



Introduction to Data Communications (COMP 3721)

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Fall 2021

Learning Outcomes of This Lecture

- **By the end of this lecture you will be able to**
 - Explain the services of the data-link layer.
 - Explain how the link-layer addressing work.
 - Explain the purpose and functionality of ARP.

Agenda

- Introduction
- Services of the Data-Link Layer
- Two Sublayers
- Link-Layer Addressing
- Address Resolution Protocol (ARP)
- Summary

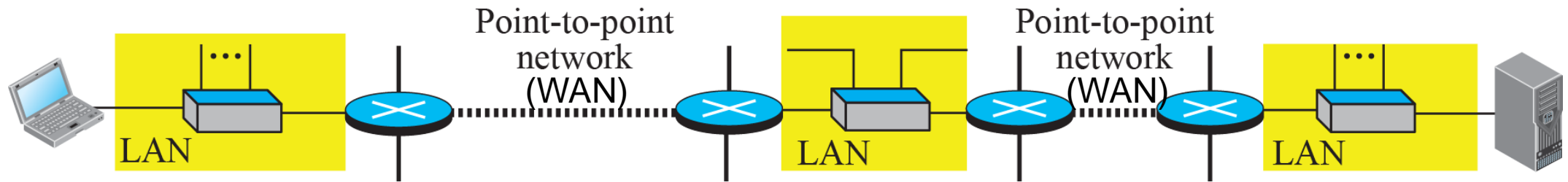
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Introduction

- The Internet
 - combination of networks glued together by connecting devices (routers or switches).
 - a packet traveling from a host to another host needs to pass through these networks.

