CS321: Computer Networks

Data-link Layer

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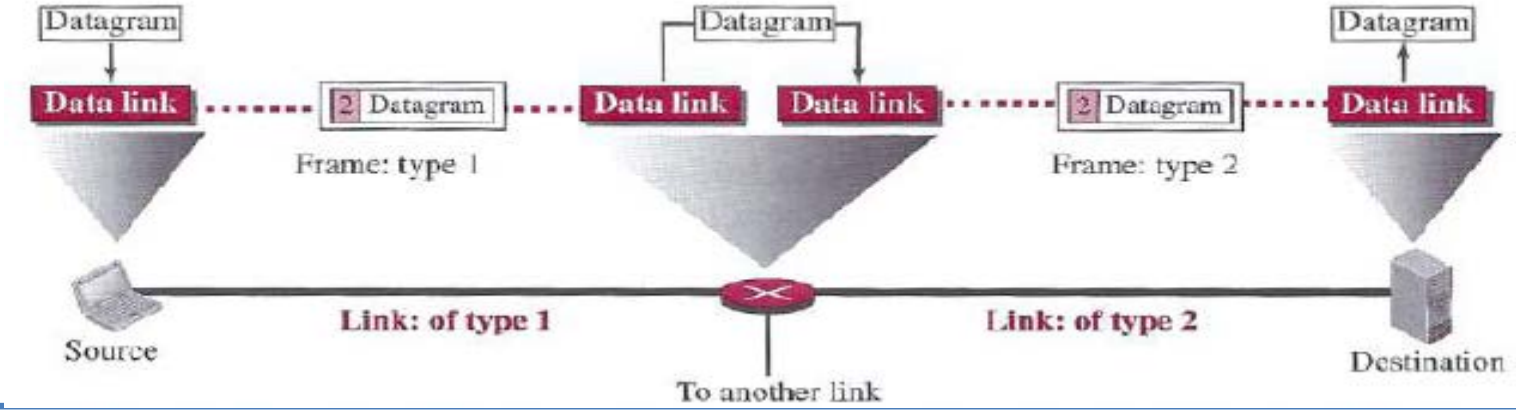
Introduction to DLL

- Study of algorithms for achieving reliable, efficient communication between two adjacent machines at DLL.
  - Adjacent: two machines physically connected using a (wired/wireless) communication channel
  - Basic Requirement: bits should be delivered in the same order as they are sent

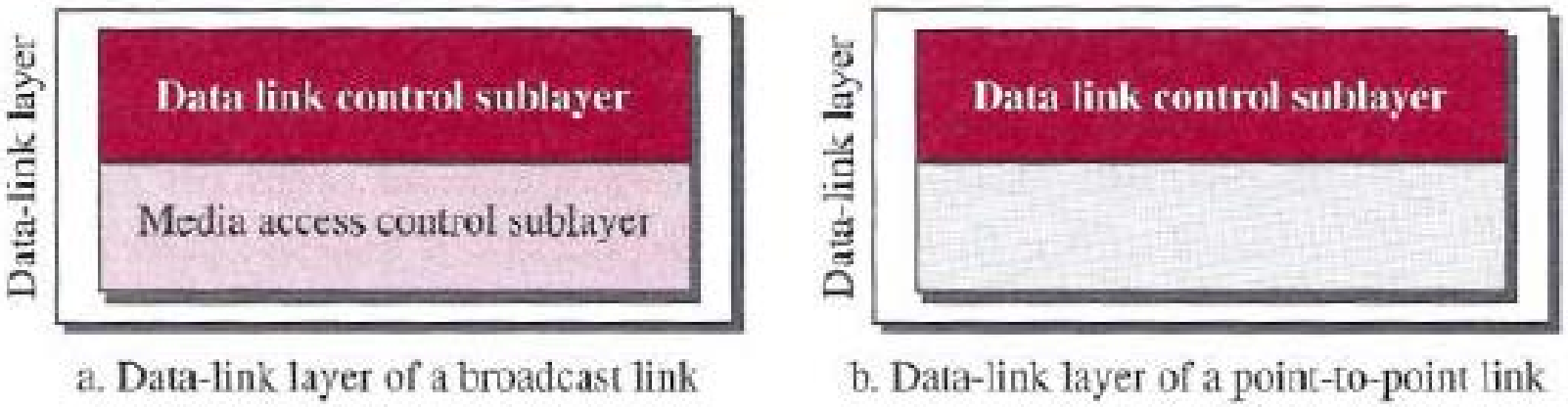


Why so difficult?

- Problem in Communication Circuit
  - introduce propagation delay
  - circuits have a finite data rate
  - different types of links
    - Framing
  - introduce errors
    - Error control
- Problem in End Systems
  - Not all machines have the same speed
    - Flow control
  - Lack of mutual understanding
    - Synchronization

Sublayers in DLL

- Two sublayers in Data-link Layer
  - Data link control (DLC)
  - Medium access control (MAC)

