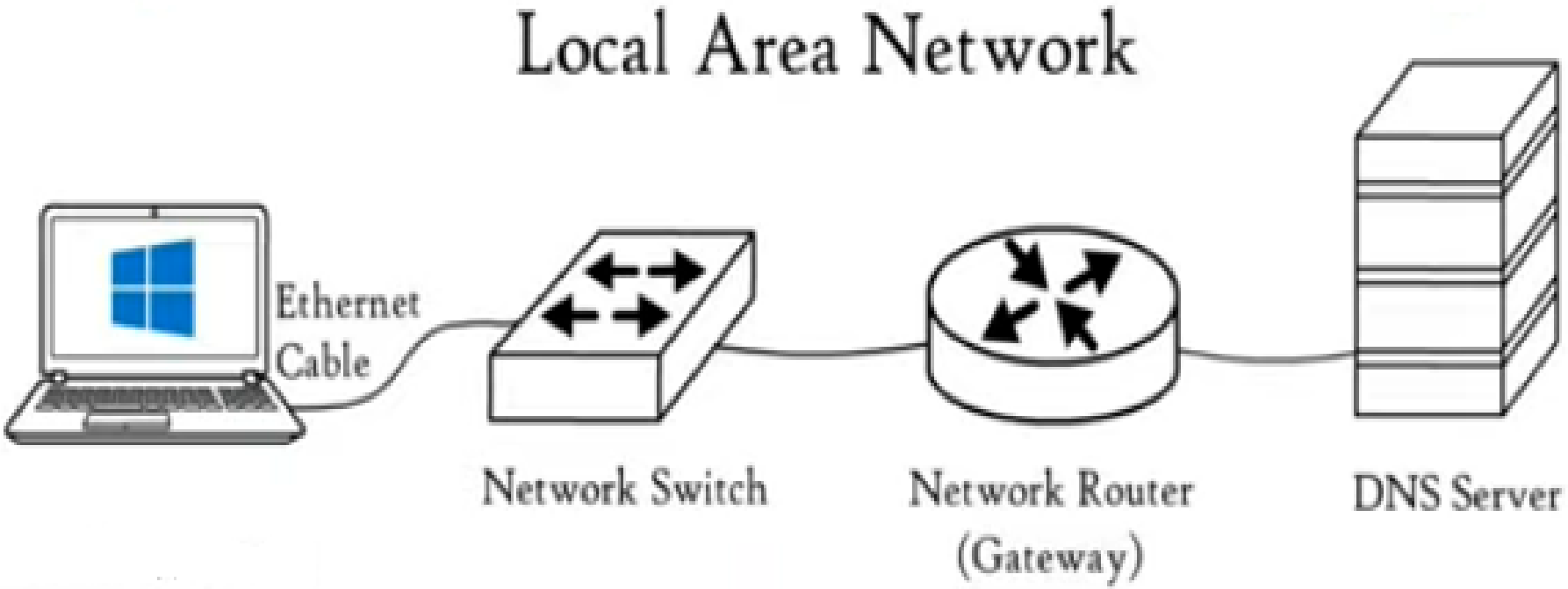
Exercise - 1

Host A transmits data to Host B. Provide the following details for the Data Link Frame at Link 0,1,2,3,4.

- Source IP
- Dst IP
- Source MAC
- Destination MAC

Idea of ARP


8
6
6
2
46-1500
4
Preamble
Destination Address
Source Address
Type
Data
FCS


Local Area Network
Ethernet Cable
Network Switch
Network Router (Gateway)
DNS Server

Idea of ARP

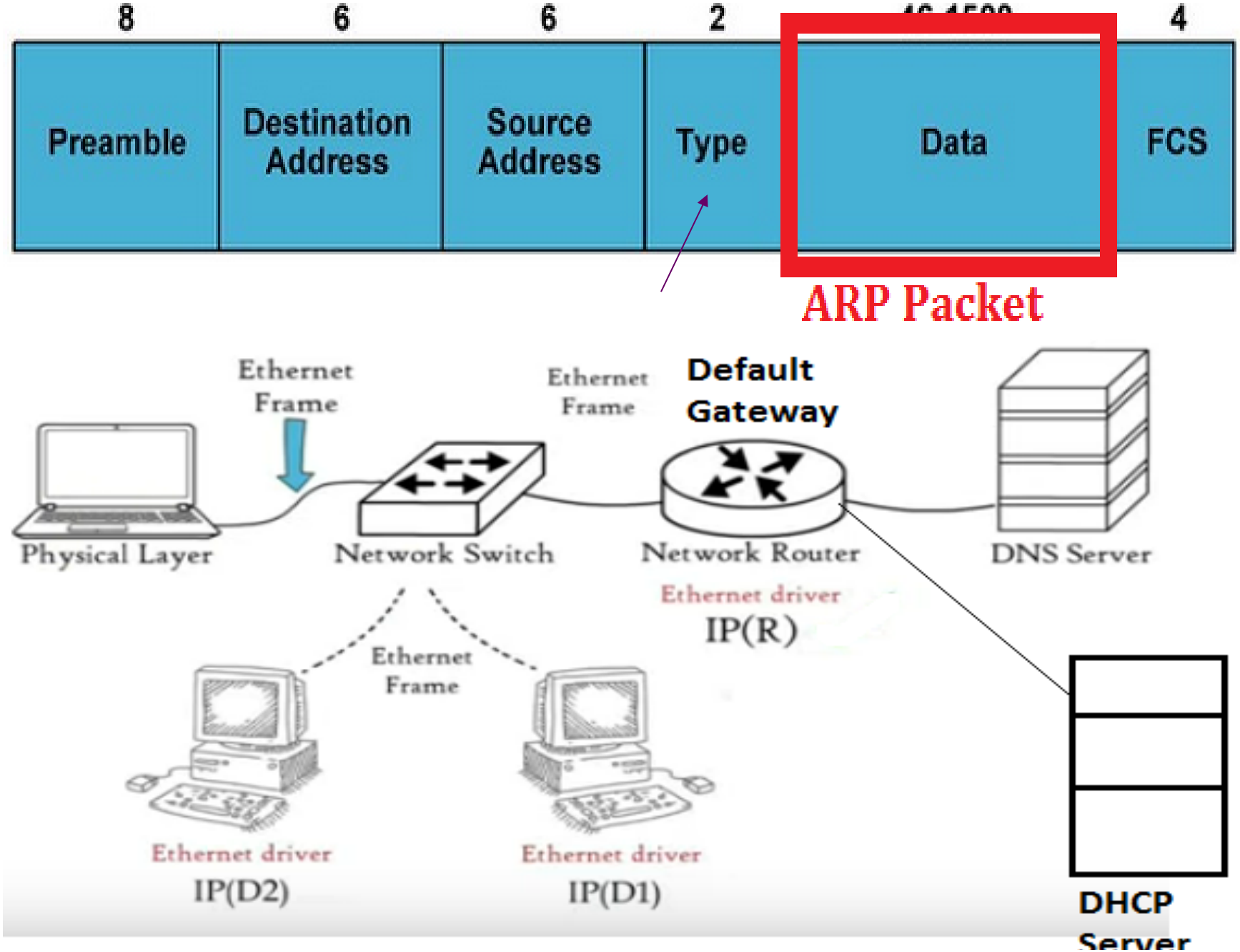

8
6
6
2
4
Preamble
Destination Address
Source Address
Type
Data
FCS
ARP Packet
Ethernet Frame
Ethernet Frame
Default Gateway
Physical Layer
Network Switch
Network Router
DNS Server
Ethernet driver
IP(R)
Ethernet Frame
Ethernet driver
IP(D2)
Ethernet driver
IP(D1)
DHCP Server

