Introduction To Data-Link Layer

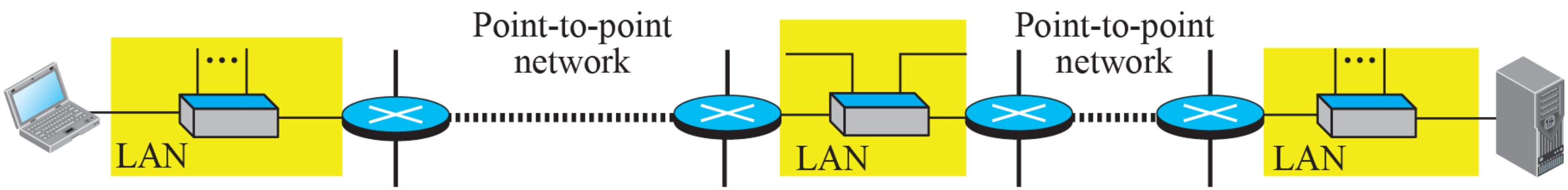
9-1 INTRODUCTION

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 networks.

Nodes and Links

- Communication at the data-link layer is node-to-node. 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 is a simple representation of links and nodes when the path of the data unit is only six nodes.

Nodes and Links



a. A small part of the Internet

b. Nodes and links

- **The first node is the source host; the last node is the destination host. The other four nodes are four routers. The first, the third, and the fifth links represent the three LANs; the second and the fourth links represent the two WANs**

Services

- The data-link layer is located between the physical and the network layers.
- The data-link layer provides services to the network layer; it receives services from the physical layer. Let us discuss services provided by the data-link layer.
- The data-link layer of the sending node needs to encapsulate the datagram(packate) received from the network in a frame, and the data-link layer of the receiving node needs to decapsulate the datagram from the frame.
- Each intermediate node needs to both encapsulate and decapsulate.

Services

- **Framing**
  - The first service provided by the data-link layer is framing.
  - The data-link layer at each node needs to encapsulate the datagram 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.
- **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 consumed
  - We cannot have infinite buffer space so there are two ways to handle it:
    - First, to let the receiving data-link layer drop the frames if its buffer is full.
    - Second, to let the receiving data-link layer send a feedback to the sending data-link layer to ask it to stop or slow down.

Services

- **Error Control**
  - A frame in a data-link layer needs to be changed to bits, transformed to electromagnetic signals, and transmitted.
  - At the receiving node, electromagnetic signals are received, transformed to bits, and put together to create a frame.
  - Since electromagnetic signals are susceptible to error, a frame is susceptible to error. The error needs be detected corrected or discarded, and resent by the sender.
- **Congestion Control**
  - Most data-link-layer protocols do not directly use a congestion control to alleviate congestion.
  - Congestion control is considered an issue in the network layer or the transport layer because of its end-to-end nature.

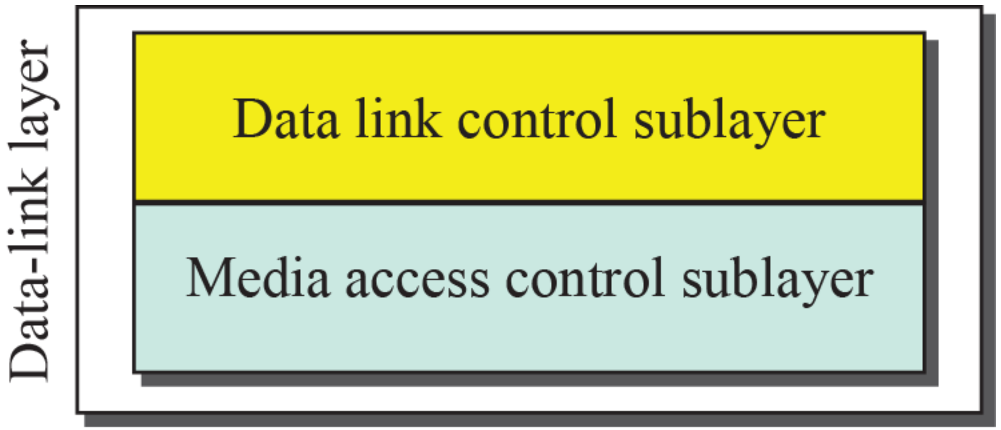
Two Categories of Links

- Although two nodes are physically connected by a transmission medium such as cable or air, we need to remember that the data-link layer controls how the medium is used.
- We can have a data-link layer that uses the whole capacity of the medium; we can also have a data-link layer that uses only part of the capacity of the link.
- In other words, we can have a point-to-point link or a broadcast link.

