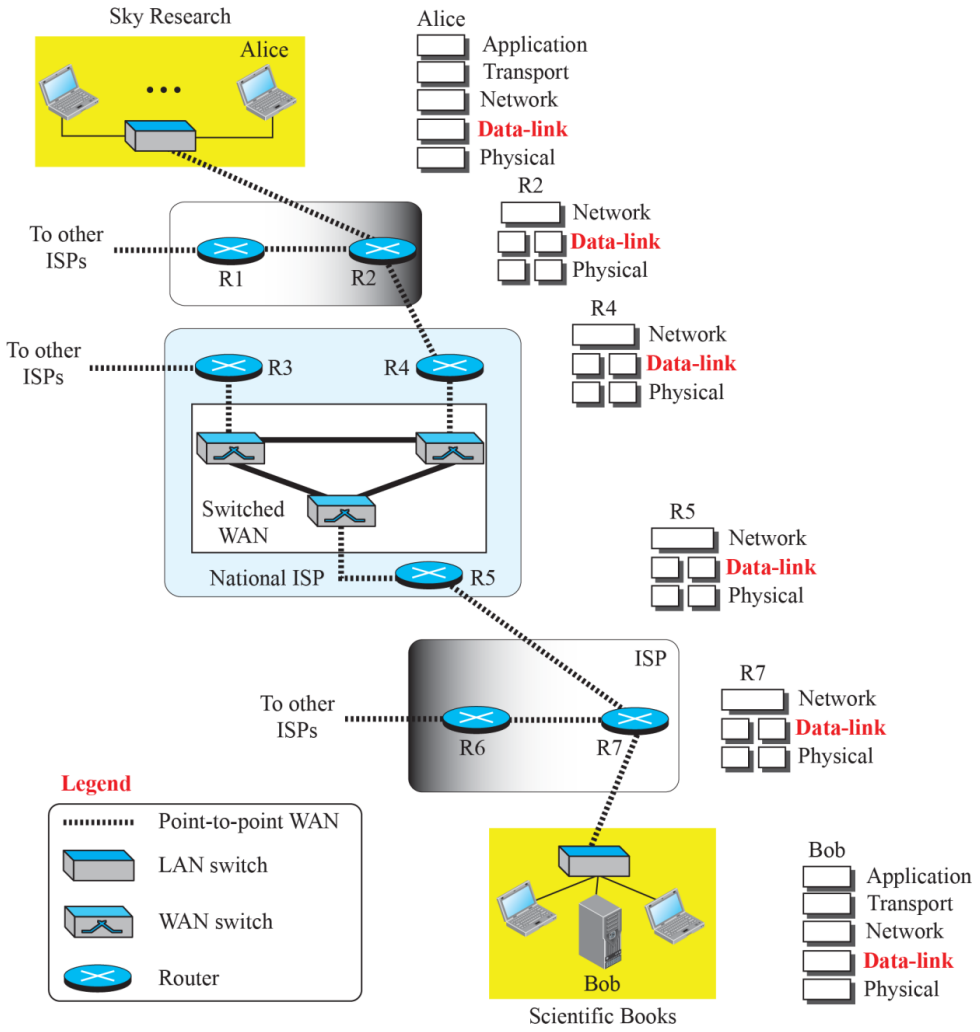
CSE 365: Communication Engineering

Chapter 9: Introduction to Data Link Layer

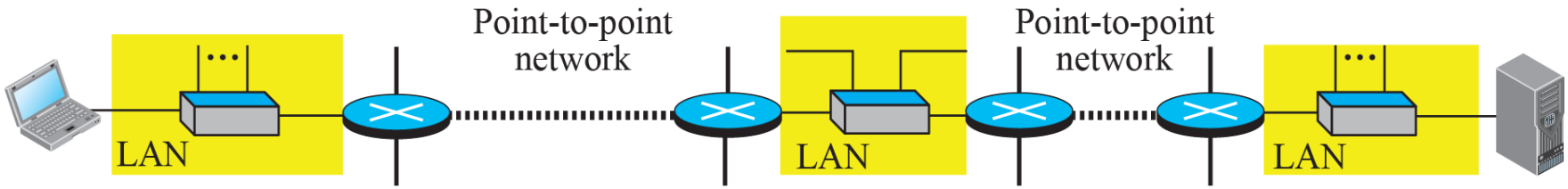
Introduction

- 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 (LANs and WANs) .



Nodes and Links

- Communication at the data-link layer is node-to-node (hop-to-hop).
- The two end hosts and the routers are referred to as *Nodes* and the networks in between as *Links*.