Node-to-Node Communication at the Data-Link Layer

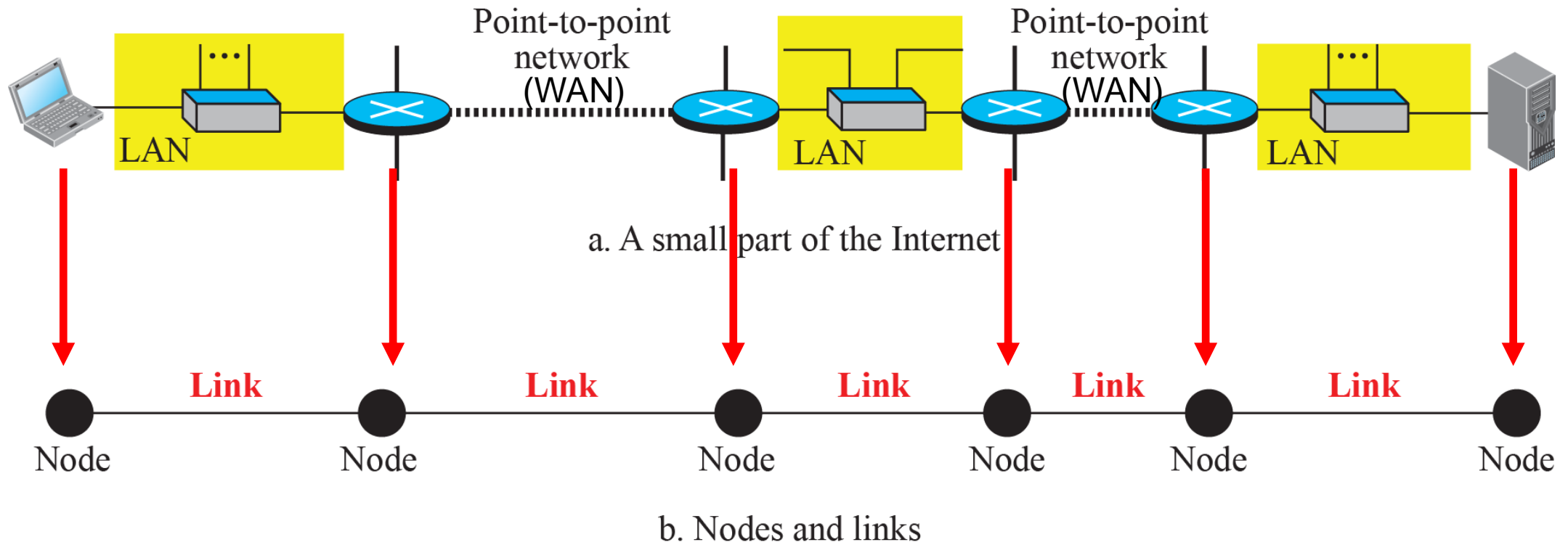


a. A small part of the Internet

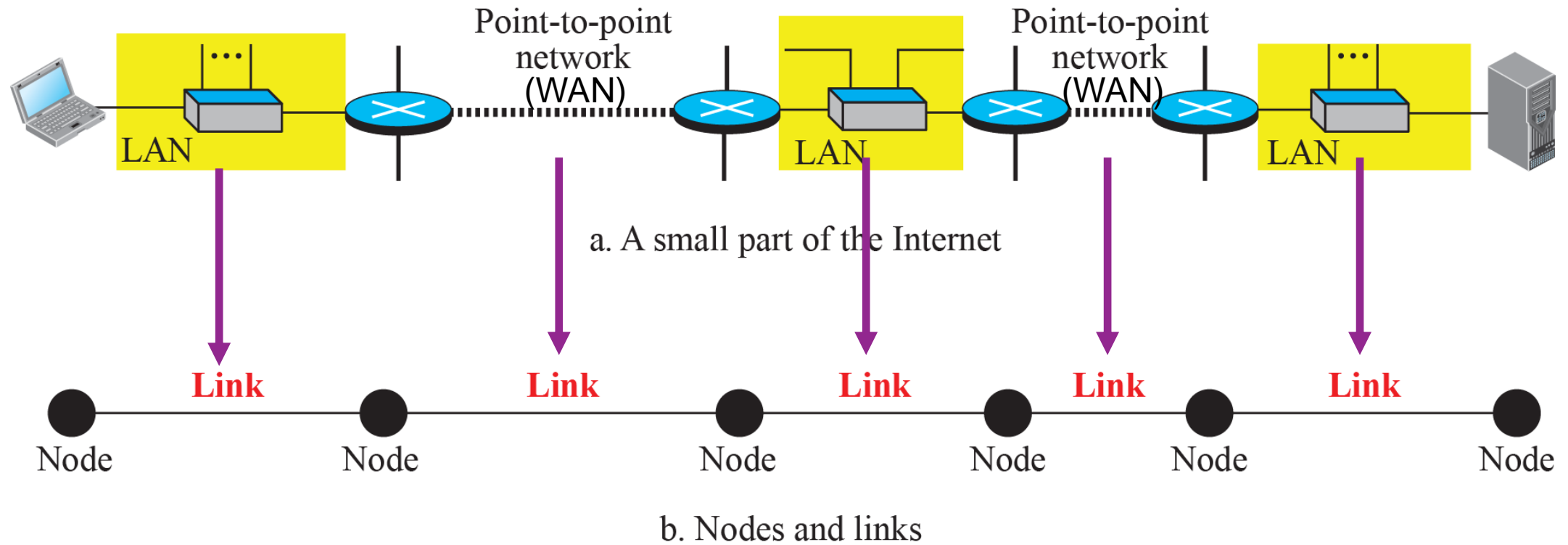


b. Nodes and links

Node-to-Node Communication at the Data-Link Layer



Node-to-Node Communication at the Data-Link Layer



Encapsulation and Decapsulation at the Data-Link Layer – An Analogy

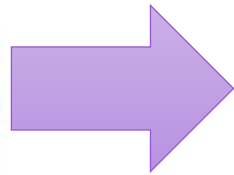
Encapsulation and Decapsulation at the Data-Link Layer – An Analogy

Home (source city)

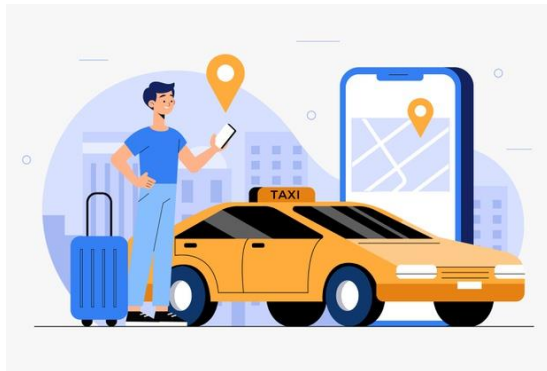


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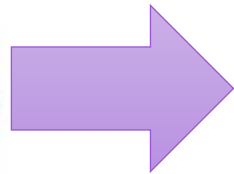


Train Station (in the source city)

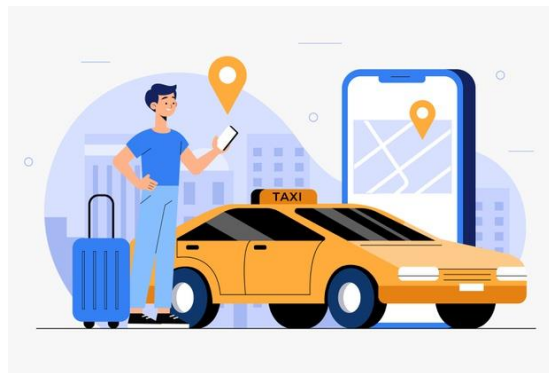


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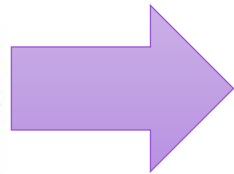


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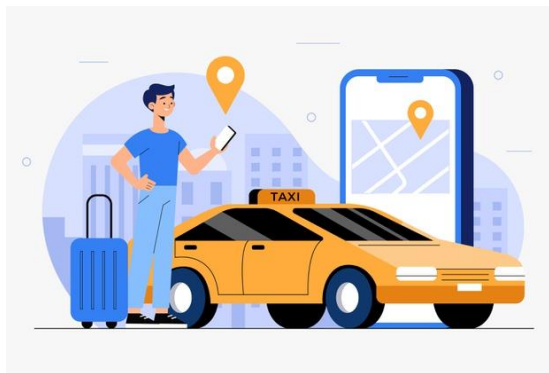


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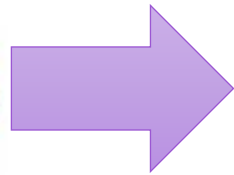


Train Station (at the destination city)