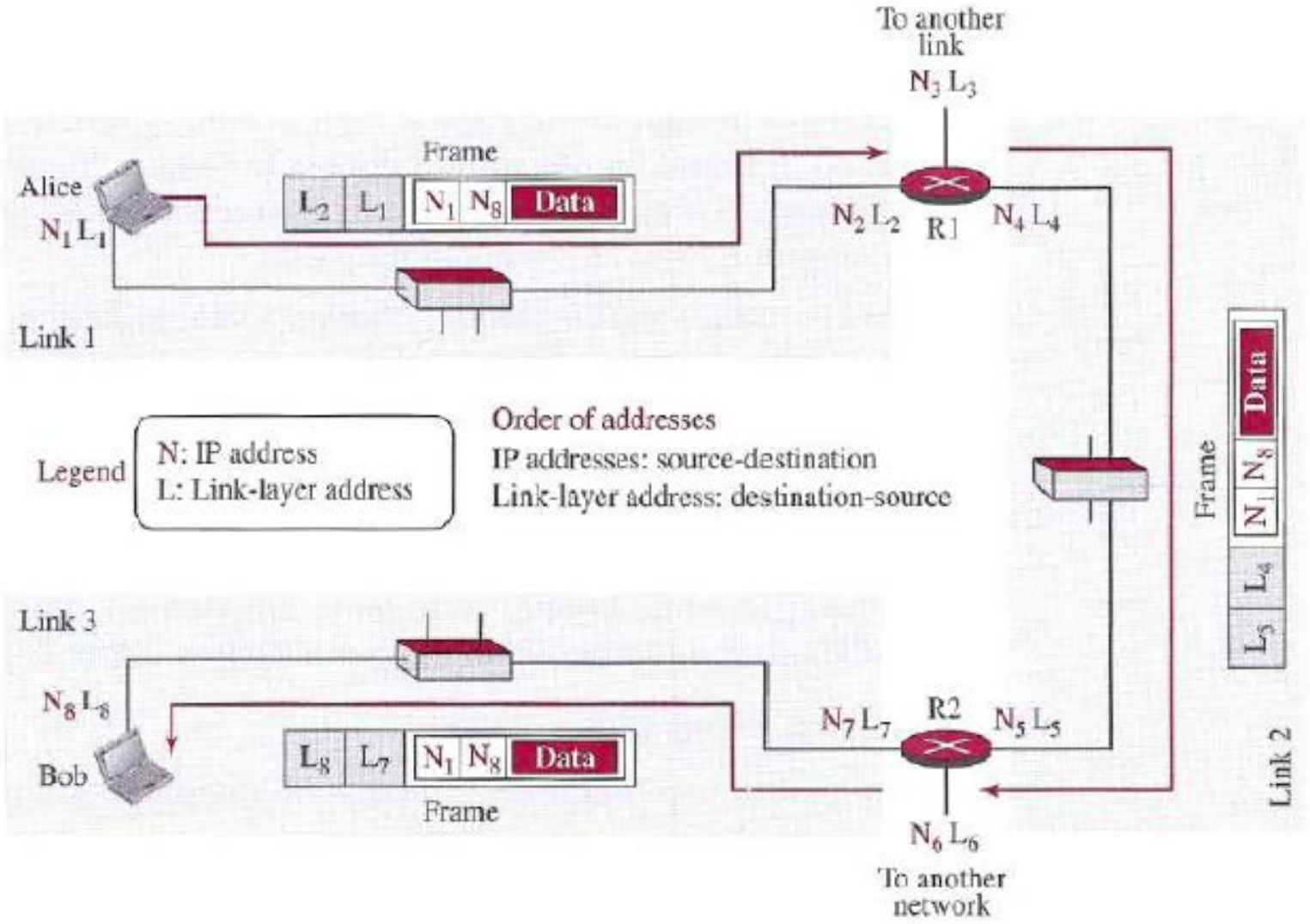


  - DLC handles issues common to broadcast & p2p
  - MAC handles issues specific to broadcast channel

Major Functions of DLL

- Related to DLC
  - Link Layer Addressing
  - Framing
  - Error Control
  - Flow Control
- Related to MAC
  - Multiple Access

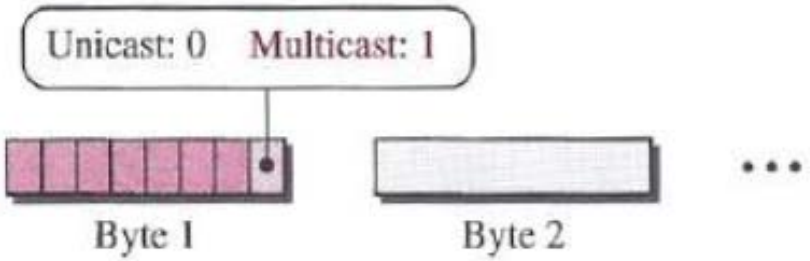
Link Layer Addressing



Types of Addresses

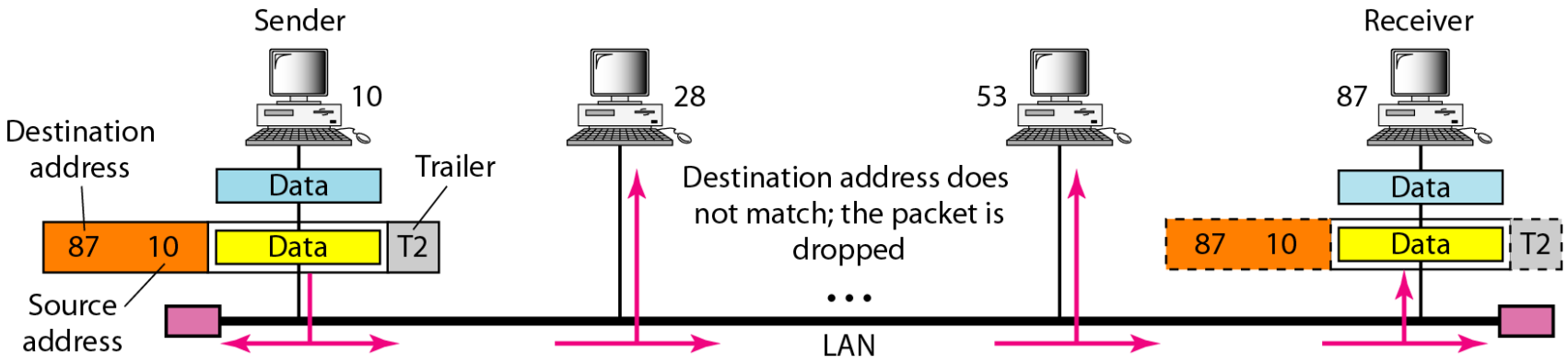
- Format: 48 bits (six bytes) that are presented as 12 hexadecimal digits separated by colons

- Unicast Address
  - e.g., A2:34:45:11:92:F1
- Multicast Address
  - e.g., A3:34:45:11:92:F1
- Broadcast Address
  - FF:FF:FF:FF:FF:FF

