# 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
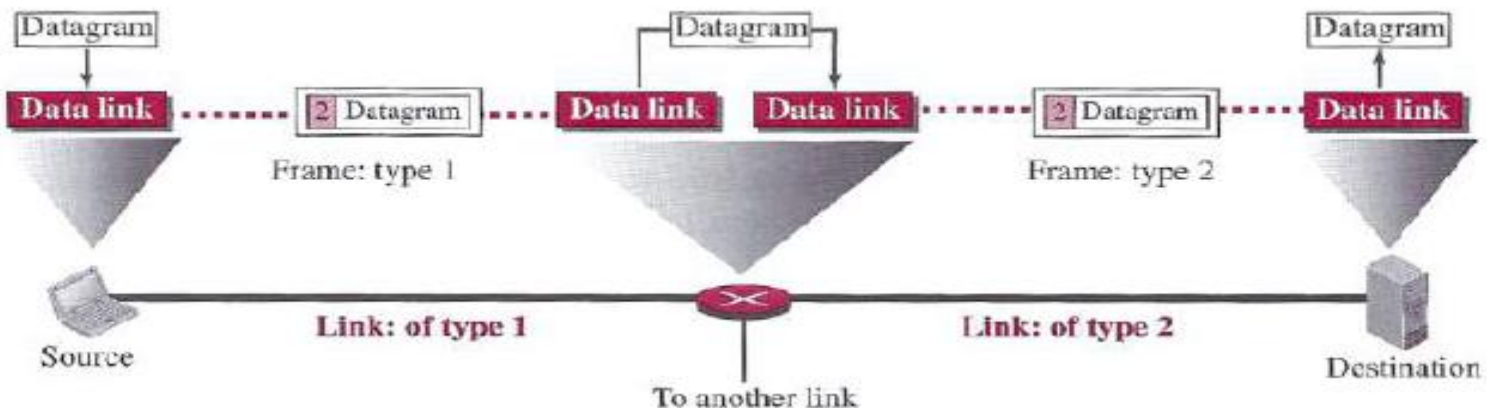
Why so difficult?

- 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 types of network links:
  - point-to-point (p2p) links
    - protocol => PPP, HDLC
    - networks => switched network (mesh topology among routers), office computer to nearby Ethernet switch,

  - broadcast links
    - protocol => multiple access control (MAC) protocols
    - networks => wireless LAN, satellite networks, hybrid fiber-coaxial cable access network

- Two sublayers in Data-link Layer
  - Data link control (DLC)
  - Medium access control (MAC)
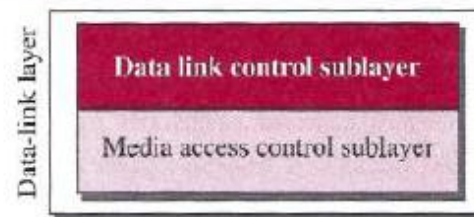
a. Data-link layer of a broadcast link   b. Data-link layer of a point-to-point link

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

# Major Services of DLL

- Related to DLC
  - Link Layer Addressing
  - Framing
  - Error Control (detection and correction)

  - Reliable delivery (using ACK and retransmission)
    - Optional for less bit-error links such as wired links

- Related to MAC
  - Link Access / channel access
  - Multiple access

Where is the DLL implemented?

- much of a link-layer controller's functionality is implemented in hardware

(framing, link access, error detection, and so on).

- part of the link layer is implemented in software that runs on the host's CPU

(higher-level linklayer functionality such as activating the controller hardware)

