LINK-LAYER ADDRESSING

Data-Link Layer

- Provides services to the network layer; receives services from the physical layer.
- Scope of the data-link layer is node-to-node.
- When a packet is travelling in the internet, the dl layer of a node (host or router) is responsible for delivering a datagram to the next node in the path.
- The data-link layer of the sending node needs to encapsulate the datagram received from the network in a frame,
- The data-link layer of the receiving node needs to decapsulate the datagram from the frame.

Flow Control, Error Control

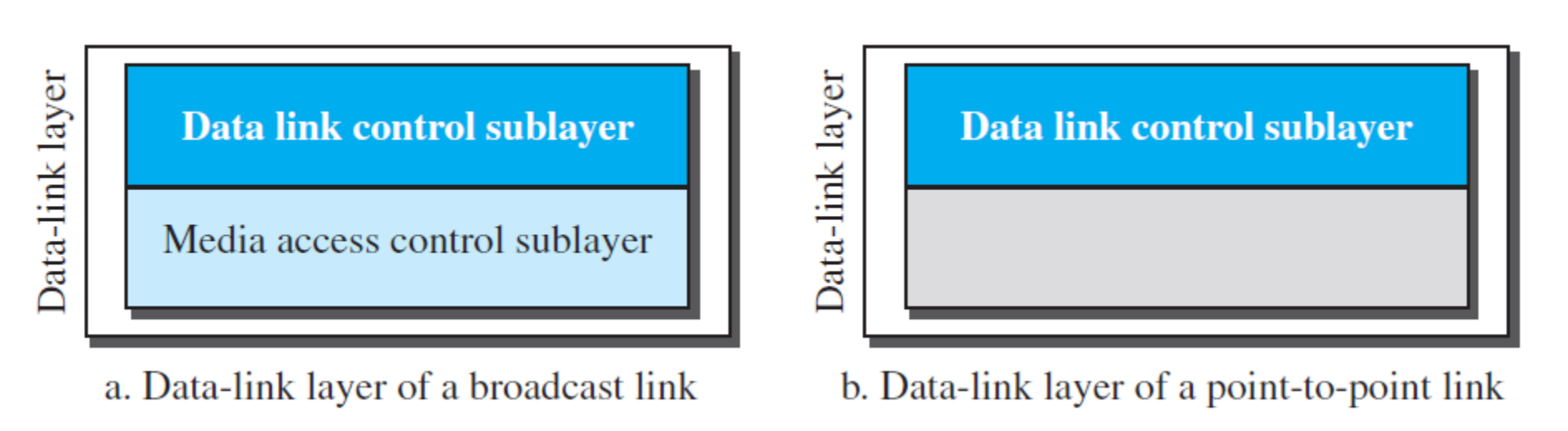
- If the rate of produced frames is higher than the rate of consumed frames, frames at the receiving end need to be buffered while waiting to be consumed
- Receiving data-link layer drop the frames if its buffer is full.
- Send a feedback to the sending data-link layer to ask it to stop or slow down.

Error control

- Electromagnetic signals are susceptible to error, a frame is susceptible to error.
- The error needs first to be detected. And corrected at the receiver node or discarded and retransmitted by the sending node.

Congestion Control

- Congested links result in frame loss
- **Two Categories of Links:** *point-to-point link* or a *broadcast link*
- **Two Sublayers:** data link control (DLC) and media access control (MAC)