Figure 8.1 *Position of ARP in TCP/IP protocol suite*

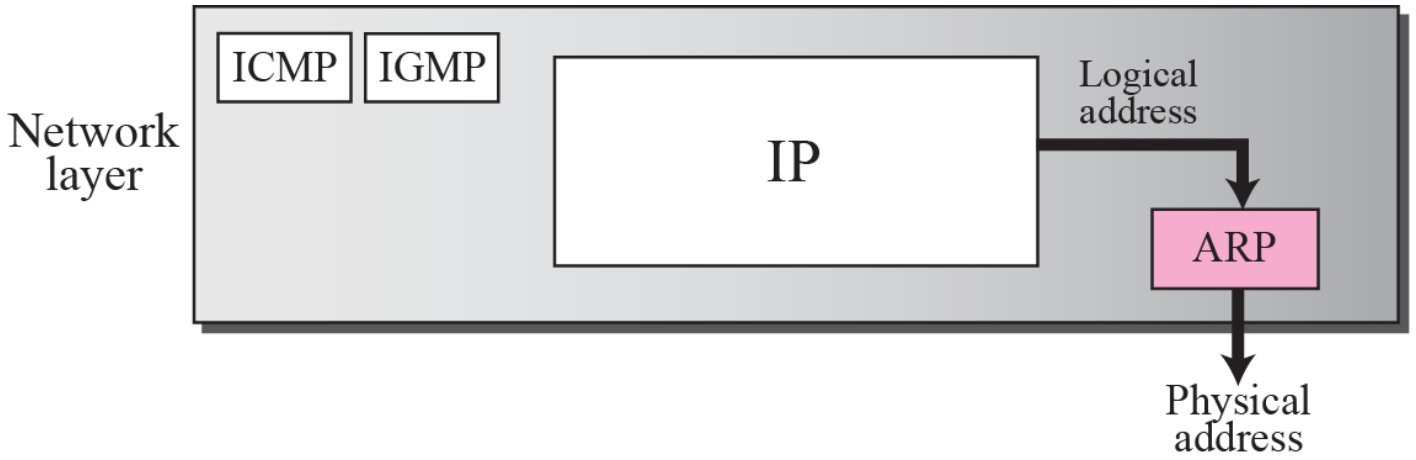
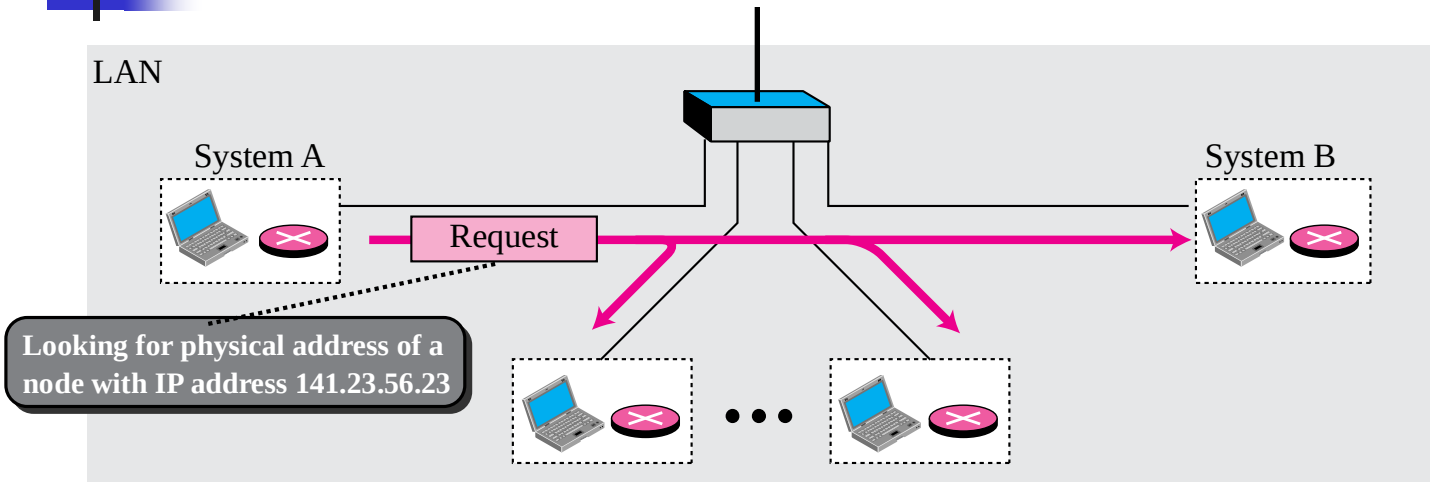
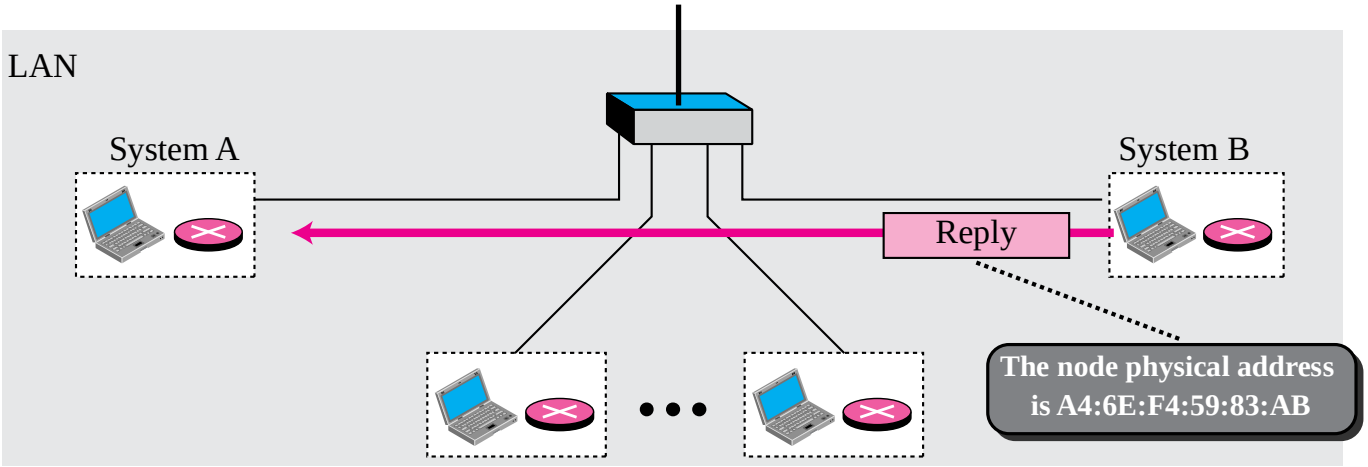