- Thus, the link layer is a combination of hardware and software - the place in the protocol stack
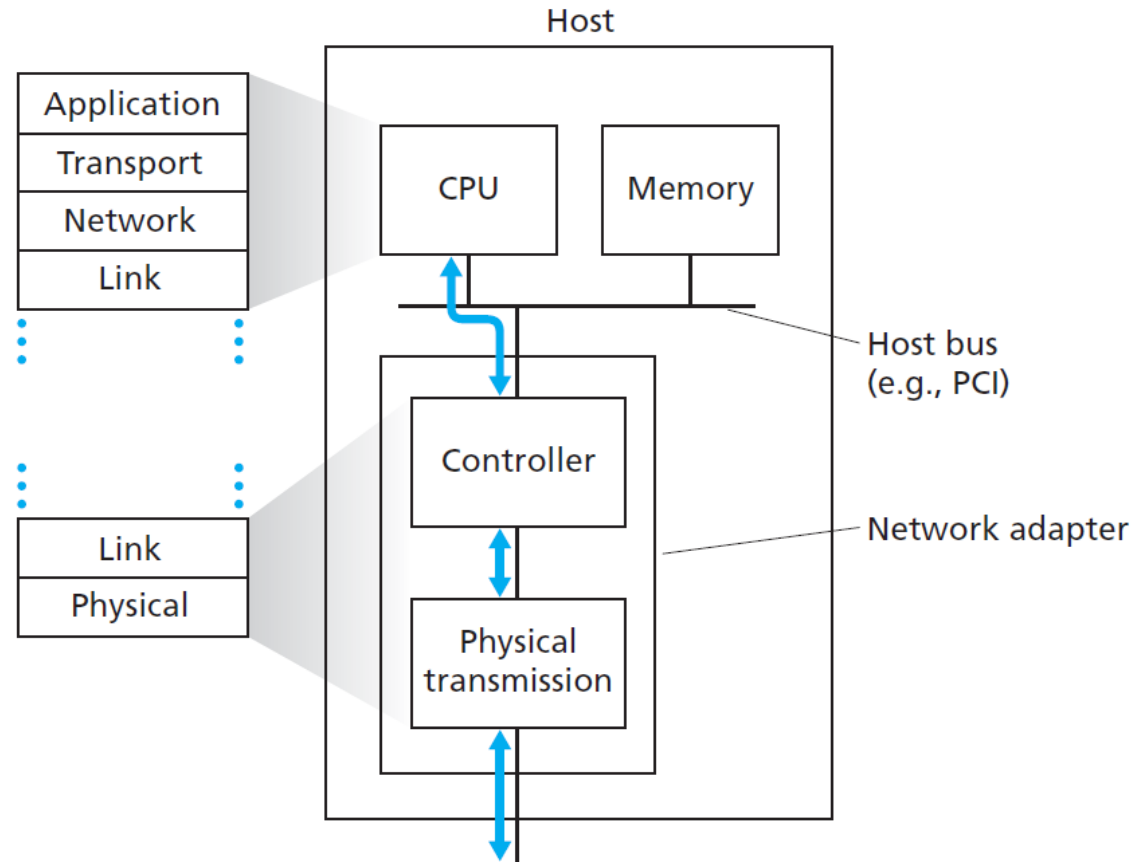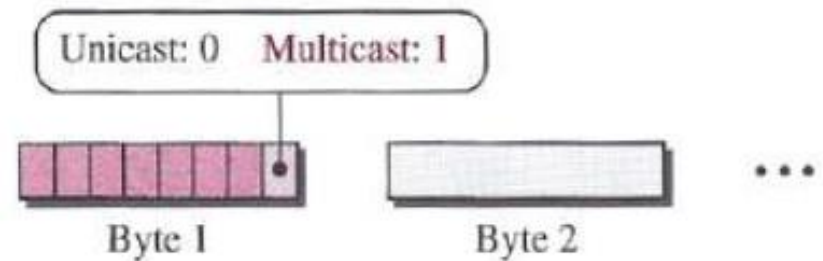
Link Layer Addressing
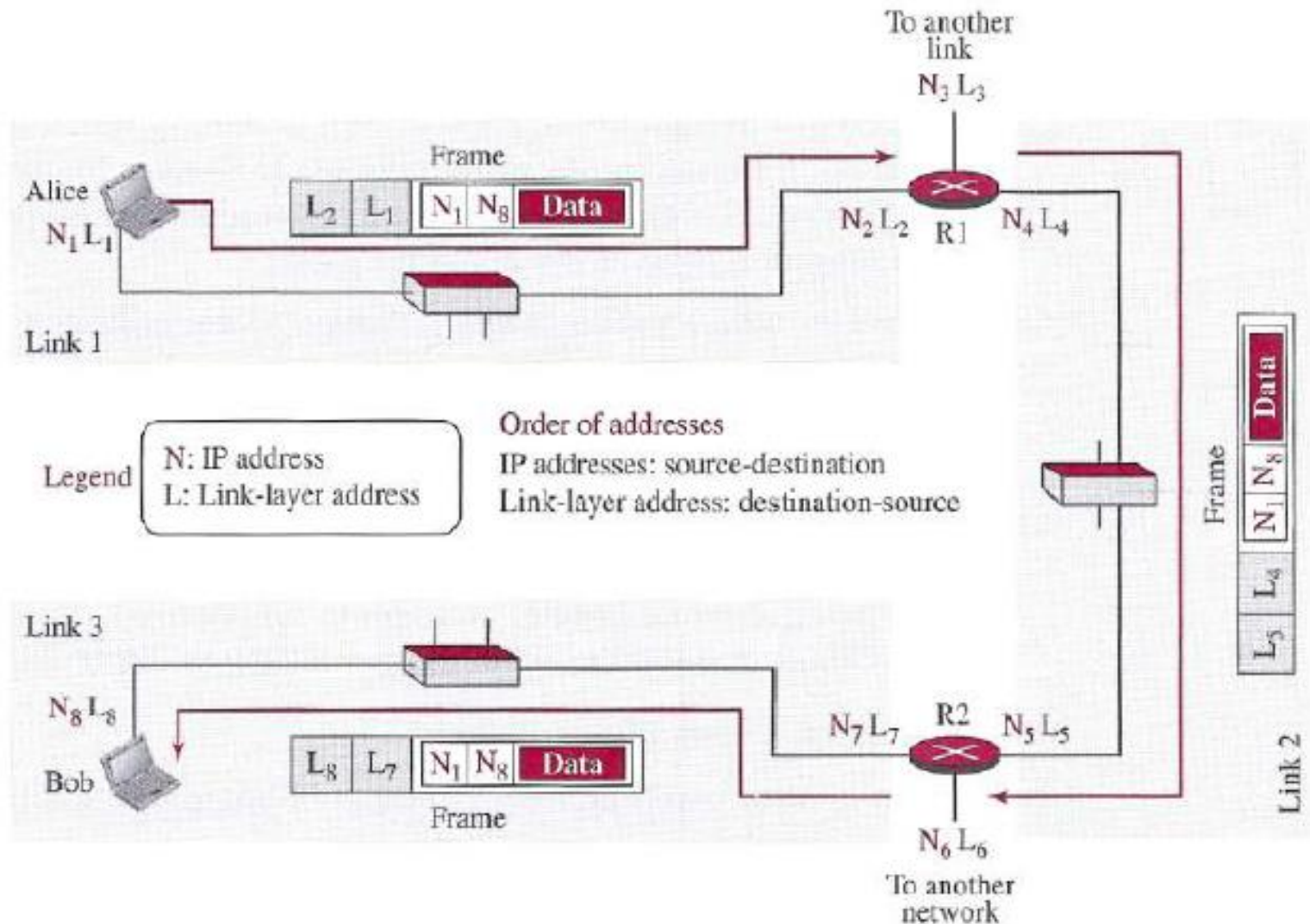
MAC address v/s IP address

- 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 (MAC address) of the next node