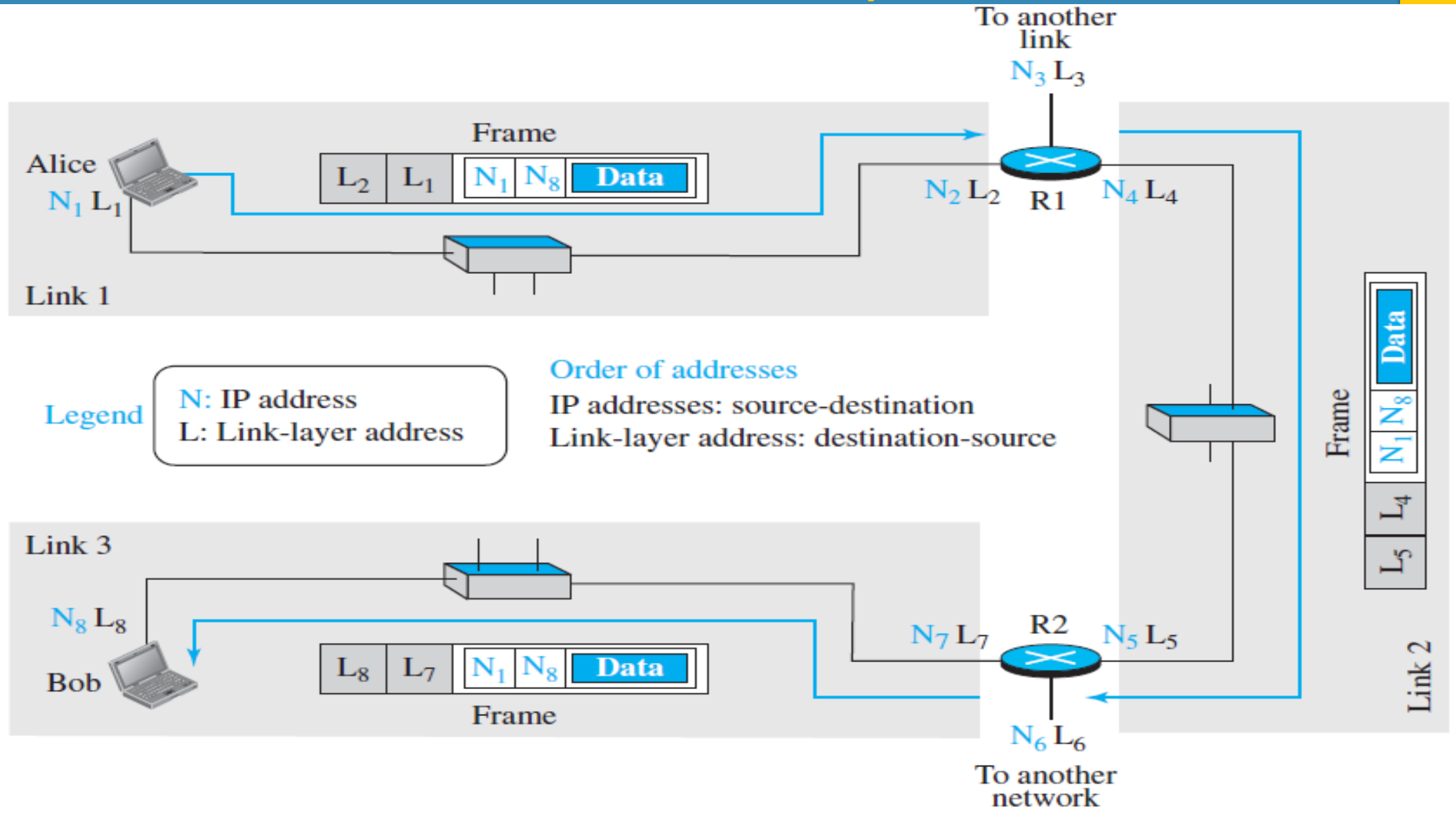
a. Data-link layer of a broadcast link

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

LINK-LAYER ADDRESSING

- A link-layer address is called a link address/physical address/ MAC address
- When a datagram passes from the network layer to the data-link layer, the datagram will be encapsulated in a frame and two data-link addresses are added to the frame header.
- These two addresses are changed every time the frame moves from one link to another.

IP addresses and link-layer addresses



Three Types of addresses
unicast, multicast, & broadcast.

Unicast Address

- Each host or each interface of a router is assigned a unicast address, means one-to-one communication.
- A frame with a unicast address destination is destined only for one entity in the link.
- 48 bits (six bytes) that are presented as 12 hexadecimal digits separated by colons; The second digit needs to be an odd number.

A3:34:45:11:92:F1

Types of addresses

Multicast address :

- Multicasting means one-to-many communication, the jurisdiction is local (inside the link).
- 48 bits (six bytes) that are presented as 12 hexadecimal digits separated by colons.
- The second digit, however, needs to be an even number in hexadecimal.

A2:34:45:11:92:F1

Broadcast address

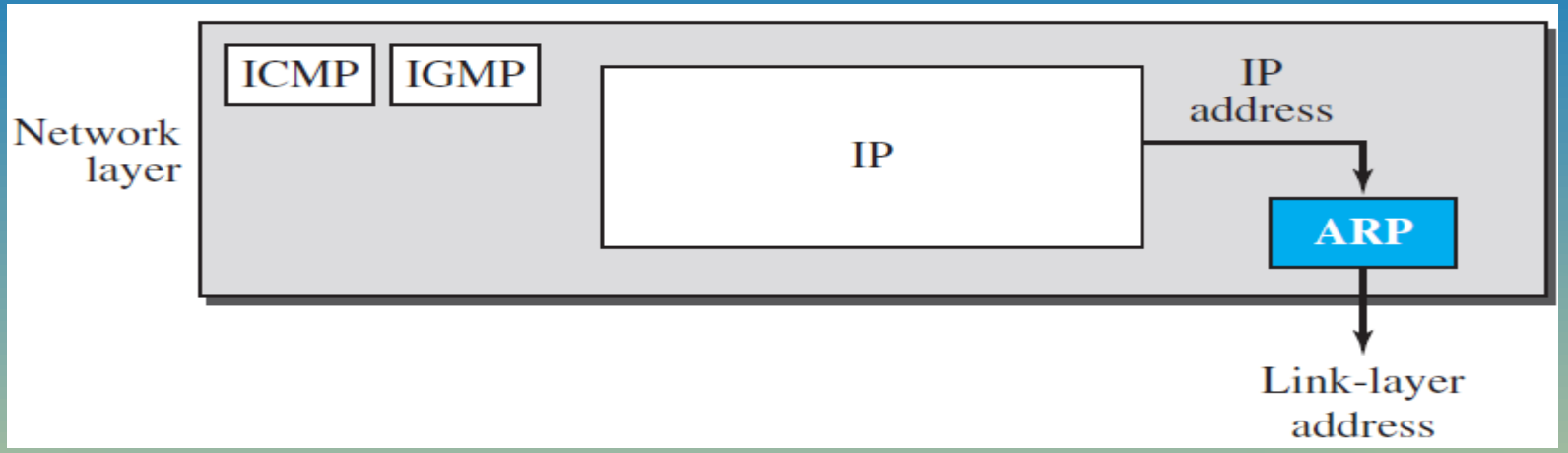
- Means one-to-all communication.
- A frame with a destination broadcast address is sent to all entities in the link.