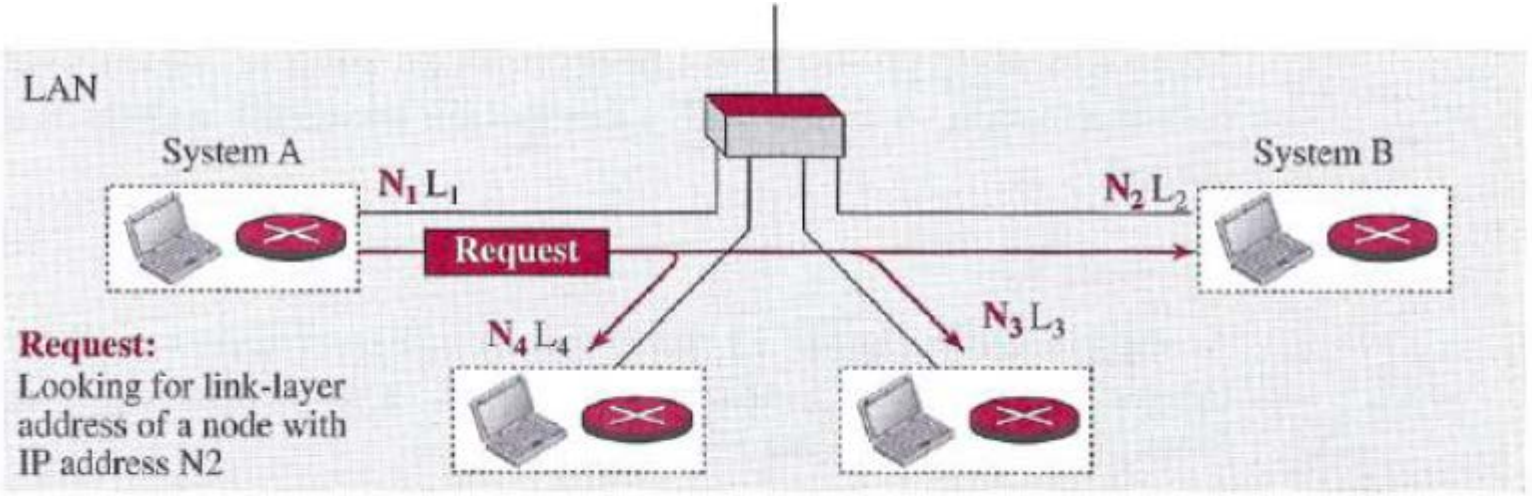


Address Resolution Protocol (ARP)

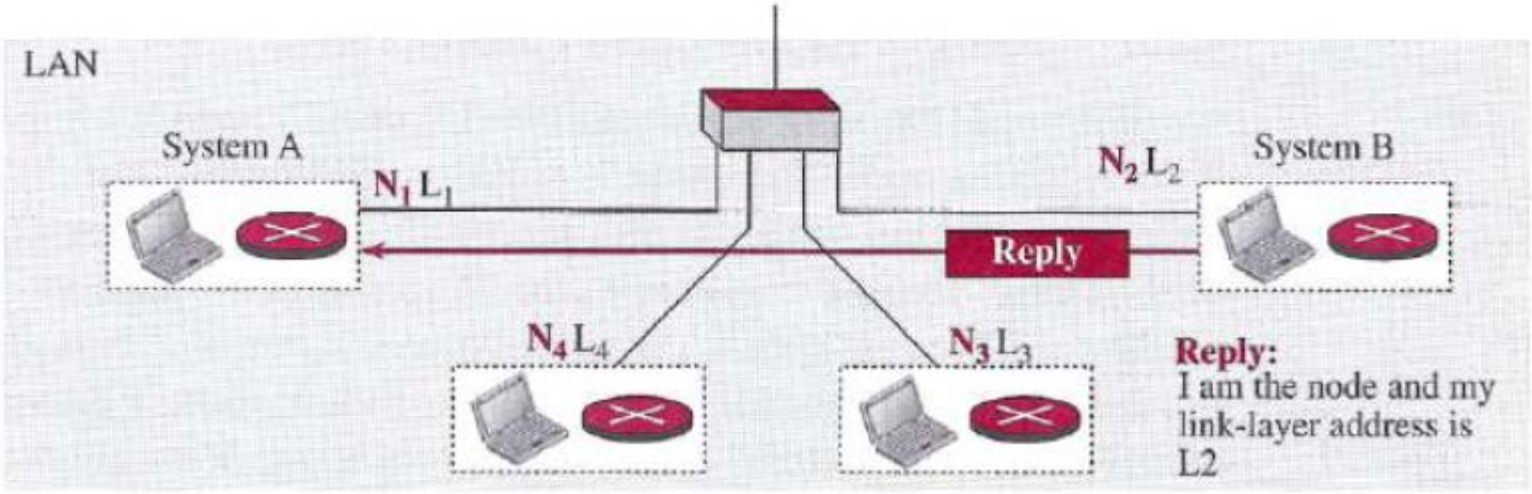
- Source node knows the IP address of the destination node and the default router. But, IP address is not helpful in moving a frame through the link.
- We need link-layer address of the next node
  - Why?