Figure 8.2 *ARP operation*

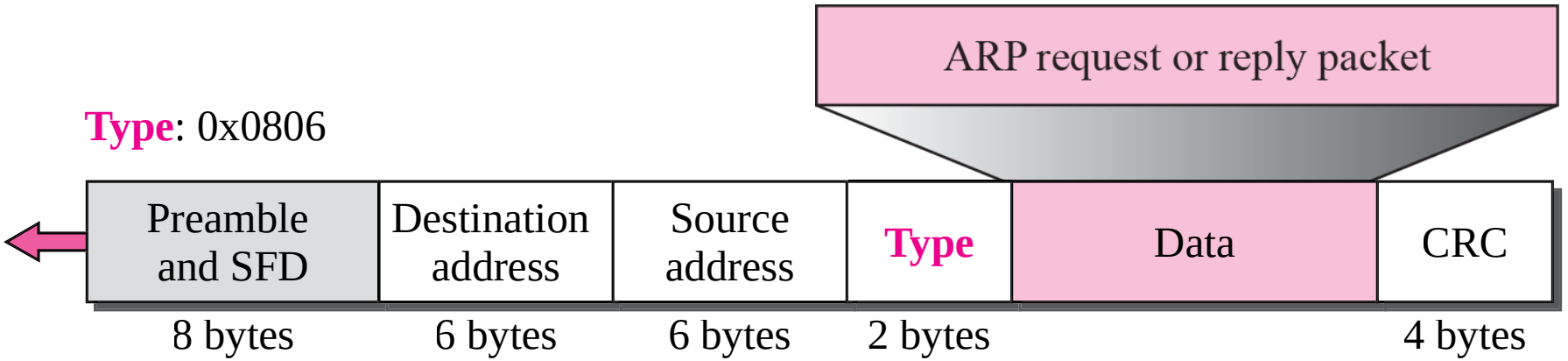


a. ARP request is **broadcast**



b. ARP reply is unicast

8.4 Encapsulation of ARP packet [ARP in data link frame]



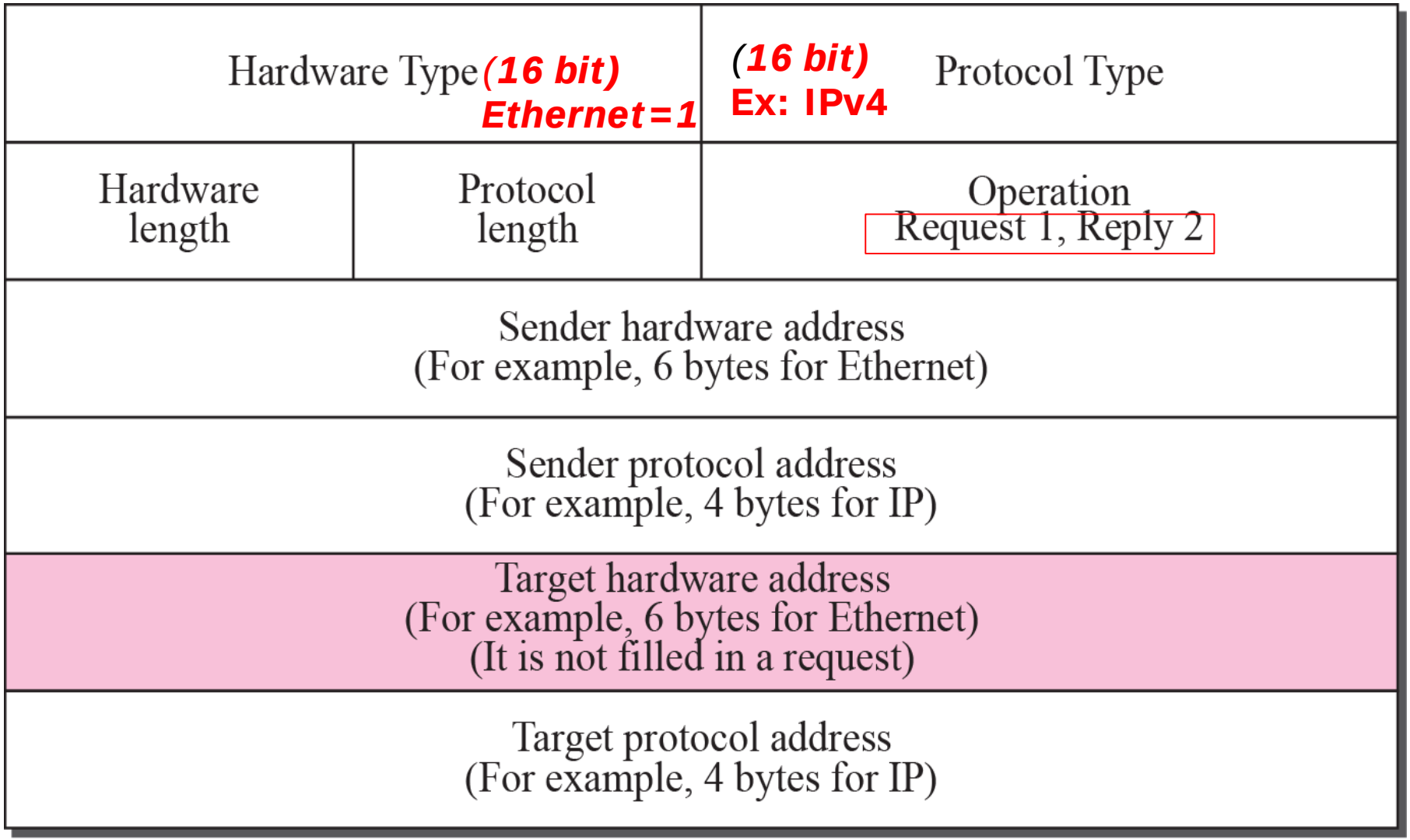
Broadcast MAC: (Destination address)

[FF: FF: FF: FF: FF: FF]

Note

An ARP request is broadcast; an ARP reply is unicast.

Figure 8.3 *ARP packet Format*



ARP message contents

- **Hardware Type** - type of physical network on which ARP runs
- **Protocol type –** type of layer 3 address used
- The **Hardware Type** and **Protocol Type** fields indicate what type of addresses are being mapped to each other.
  - For example: Ethernet address (MAC address) can be mapped to an IPv4 address
- **Hardware length** and **Protocol length** refer to the amount of bytes in each of the types of addresses:
  - a MAC address is 6 bytes (or 48 bits), and an IPv4 address is 4 bytes (or 32 bits).
- **Hardware length –** physical address length
- **Protocol length –** logical address length

Target IP concept

- The "**next NIC"** in the path will become the target of the ARP request.
- If a host is speaking to **another host (Dst)** on the ***same* IP network**, the target for the ARP request is the **host's IP address (Dst).**
- If a host is speaking to **another host** on a ***different* IP network**, the target for the ARP request will be the **Default Gateway's IP address.**
- If a **Router** is delivering a packet to the **destination host**, the Router's ARP target will be **the Host's IP address**.
- If a **Router** is delivering a packet to the **next Router in the path to the host,** the ARP target will be the other Router's Interface IP address.

ARP operation

- Sender knows IP of target. Checks its ARP cache table to find MAC for this IP. If found uses the same else proceeds to use ARP to find MAC.

- IP asks ARP to create an ARP request message
  - Fills in **sender IP, Sender MAC, Target IP**
  - Target MAC: **all 0's**
  - Means: "if you are the owner of this IP address, please respond to me with your hardware address."
  - **Broadcasted**

- This ARP message is encapsulated in data link layer frame
  - **Destination address in L2: Broadcast MAC**

- Every host and router in the same network receives this ARP request broadcast

ARP operation

- Only target host responds with ARP response – containing MAC
  - “I am the owner of this IP address, my hardware address is this.“
  - This is Unicast message
- Source updates its ARP table

