Computer Networks (ITPC-205)

Dr Aruna Malik

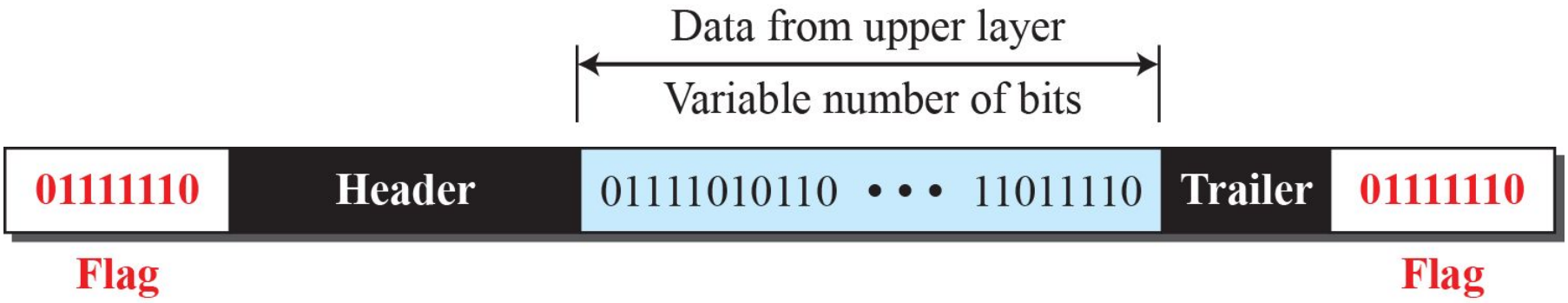
Data Link Layer

Framing, Flow Control

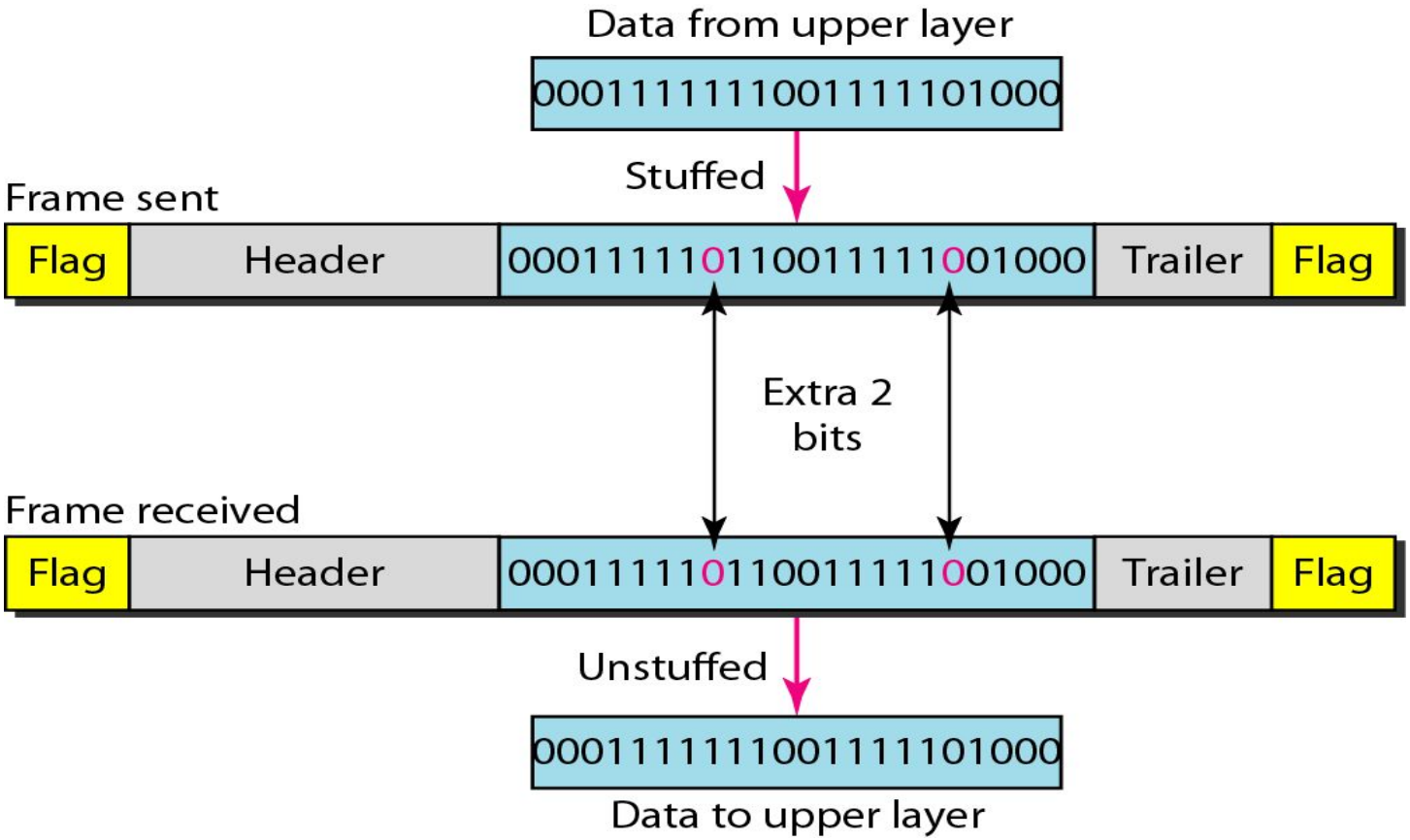
Data Link Layer

- Data link layer is divided into two sub-layers: Data Link Control (DLC) and Multiple Access Control (MAC).
- The data link control needs to pack bits into frames, so that each frame is distinguishable from another.
- Our postal system practices a type of framing. The simple act of inserting a letter into an envelope separates one piece of information from another; the envelope serves as the delimiter.
- Types of framing:
    - Fixed-Size Framing
    - Variable-Size Framing