ARP operation

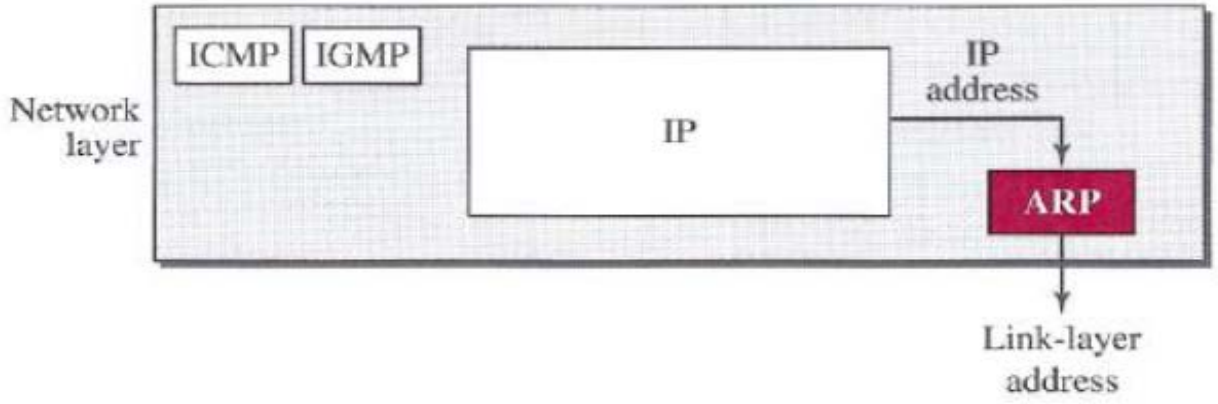


a. ARP request is broadcast



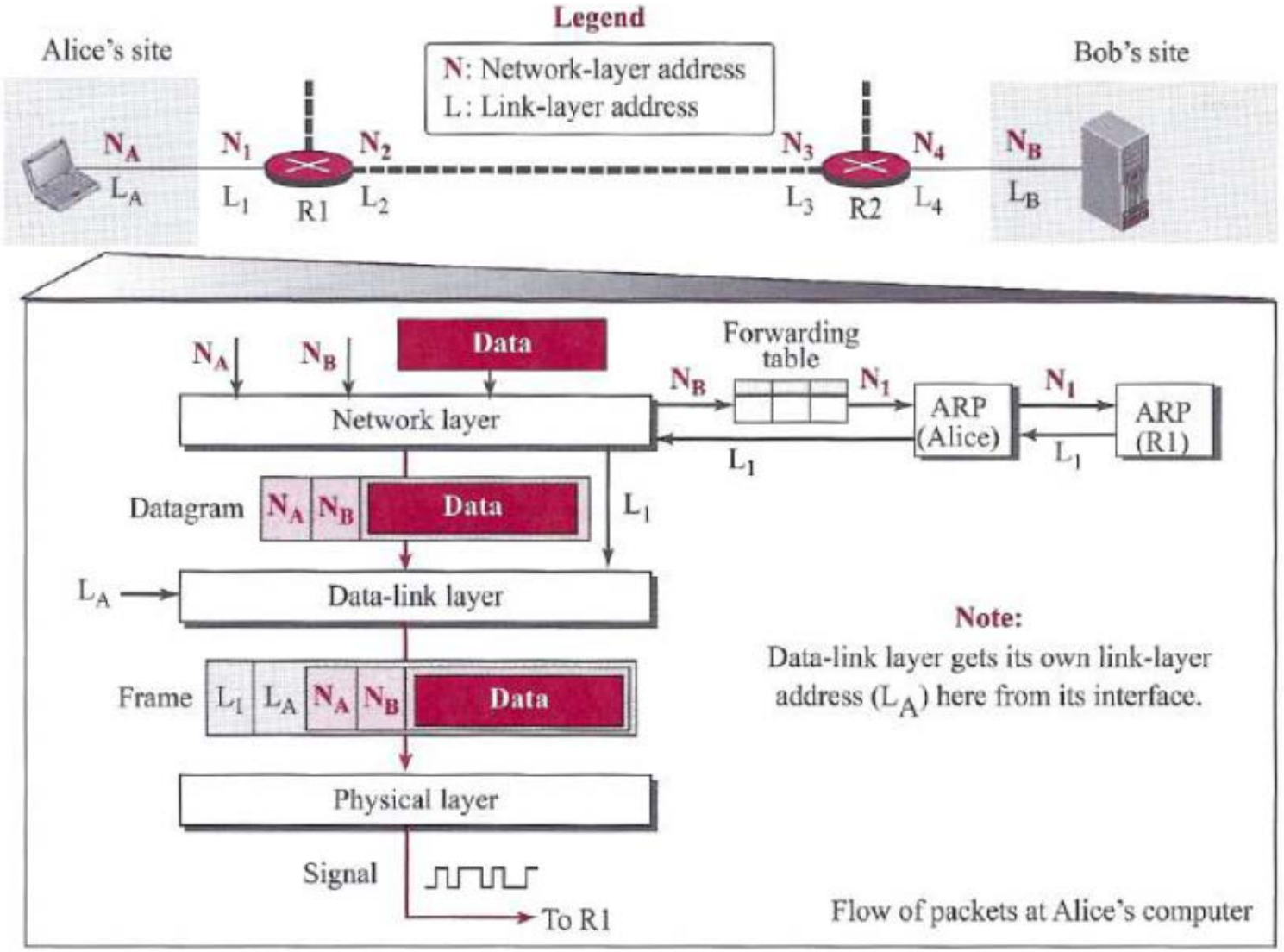
b. ARP reply is unicast

Approaches in Packet-switching

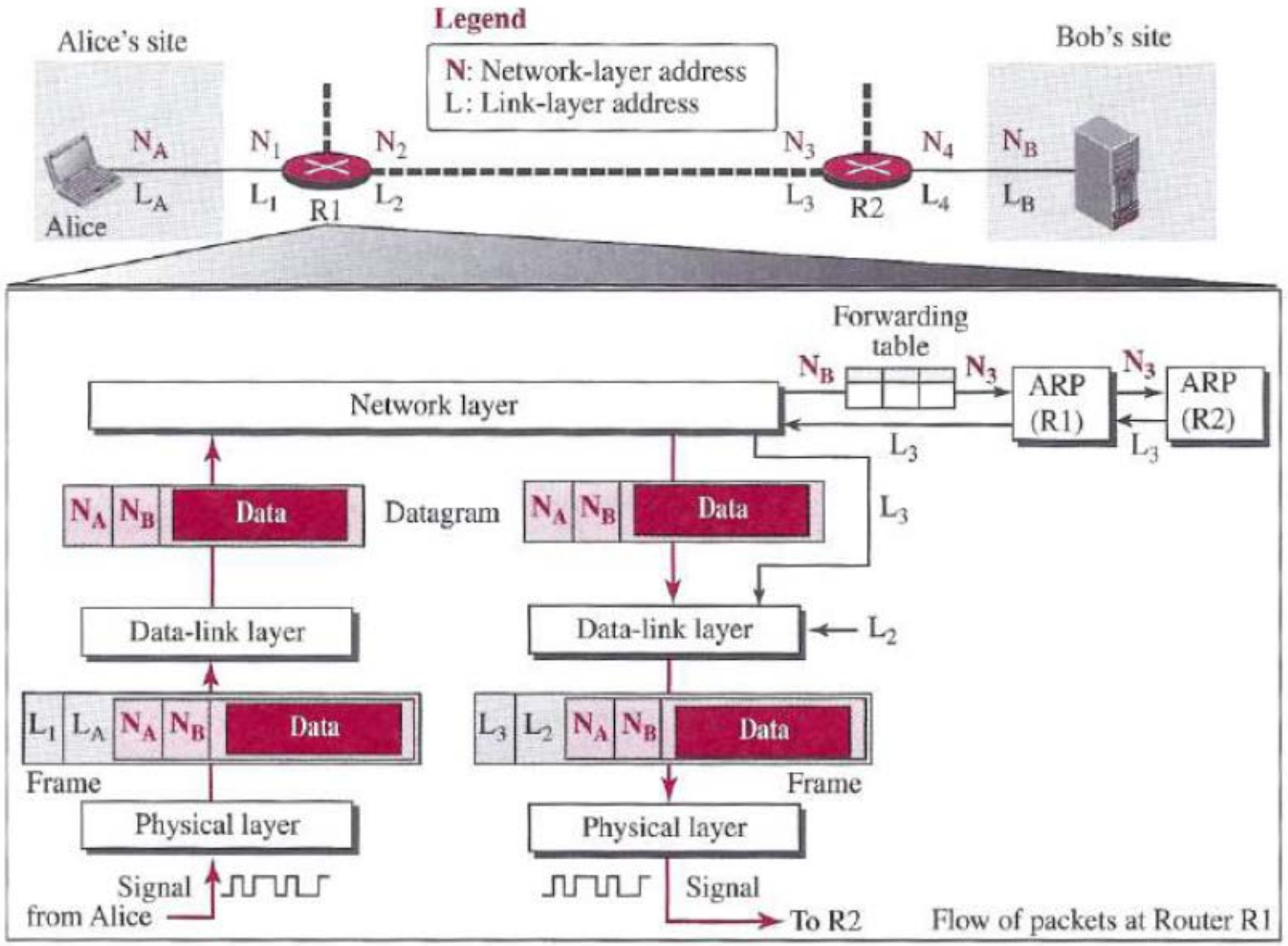


- ARP is an auxiliary protocol defined in Network layer
- Why these steps?
  - ARP Request Broadcast
  - ARP Response Unicast