Figure 8.5 *Four cases using ARP*

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

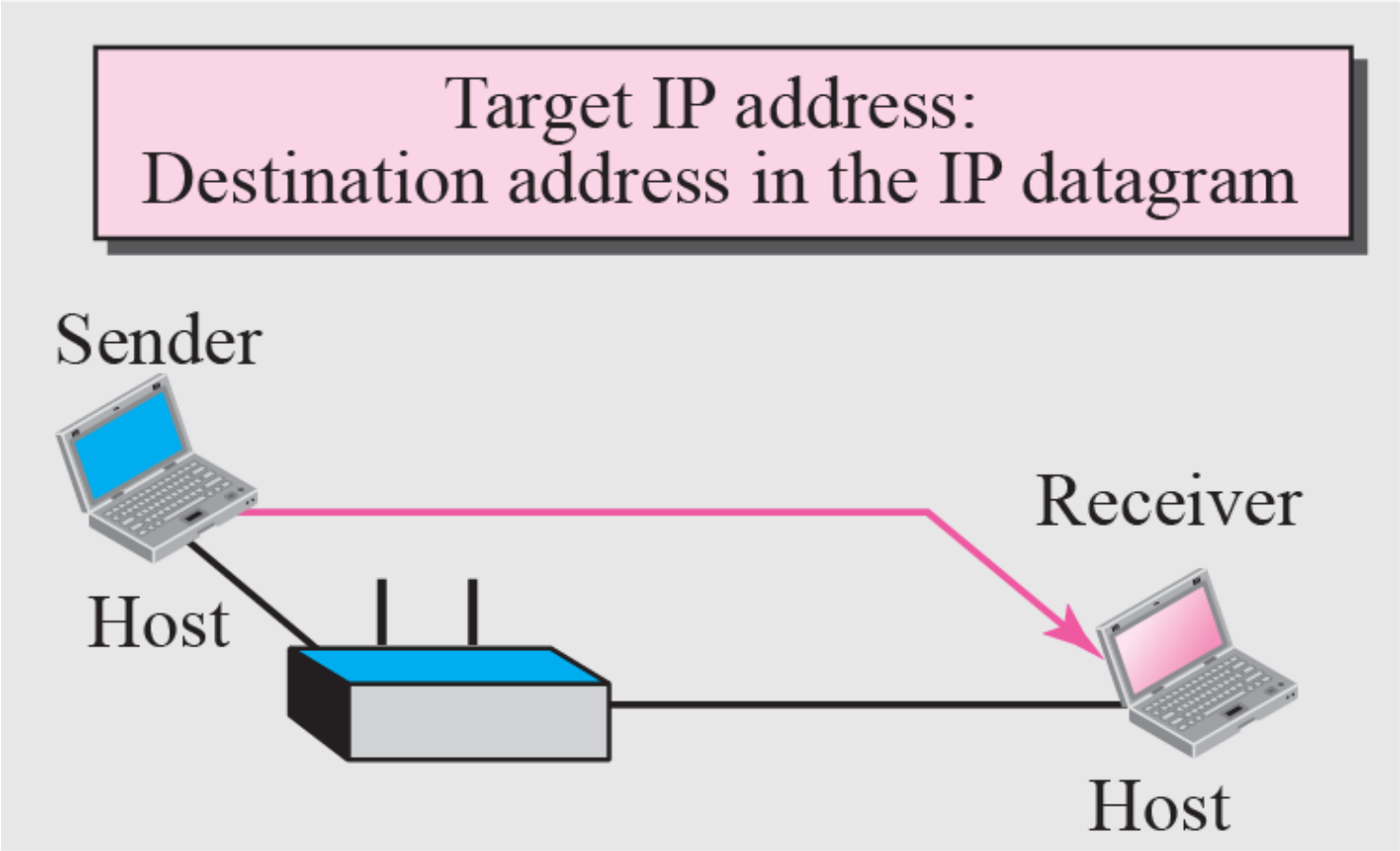


Figure 8.5 *Four cases using ARP*

Case 2: A host has a packet to send to a host on another network.

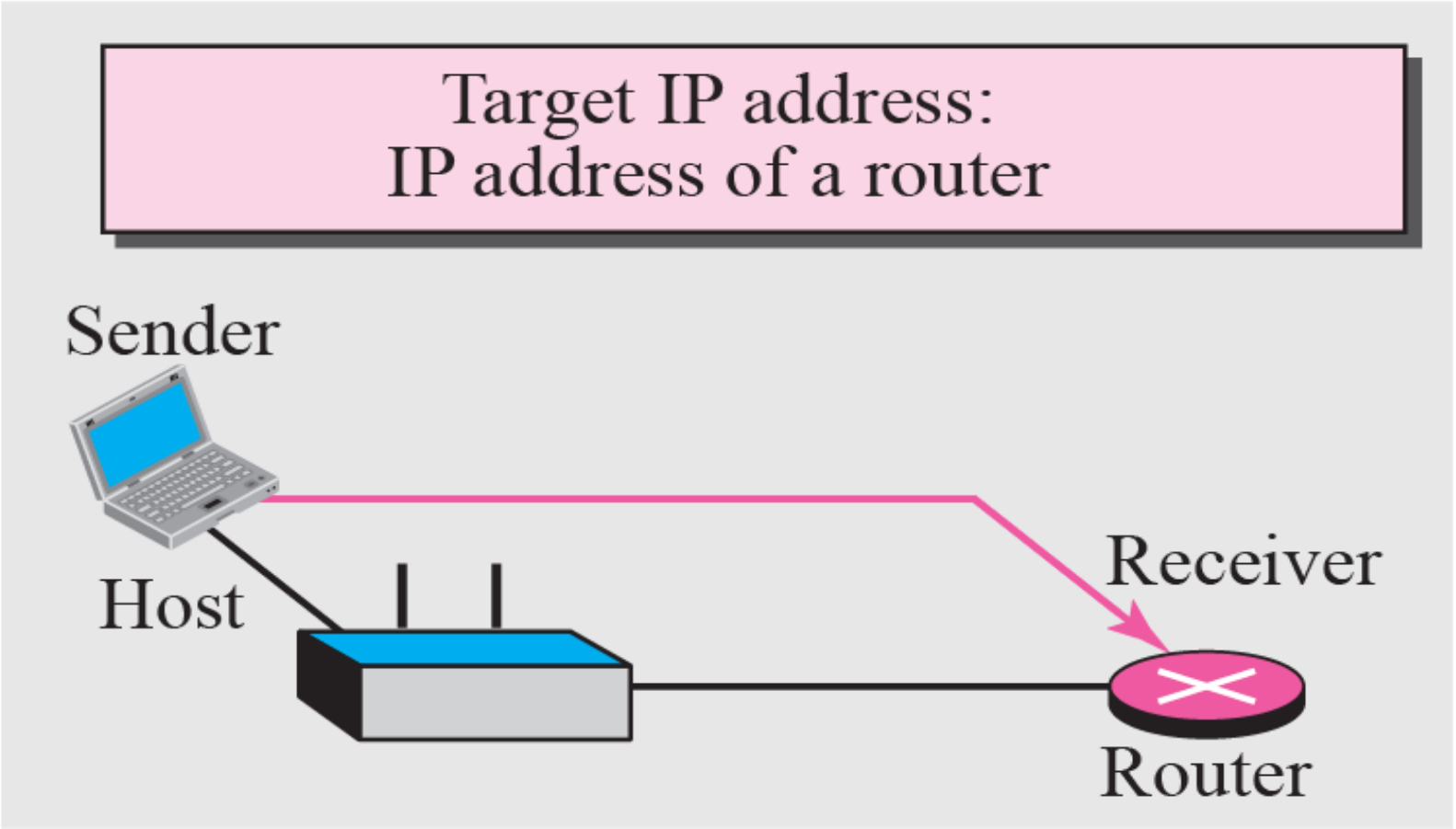


Figure 8.5 *Four cases using ARP*

Case 3: A router has a packet to send to a host on another network.