a. A small part of the Internet

b. Nodes and links

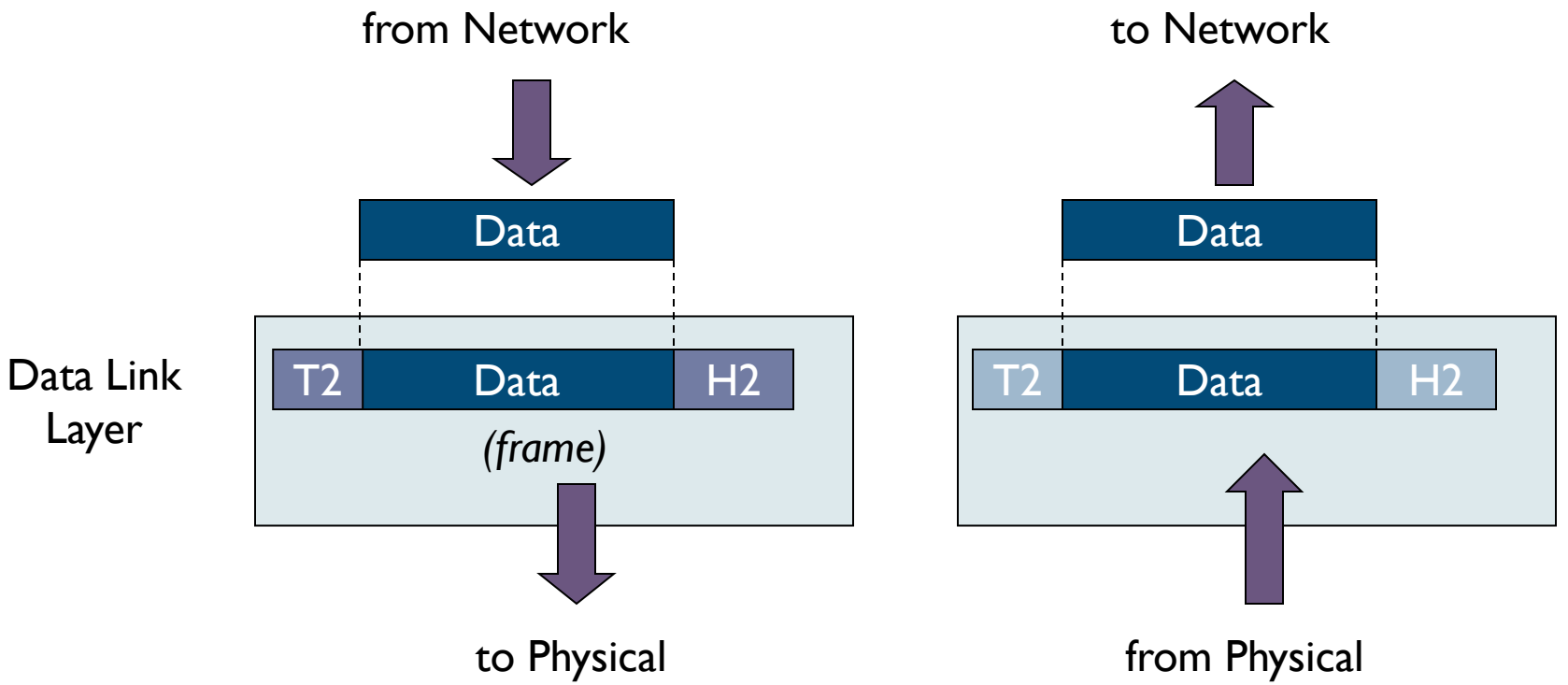
Data Link Layer

- Located between the physical and the network layers.
- Provides services to the network layer; it receives services from the physical layer.
- Duties/services
  - Framing
  - Physical addressing
  - Flow control (hop-to-hop)
  - Error control (hop-to-hop)
  - Congestion control
  - Access control

Framing

- A packet at the data-link layer is normally called a frame.
- The data-link layer at each node needs to encapsulate the datagram (packet received from the network layer) in a frame before sending it to the next node.
- The node also needs to decapsulate the datagram from the frame received on the logical channel.

Framing


from Network
to Network
Data
Data
Data Link Layer
T2
Data
H2
T2
Data
H2
(frame)
to Physical
from Physical

Flow Control

- The sending data-link layer at the end of a link is a *producer* of frames; the receiving data-link layer at the other end of a link is a *consumer*.
- If the rate of produced frames is higher than the rate of consumed frames, frames at the receiving end need to be buffered while waiting to be processed.
- We cannot have an unlimited buffer size at the receiving side.
- We have two choices:
  - Drop the frames if its buffer is full.
  - Send a feedback to the sending data-link layer to stop or slow down.

Error Control

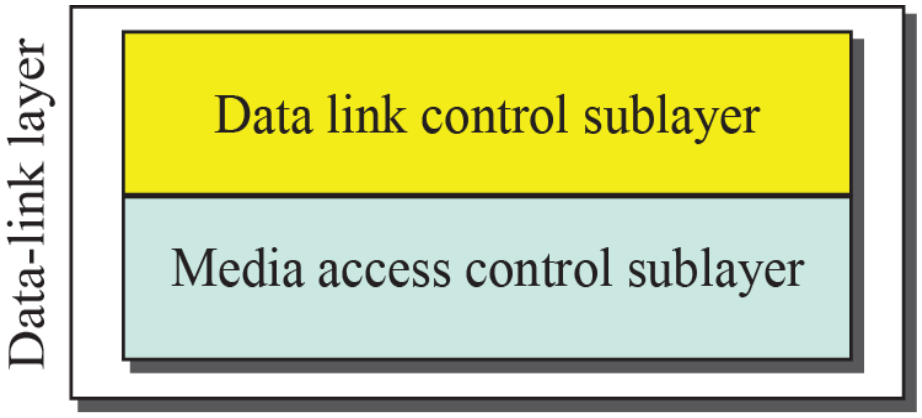
- Since electromagnetic signals are susceptible to error, a frame is susceptible to error.
- The error needs first to be detected.
- After detection, it needs to be either corrected at the receiver node or discarded and retransmitted by the sending node.

Two Categories of Links

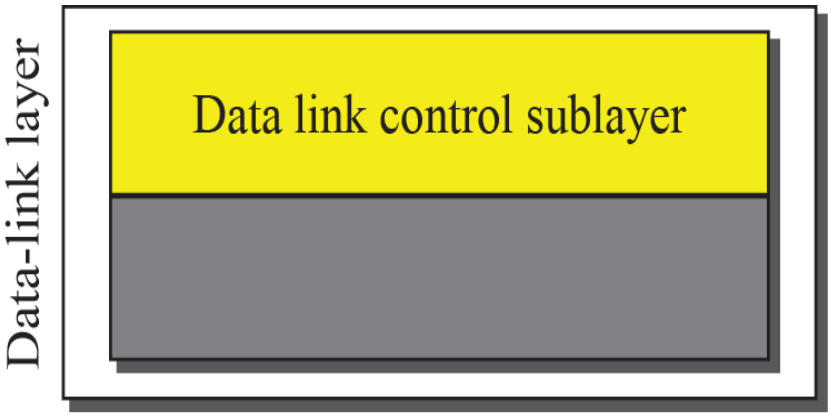
- Data-Link layer controls how the medium is used.
- Two categories:
  - A point-to-point link
  - A broadcast link.
- In a point-to-point link, the link is dedicated to the two devices.
- In a broadcast link, the link is shared between several pairs of devices.