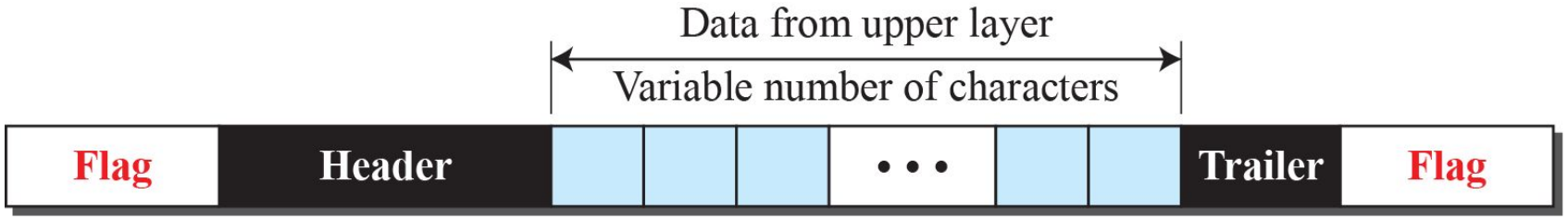
A frame in a bit-oriented protocol



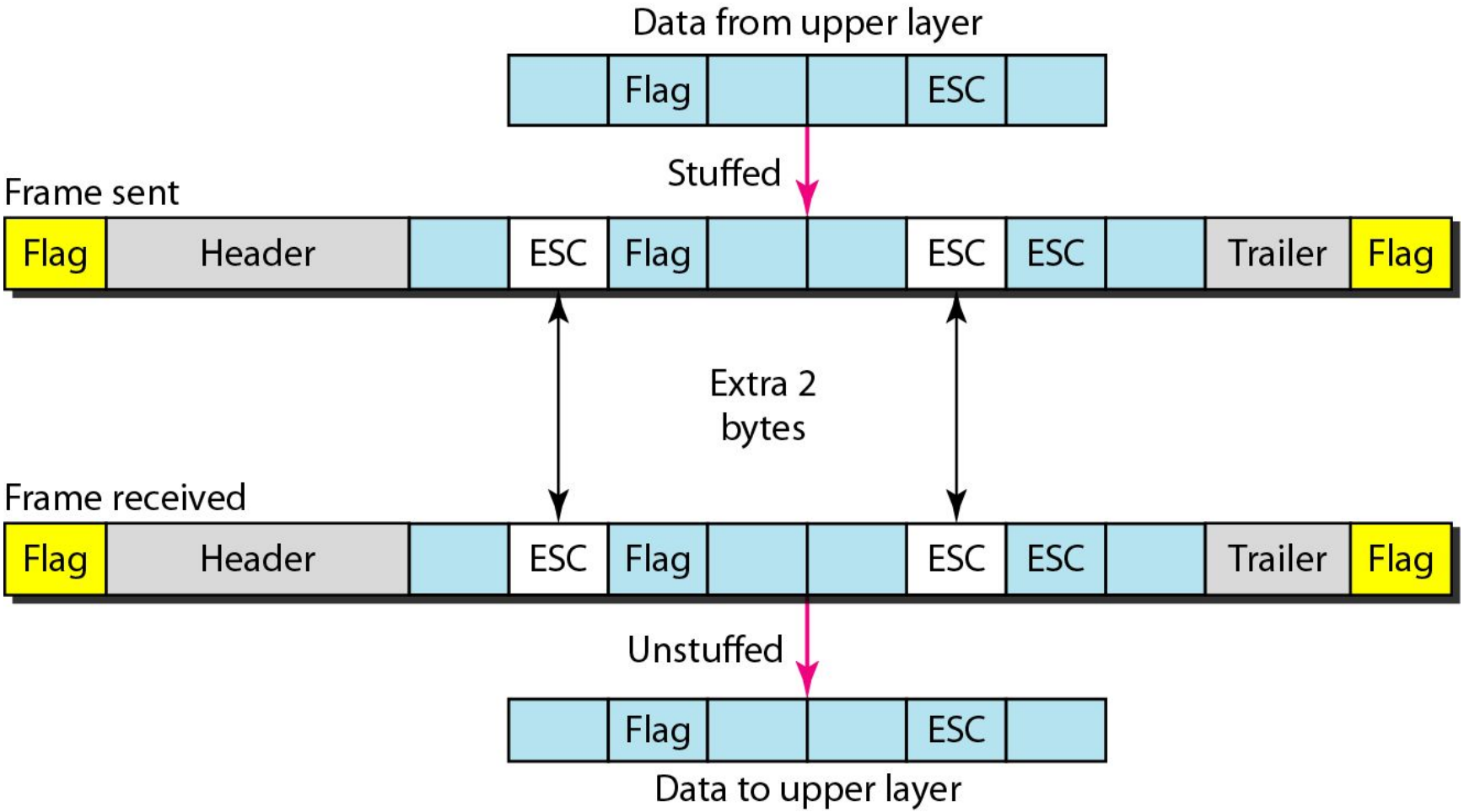
Variable-Size Framing: Bit Stuffing and Unstuffing