  - Datagram Unicast

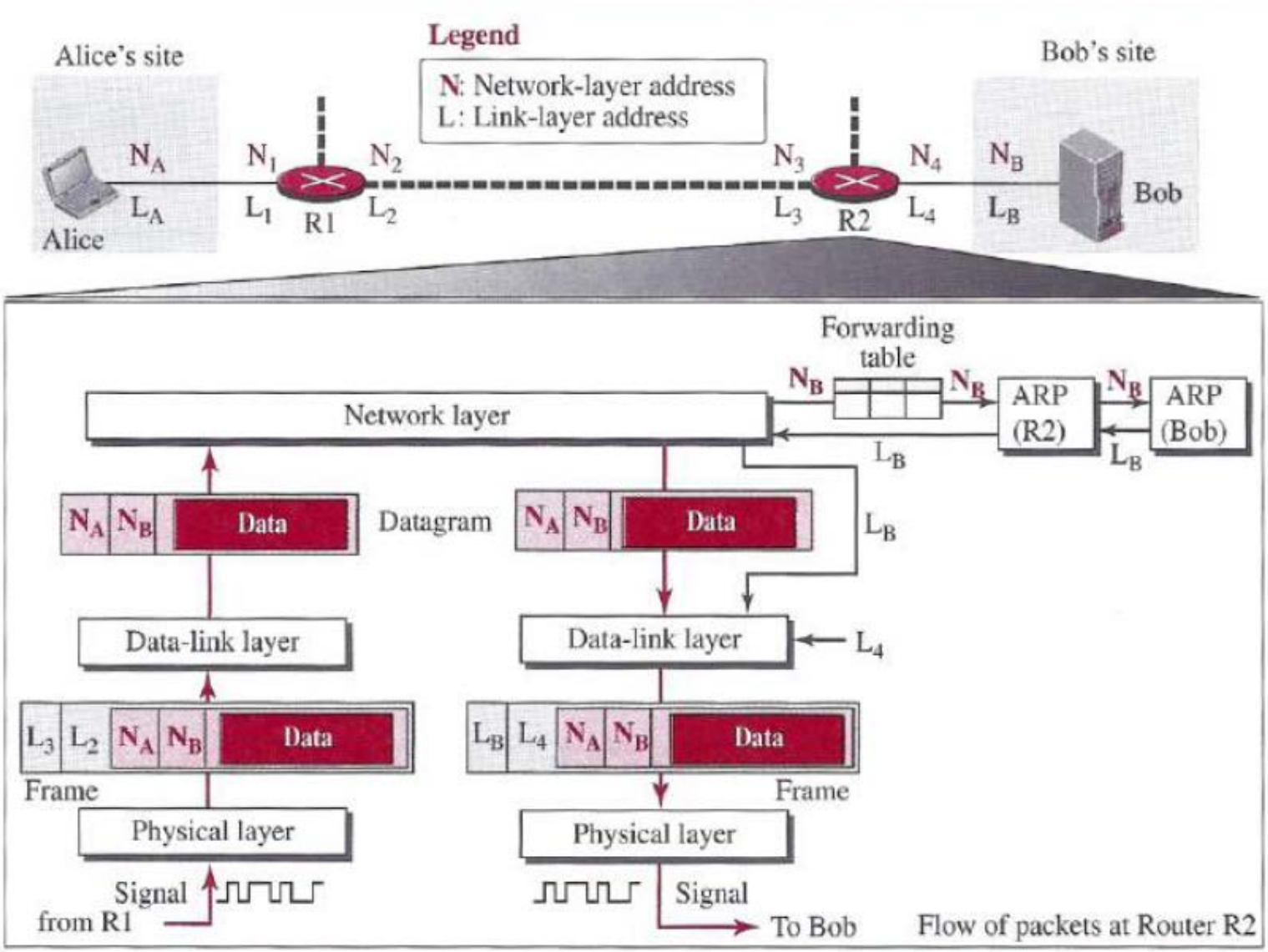
Example


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
Data
Forwarding table
Network layer
ARP (Alice)
ARP (R1)
Datagram
Data-link layer
Frame
Physical layer
Signal
To R1
Note:
Data-link layer gets its own link-layer address (L_A) here from its interface.
Flow of packets at Alice's computer