Data Link Sub-layers

- To better understand the functionality of and the services provided by the link layer, we divide the data-link layer into two sublayers:
  - 1. Data Link Control (DLC) and
  - 2. Media Access Control (MAC).



a. Data-link layer of a broadcast link

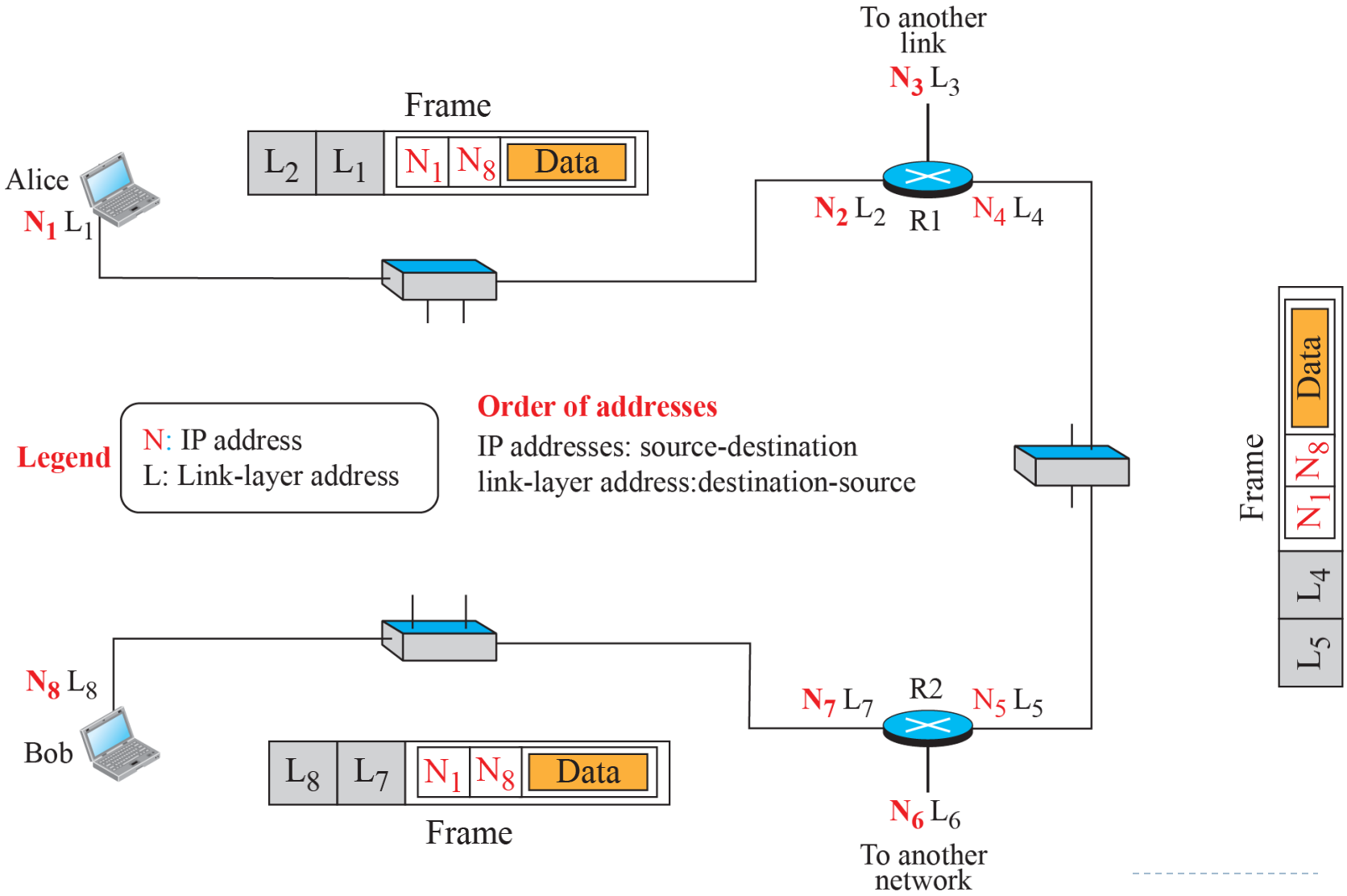


b. Data-link layer of a point-to-point link

Link Layer Addressing

- In a connectionless internetwork such as the Internet we cannot make a datagram reach its destination using only IP addresses.
- 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 packet should pass through.
- A link-layer address is sometimes called a *link address*, sometimes a *physical address*, and sometimes a *MAC address*.

IP addresses and link-layer addresses in a small internet



Raised Questions

- If the IP address of a router does not appear in any datagram sent from a source to a destination, why do we need to assign IP addresses to routers?
- Why do we need more than one IP address in a router, one for each interface?
- How are the source and destination IP addresses in a packet determined?
- How are the source and destination link-layer addresses determined for each link?

Three Types of addresses

- Some link-layer protocols define three types of addresses: unicast, multicast, and broadcast.
- 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.

Multicast and Broadcast Address

- Multicast Address:
  - Multicasting means one-to-many communication.

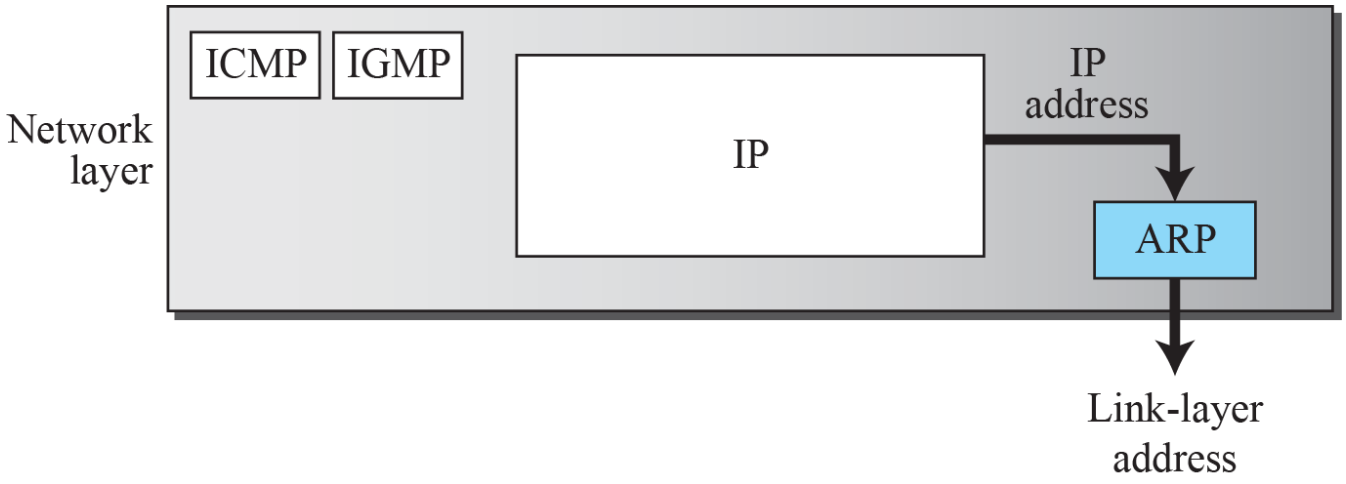
- Broadcast Address:
  - Broadcasting means one-to-all communication.
  - A frame with a destination broadcast address is sent to all entities in the link.