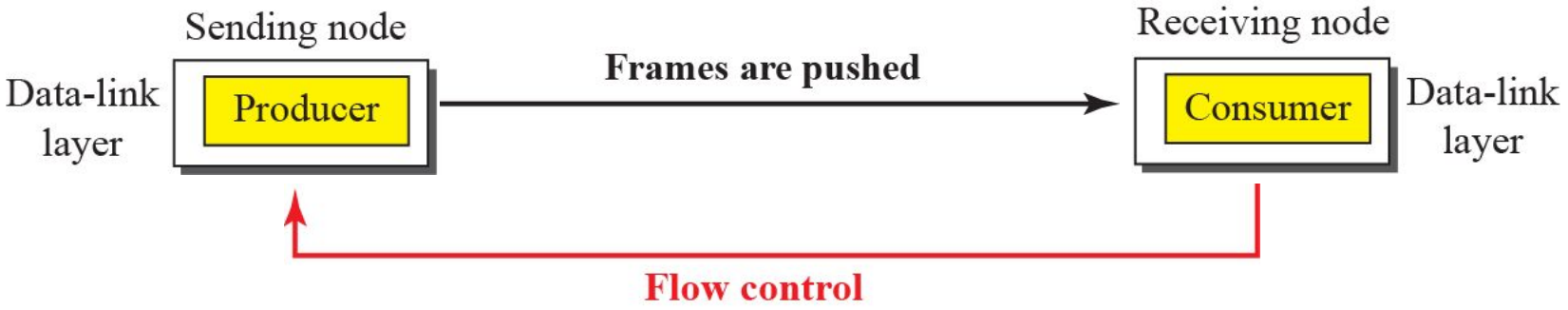
A frame in a character-oriented protocol



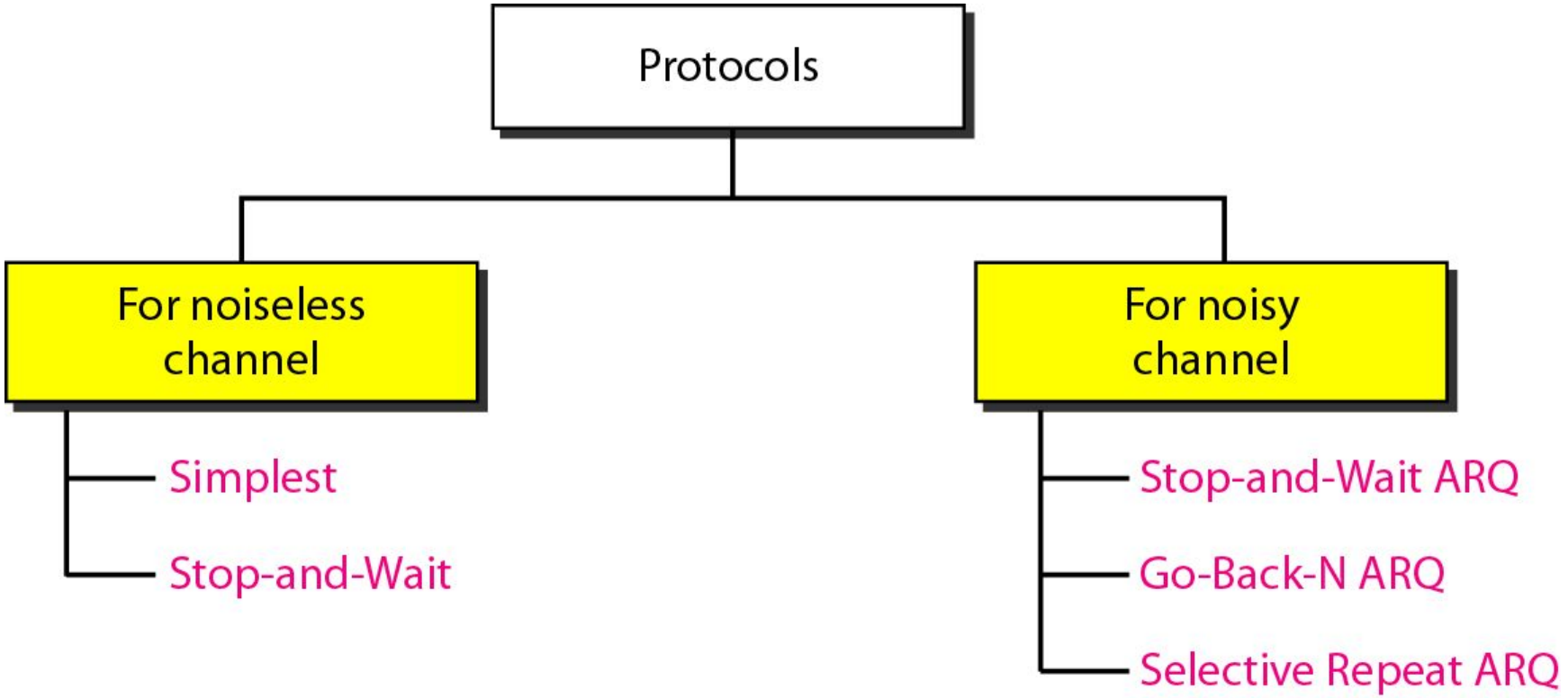
Variable-Size Framing: Byte Stuffing and Unstuffing



