Department of Computer science and Information Technology


# Chapter 9: Introduction to Data-Link Layer

# 9-1 INTRODUCTION

The Internet is a combination of networks glued together by connecting devices (routers or switches). If a packet is to travel from a host to another host, it needs to pass through these networks.

# 9.1.1 Nodes and Links

A data unit from one point in the Internet needs to pass through many networks (LANs and WANs) to reach another point. Theses LANs and WANs are connected by routers. It is customary to refer to the two end hosts and the routers as nodes and the networks in between as links.

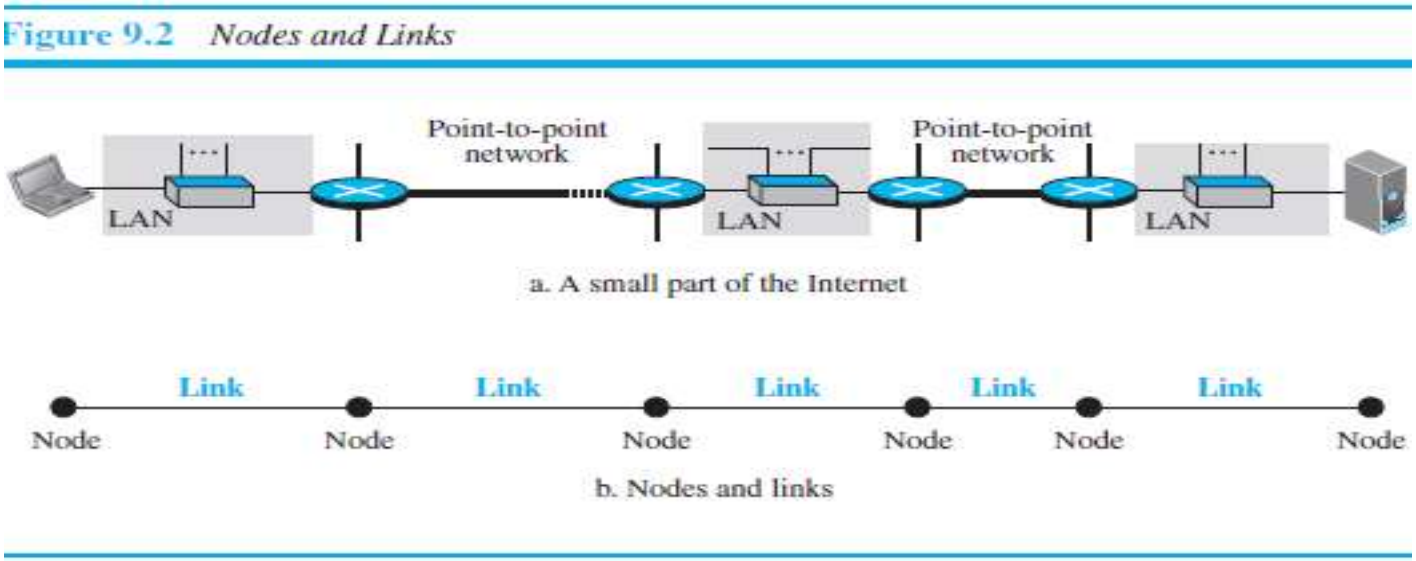
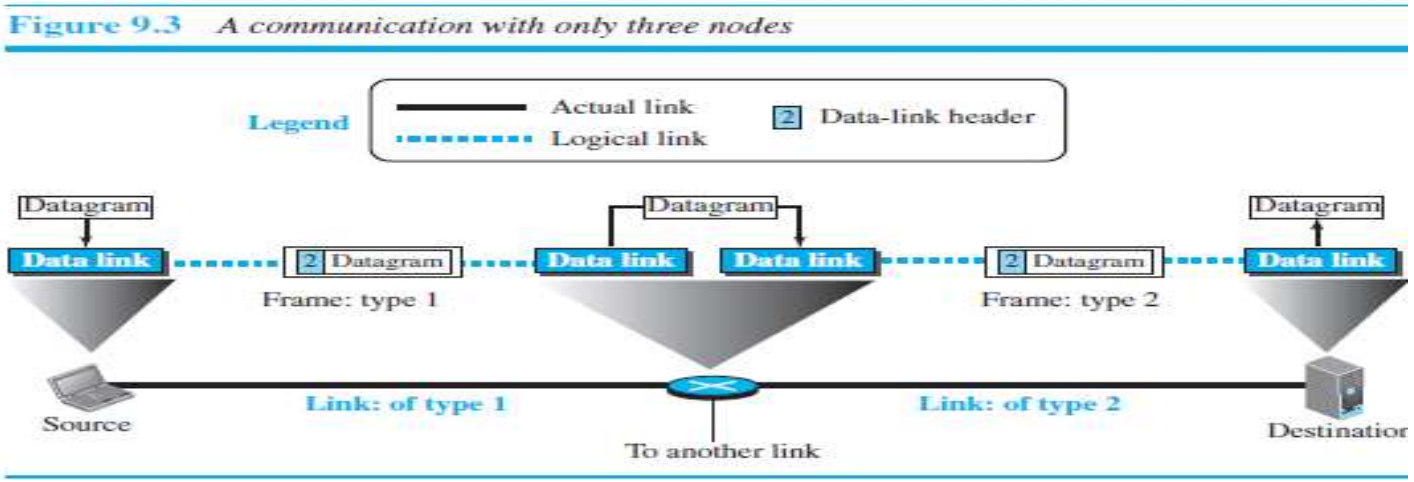