Three Types of addresses

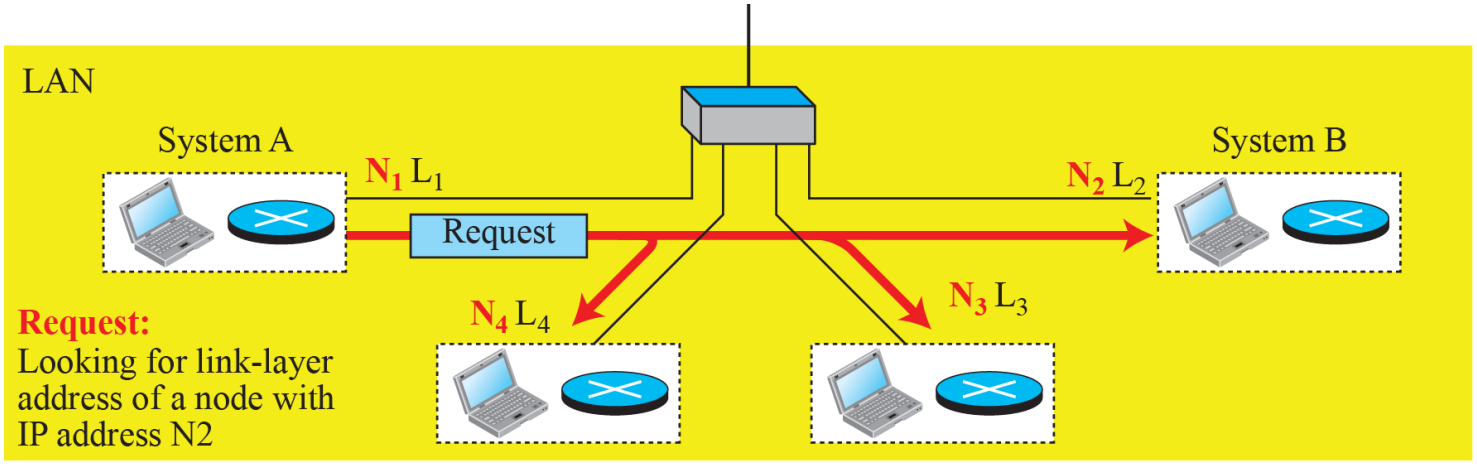
- All these link-layer addresses are present in the most common LAN, Ethernet and are 48 bits (six bytes) that are presented as 12 hexadecimal digits separated by colons.
- Unicast:
  - The second digit needs to be an odd number.
  - A3:34:45:11:92:F1
- Multicast:
  - The second digit needs to be an even number.
  - A2:34:45:11:92:F1
- Broadcast:
  - FF:FF:FF:FF:FF:FF

Address Resolution Protocol (ARP)

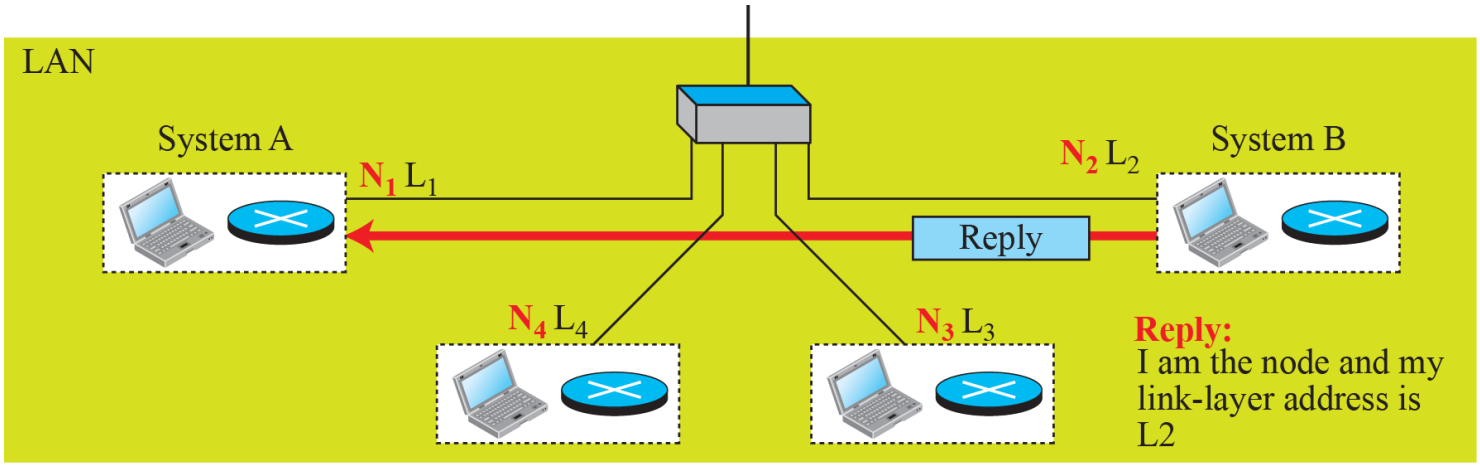
- Anytime a node has an IP datagram to send to another node in a link, it has the IP address of the receiving node.
- But we need the link-layer address of the next node.
- Address Resolution Protocol (ARP) – accepts an IP address from the IP protocol, maps the address to the corresponding link layer address, and passes it to the data-link layer