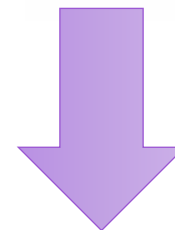


Encapsulation and Decapsulation at the Data-Link Layer – An Analogy

Home (source city)



Train Station (in the source city)

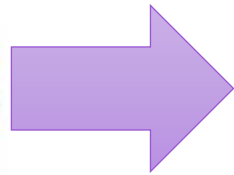


Train Station (at the destination city)

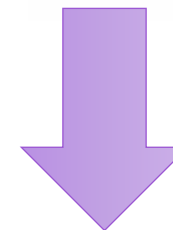
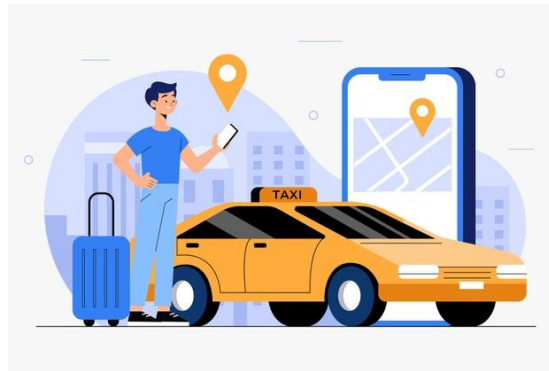


Encapsulation and Decapsulation at the Data-Link Layer – An Analogy

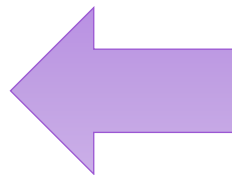
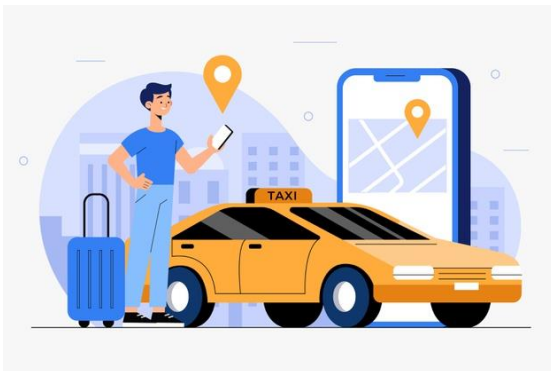
Home (source city)



Train Station (in the source city)



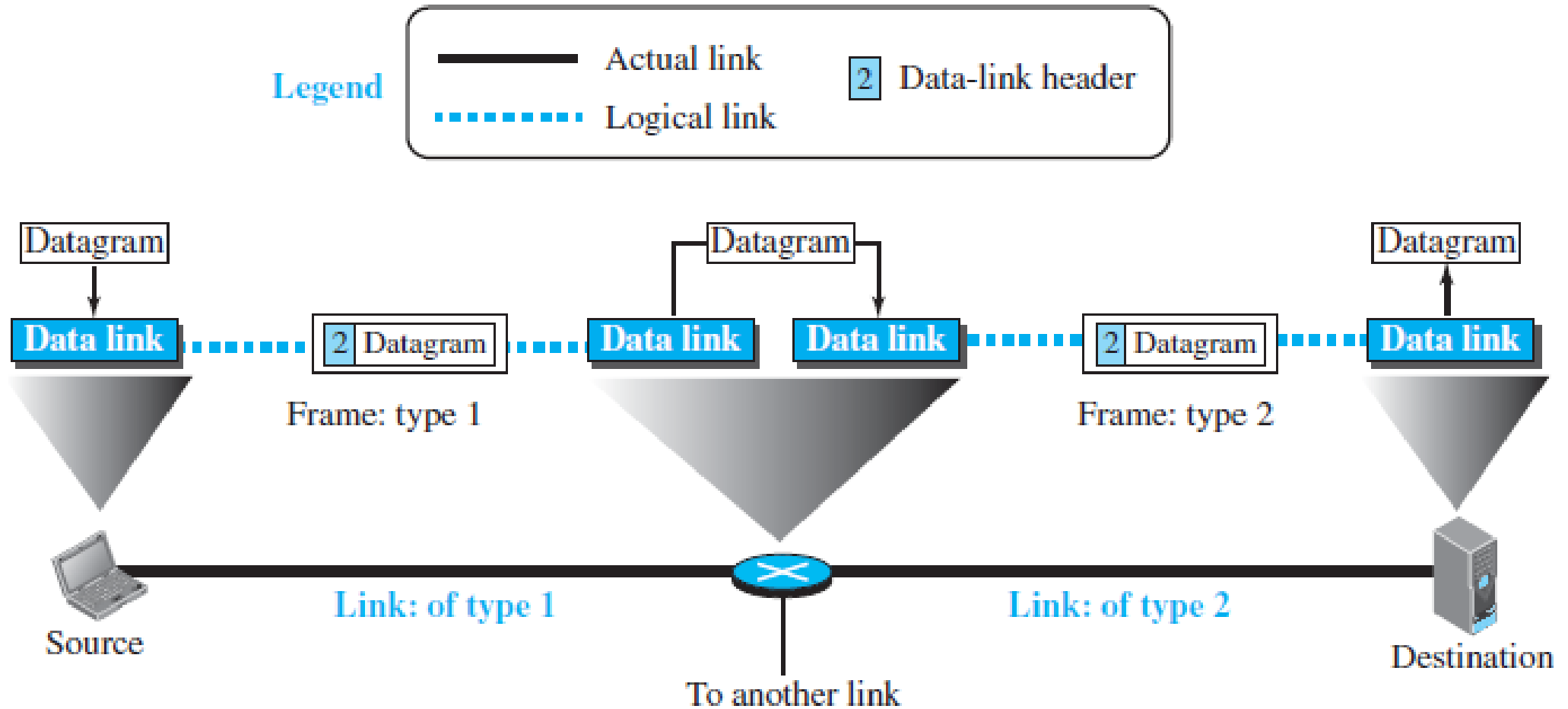
Friends' home (at the destination city)