- Why simply don't eliminate the MAC address and use just TCP/IP address?
  - easy to group TCP/IP addresses
  - it doesn't matter if your network cards all have a similar MAC address or not, we'll group our computer so that all TCP/IP address that began with 10.0.x.x. are part of the engineering group, and those of 10.1.x.x. are the printers, so on.
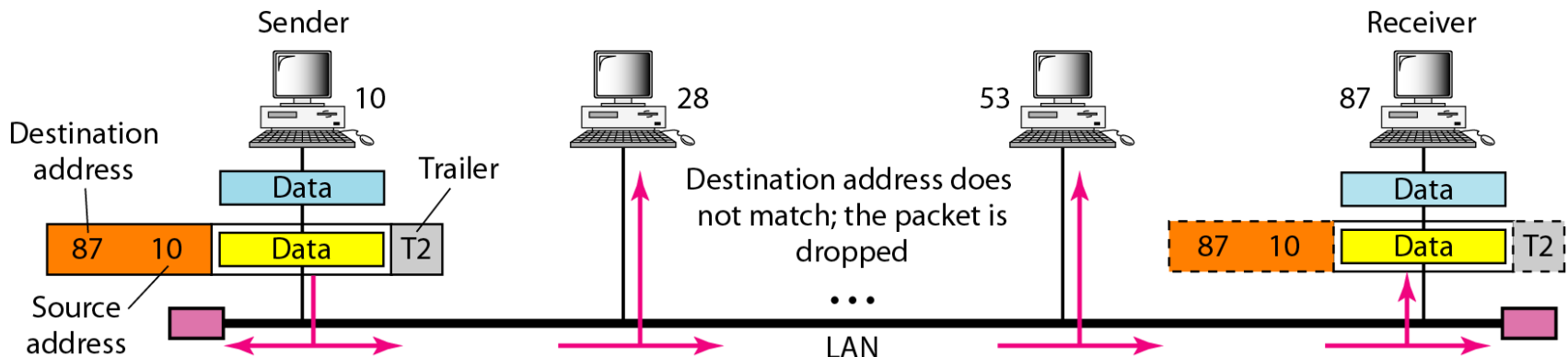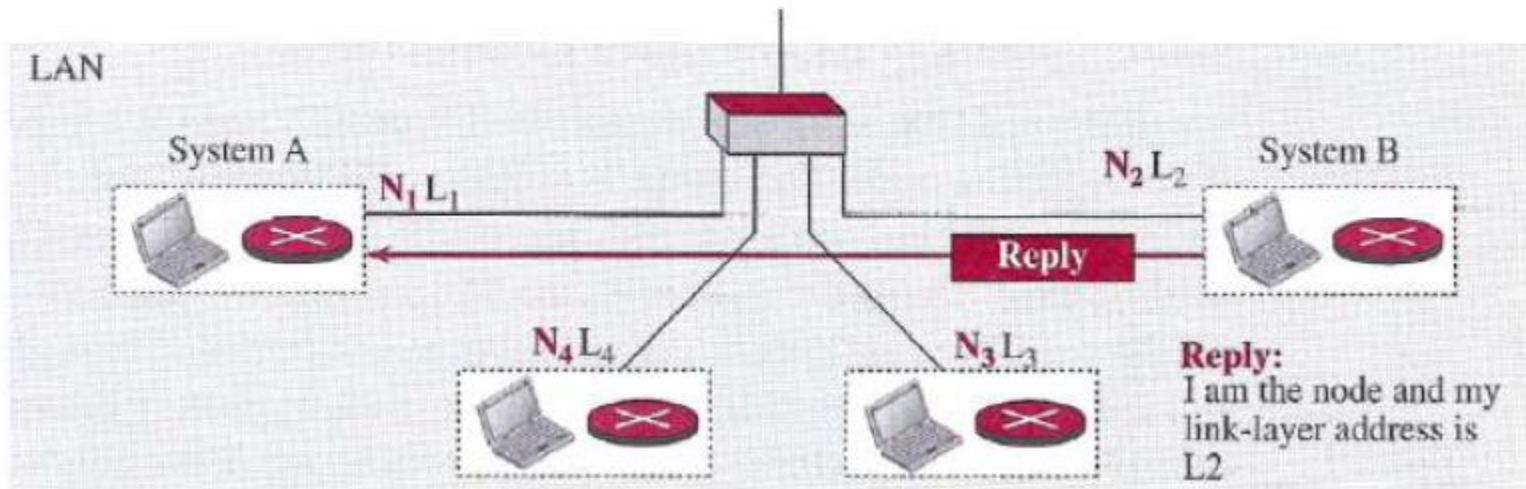
Types of Addresses

- 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)
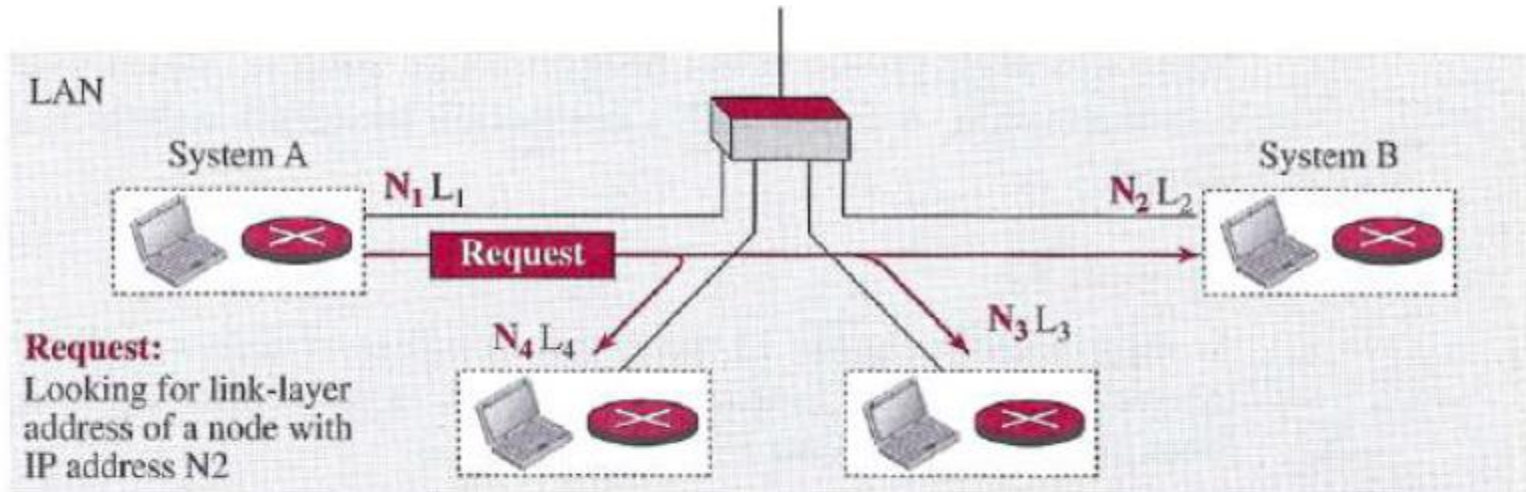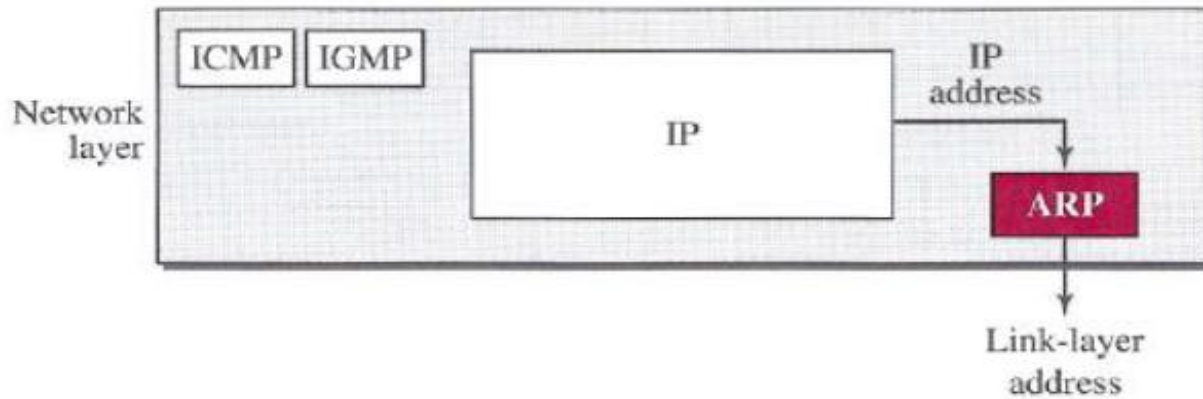