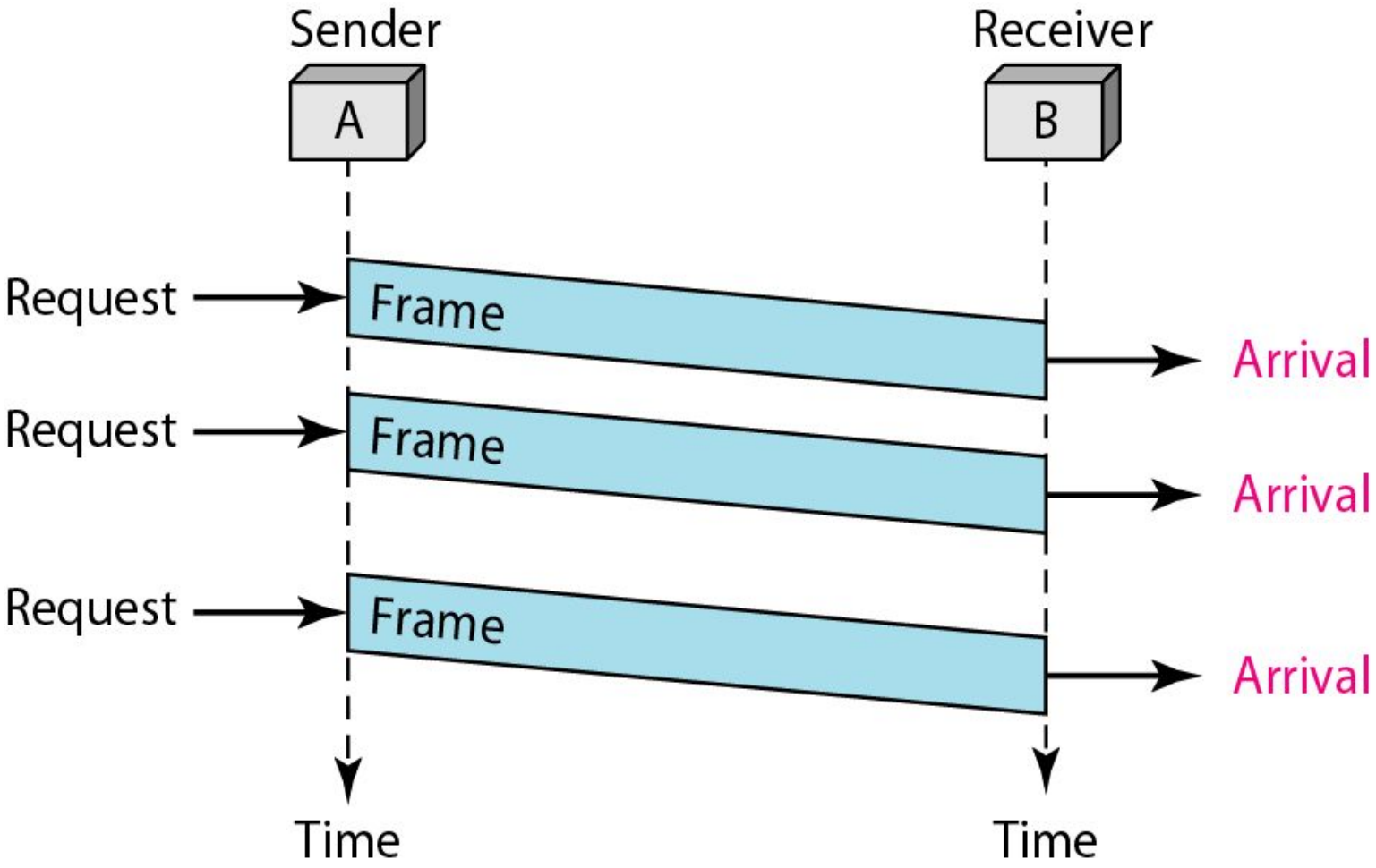
Flow control at the data link layer



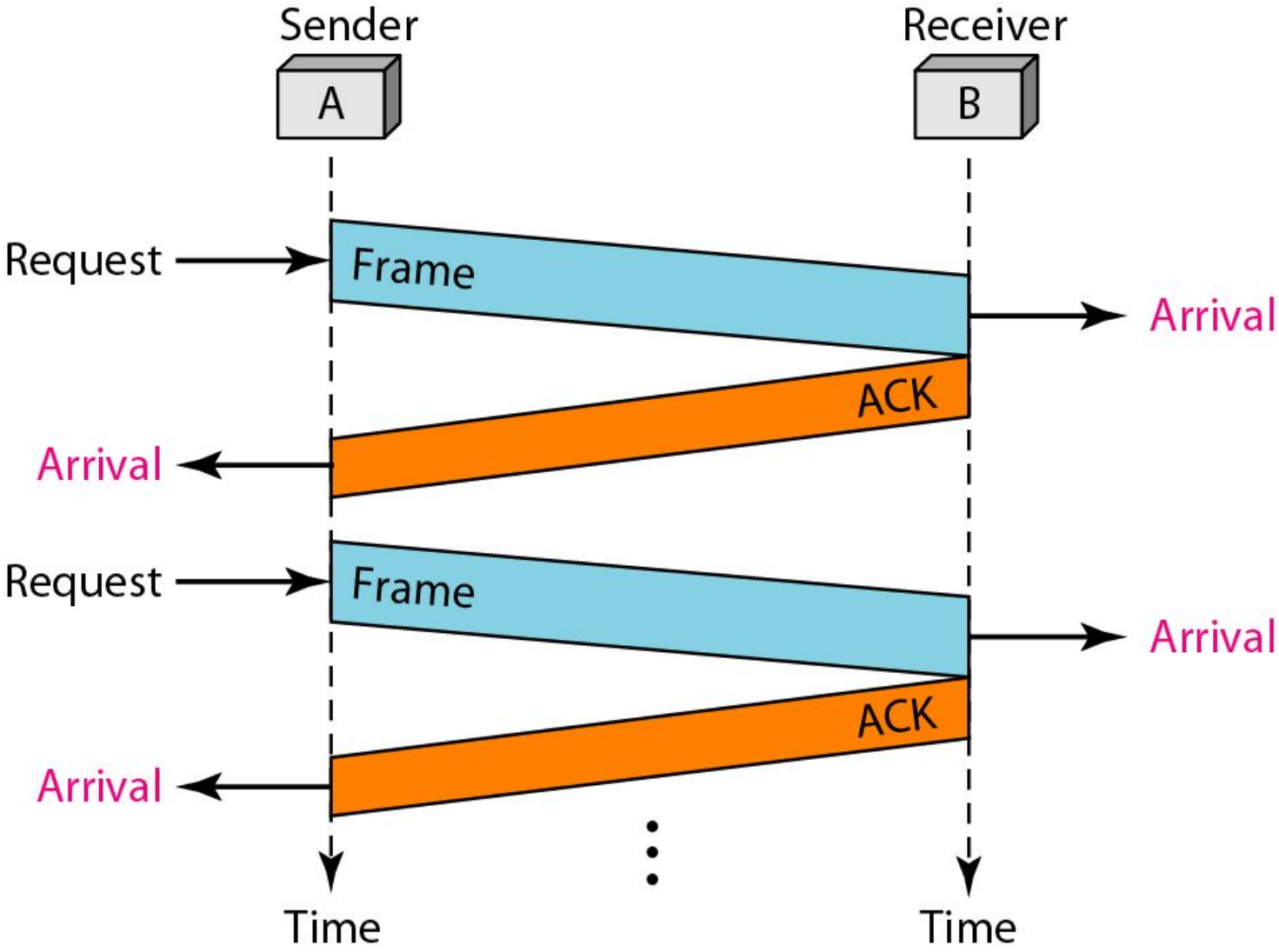
Data Link Layer protocols



Simplest Protocol



Stop-and-Wait Protocol



Stop-and-Wait Automatic Repeat Request

- The sender will not send the next frame until it is sure that the current one is correctly receive
- Sequence number is necessary to check for duplicated frames