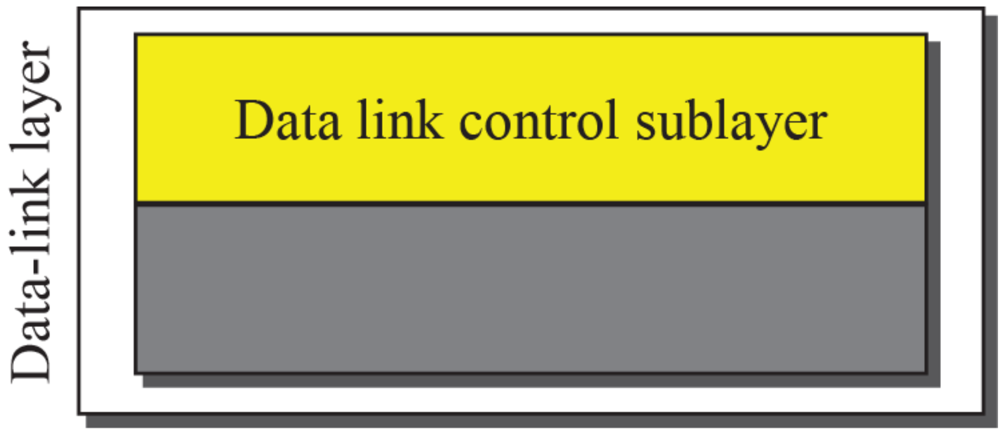
Two Sublayers

- To better understand the functionality of and the services provided by the link layer, we can divide the data-link layer into two sublayers: data link control (DLC) and media access control (MAC).
- This is not unusual because, as we will see in later chapters, LAN protocols actually use the same strategy.
- 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 9.3: 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

5-4 LINK-LAYER ADDRESSING

- In a internetwork such as the Internet we cannot make a datagram reach its destination using only IP addresses.
- The source and destination IP addresses define the two ends but cannot define which links the packet should pass through.
- IP addresses in a datagram should not be changed. If the destination IP address in a datagram changes, the packet never reaches its destination; if the source IP address in a datagram changes, the destination host or a router can never communicate with the source if a response needs to be sent back or an error needs to be reported back to the source.
- 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 some times a MAC address.

5-4 LINK-LAYER ADDRESSING

- 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. Figure demonstrates the concept in a small internet.
- Note that the IP addresses and the link-layer addresses are not in the same order.
- For IP addresses, the source address comes before the destination address; for link-layer addresses, the destination address comes before the source.

Three Types of addresses

- Some link-layer protocols define 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.
- Multicast Address
  - Multicasting means one-to-many communication. However, the jurisdiction is local (inside the link).
- Broadcast Address
  - Broadcasting means one-to-all communication. A frame with a destination broadcast address is sent to all entities in the link.

Example

the unicast link-layer addresses in the most common LAN, Ethernet, are 48 bits (six bytes) that are presented as 12 hexadecimal digits separated by colons; for example, the following is a link-layer address of a computer. The second digit needs to be an odd number.

A3:34:45:11:92:F1

Example

As the multicast link-layer addresses in the most common LAN, Ethernet, are 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. The following shows a
multicast address:

A2:34:45:11:92:F1

Example

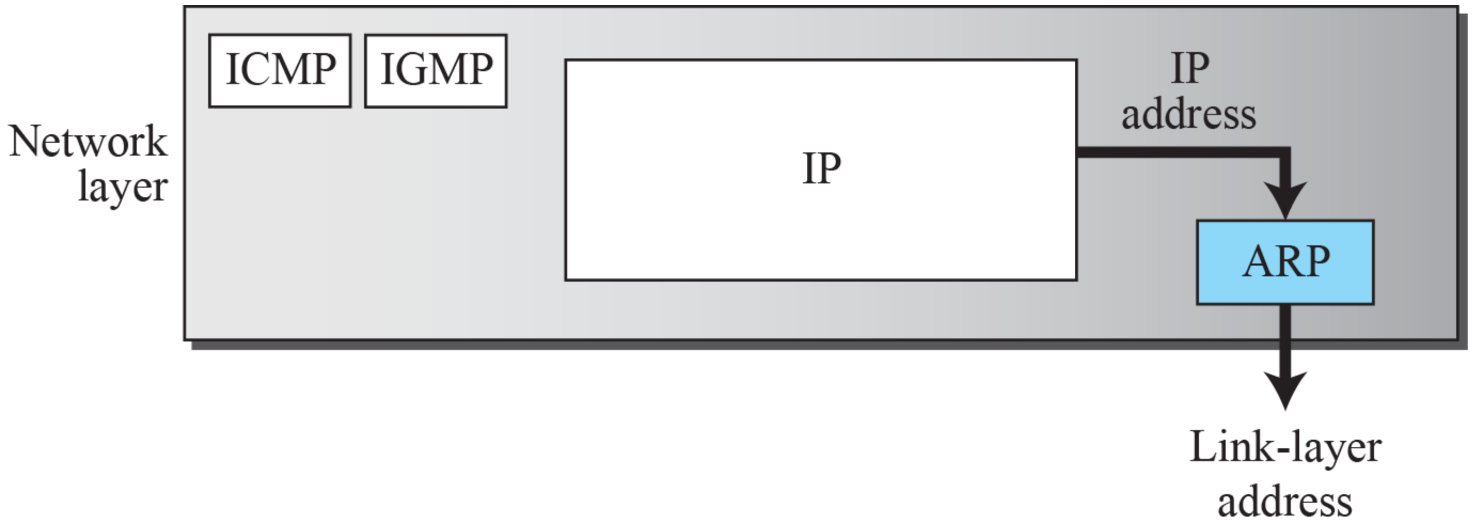
the broadcast link-layer addresses in the most common LAN, Ethernet, are 48 bits, all 1s, that are presented as 12 hexadecimal digits separated by colons. The following shows a broadcast address:

FF:FF:FF:FF:FF:FF

ARP

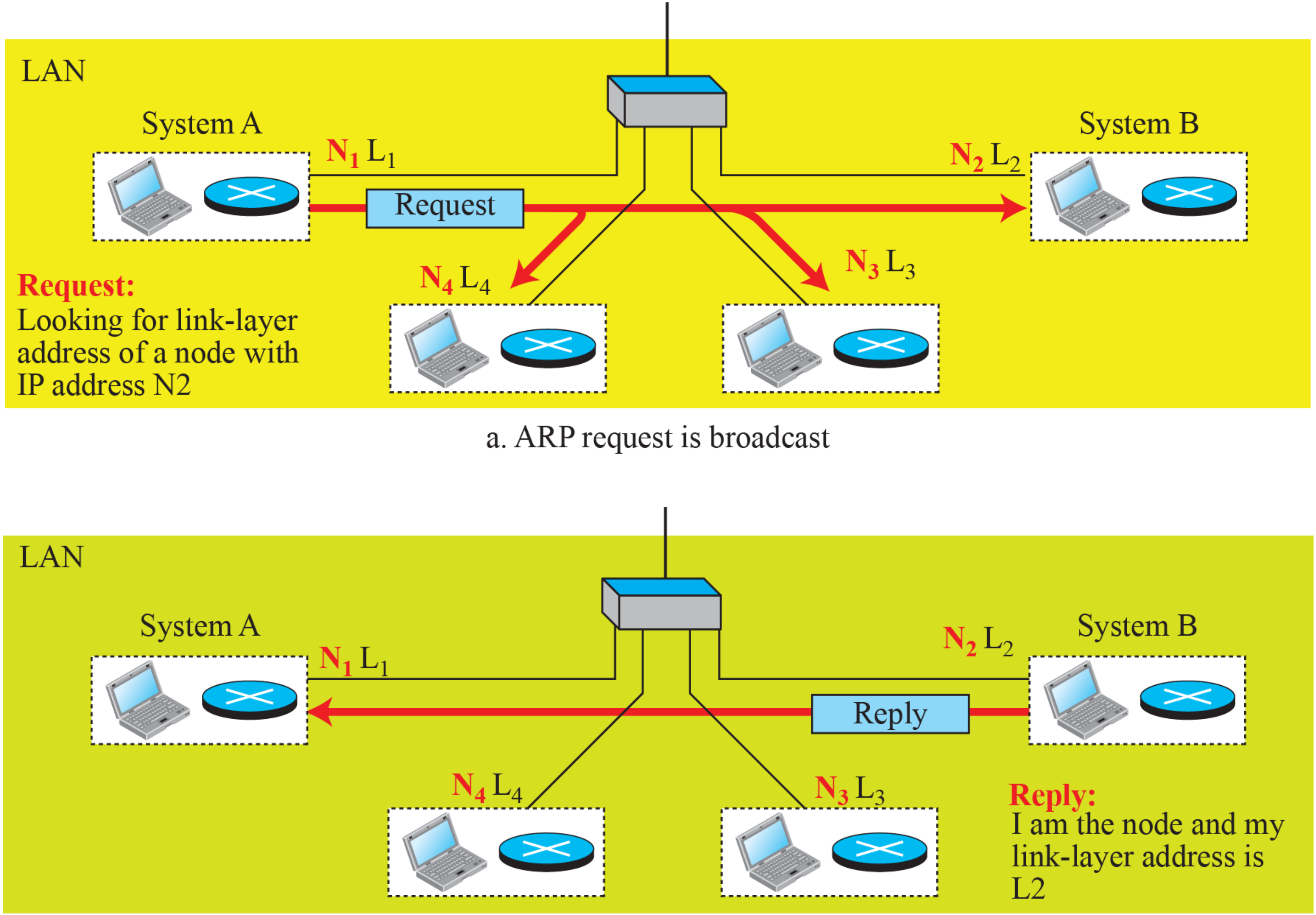
- Anytime a node has an IP datagram to send to another node in a link, it has the IP address of the receiving node which is not helpful in moving a frame through a link; we need the link-layer address of the next node.
- This is the time when the Address Resolution Protocol (ARP) becomes helpful.
- ARP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