FF:FF:FF:FF:FF:FF

Address Resolution Protocol (ARP)

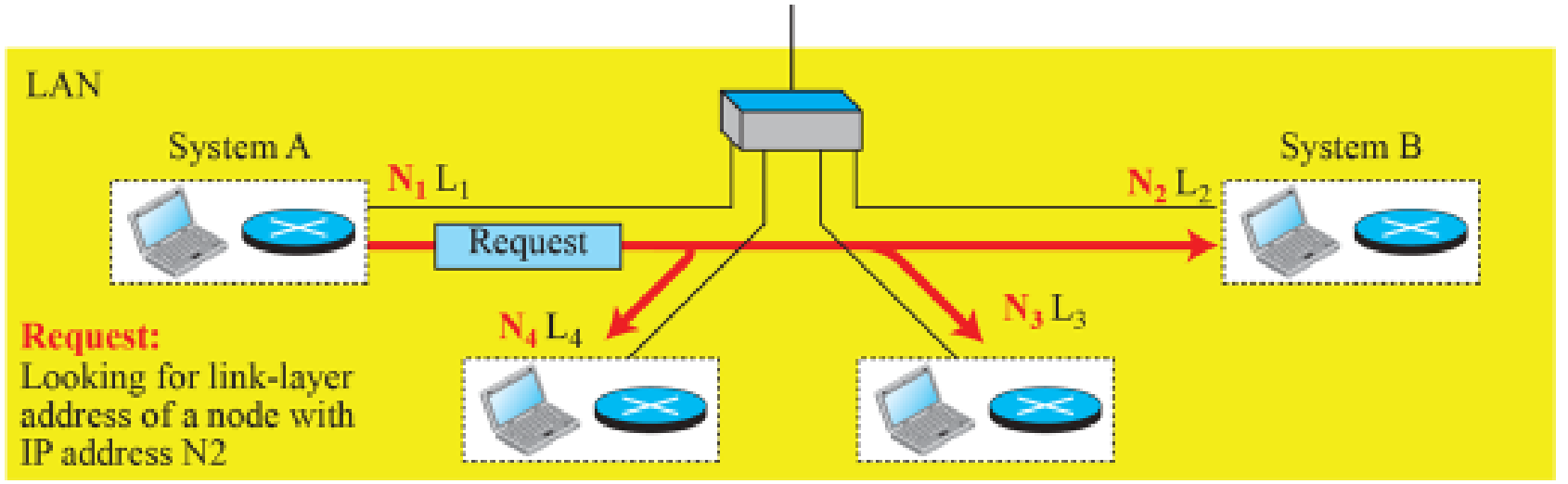
- Anytime a node has an IP datagram to send to another node in a link, it has the IP address of the receiving node.
- The source host knows the IP address of the default router.
- Each router except the last one in the path gets the IP address of the next router by using its forwarding table.
- The last router knows the IP address of the destination host
- The ARP protocol is one of the auxiliary protocols defined in the network layer -- it maps ***an IP address to a logical-link address***

ARP

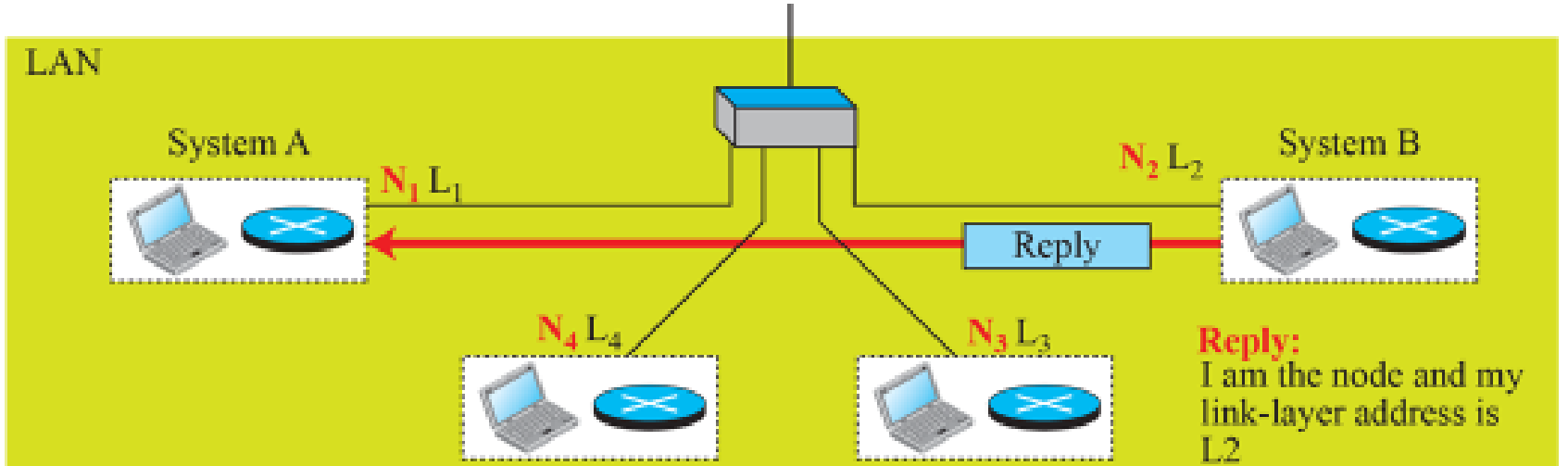


- Anytime a host or a router needs to find the link-layer address of another host or router in its network, it sends an ARP request packet.
- The packet includes the link-layer and IP addresses of the sender and the IP address of the receiver.
- Because the sender does not know the link-layer address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