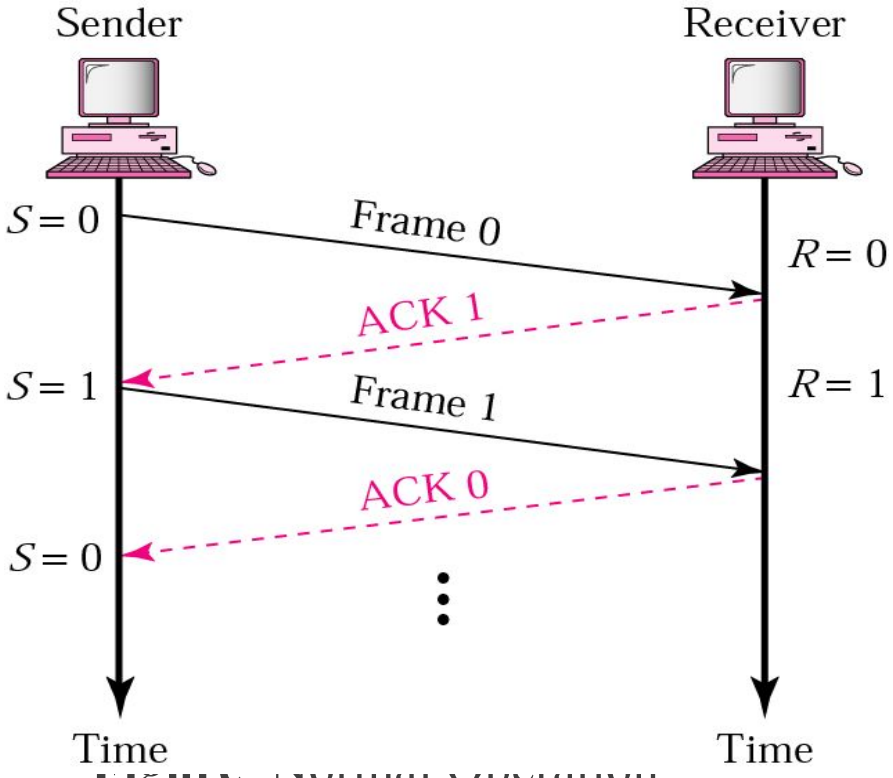


Figure: Normal Operation

Stop-and-Wait ARQ

- A damage or lost frame treated by the same manner by the receiver.