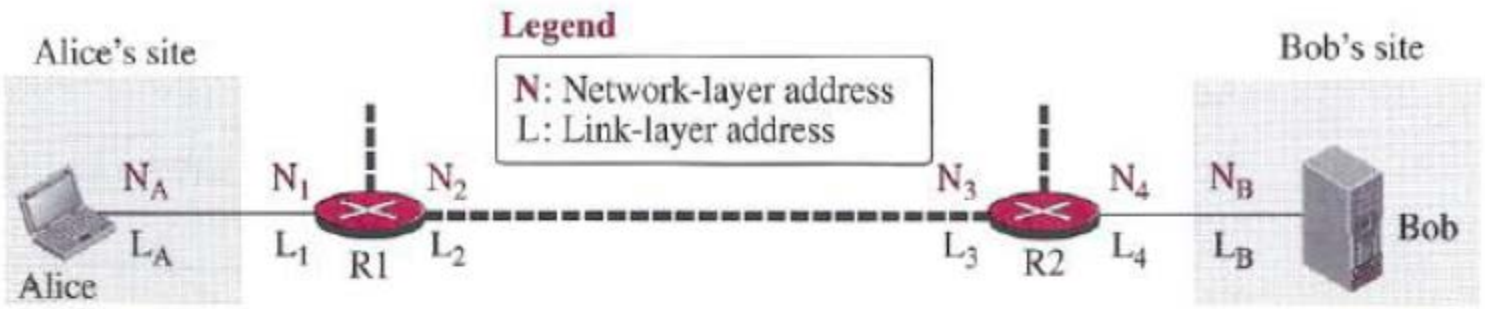
Cont…

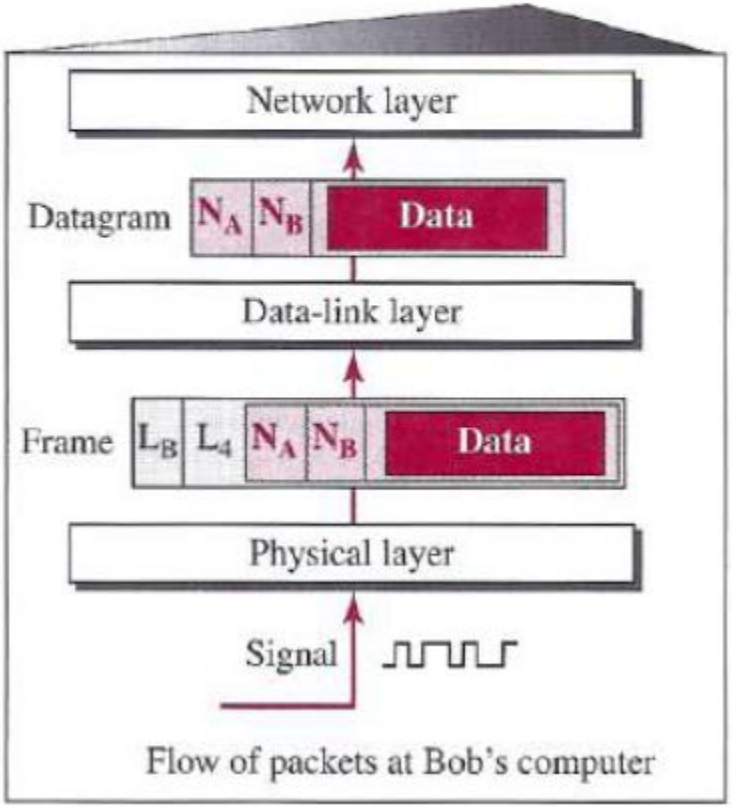

Legend
N: Network-layer address
L: Link-layer address
Alice's site
Bob's site
Alice
R1
R2
Forwarding table
Network layer
ARP (R1)
ARP (R2)
Datagram
Data
Data-link layer
Frame
Physical layer
Signal from Alice
Signal
To R2
Flow of packets at Router R1

Cont…

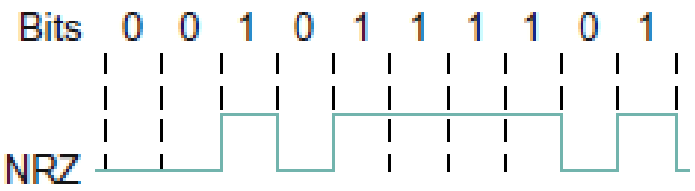

Legend
N: Network-layer address
L: Link-layer address
Alice's site
Bob's site
Alice
Bob
R1
R2
Forwarding table
Network layer
ARP (R2)
ARP (Bob)
Data
Datagram
Data-link layer
Frame
Physical layer
Signal
from R1
To Bob
Flow of packets at Router R2