Address Resolution Protocol Operation

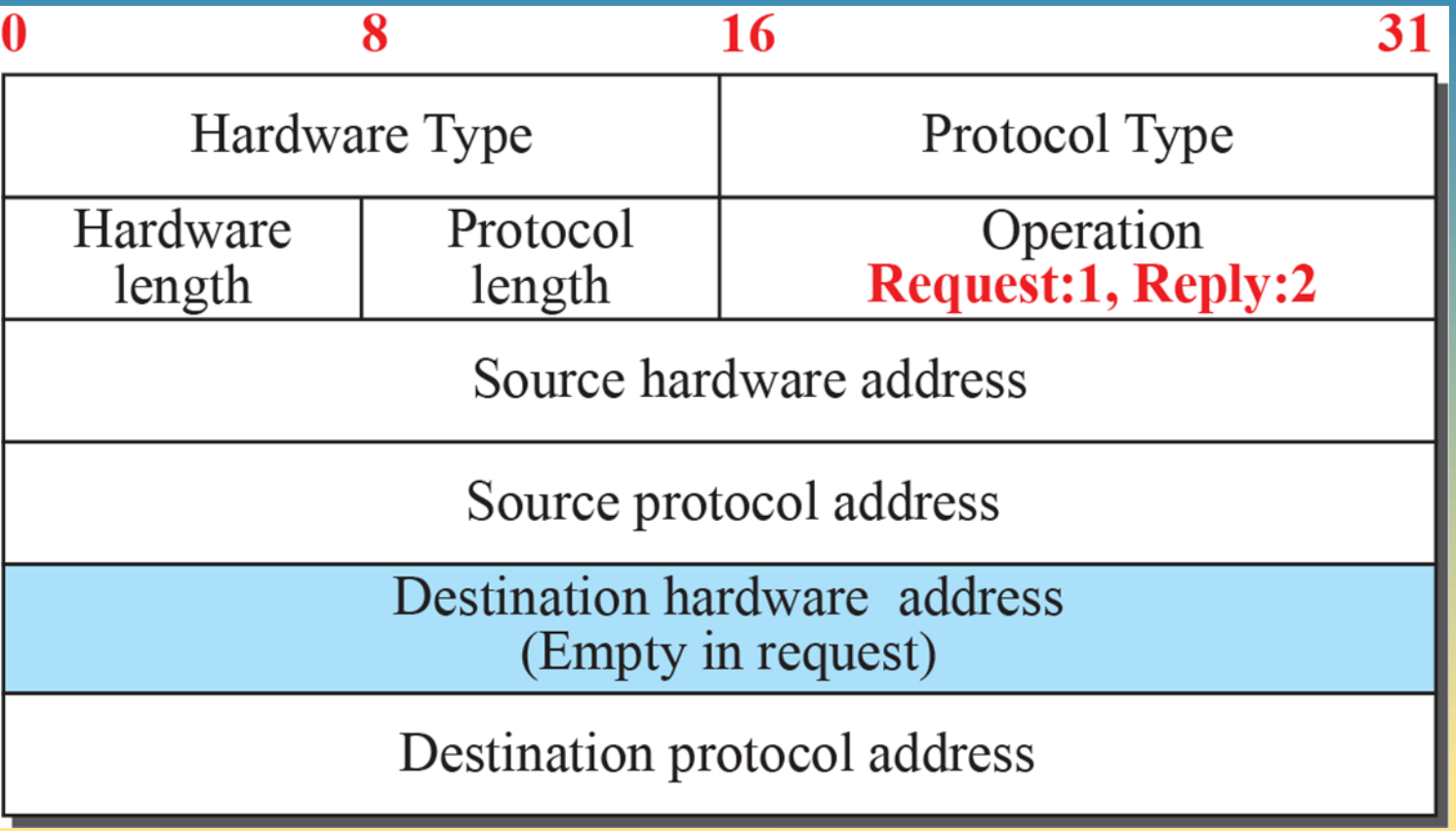


a. ARP request is broadcast



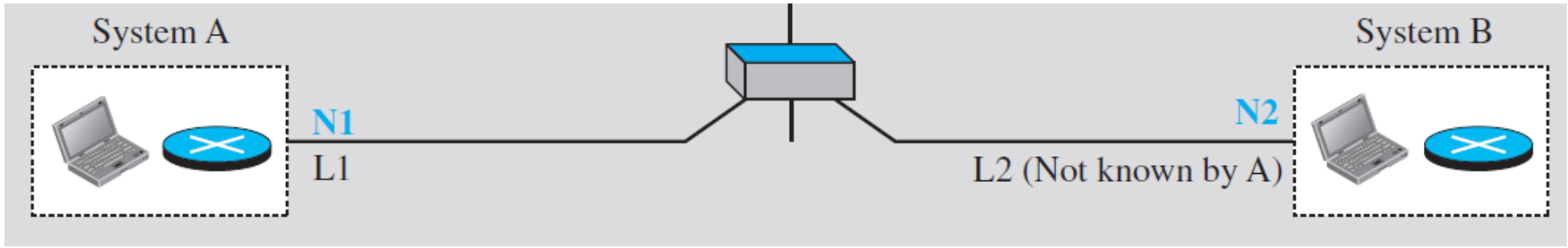
- Only the intended recipient recognizes its IP address
- Response packet contains the recipient's IP and link-layer addresses.
- The packet is unicast directly to sender