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



- 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,

Figure 9.7: ARP operation



a. ARP request is broadcast

b. ARP reply is unicast

Figure ARP packet

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

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 shows the ARP request and response messages.

Figure Example

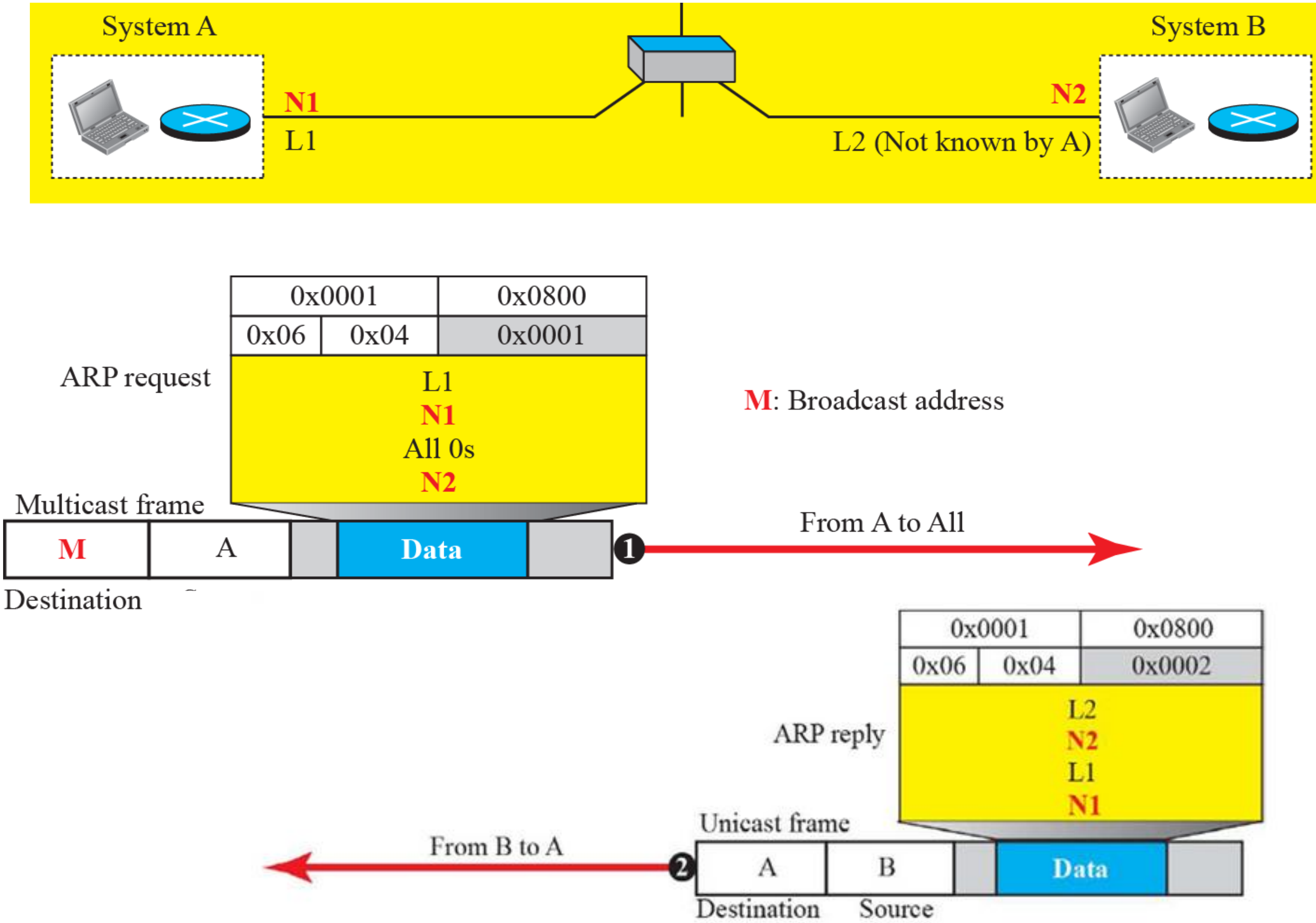
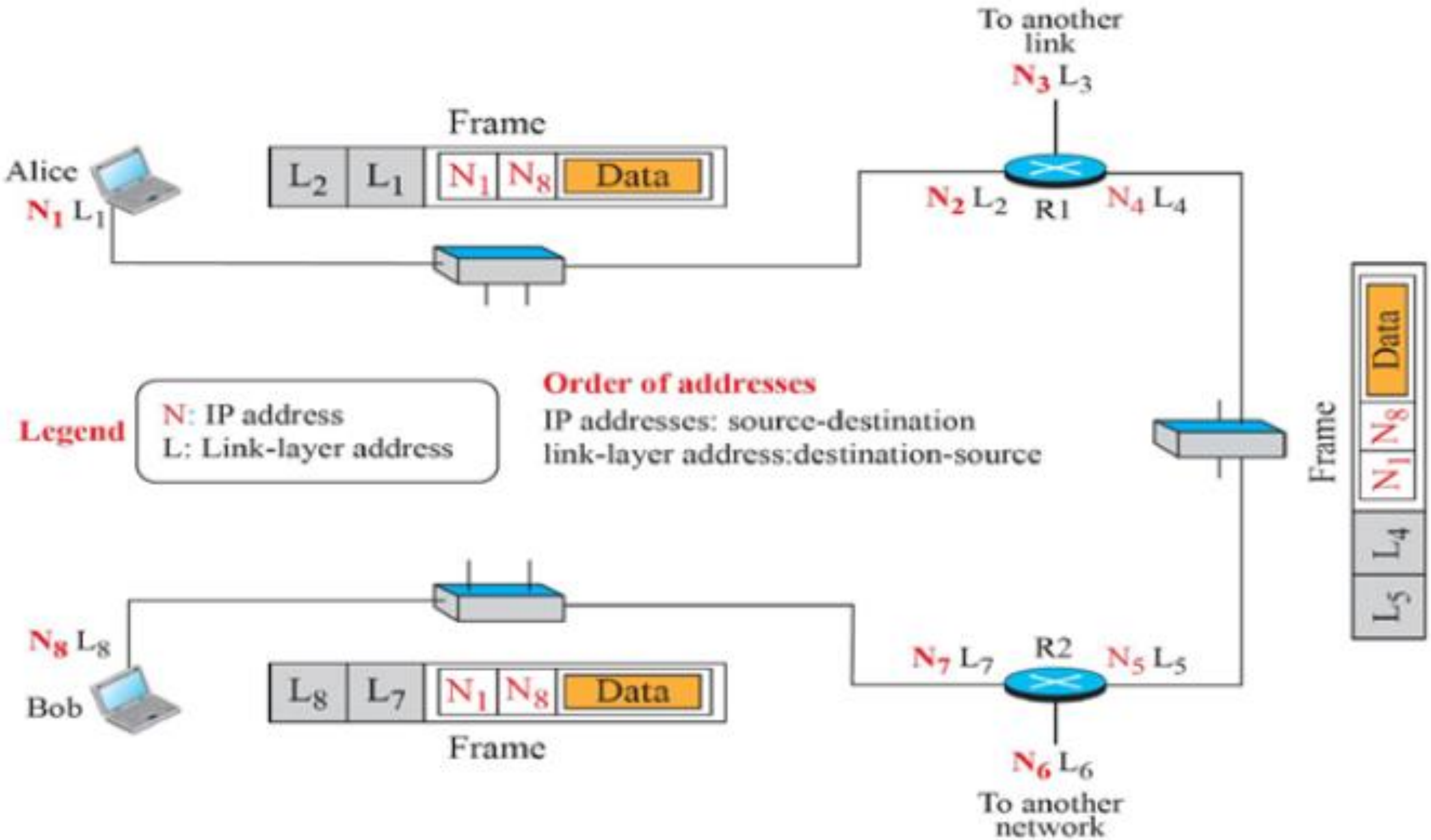