Figure 9.2 *Nodes and Links*

# 9.1.2 Services

- The datalink layer provides services to the network layer; it receives services from the physical layer.
- the data-link layer of the sending node needs to encapsulate the datagram received from the network in a frame, and the data-link layer of the receiving node needs to decapsulate the datagram from the frame.



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Services are:

- Framing
- Flow control
- Error Control
- Congestion Control

# 9.1.3 Two Categories of Links

We can have a point-to-point link or a broadcast link. In a point-to-point link, the link is dedicated to the two devices; in a broadcast link, the link is shared between several pairs of devices.

# 9.1.4 Two Sublayers

- We can divide the data-link layer into two sublayers: **data link control (DLC)** and **Media access control (MAC).**
- The data link control sublayer deals with all issues common to both point-to-point and broadcast links; the media access control sublayer deals only with issues specific to broadcast links.

**Figure 9.4** *Dividing the data-link layer into two sublayers*


a. Data-link layer of a broadcast link

b. Data-link layer of a point-to-point link

# 9-2 LINK-LAYER ADDRESSING

- in a connectionless internetwork such as the Internet we cannot make a datagram reach its destination using only IP addresses. The reason is that each datagram in the Internet, from the same source host to the same destination host, may take a different path. The source and destination IP addresses define the two ends but cannot define which links the datagram should pass through.

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we need another addressing mechanism in a connectionless internetwork: the link-layer addresses of the two nodes. A link-layer address is sometimes called a link address, sometimes a physical address, and sometimes a MAC address.