ARP Operation



a. ARP request is broadcast

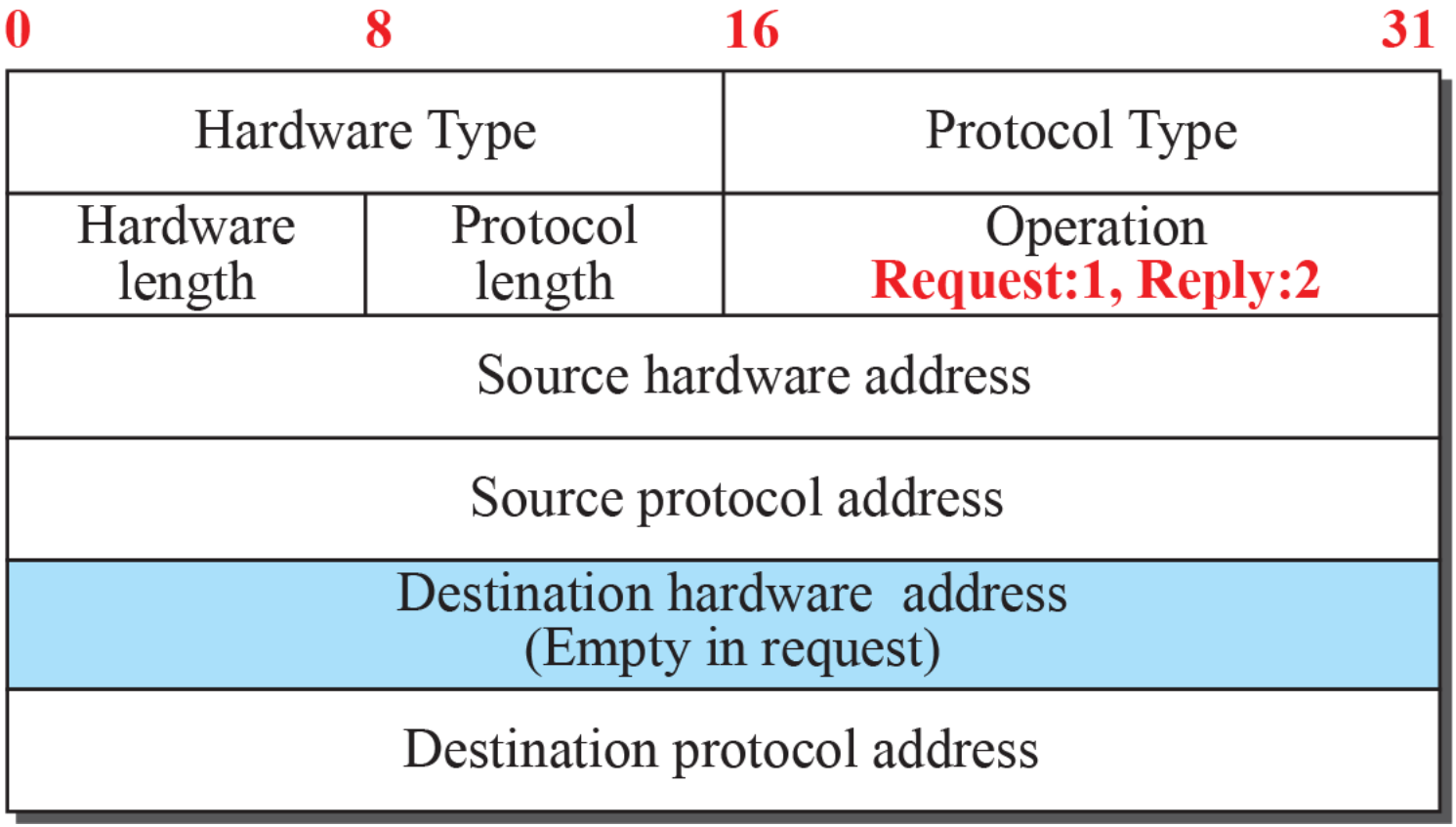


b. ARP reply is unicast

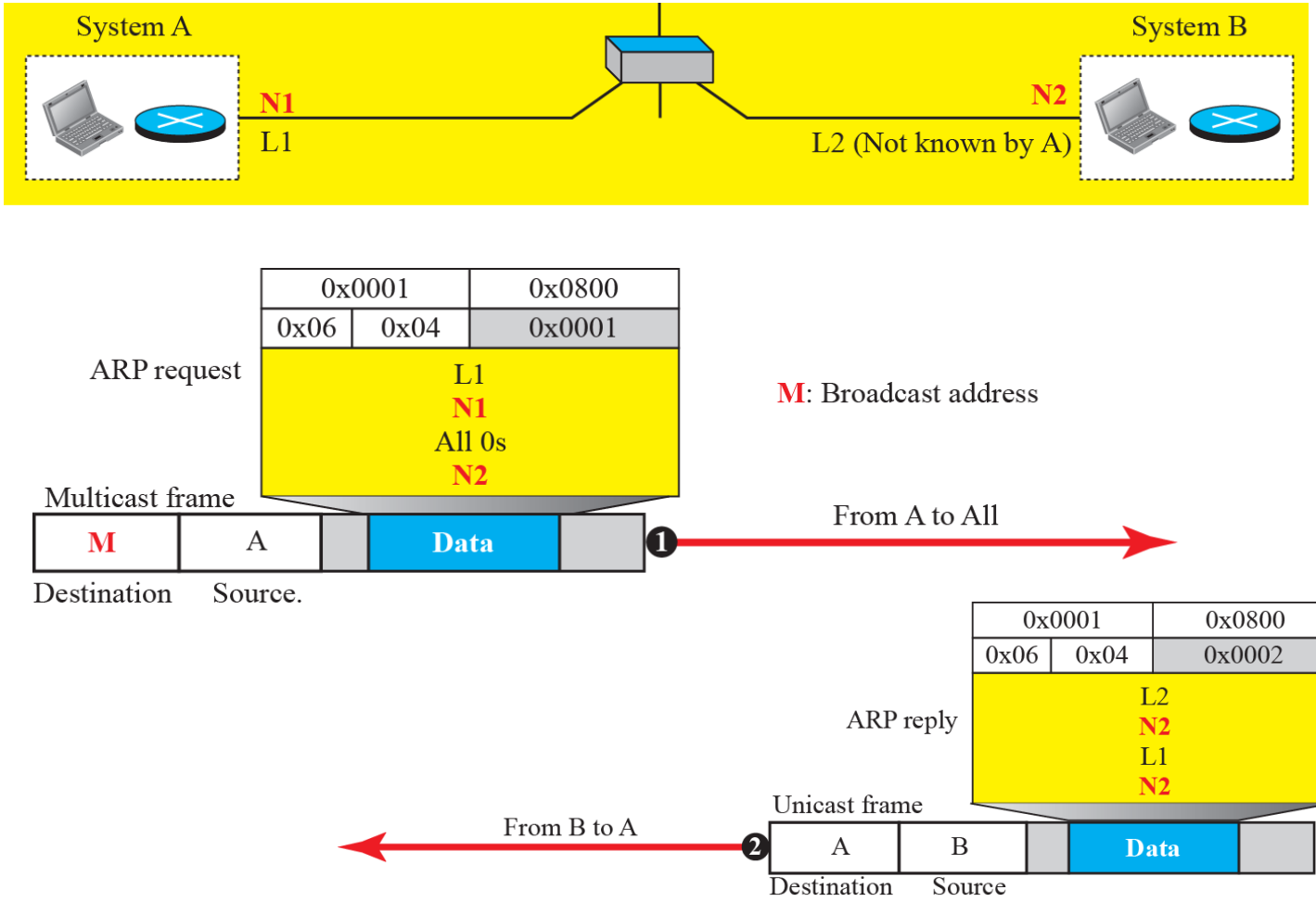
ARP Packet Format