Train Station (at the destination city)



Encapsulation and Decapsulation at the Data-Link Layer



A packet at the data-link layer is called a **frame**.

Encapsulation and Decapsulation at the Data-Link Layer

Why we need encapsulation and decapsulation at each intermediate node?

Encapsulation and Decapsulation at the Data-Link Layer

Why we need encapsulation and decapsulation at each intermediate node?

➤ two reasons:

- 1) Each link may be using a **different protocol with a different frame format**.
- 2) Even if one link and the next are using the same protocol, encapsulation and decapsulation are needed because the link-layer addresses are normally different.

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- Introduction
- **Services of the Data-Link Layer**
- Categories of Links
- Two Sublayers
- Link-Layer Addressing
- Address Resolution Protocol (ARP)
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Services

- **The data-link layer is located between the physical layer and the network layer.**
 - provides services to the network layer
 - receives services from the physical layer

Services

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 - provides services to the network layer
 - receives services from the physical layer
- **Services provided by the data-link layer**
 - **framing** → encapsulating the datagram in a **frame** before sending it to the next node.
 - **flow control** → controlling the rate of producing frames w.r.t. the rate of consumed frames.
 - **error control** → error detection and correction
 - **controlling how the medium is used.**

Switch as a Layer 2 Device

- **A link-layer switch** is involved only in one data-link and one physical layer (connections are in the same link/network)
- **Link-layer switches** implement the physical layer and data-link layer (layers 1 and 2) of the protocol stack.

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Two Sublayers

1) Data Link Control (DLC)

- deals with issues common to both **point-to-point (dedicated)** and **broadcast (shared)** links.
- services, including framing, flow control, and error control

2) Media Access Control (MAC)