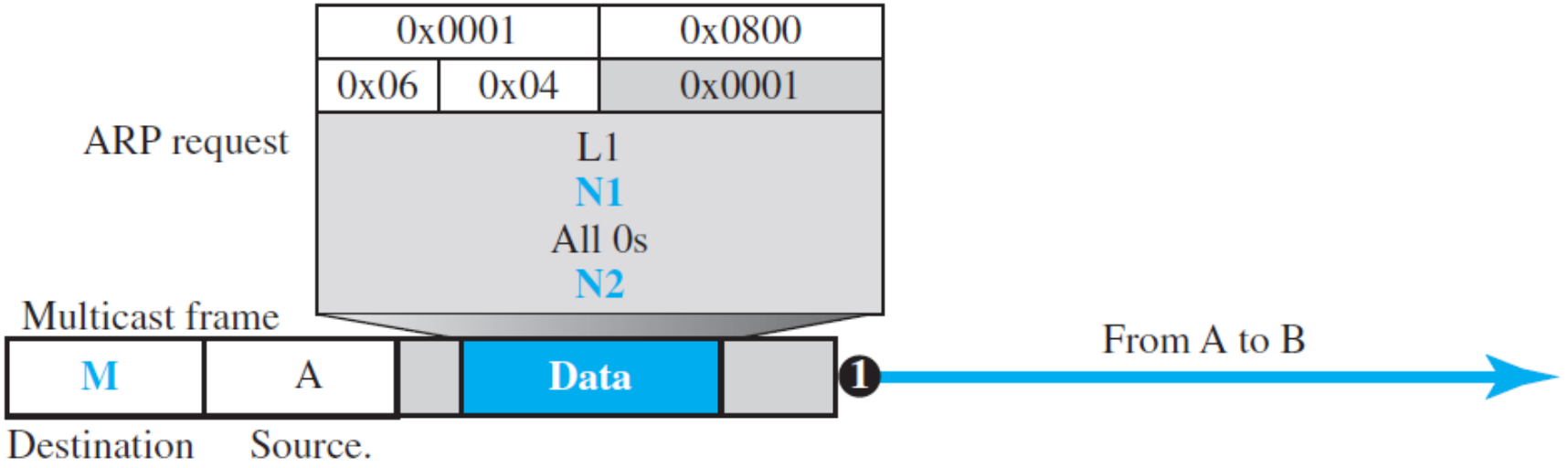
Packet Format



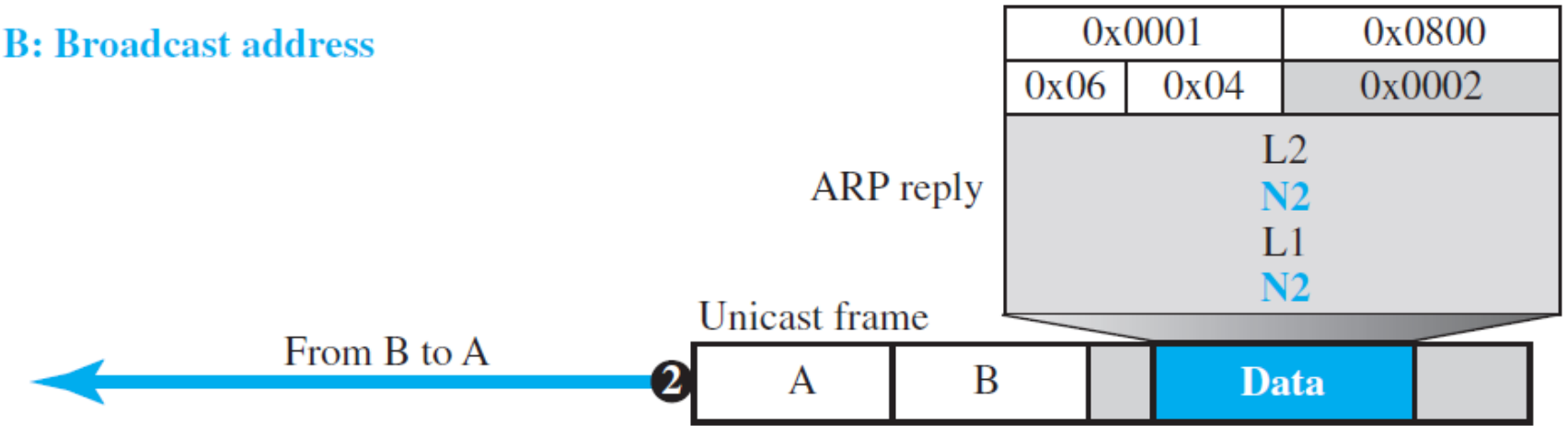
- An ARP packet is encapsulated directly into a data-link frame.
- The frame needs to have a field to show that the payload belongs to the ARP and not to the network-layer datagram

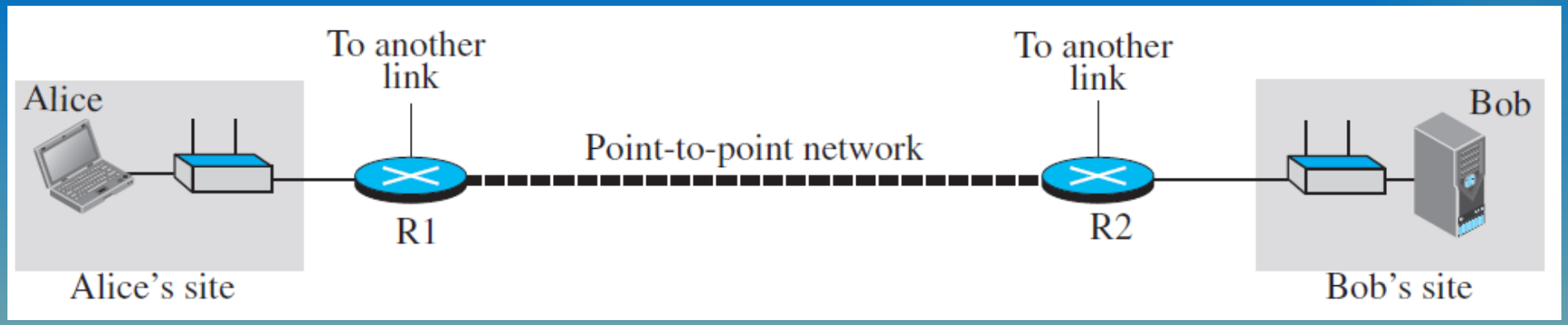
Hardware: LAN or WAN protocol
Protocol: Network-layer protocol