Hardware: LAN or WAN protocol

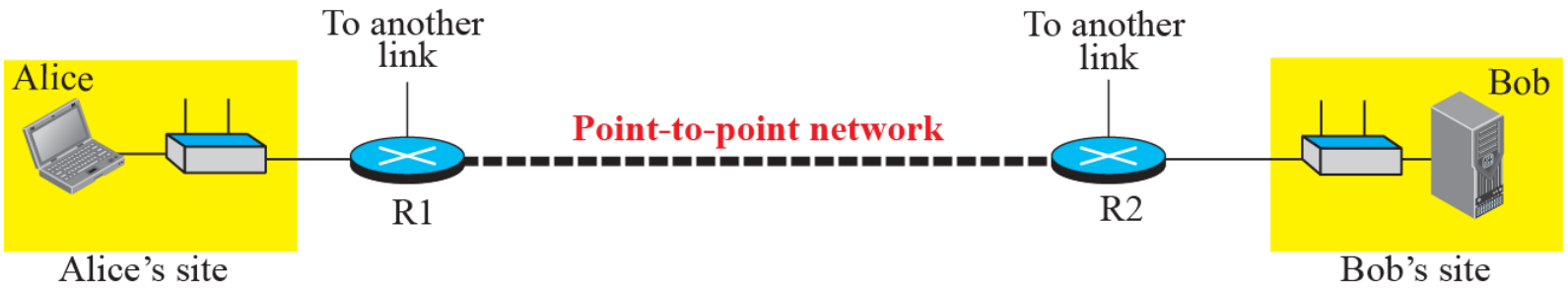
Protocol: Network-layer protocol



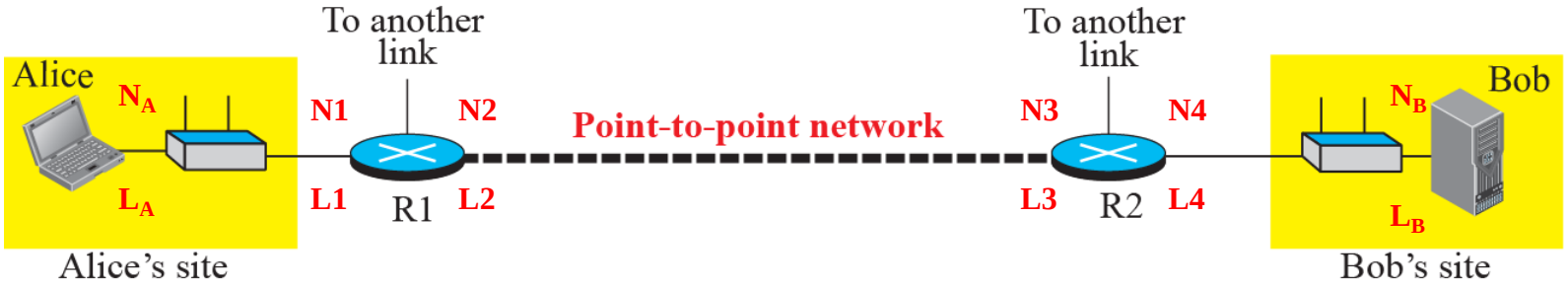
ARP Request and Response Messages