- deals only with issues specific to **broadcast links**

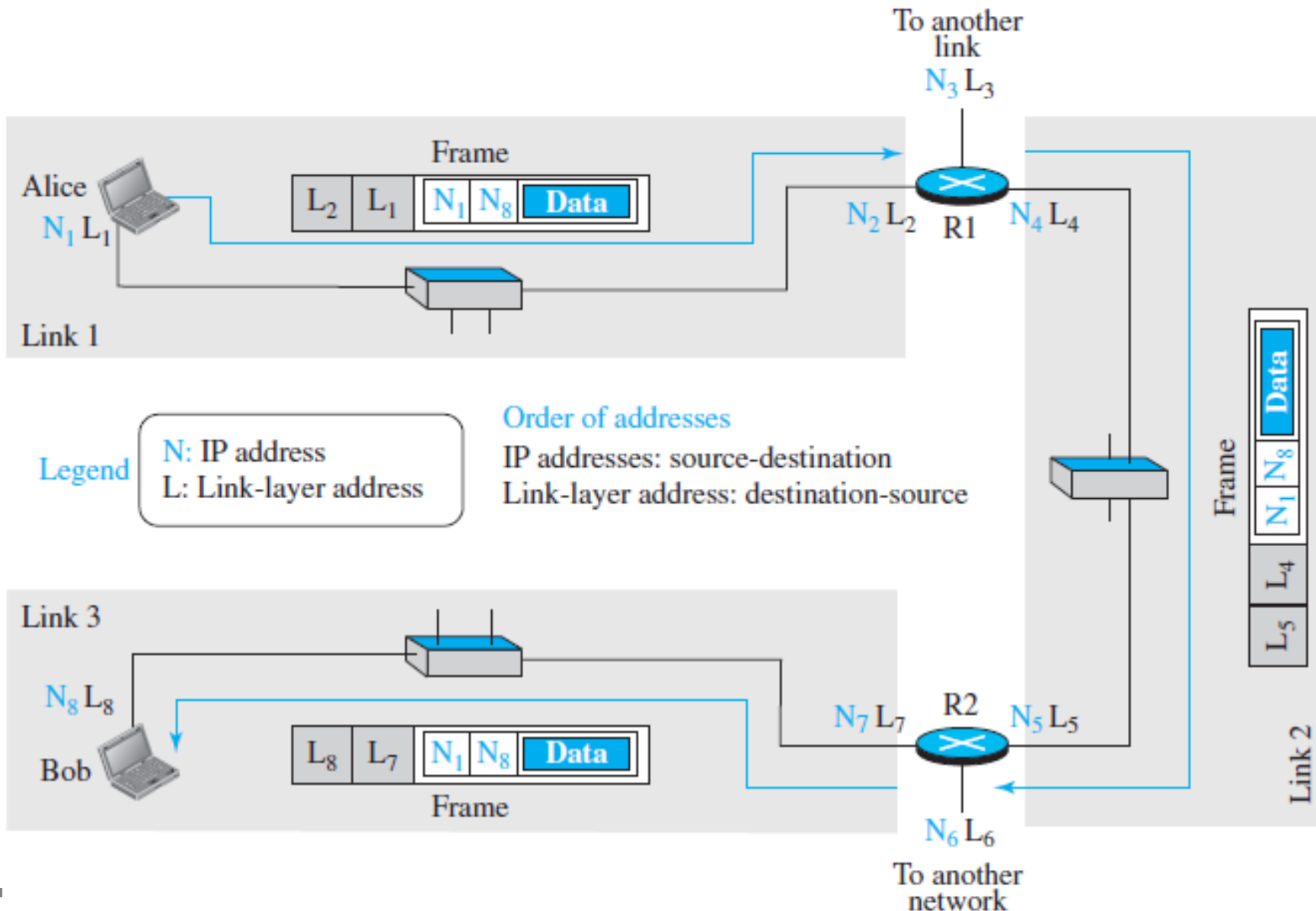
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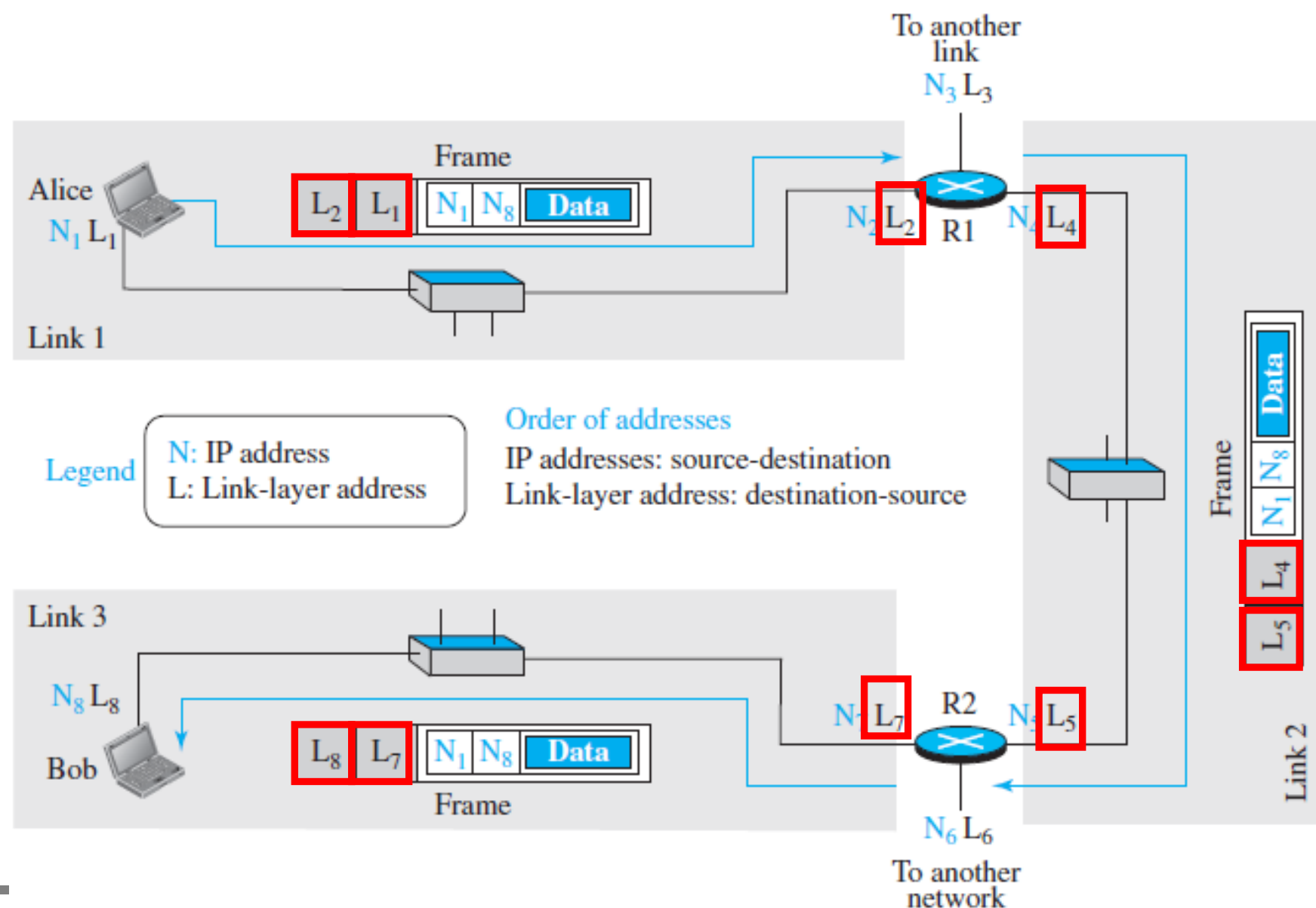
Link-Layer Addressing

- **Why do we need link-layer addressing?**
- **Link-layer address = physical address = MAC (Media Access Control) address**
- In the most common LAN, **Ethernet**, MAC addresses are **48 bits** (6 bytes) and are presented as **12 hexadecimal digits separated by colons**.