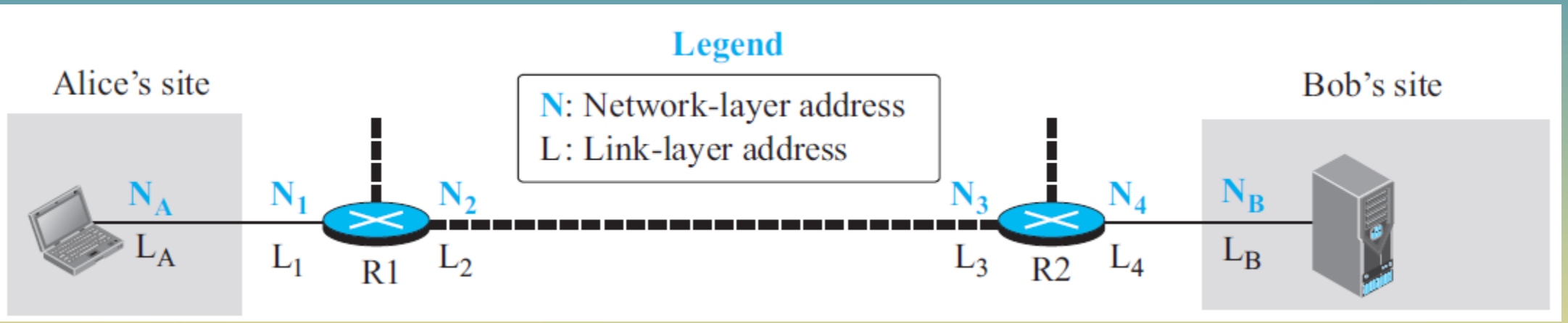


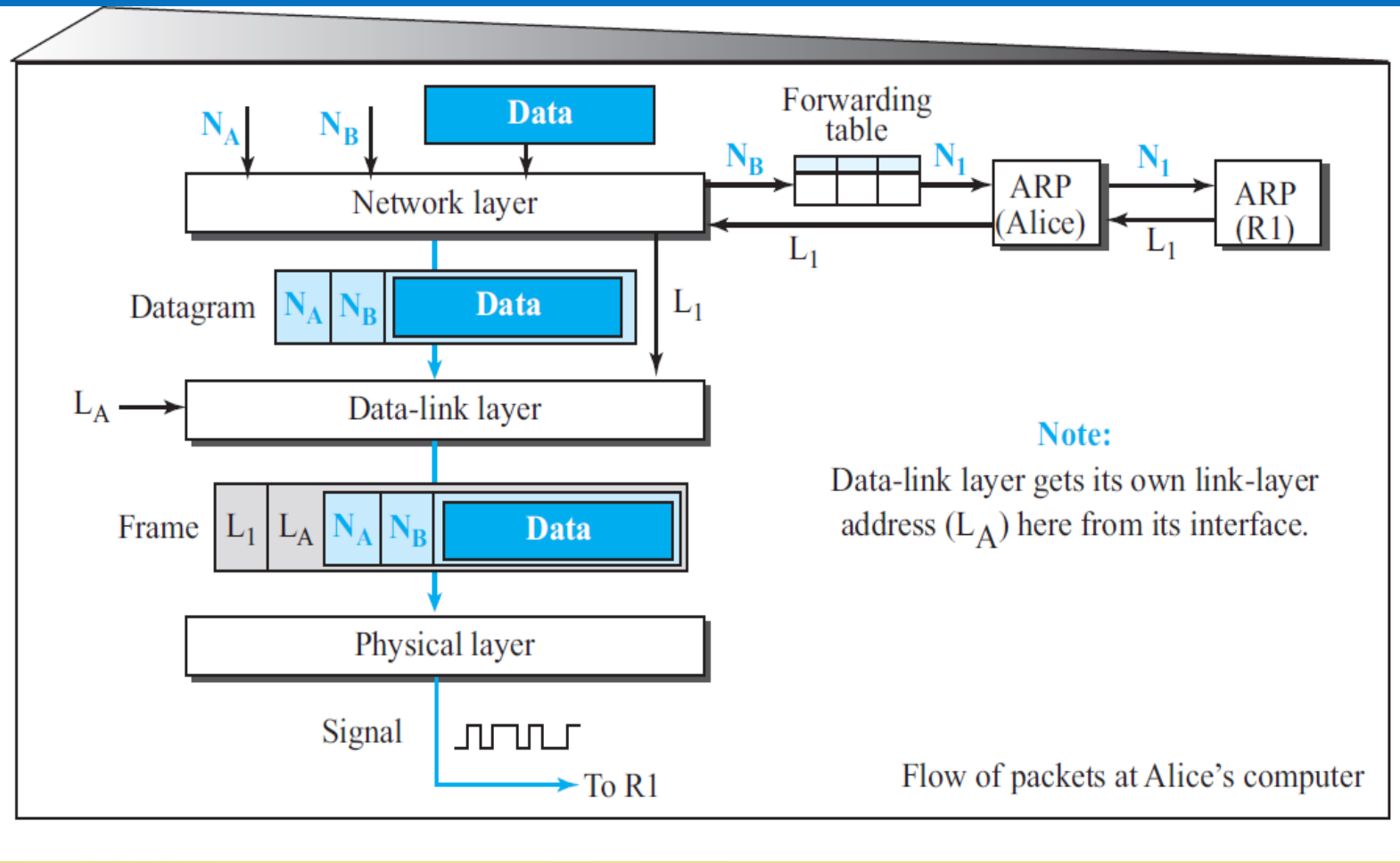


B: Broadcast address




To another link
To another link
Alice
Bob
Point-to-point network
R1
R2
Alice's site
Bob's site

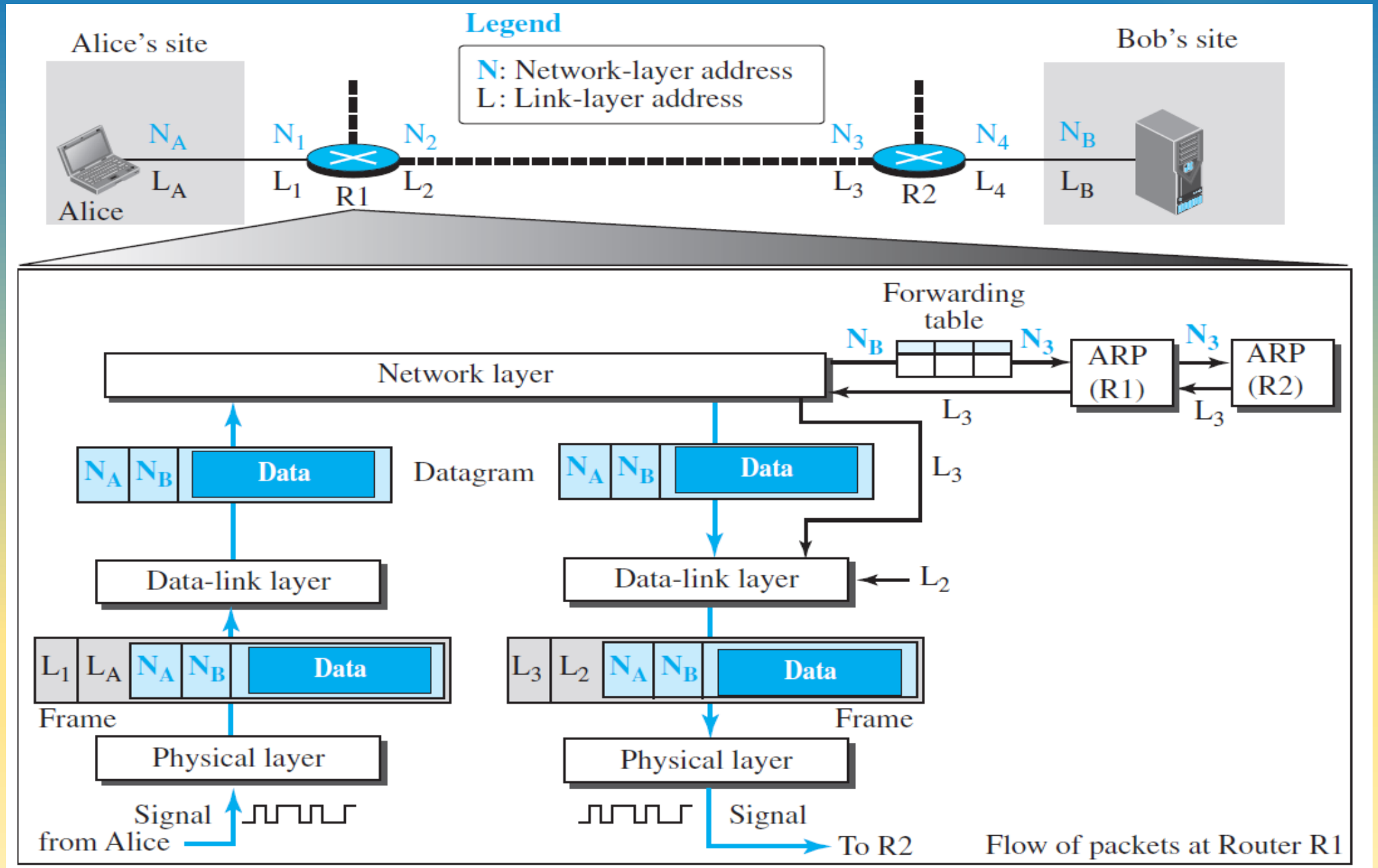

Legend
N: Network-layer address
L: Link-layer address
Alice's site
Bob's site
N_A
L_A
N_1
L_1
R1
N_2
L_2
N_3
L_3
R2
N_4
L_4
N_B
L_B



- Routing table gives N1.
- But the network layer needs to find the link-layer address of router R1.
- It uses its ARP to find the link-layer address L1.

- The network layer can now pass the datagram with the link-layer address to the data-link layer.
- The data-link layer knows its own link-layer address, LA.
- It creates the frame and passes it to the physical layer, where the address is converted to signals and sent through the media.