Figure : Ip addressing and Link layer in small internet



Alice send the data to BOB

Figure : The internet for our example

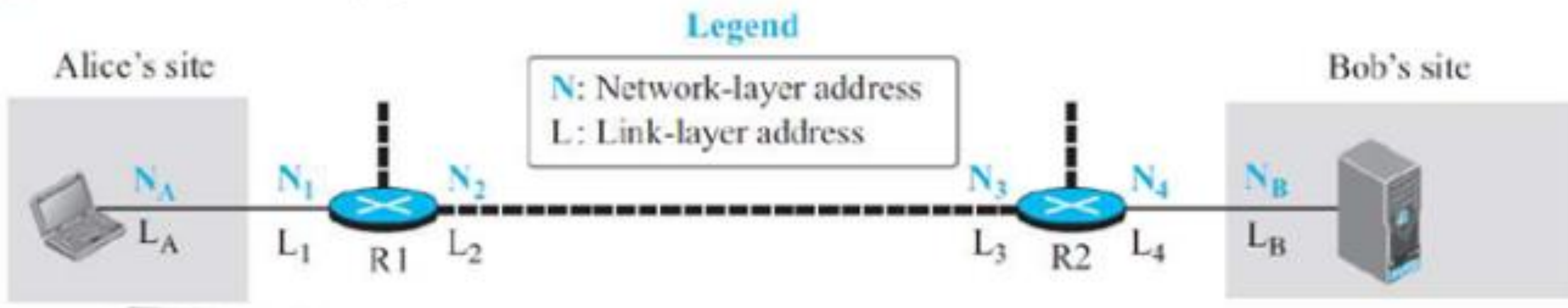