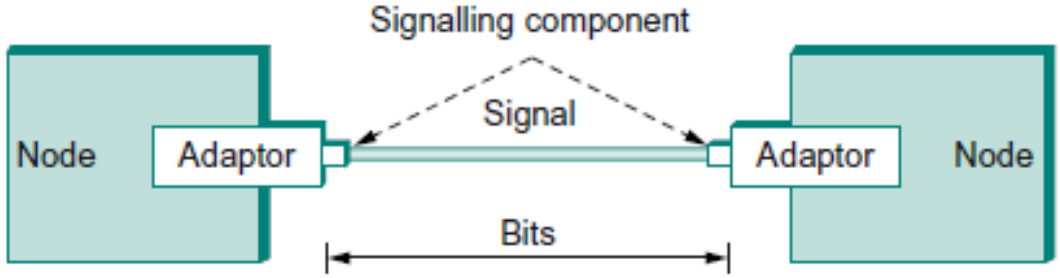
Cont…

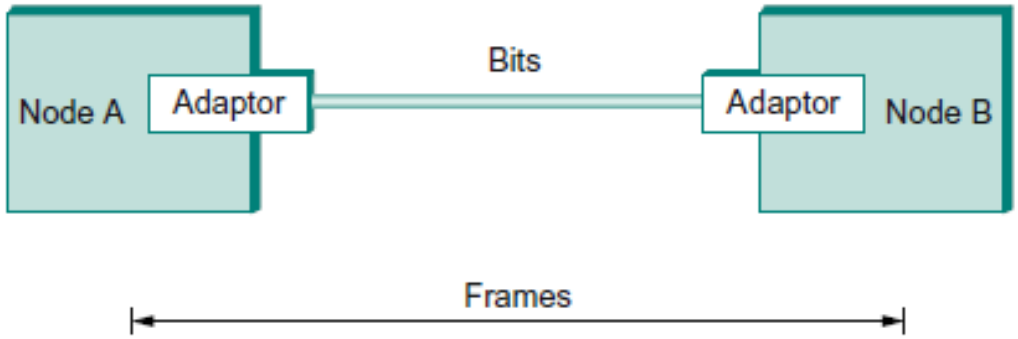

Legend
N: Network-layer address
L: Link-layer address
Alice's site
Bob's site
N_A
L_A
Alice
N_1
L_1
R1
N_2
L_2
N_3
L_3
R2
N_4
L_4
N_B
L_B
Bob


Network layer
Datagram
N_A N_B Data
Data-link layer
Frame
L_B L_4 N_A N_B Data
Physical layer
Signal
Flow of packets at Bob's computer

Framing







- Signals travel between signalling components
- Bits flow between adaptors
- Frames between hosts

Cont…

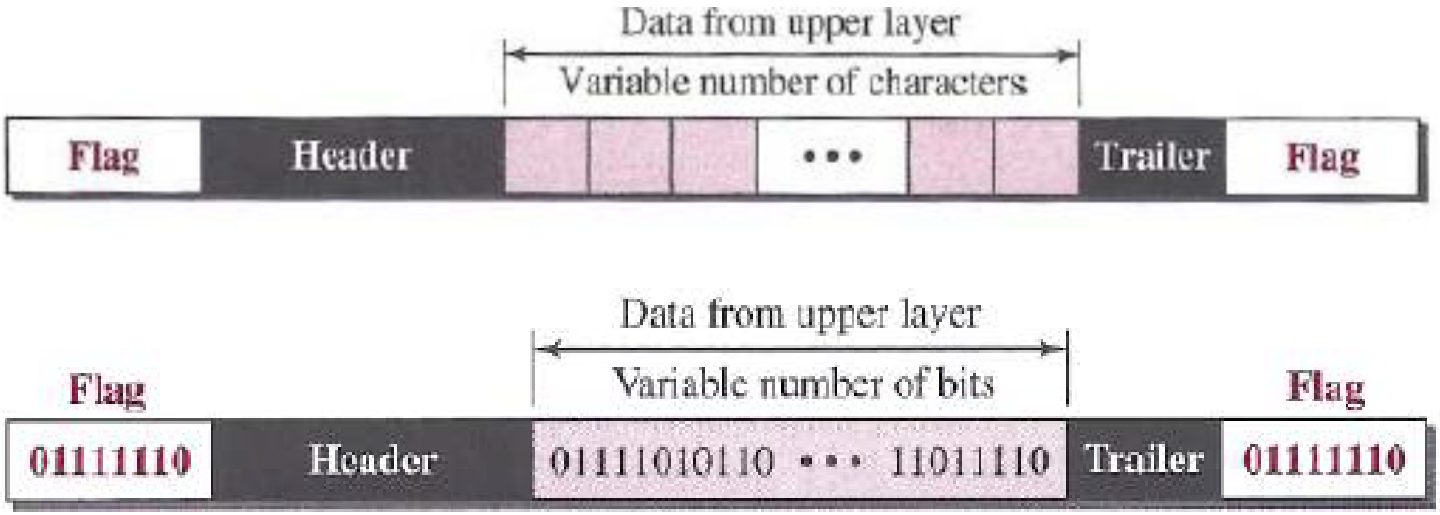
- Two size:
  - Fixed size
  - Variable size

- Character-Oriented Framing
  - View each frame as a collection of bytes (characters)
  - Suitable for Byte-oriented protocol (e.g. PPP)
  - Useful for text data only

- Bit-Oriented Framing
  - View each frame as a collection of bits
  - Suitable for bit-oriented protocol (e.g. HDLC)
  - Useful for any type of data (text, graph, audio, video, etc.)

Cont…

- Both are variable size framing
- Frame format:



- Byte & Bit stuffing: addition of special byte/bit for avoiding the appearance of flag pattern inside of data stream

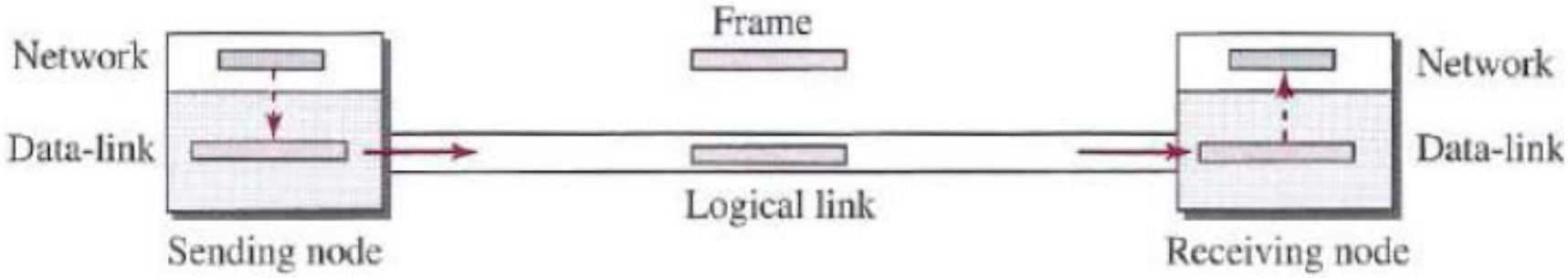
DLC Protocols

- Four Mechanisms:
  - Simple
  - Stop-and-Wait
  - Go-Back-N
  - Selective Repeat