a. ARP request is broadcast

Request:
Looking for link-layer address of a node with IP address N2

b. ARP reply is unicast

Reply:
I am the node and my link-layer address is L2
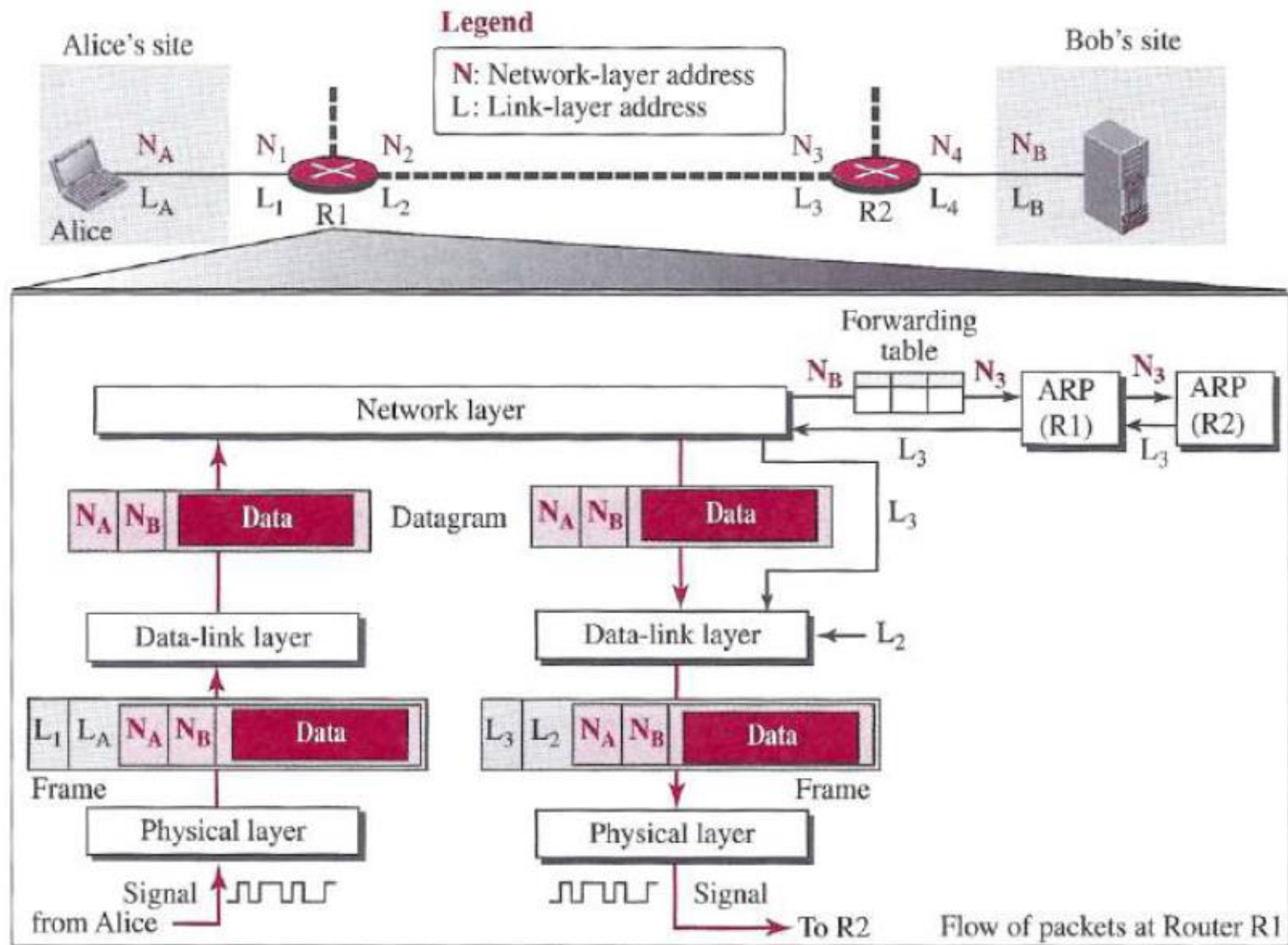
Approaches in Packet-switching