IP addresses and link-layer addresses in a Small Internet



IP addresses and link-layer addresses in a Small Internet



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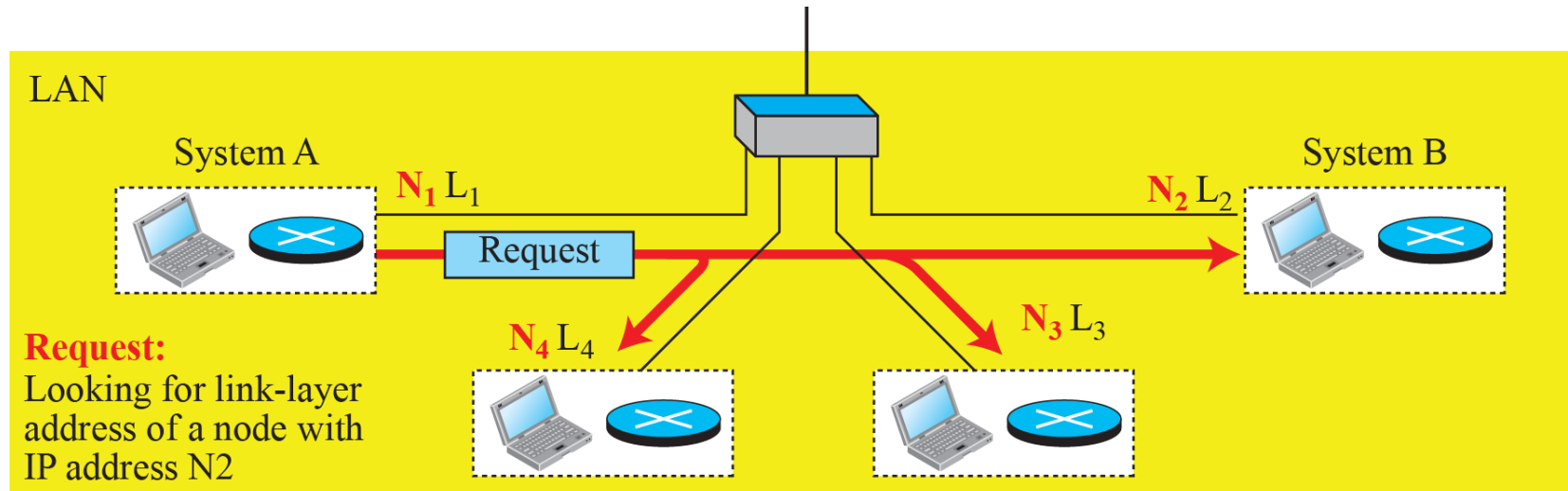
Address Resolution Protocol (ARP)

- Consider the previous example for communication between Alice and Bob.
- **How does each node acquire the MAC address of the next node on the path from source to destination?**

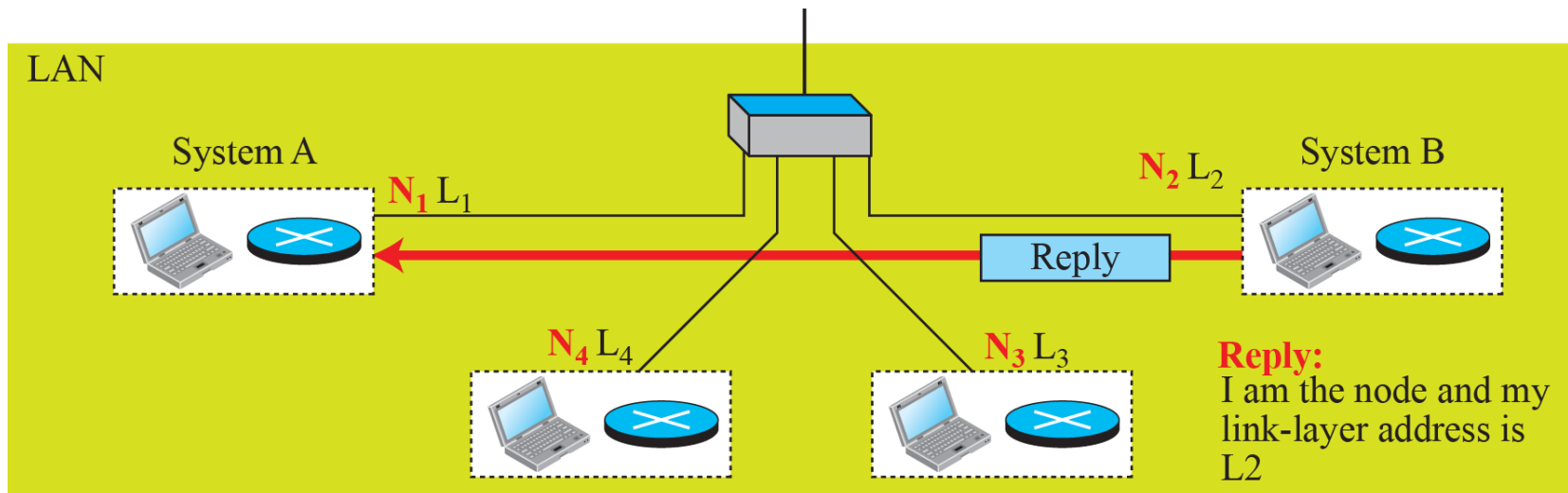
Address Resolution Protocol (ARP)

- Useful when moving a frame through a link.
- One of the auxiliary protocols defined in the network layer.
- **It maps an IP address to a logical-link address.**
- A host or a router need to run the ARP program all of the time in the background.
 - a host does not know when another host sends an ARP request; it needs to be ready all of the time to respond to an ARP request.