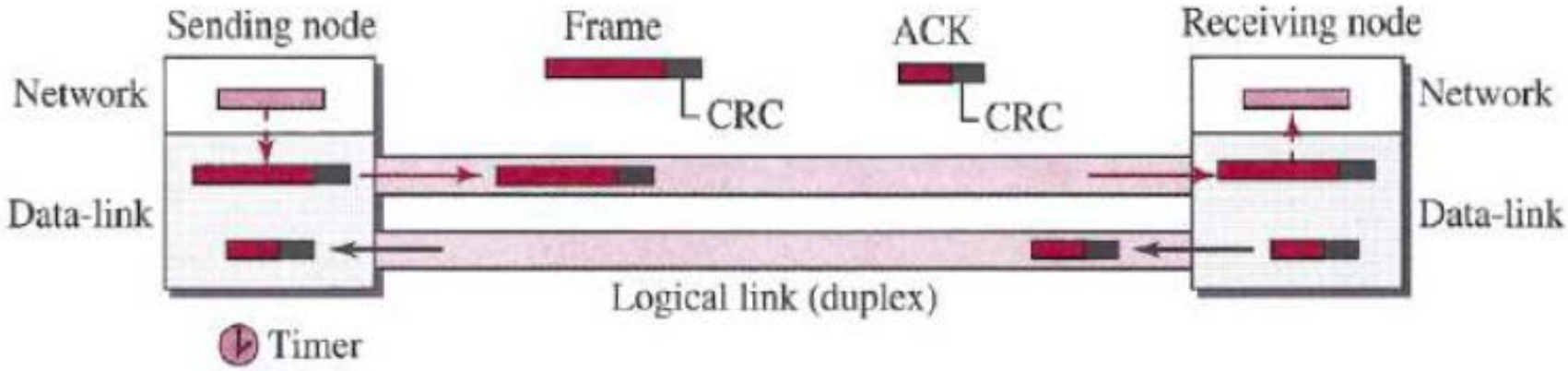
- Protocols:
  - HDLC (High-level Data Link Control)
  - PPP (Point-to-Point Protocol)
  - Ethernet

Cont…

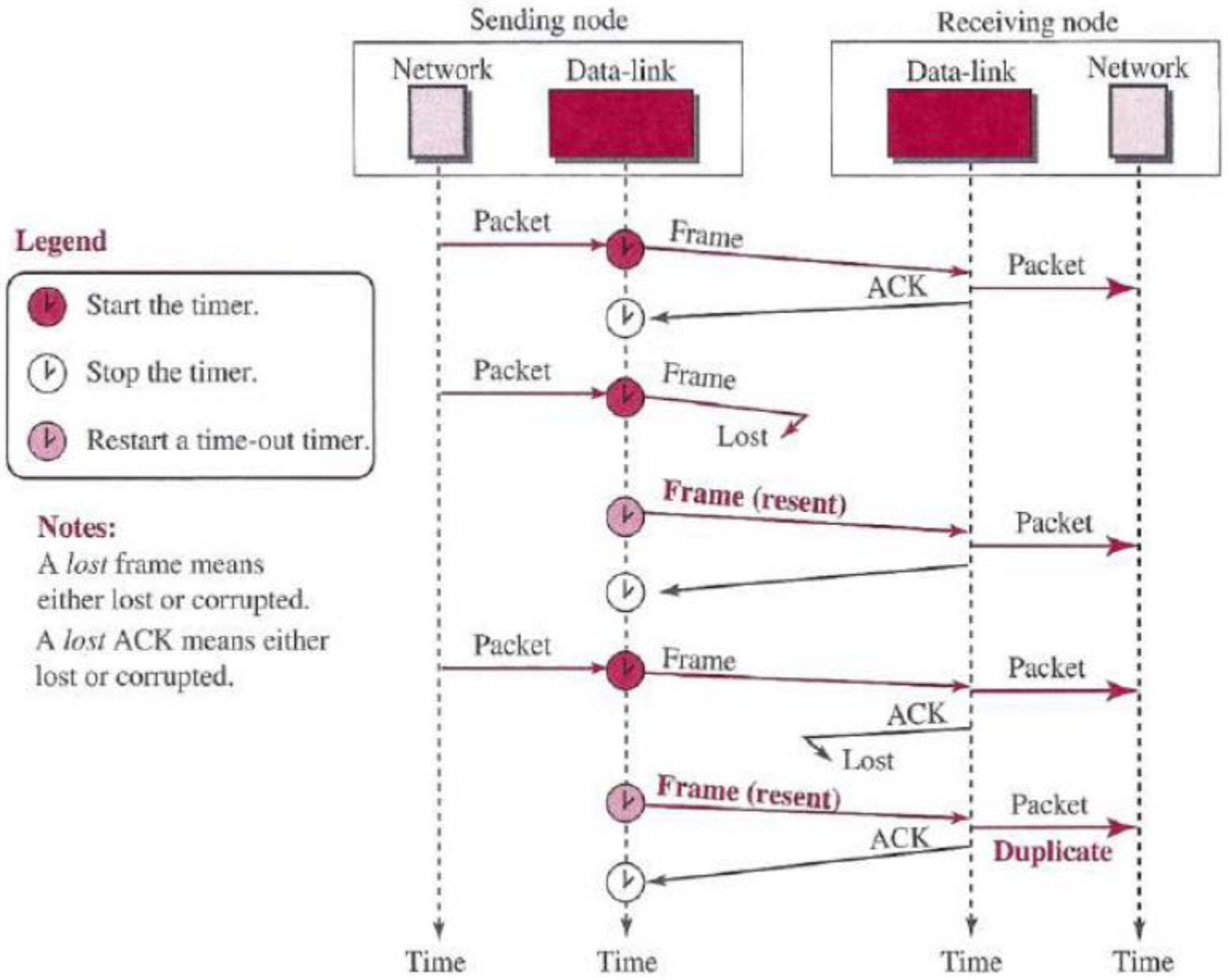
- Simple



- Stop-and-Wait



Stop-and-Wait



Thanks!