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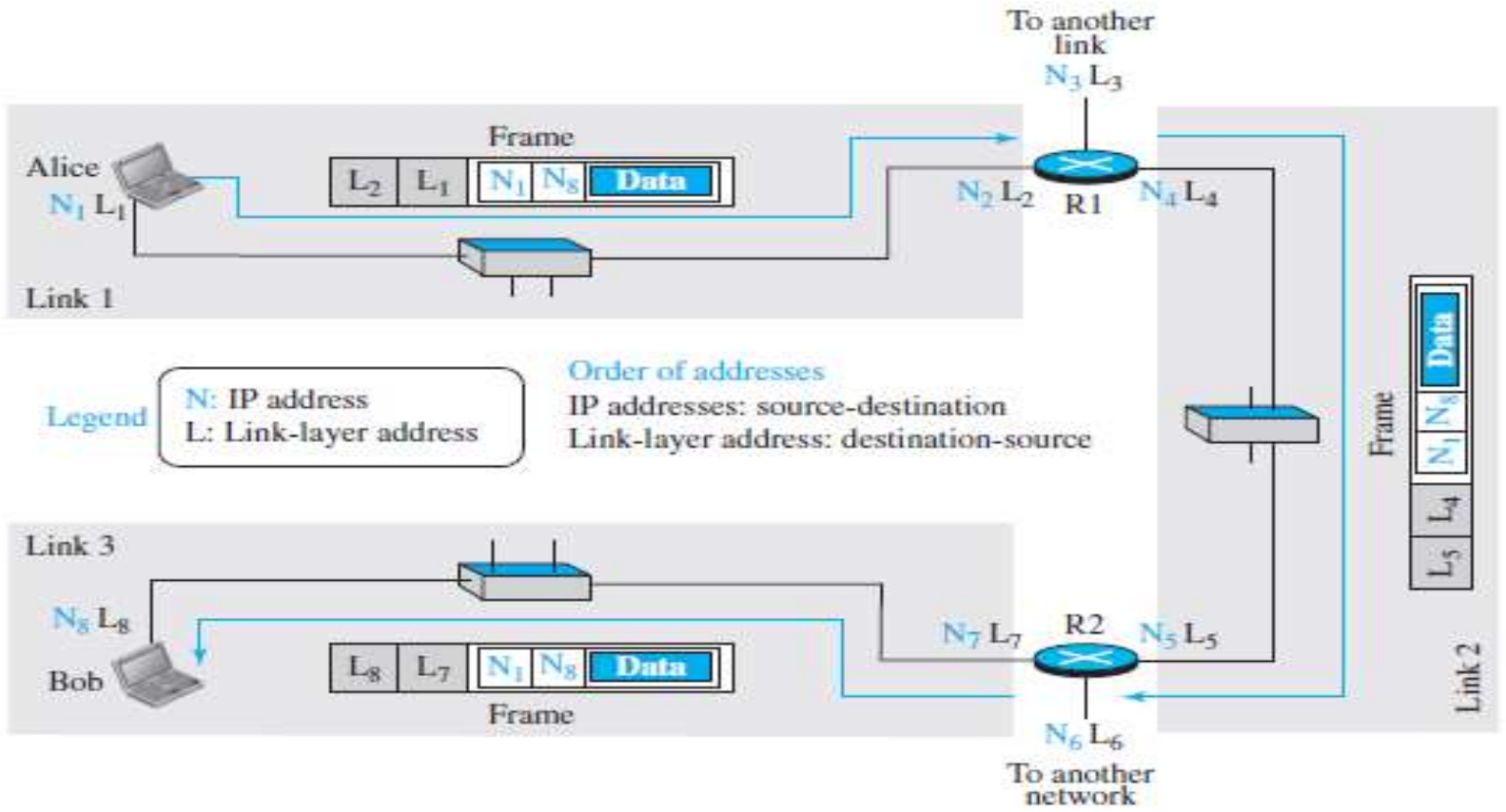
**Figure 9.5** *IP addresses and link-layer addresses in a small internet*



# 9.2.1 Three Types of addresses

Unicast Address: Each host or each interface of a router is assigned a unicast address. Unicasting means one-to-one communication. A frame with a unicast address destination is destined only for one entity in the link.

It is 48 bits (six bytes) and are presented as 12 hexadecimal digits separated by colons.

E.g. A3:34:45:11:92:F1

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Multicast Address: Some link-layer protocols define multicast addresses. Multicasting means one-to-many communication. However, the jurisdiction is local.
It is 48 bits (six bytes) and are presented as 12 hexadecimal digits separated by colons, however, needs to be an even number in hexadecimal.
E.g. A2:34:45:11:92:F1

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## Broadcast Address:

Some link-layer protocols define a broadcast address. Broadcasting means one-to-all communication. A frame with a destination broadcast address is sent to all entities in the link.

E.g. FF:FF:FF:FF:FF:FF

# 9.2.2 Address Resolution Protocol (ARP)

Anytime a node has an IP datagram to send to another node in a link, it has the IP address of the receiving node. However, the IP address of the next node is not helpful in moving a frame through a link; we need the link-layer address of the next node. This is the time when the Address Resolution Protocol (ARP) becomes helpful. The ARP protocol is one of the auxiliary protocols defined in the network layer.