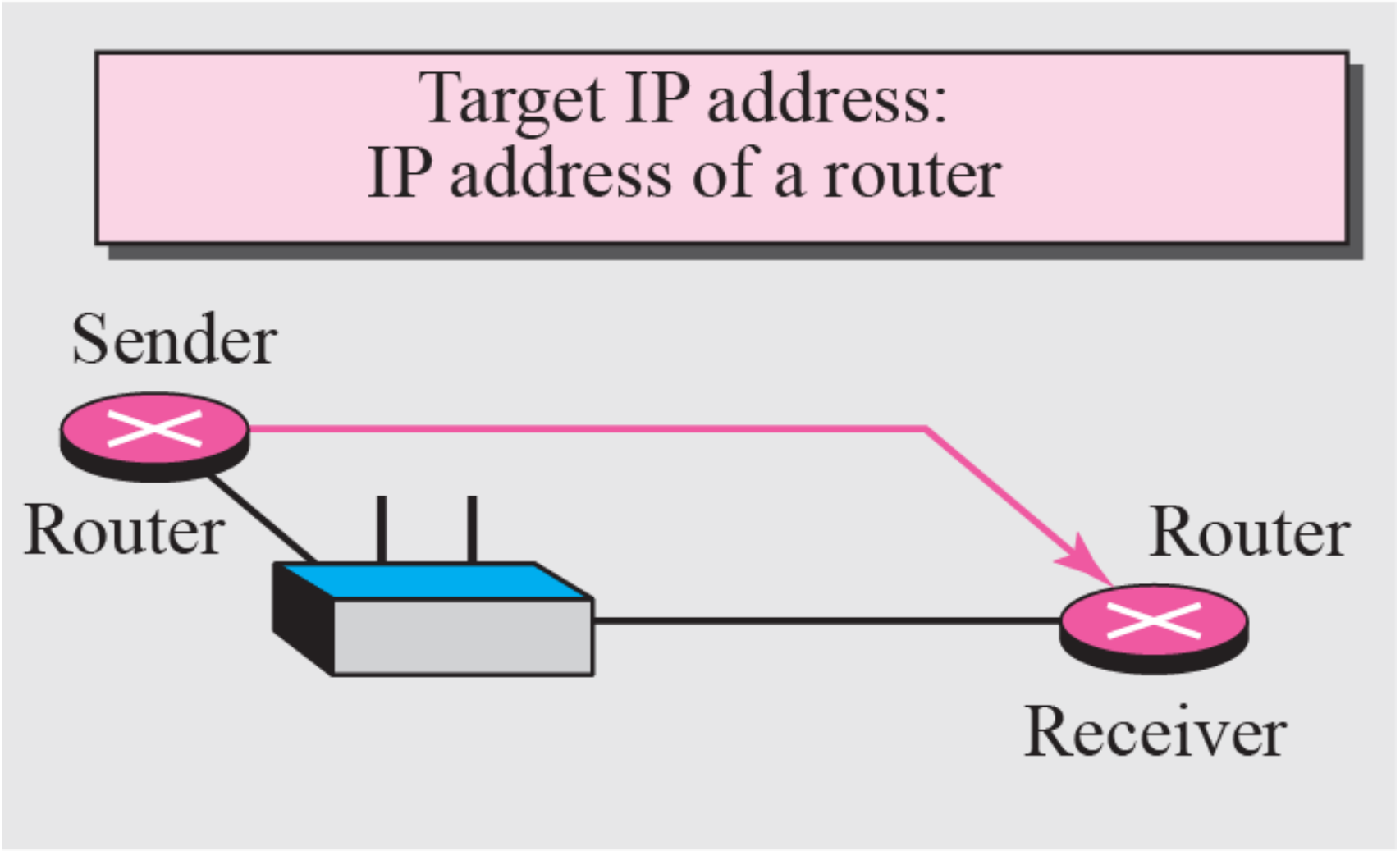
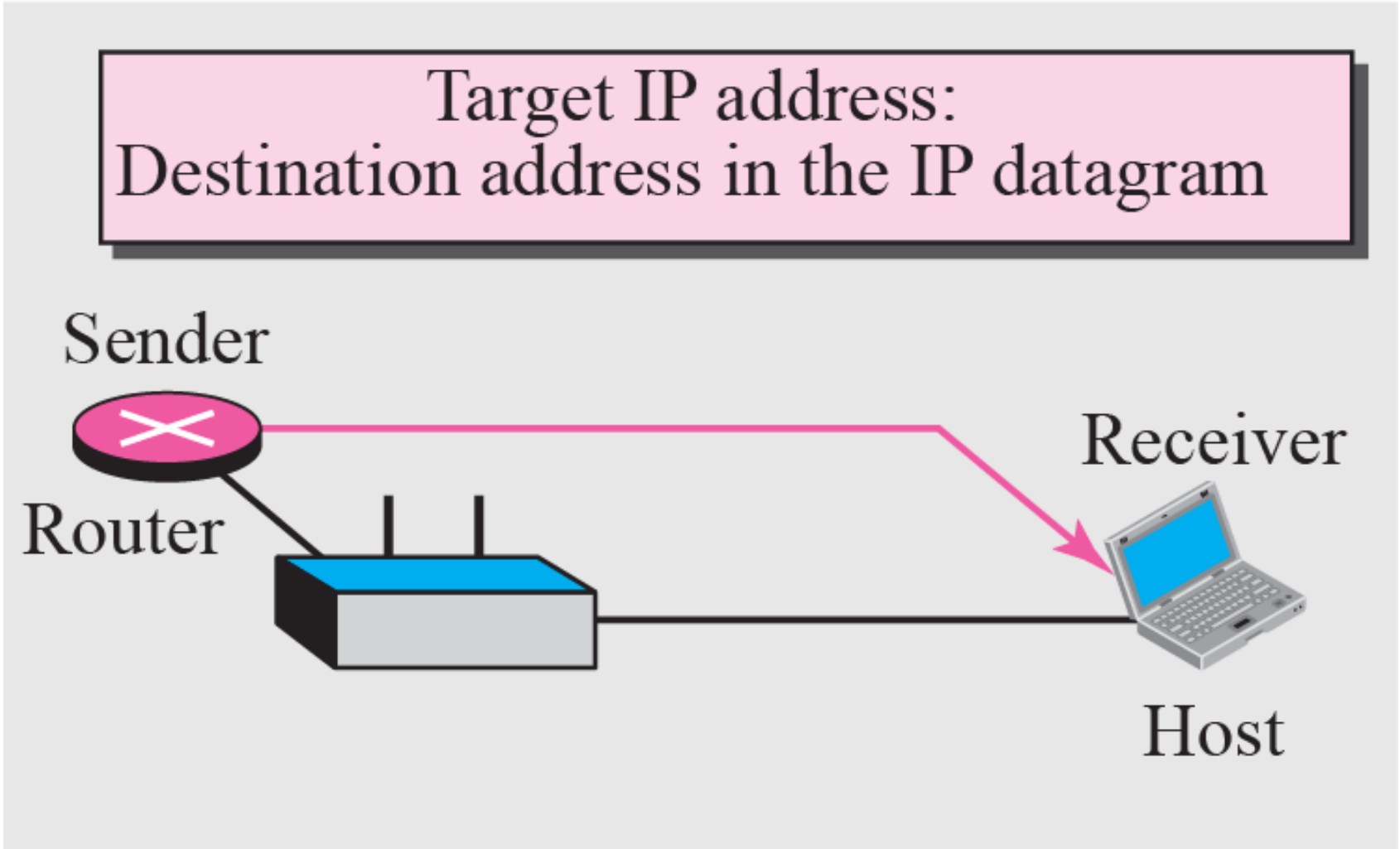


Figure 8.5 *Four cases using ARP*

Case 4: A router has a packet to send to a host on the same network.



Example 8.1

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 8.6 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. Also note that the IP addresses are shown in hexadecimal.