ARP Operation



a. ARP request is broadcast



b. ARP reply is unicast

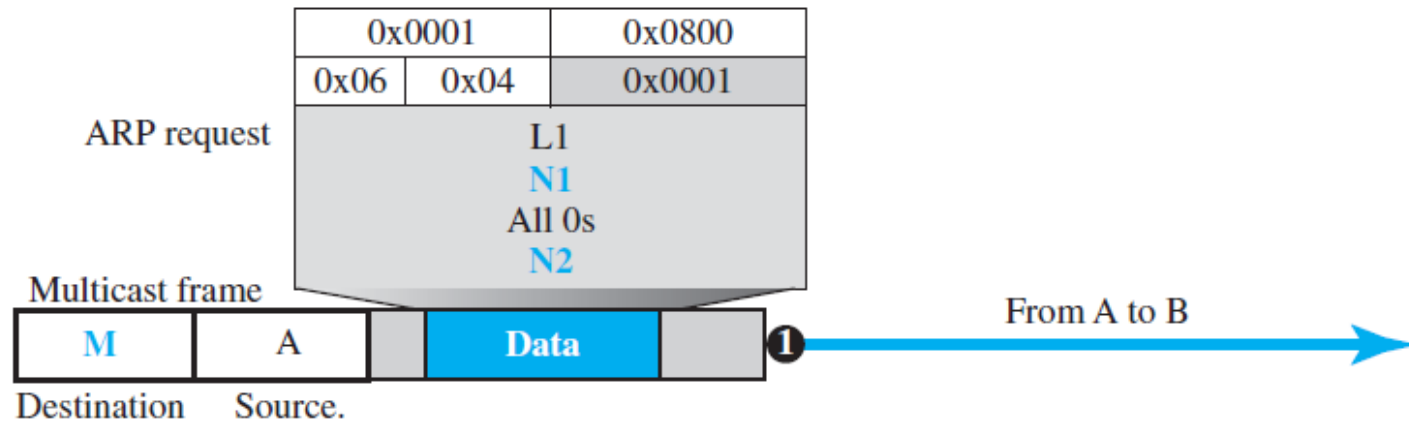
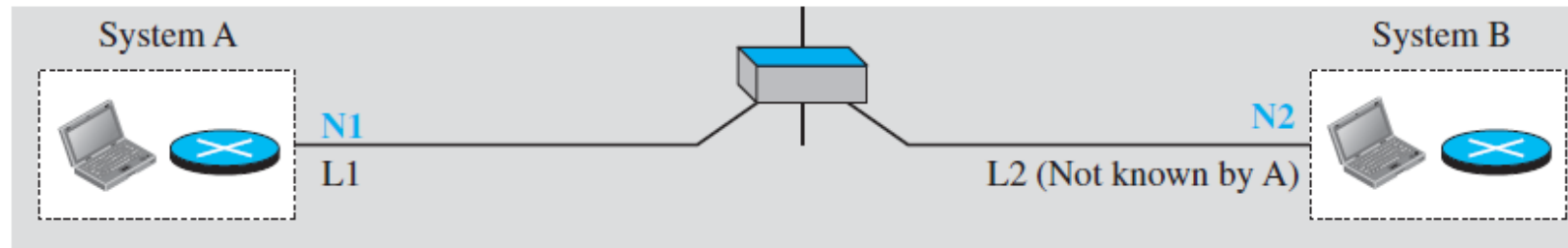
ARP Packet Format