- ARP is an auxiliary protocol defined in Network layer

- Why these steps?
  - ARP Request Broadcast
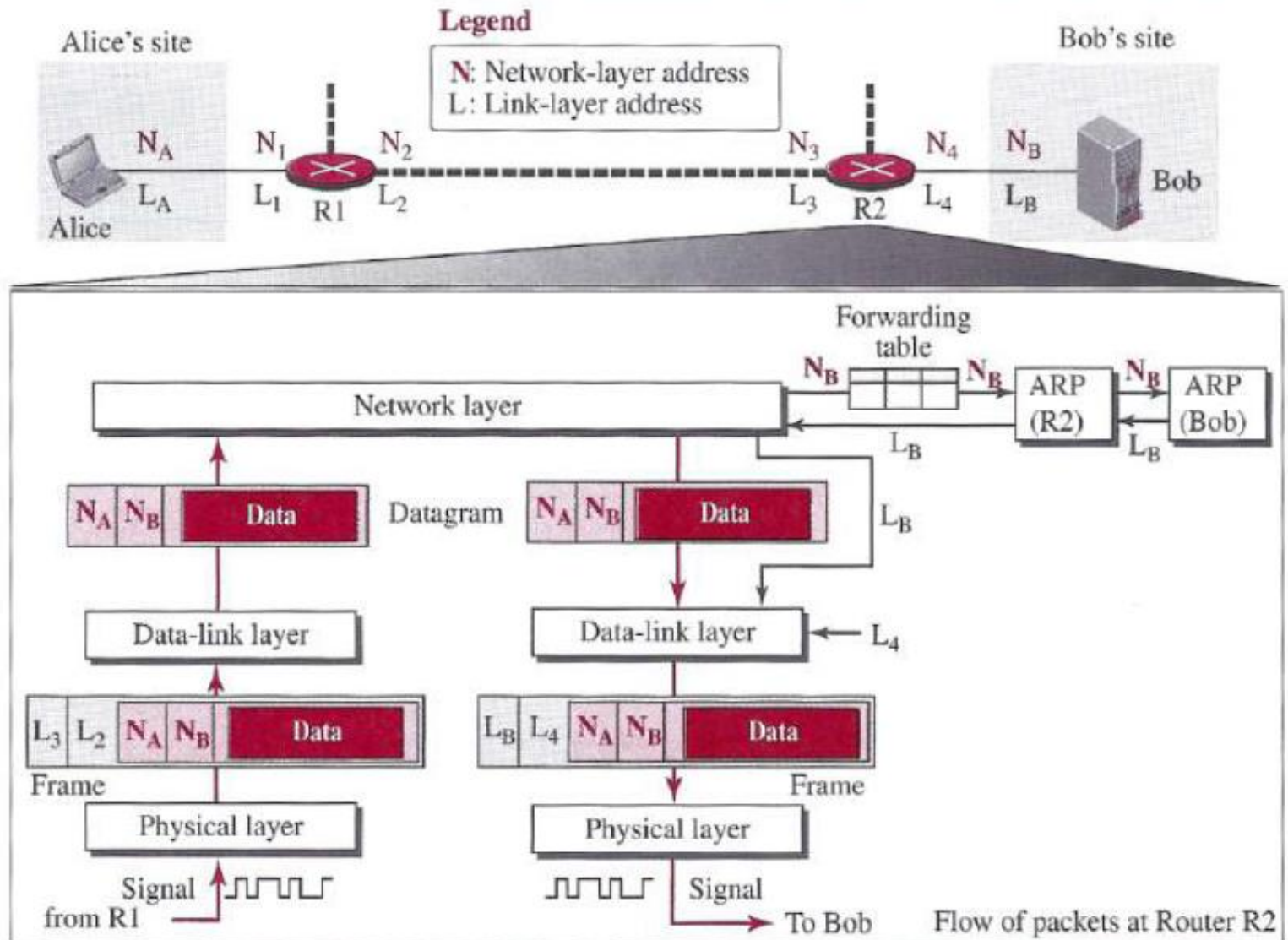 - ARP Response Unicast
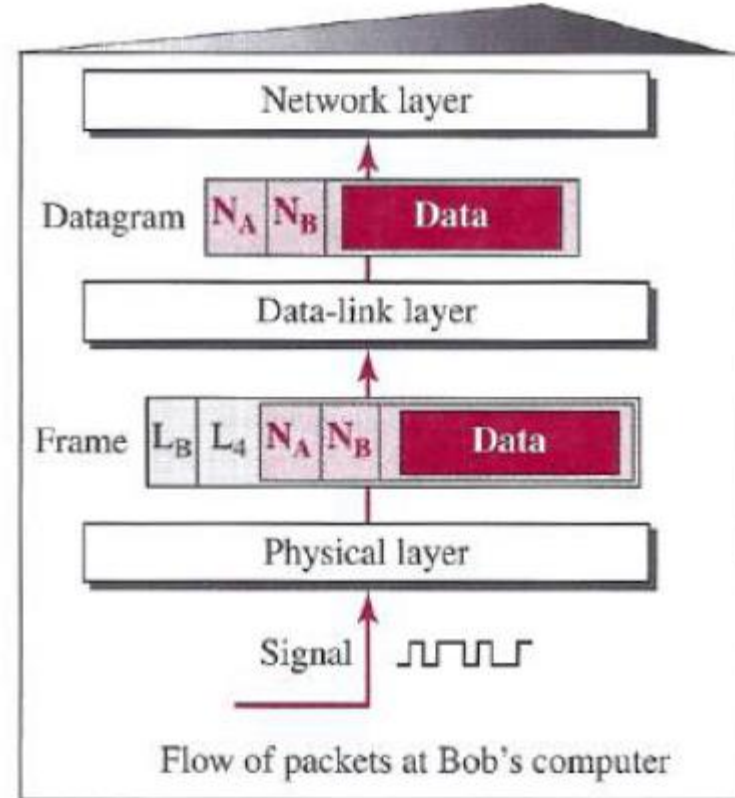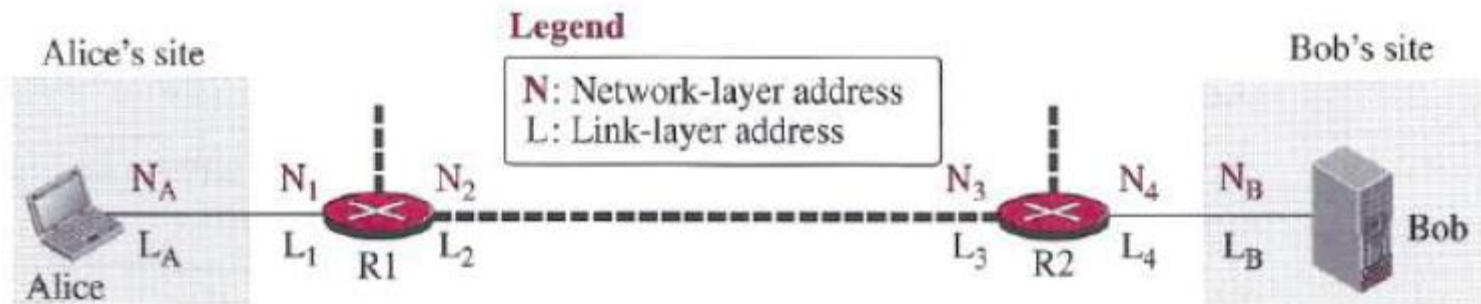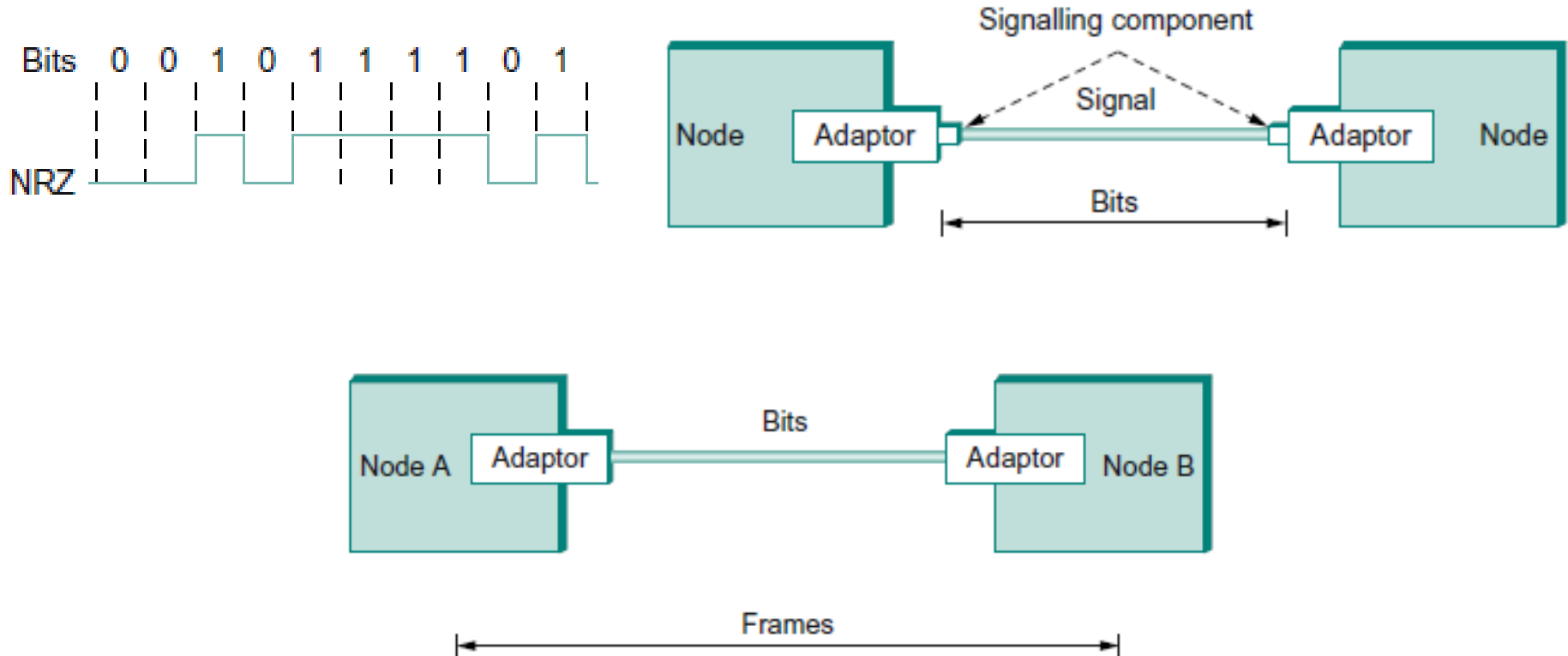 - Datagram Unicast