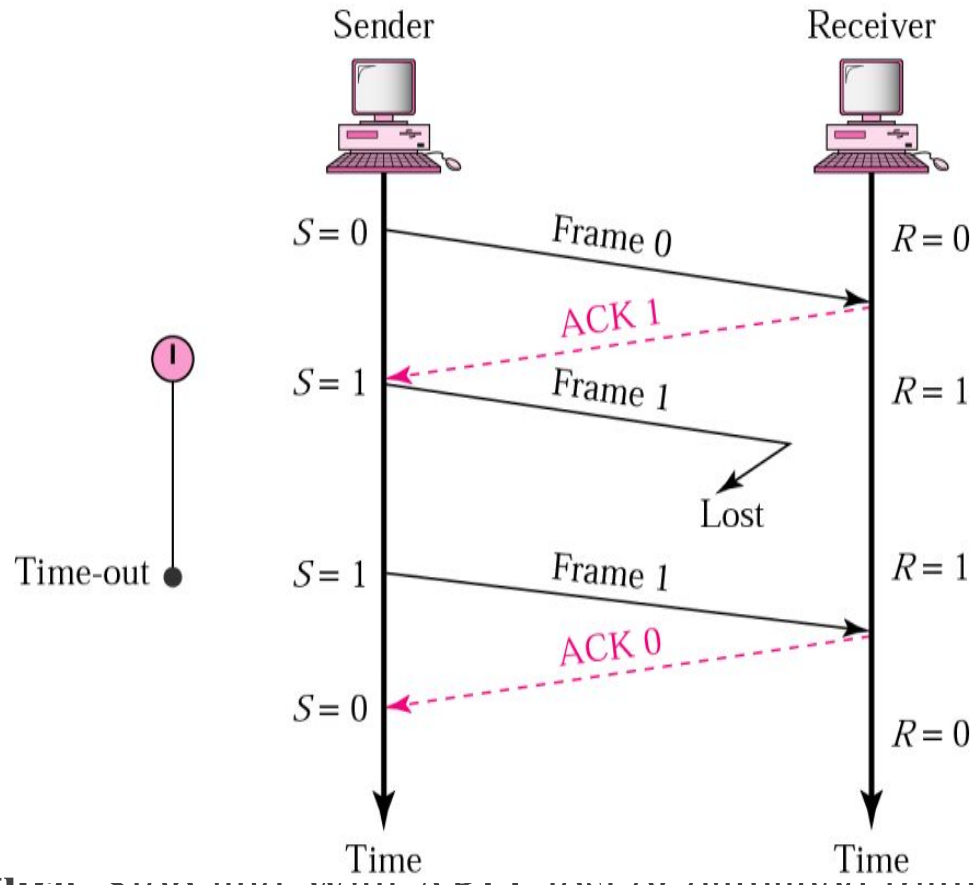


Figure. Stop-and-Wait ARQ, lost or damaged frame

Stop-and-Wait ARQ

- Importance of frame numbering: ***prevents retaining of duplicate frames.***

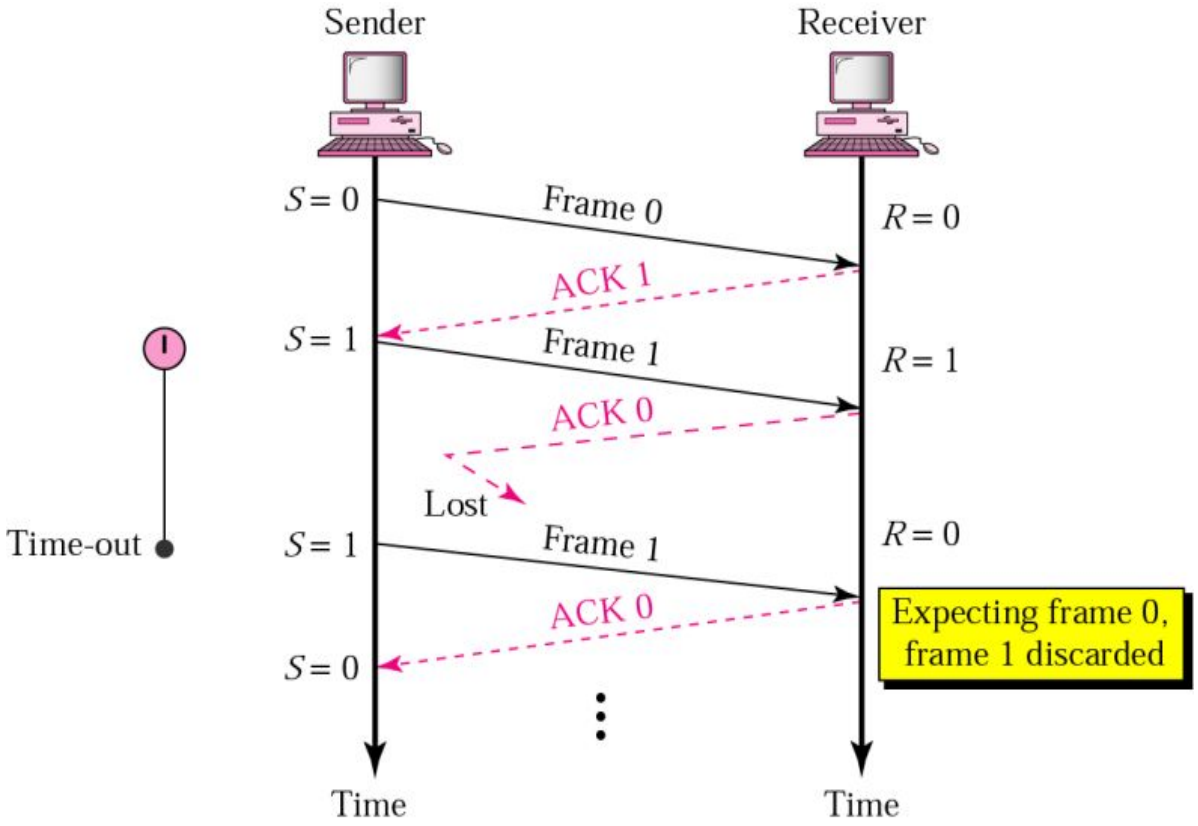


Figure: Stop-and-Wait ARQ, lost ACK frame

Stop-and-Wait ARQ

- Numbered acknowledgments are needed if an acknowledgment is delayed and the next frame is lost.