Proxy ARP

- A technique called proxy ARP – creates subnetting effect

- When a router runs a proxy ARP, receives an ARP request **looking for the IP address of one of these hosts**, router sends an ARP reply announcing its own hardware (physical) address

- Next when the router later receives actual IP packet, it sends the packet to the appropriate host or router

Figure 8.7 *Proxy ARP*

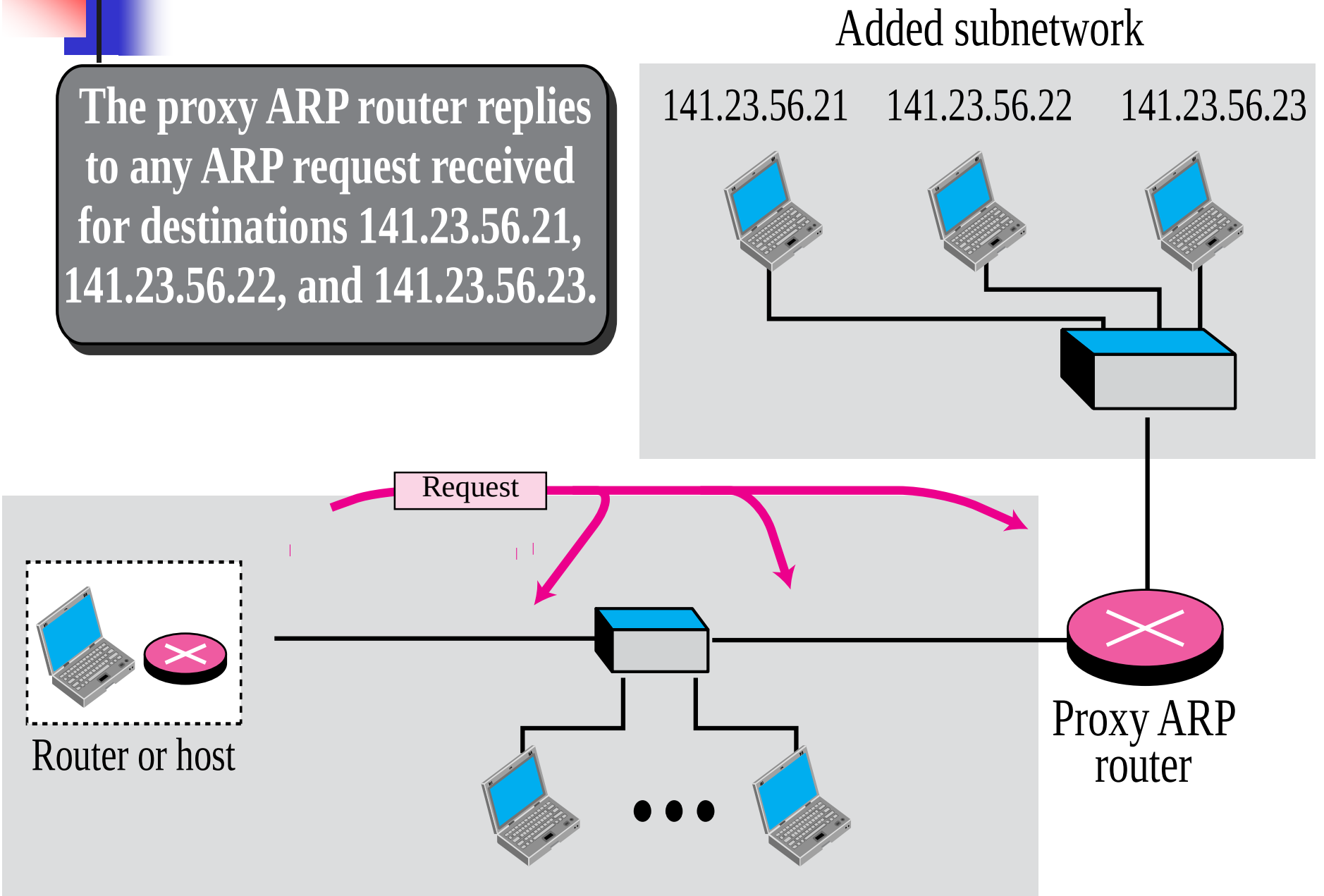


Figure 8.6 *Example 8.1*

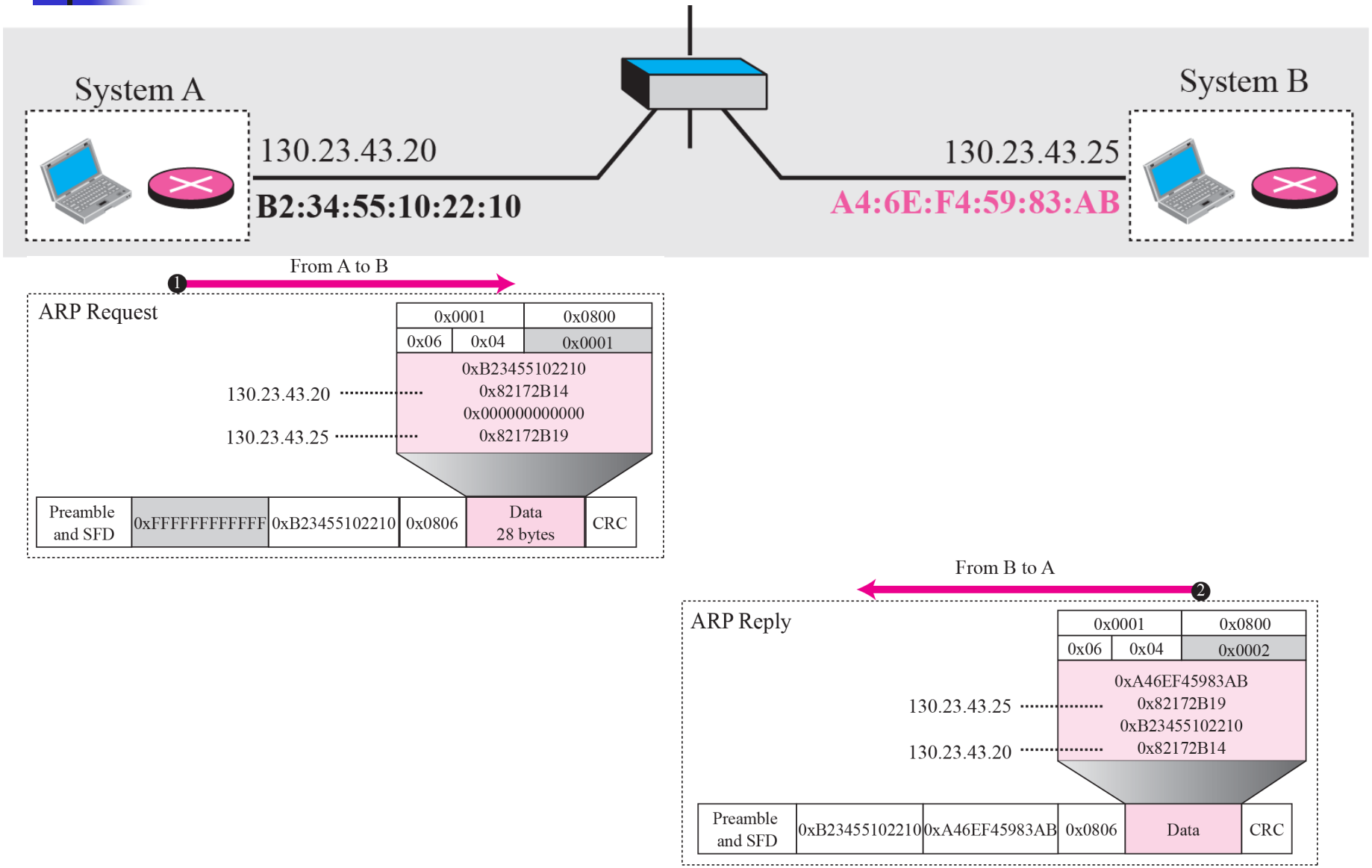


Figure 8.6 *Example 8.1*

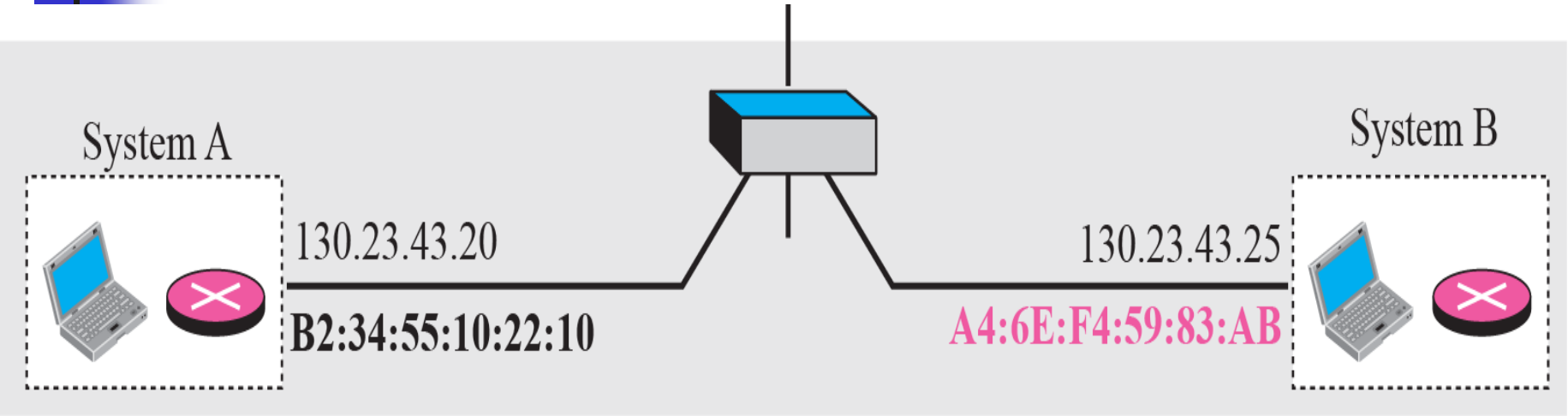


Figure 8.6 *Example 8.1*

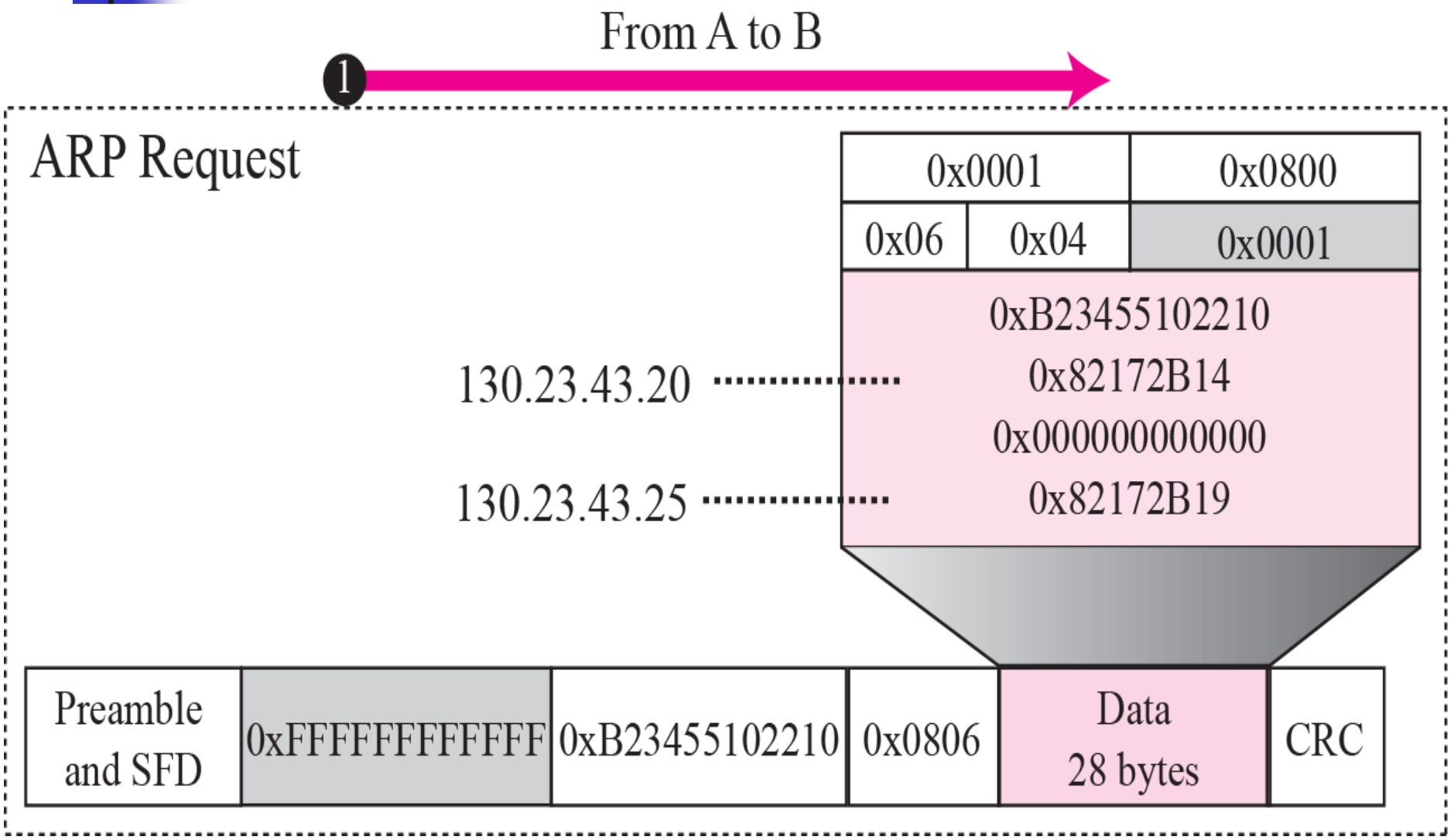
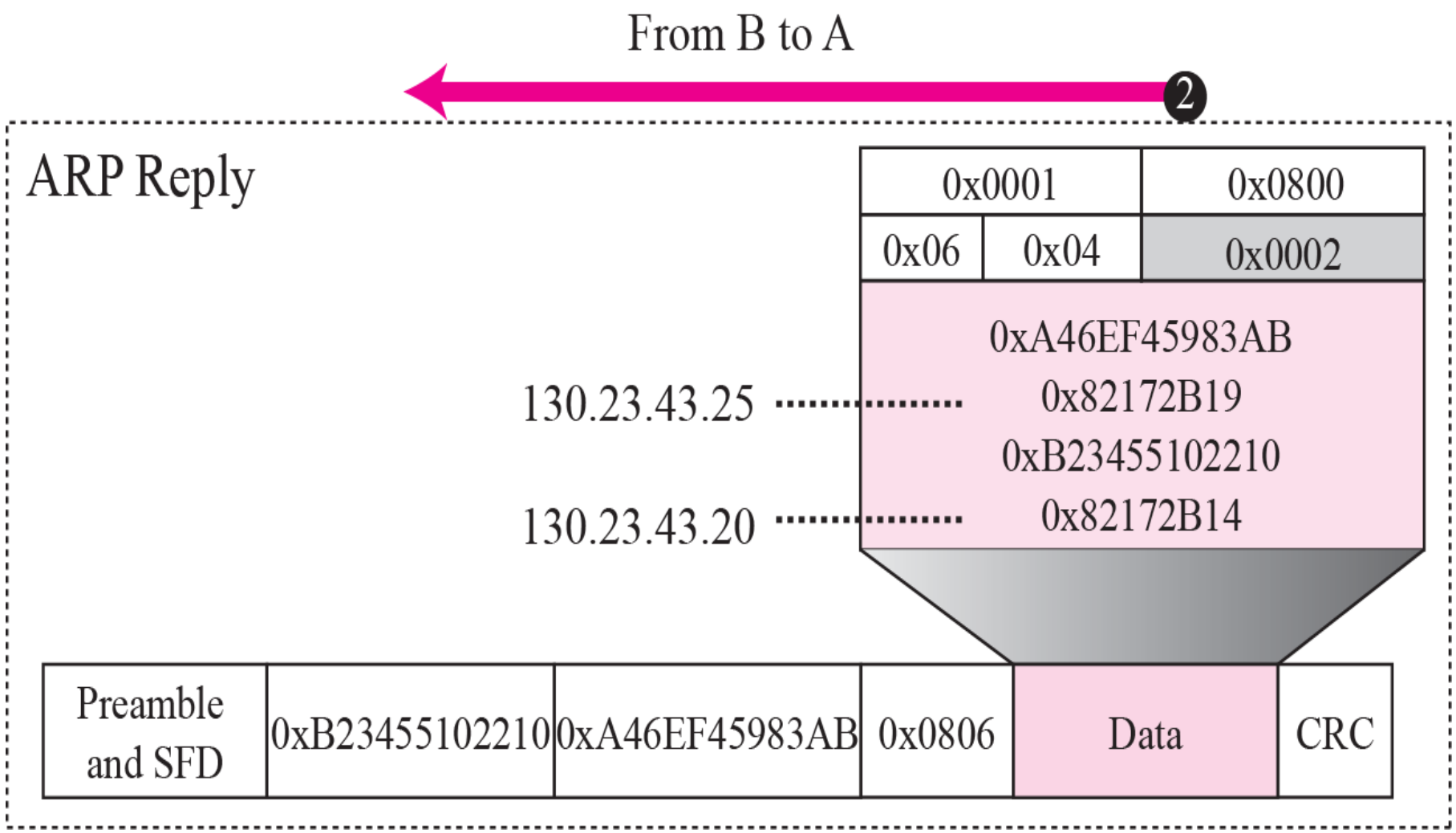