Figure : Flow of packets at Alice site

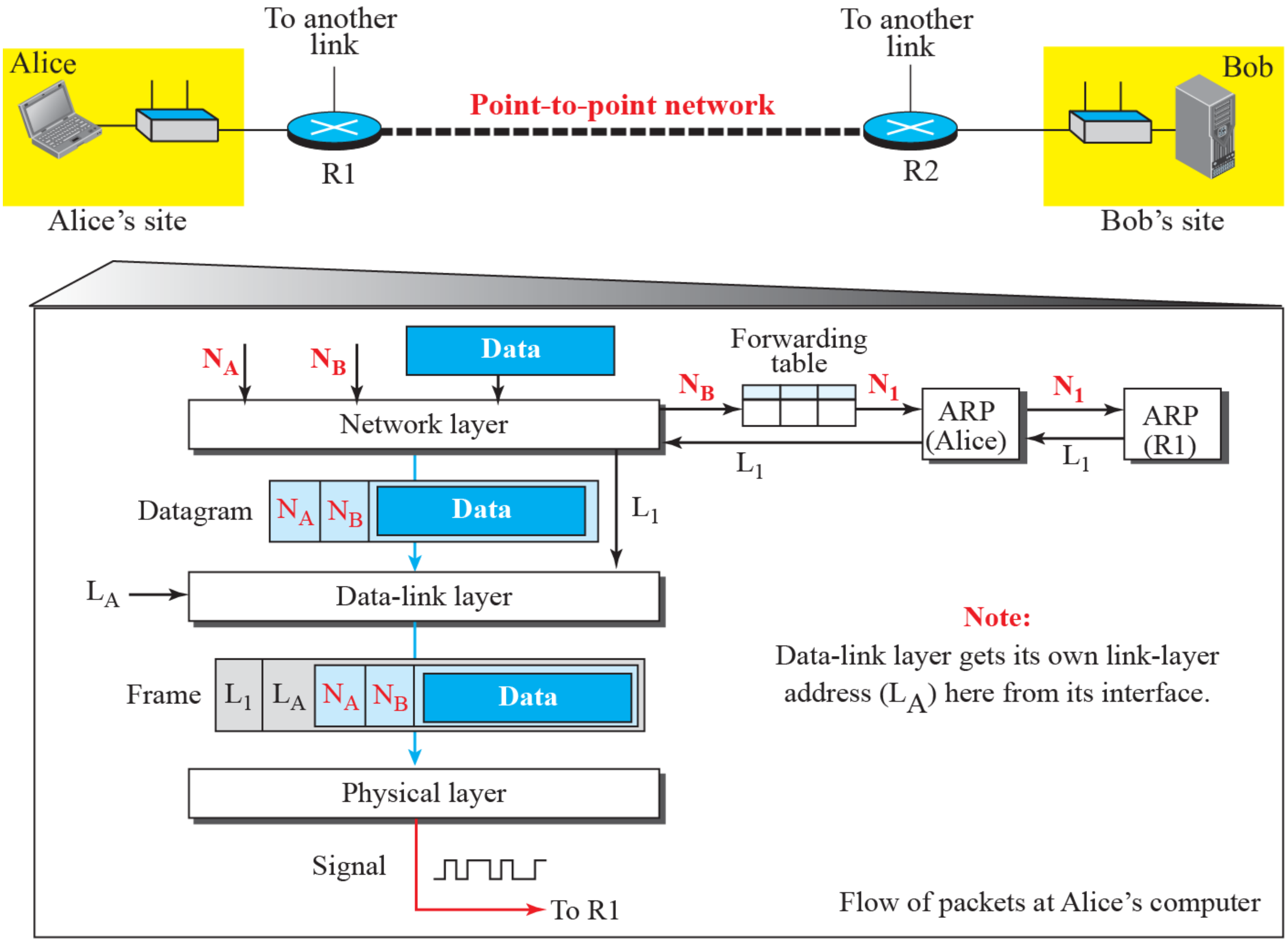


Figure Flow of activities at router R1