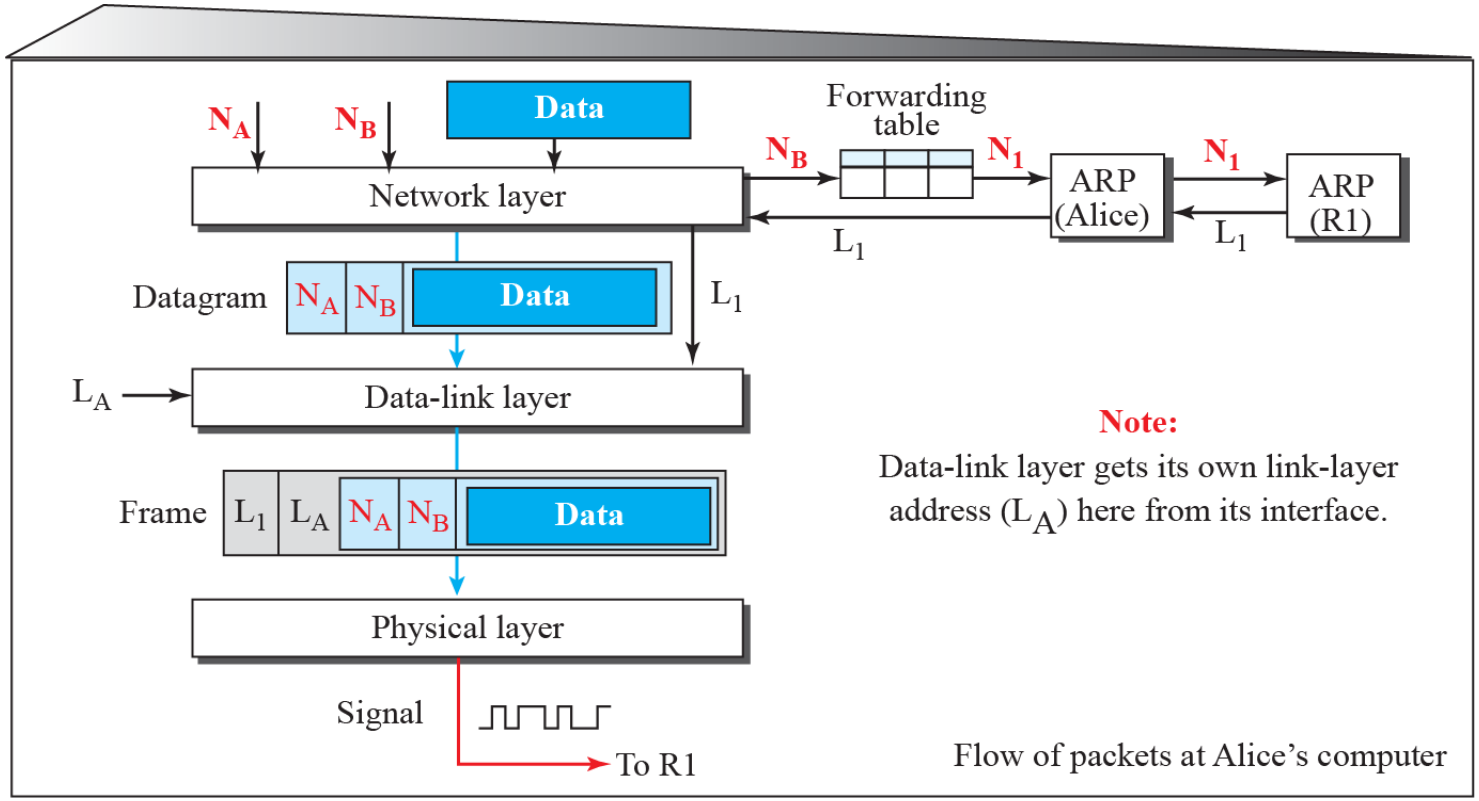


An Example of Communication

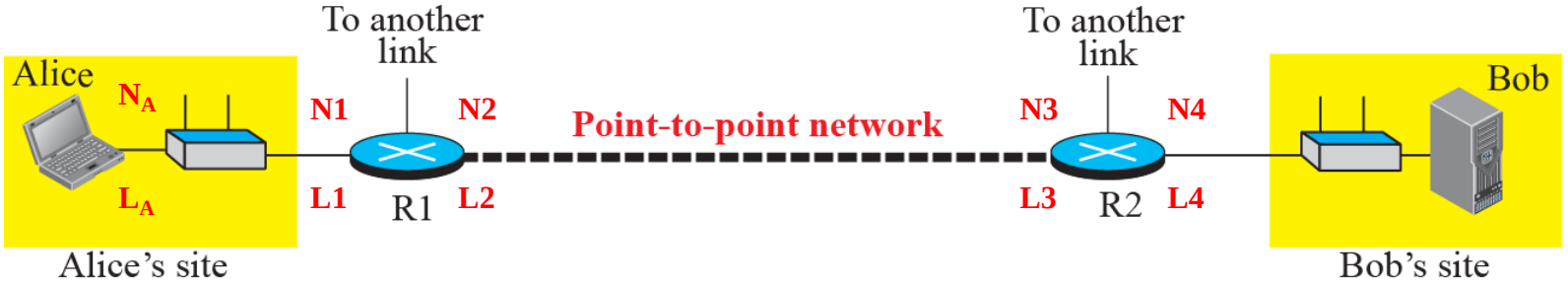


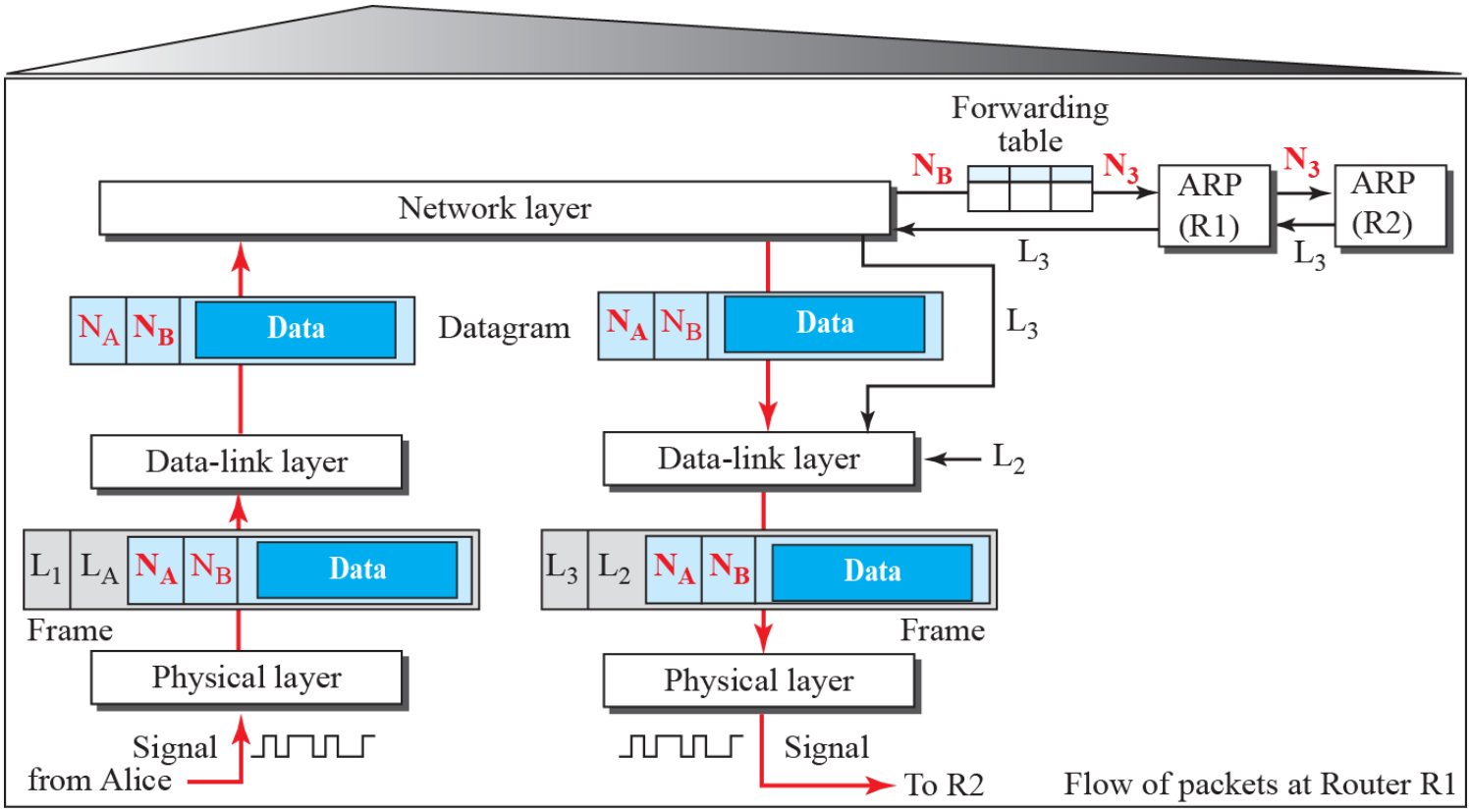
Flow of packets at Alice site