Figure 8.6 *Example 8.1*



Questions

Is ARP packet enclosed in IP datagram? Why/Why Not?

- No. ARP packet is not enclosed in IP datagram.
- It is directly encapsulated only into a data link frame. In Layer 2, “Type” field is set to “ARP” (0x806).
- Significance of Fields:
  - **Hardware Type, Hardware length:** Physical address information
  - **Protocol type, protocol length:** Logical address information
    - For Logical address to Physical address mapping

Questions

- Is Layer 3 IP address part of ARP packet?

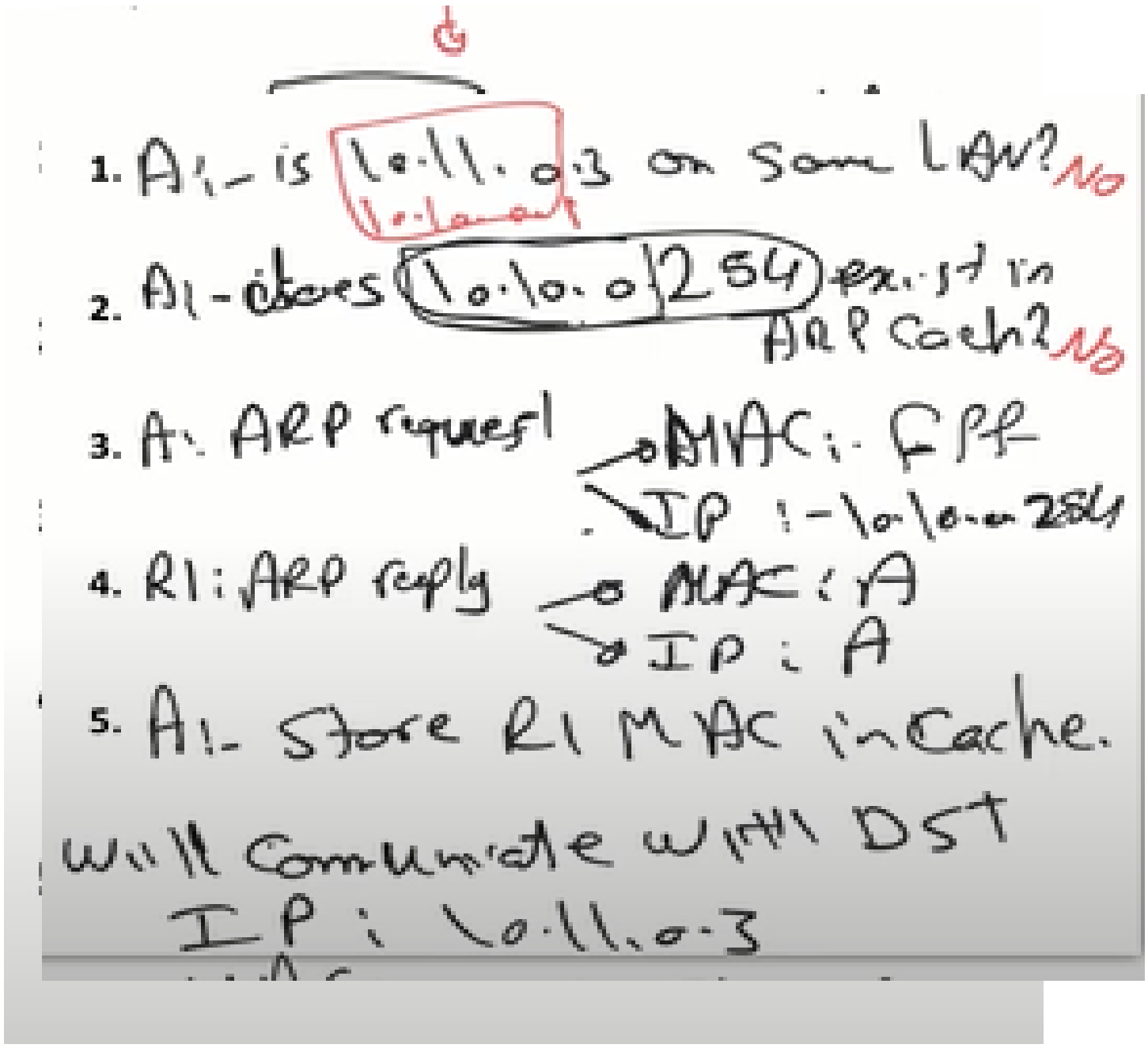
Yes. IP addresses are part of ARP packet. They are not used as addressing information for ARP packet but rather as protocol payload (for ARP to perform mapping).

Commands

- Arp –a (to display ARP Cache)

- Arp –s [IP] [MAC]

(to create static entries in ARP Cache manually)


1. A1 - is 10.11.0.3 on same LAN? NO
10.1a.a.1
2. A1 - does 10.10.0.254 exist in ARP Cache? NO
3. A: ARP request
MAC: FFF
IP: 10.10.0.254
4. R1: ARP reply
MAC: A
IP: A
5. A1 - Store R1 MAC in Cache.
Will Communicate with DST
IP: 10.11.0.3