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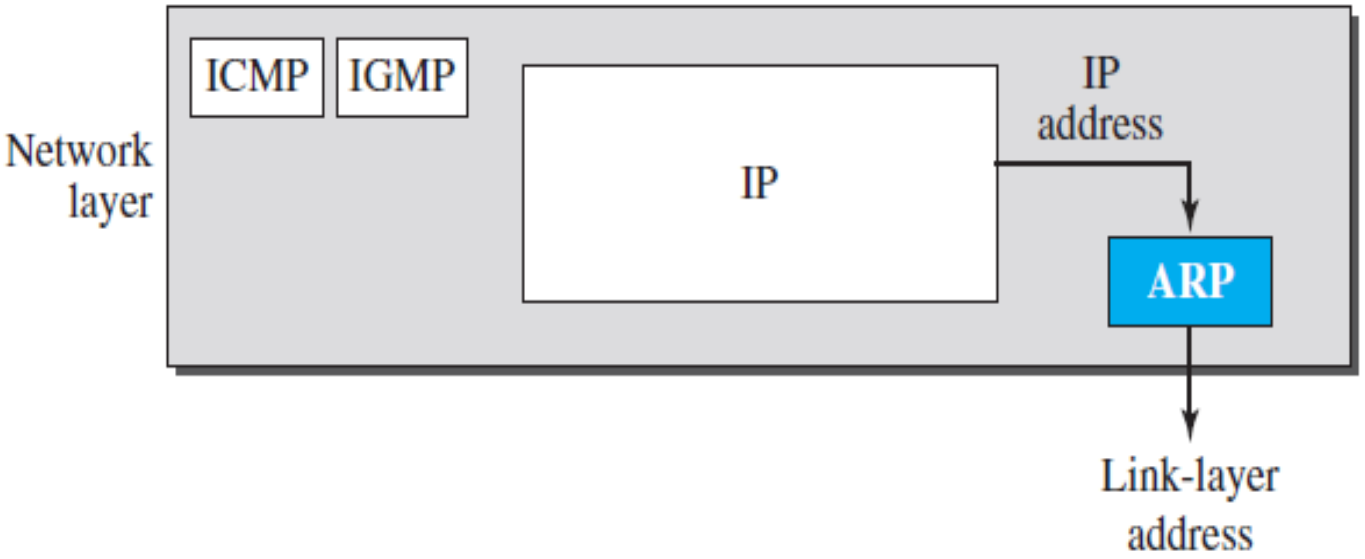
**Figure 9.6** *Position of ARP in TCP/IP protocol suite*



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Anytime a host or a router needs to find the link-layer address of another host or router in its network, it sends an ARP request packet. The packet includes the link-layer and IP addresses of the sender and the IP address of the receiver. Because the sender does not know the link-layer address of the receiver, the query is broadcast over the link using the link-layer broadcast address

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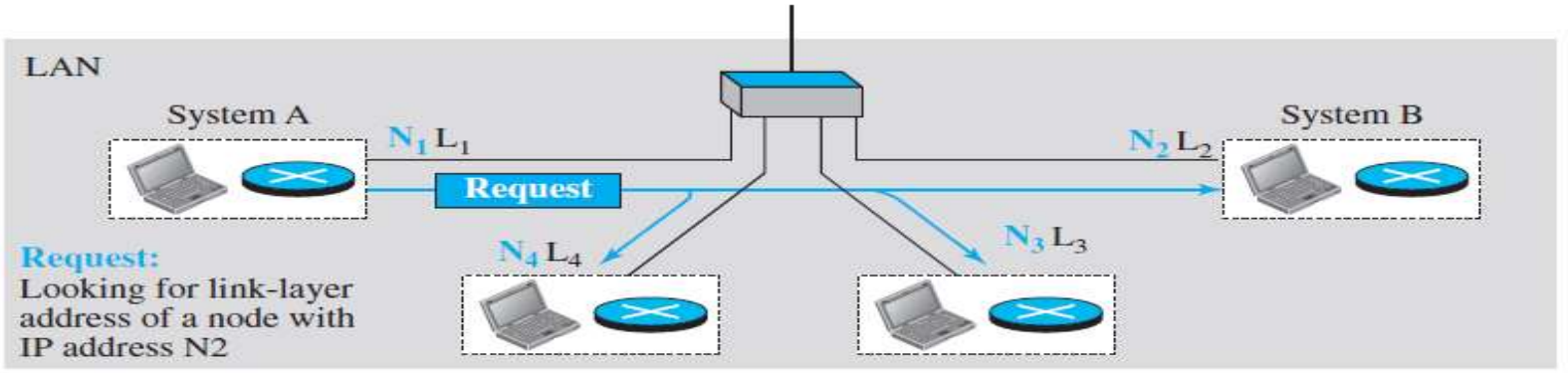
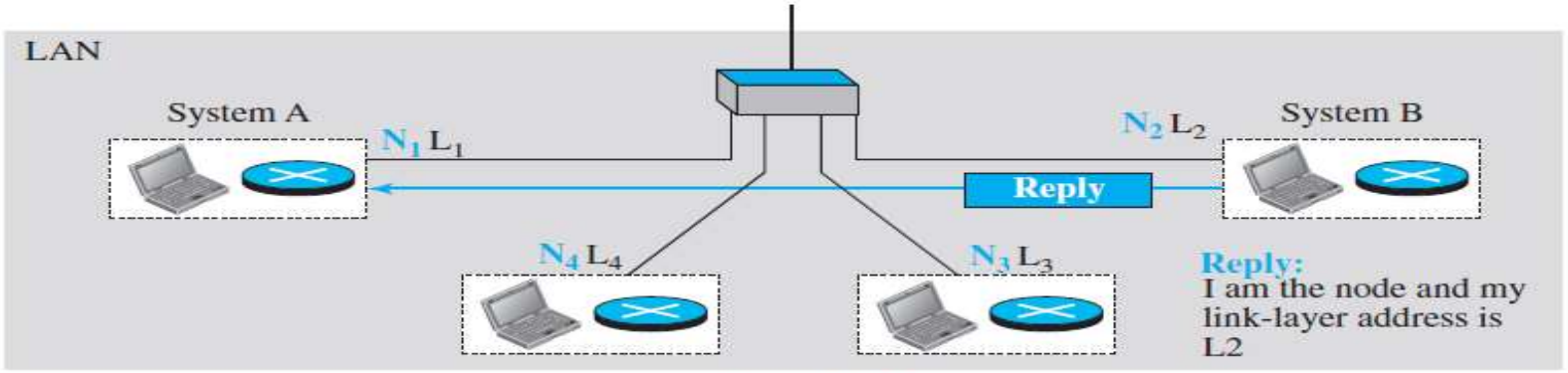
**Figure 9.7** *ARP operation*