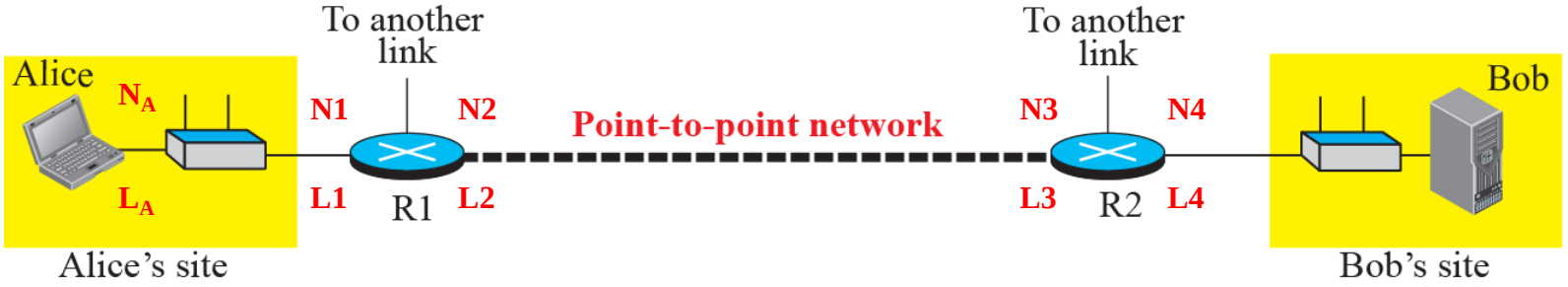


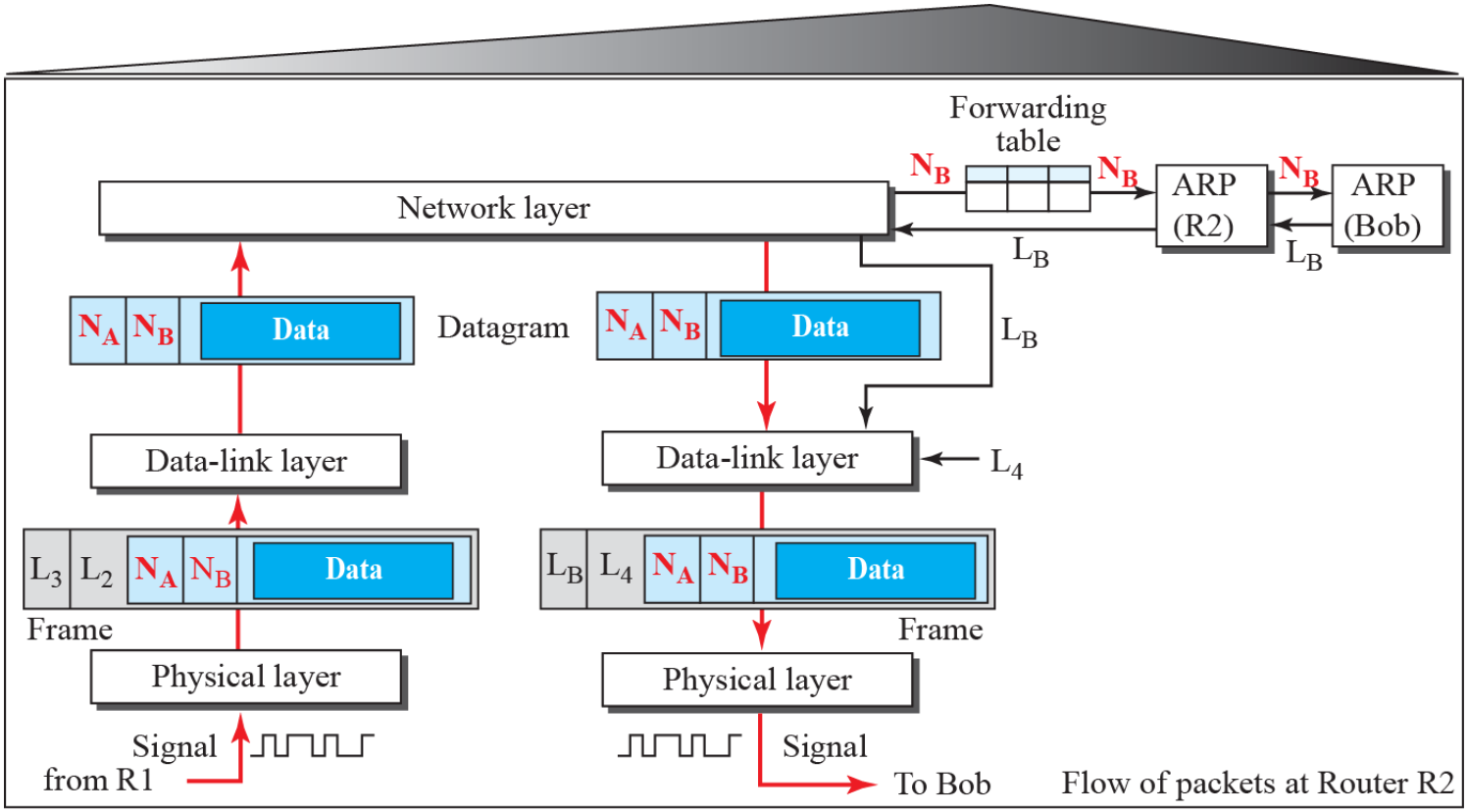
Flow of activities at router R1





Flow of activities at router R2





Flow of packets at Bob's site