Hardware: LAN or WAN protocol

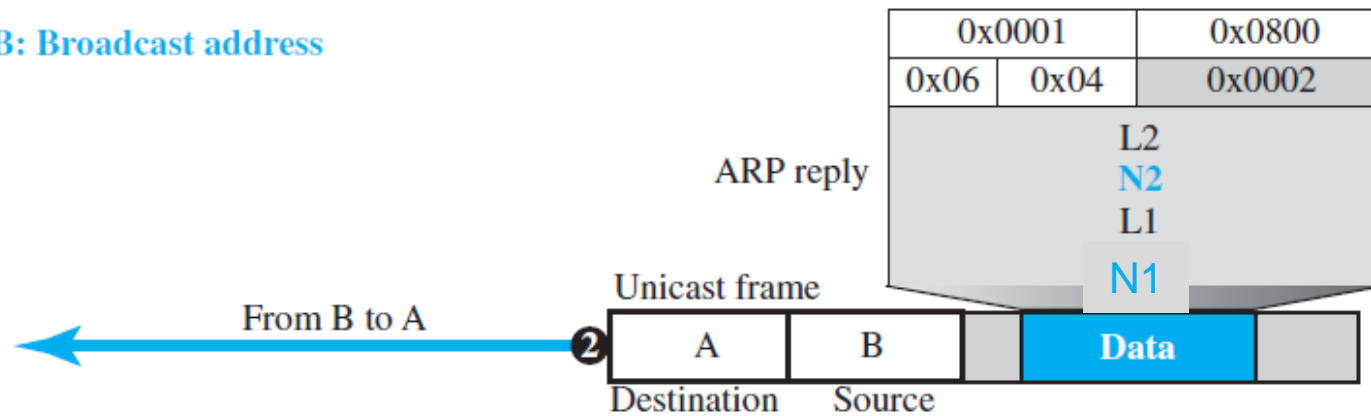
Protocol: Network-layer protocol

0	8	16	31
Hardware Type		Protocol Type	
Hardware length	Protocol length	Operation Request:1, Reply:2	
Source hardware address			
Source protocol address			
Destination hardware address (Empty in request)			
Destination protocol address			

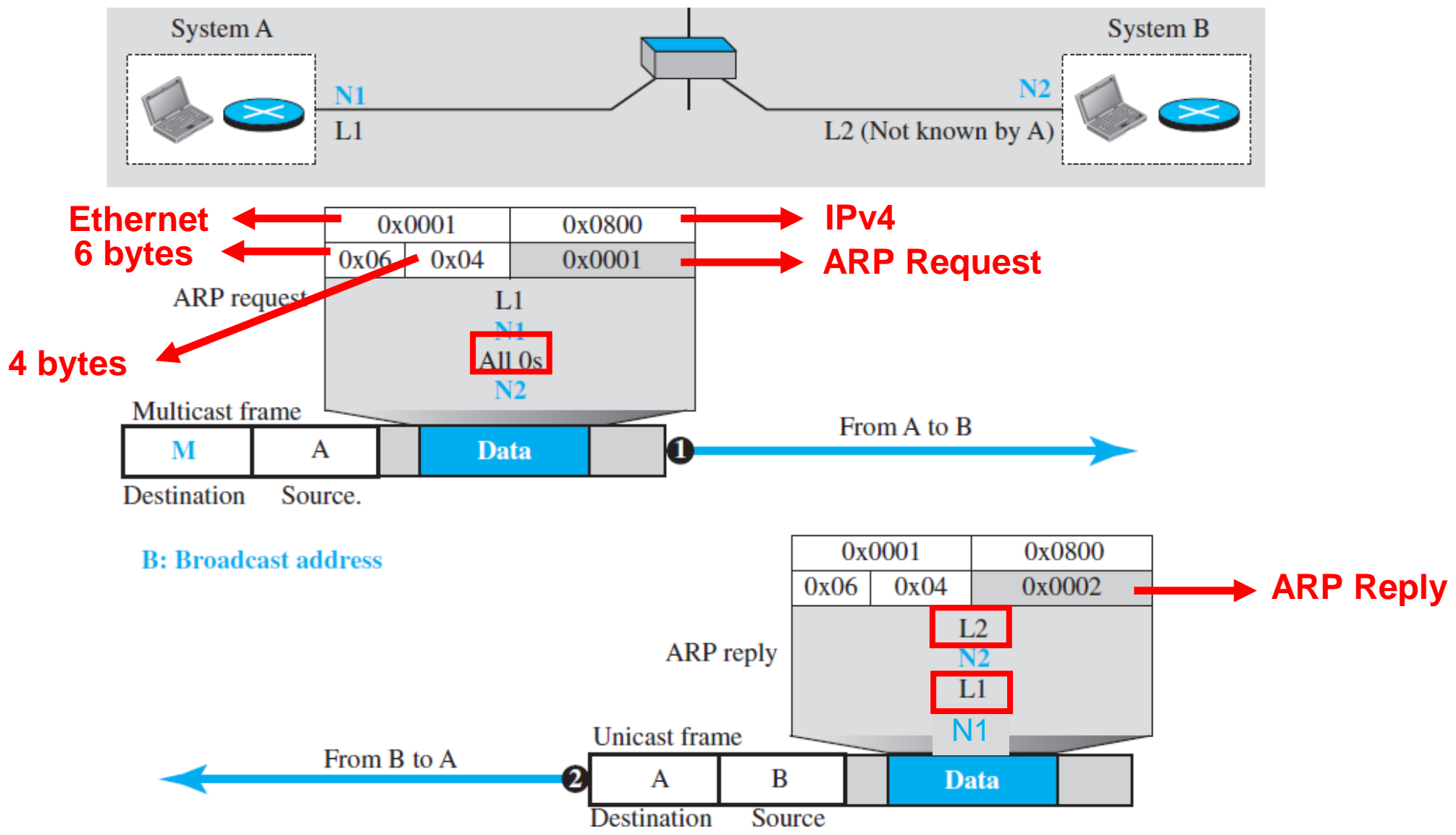
Example of ARP Request and Response Messages



B: Broadcast address



Example of ARP Request and Response Messages



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Summary

- The data-link layer is responsible for
 - the creation and delivery of a frame to another node, **along the link**
 - packetizing (framing)
 - flow control and error control **along the link**
- Link-layer addressing
- ARP to map IP addresses to MAC addresses

References

[1] Behrouz A.Forouzan, Data Communications and Networking, 5th Ed, 2013, McGraw-Hill companies.