a. ARP request is broadcast



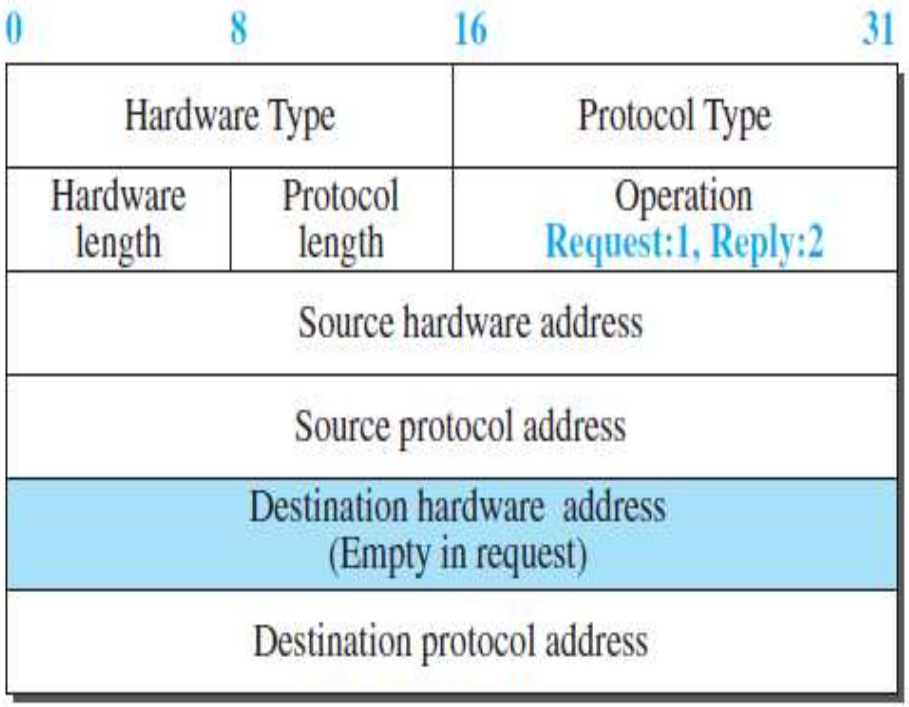

b. ARP reply is unicast

# Caching

Assume that system A has 10 datagrams to send to system B in one second. Using ARP, system A needs to send only one broadcast frame. Each of the other systems need to receive the frames, decapsulate the frames, remove the ARP message and pass the message to their ARP protocol to find that the frame must be discarded. After system B responds with its own data-link address, system A can store the link-layer address in its cache memory. The rest of the nine frames are only unicast.

# Packet Format

Figure 9.8 *ARP packet*




Hardware: LAN or WAN protocol
Protocol: Network-layer protocol

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- The hardware type field defines the type of the link-layer protocol; Ethernet is given the type 1.
- The protocol type field defines the network-layer protocol: IPv4 protocol is (0800)16.
- The source hardware and source protocol addresses are variable-length fields defining the link-layer and network-layer addresses of the sender.
- The destination hardware address and destination protocol address fields define the receiver link-layer and network-layer addresses.