Example

Cont…

Cont…

Flow of packets at Router R2

Cont…

Flow of packets at Bob's computer
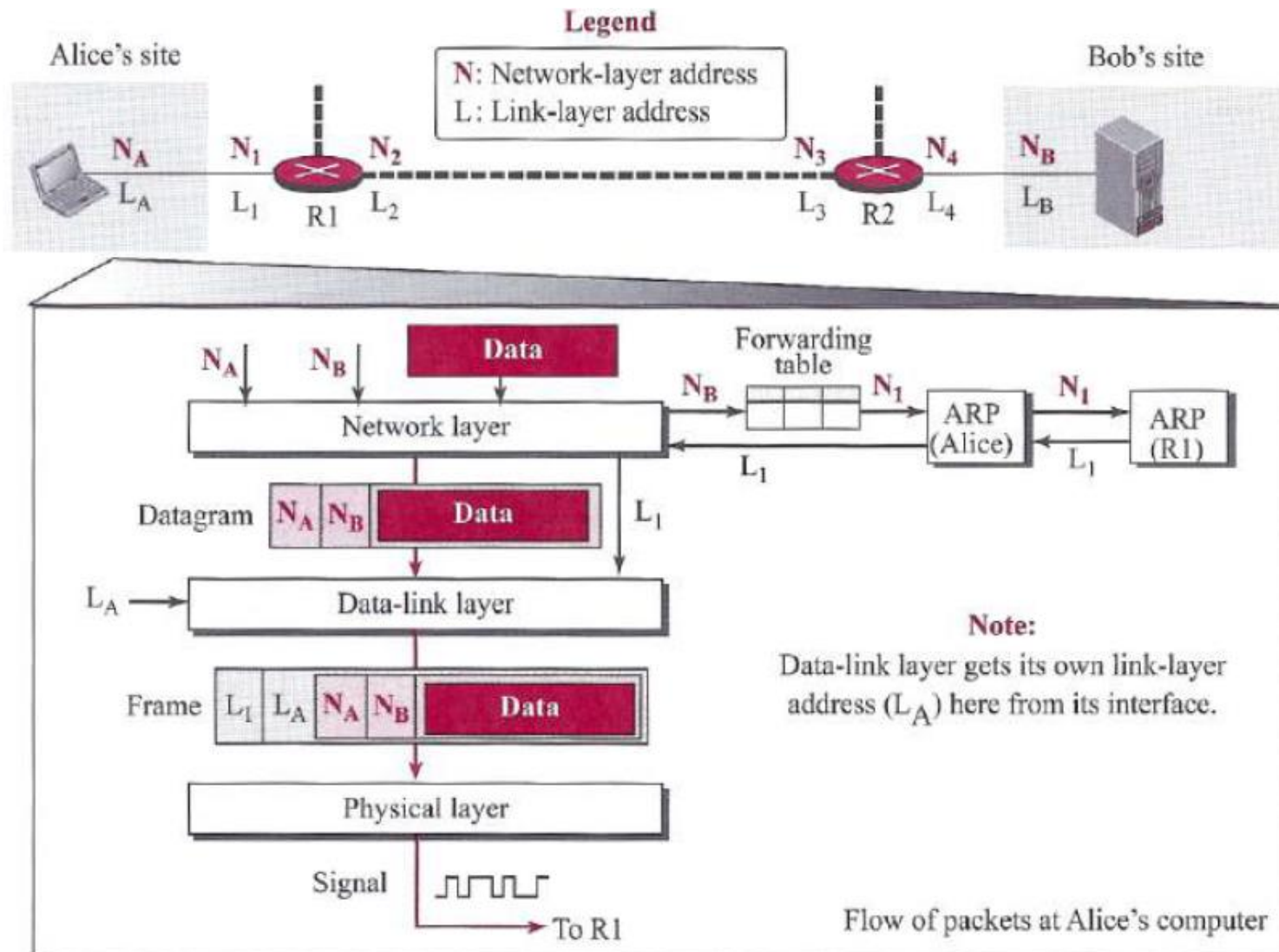
Framing