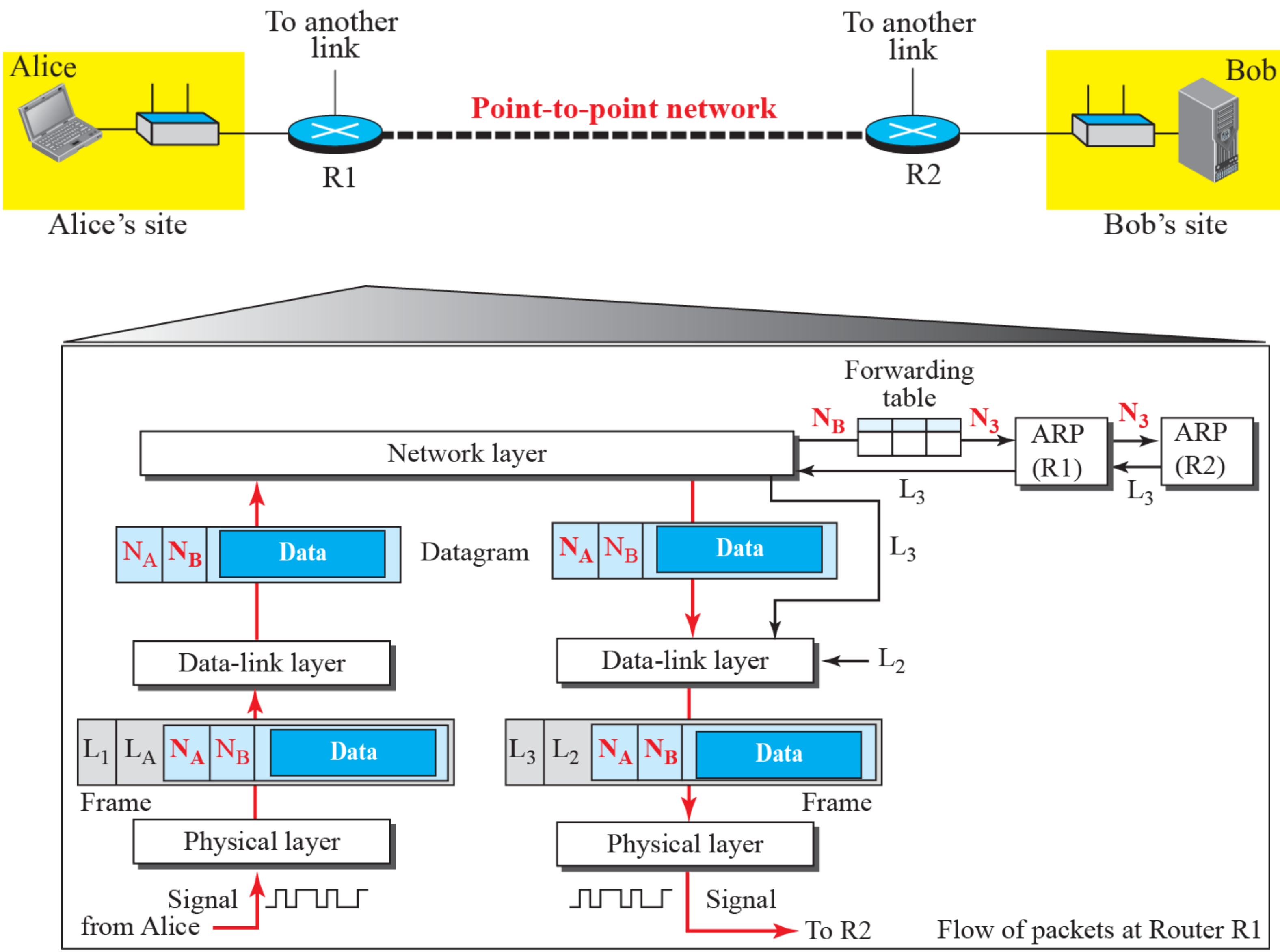


Figure 9.13: Flow of activities at router R2

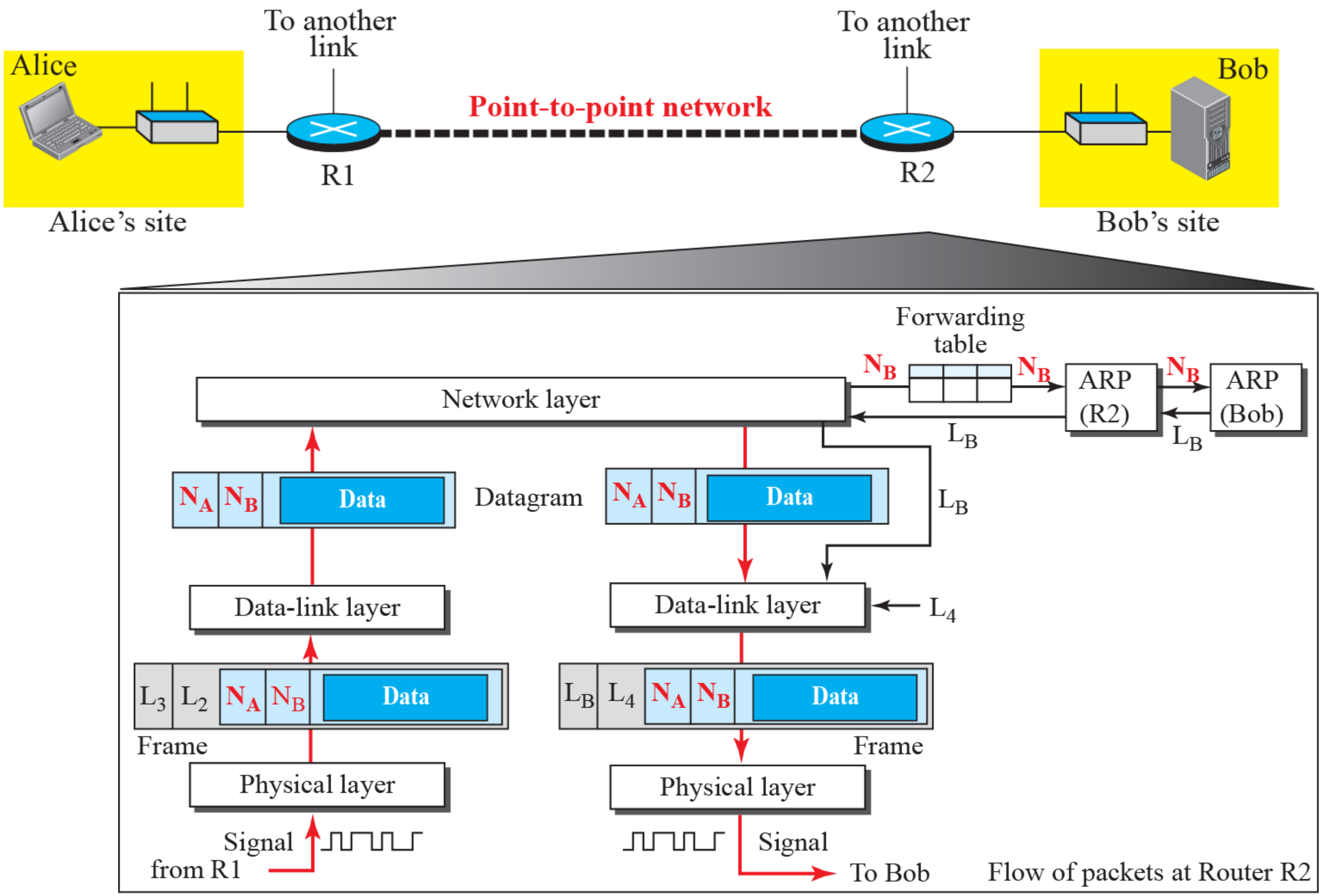


Figure Activities at Bob's site