# Example

A host with IP address N1 and MAC address L1 has a packet to send to another host with IP address N2 and physical address L2 (which is unknown to the first host). The two hosts are on the same network. Figure 9.9 shows the ARP request and response messages.

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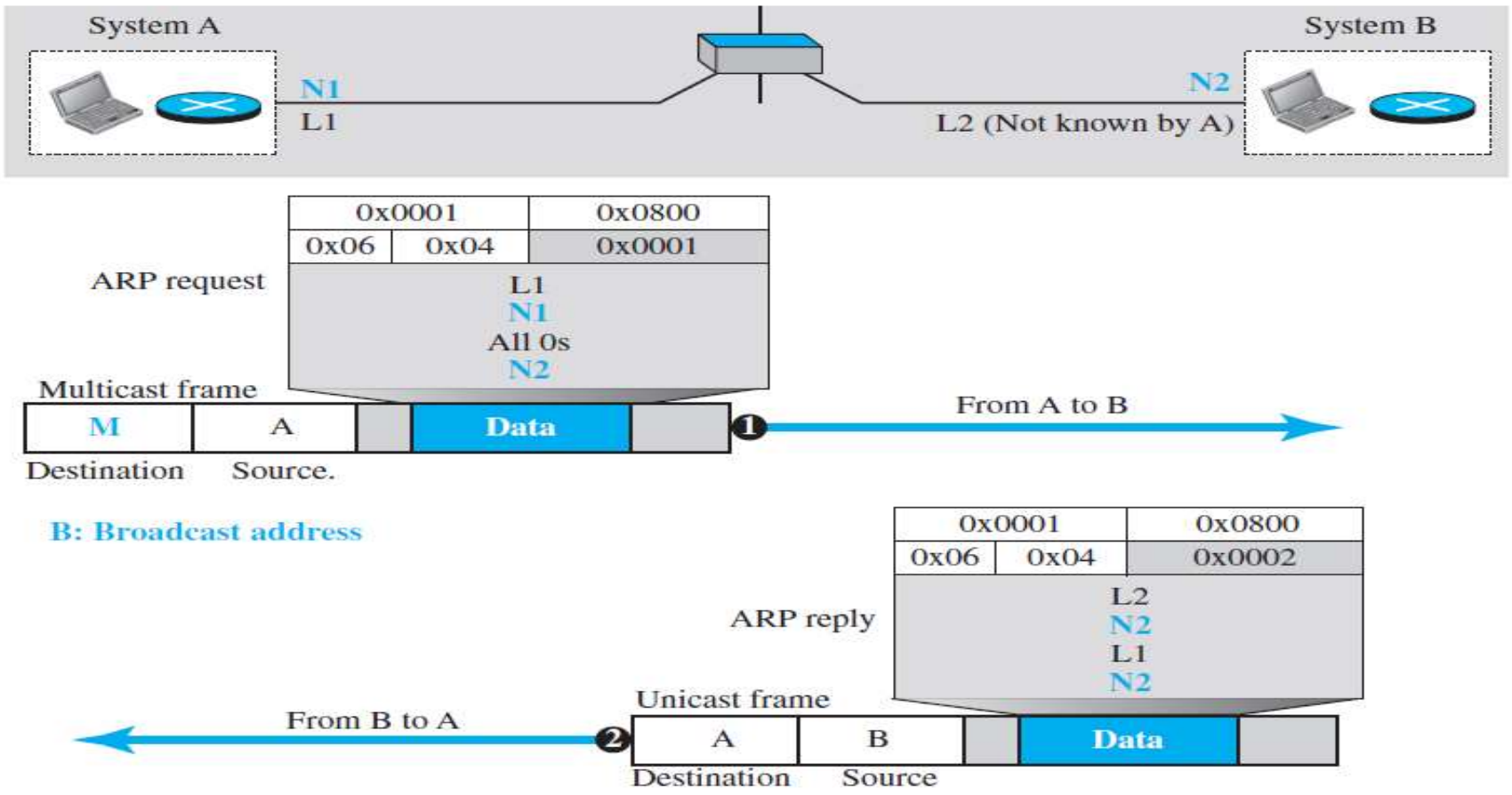
**Figure 9.9** *Example 9.4*



# References


- Data Communications and Networking, Behrouz A. Forouzan, Fifth Edition, TMH, 2013.