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

Cont…

- Two types of framing w.r.t. frame 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 the Character-Oriented and Bit-Oriented are variable size framing

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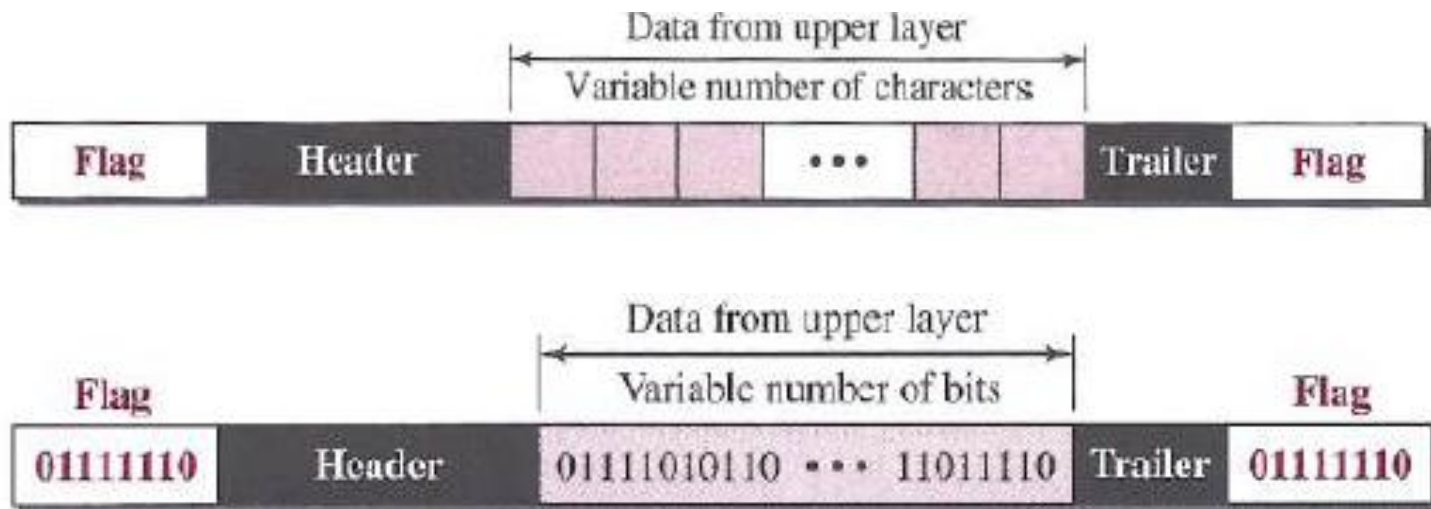
- Byte & Bit stuffing:
  - addition of special byte/bit for avoiding the appearance of flag pattern inside of data stream
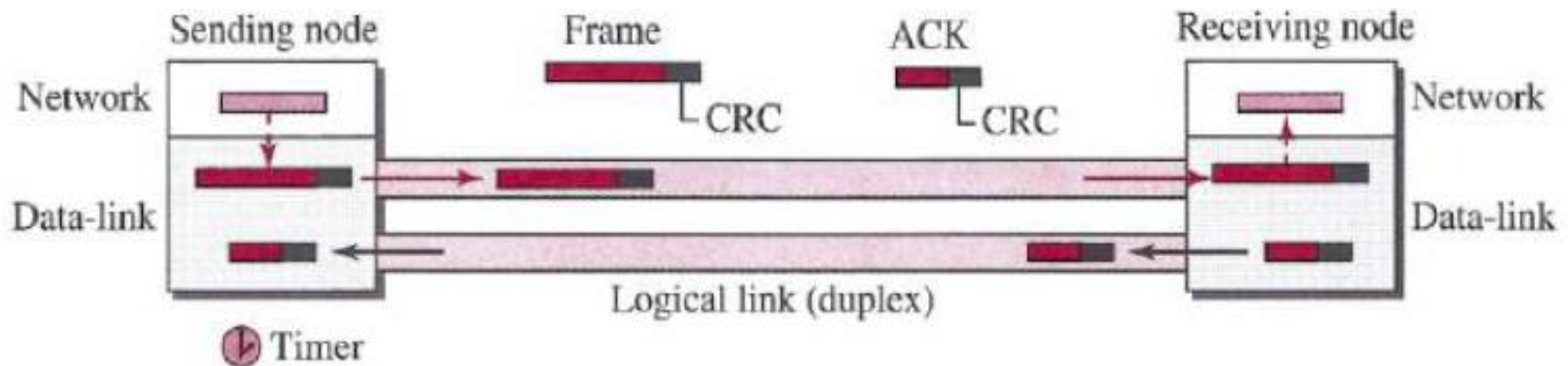
DLC Protocols