Activities at Router R1



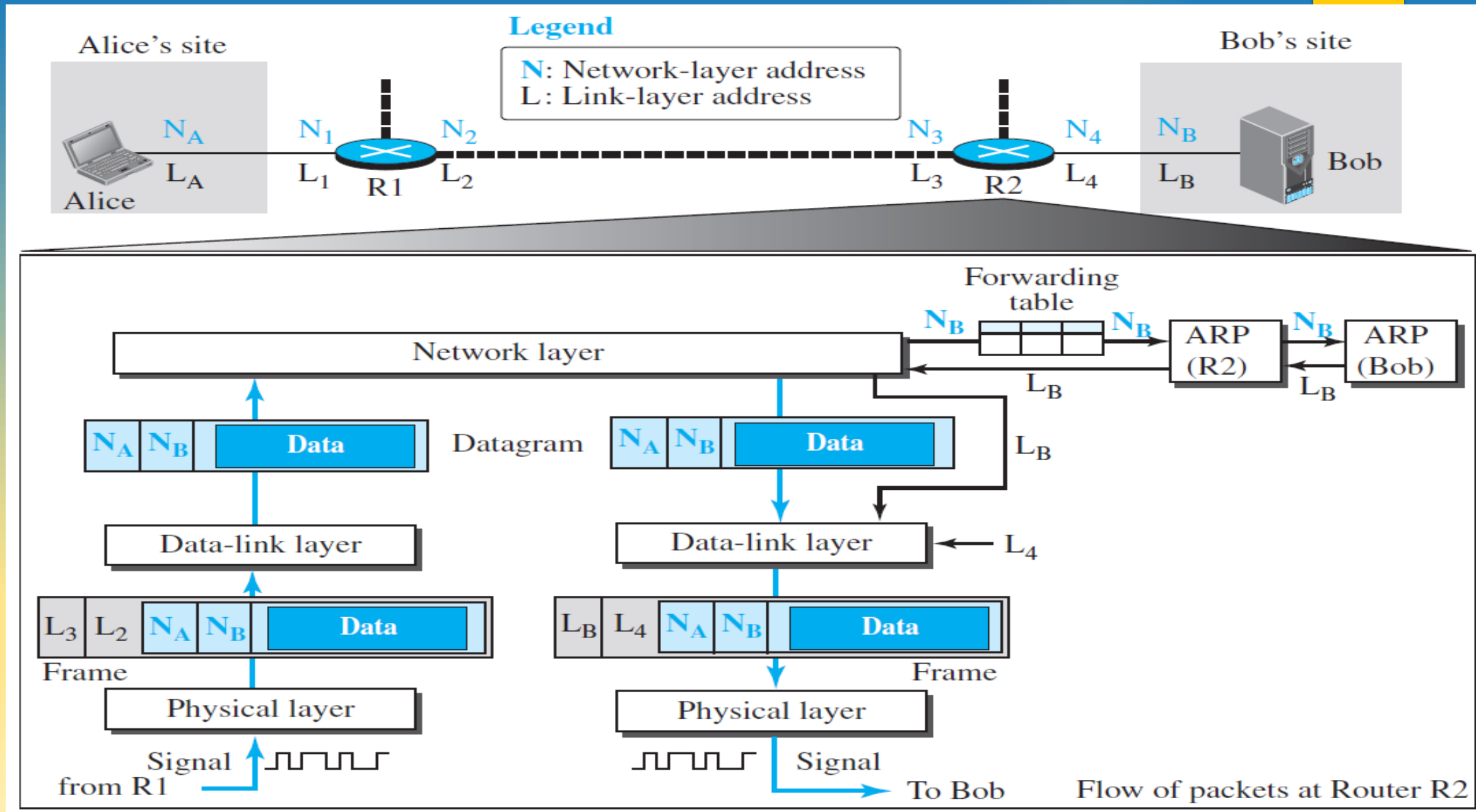
Activities at Router R1

- At arrival, the physical layer of the left link creates the frame and passes it to the DL layer.
- The DL layer decapsulates the datagram and passes it to the network layer.
- The network layer examines the network-layer address of the datagram and finds that the datagram needs to be delivered to the device with IP address NB.
- The network layer consults its routing table to find out which is the next node (router) in the path to NB.
- The forwarding table returns N3.
- The IP address of router R2 is in the same link with R1.

Activities at Router R1

- The network layer now uses the ARP to find the link-layer address of this router, which comes up as L3.
- The network layer passes the datagram and L3 to the data-link layer belonging to the link at the right side.
- The link layer encapsulates the datagram, adds L3 and L2 (its own link-layer address), and passes the frame to the physical layer.
- The physical layer encodes the bits to signals and sends them through the medium to R2.

Activities at Router R2



Activities at Router R2

- At Bob's site there are no more addresses or mapping needed.
- The signal received from the link is changed to a frame.
- The frame is passed to the data-link layer, which decapsulates the datagram and passes it to the network layer.
- The network layer decapsulates the message and passes it to the transport layer.

Changes in Addresses

- NA and NB, have not been changed during the whole journey all four network-layer
- Addresses of routers R1 and R2 (N1, N2, N3, and N4) are needed to transfer a datagram from Alice's computer to Bob's computer.

Summary

- The hosts and connecting devices are referred to as nodes; the networks are referred to as *links*.
- The data-link layer is responsible for the creation and delivery of a frame to another node, along the link.
- It is responsible for packetizing (framing), flow control, error control, and congestion control along the link
- The address resolution protocol (ARP) was devised to map an IP address to its corresponding link-layer address

Test your Understanding

- Two main functions of the data link layer are _____ & _____
- Is the size of the ARP packet fixed?_____
- Why is the destination hardware address all 0s in the arp request message?
- How does system a know what the link-layer address of system b is when it receives the arp reply?