- Protocols:
  - HDLC (High-level Data Link Control)   – for P2P link
  - PPP (Point-to-Point Protocol)   – for P2P link

  - Ethernet (IEEE 802.3)   – for Broadcast link
  - IEEE 802.11 DCF   – for Broadcast link

- The wireless links are significantly different from wired links such as
  - Highly decreasing signal strength
  - Interference from other sources as the channel is open
  - Multipath propagation occurs

- Therefore, DLC in wireless networks employ link-level reliable data transfer mechanisms

- DataLink Layer ARQ Protocols:
  - Stop-and-Wait
  - Go-Back-N
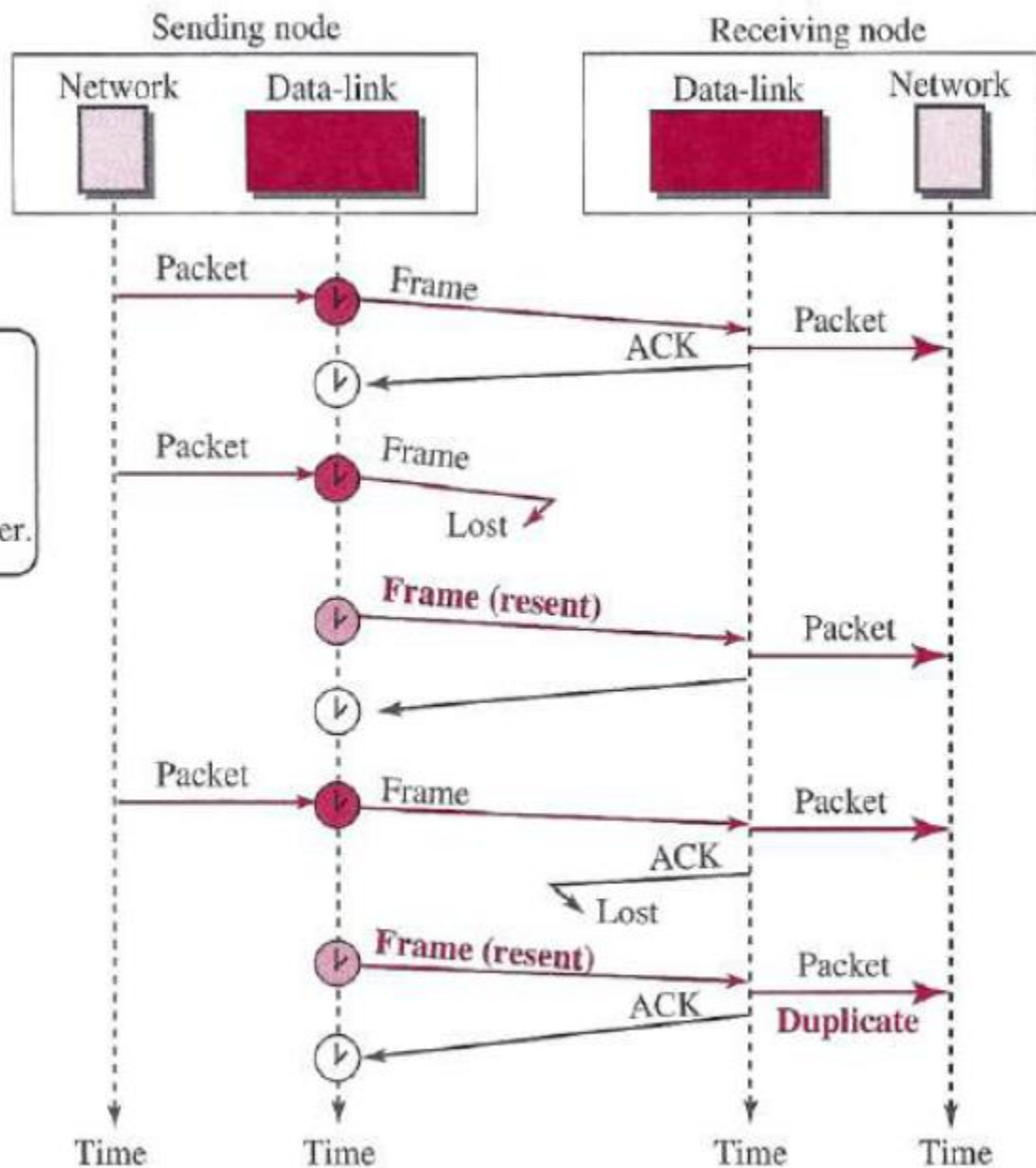 - Selective Repeat

Cont…

- Simple
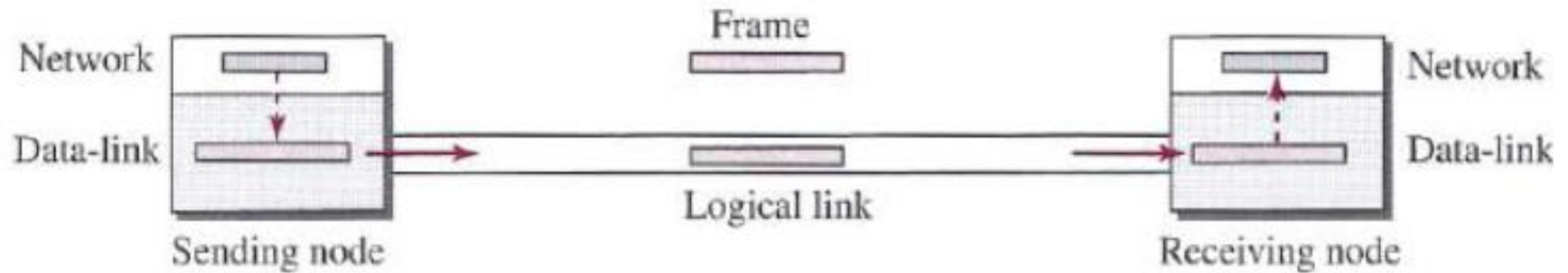
- Stop-and-Wait

Stop-and-Wait

Thanks!