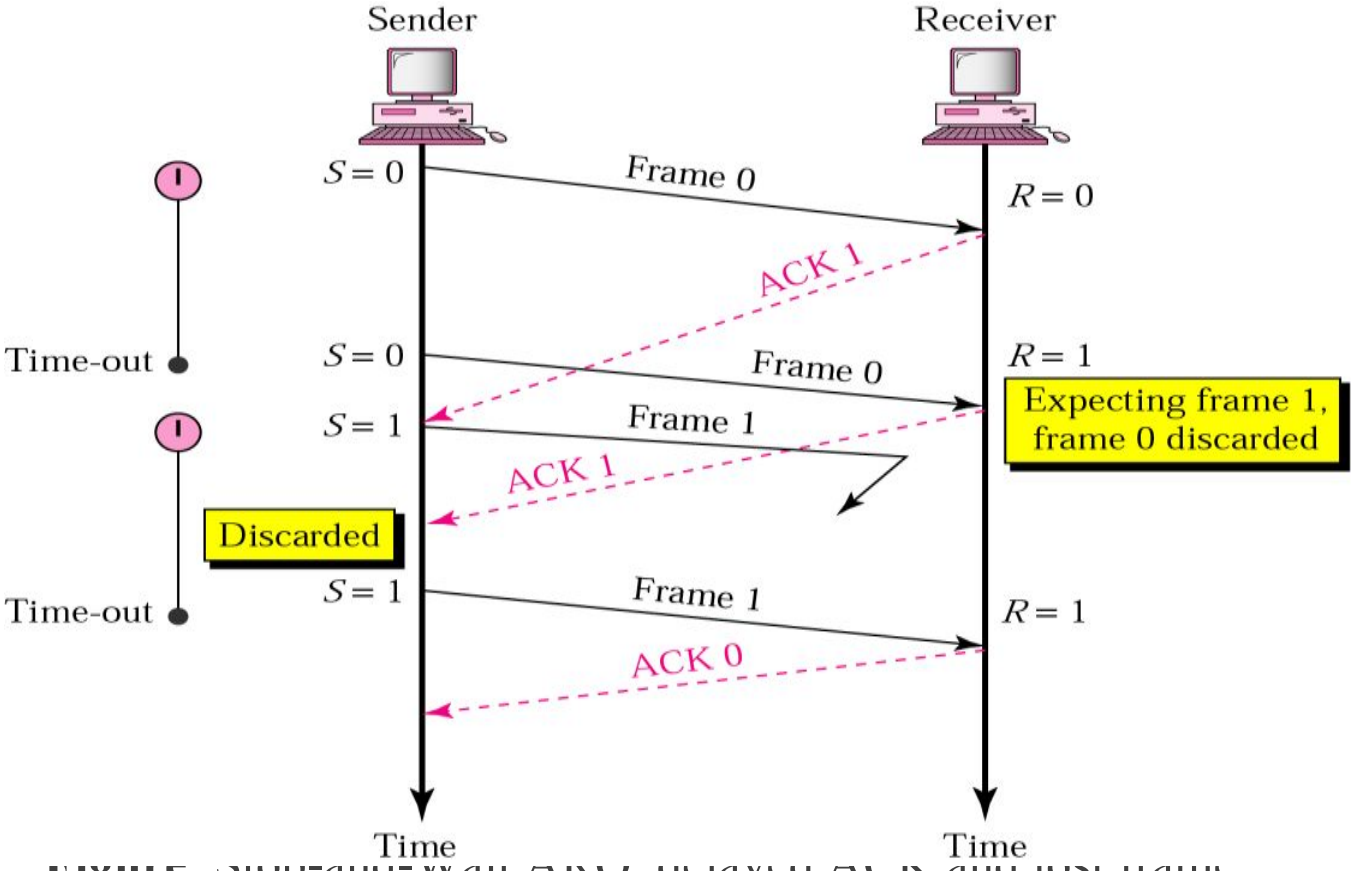
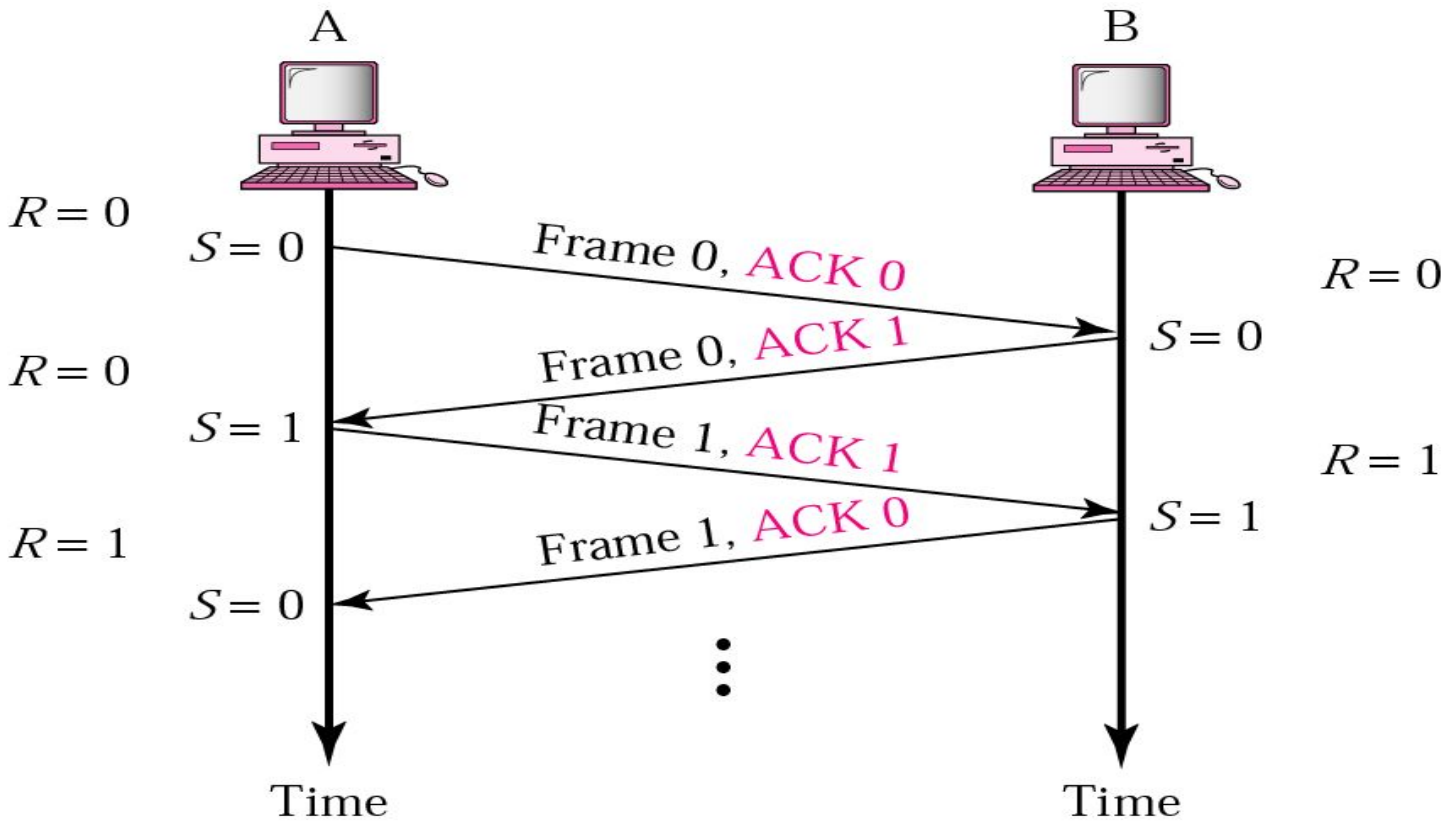


Figure: Stop-and-Wait ARQ, delayed ACK and lost frame

Piggybacking (Bidirectional transmission)

- It is a method to combine a data frame with an acknowledgment.
- It can save bandwidth because data frame and an ACK frame can combined into just one frame



Go-Back-N Automatic Repeat Request

- ACK1 is not necessary if ACK2 is sent: Cumulative ACK

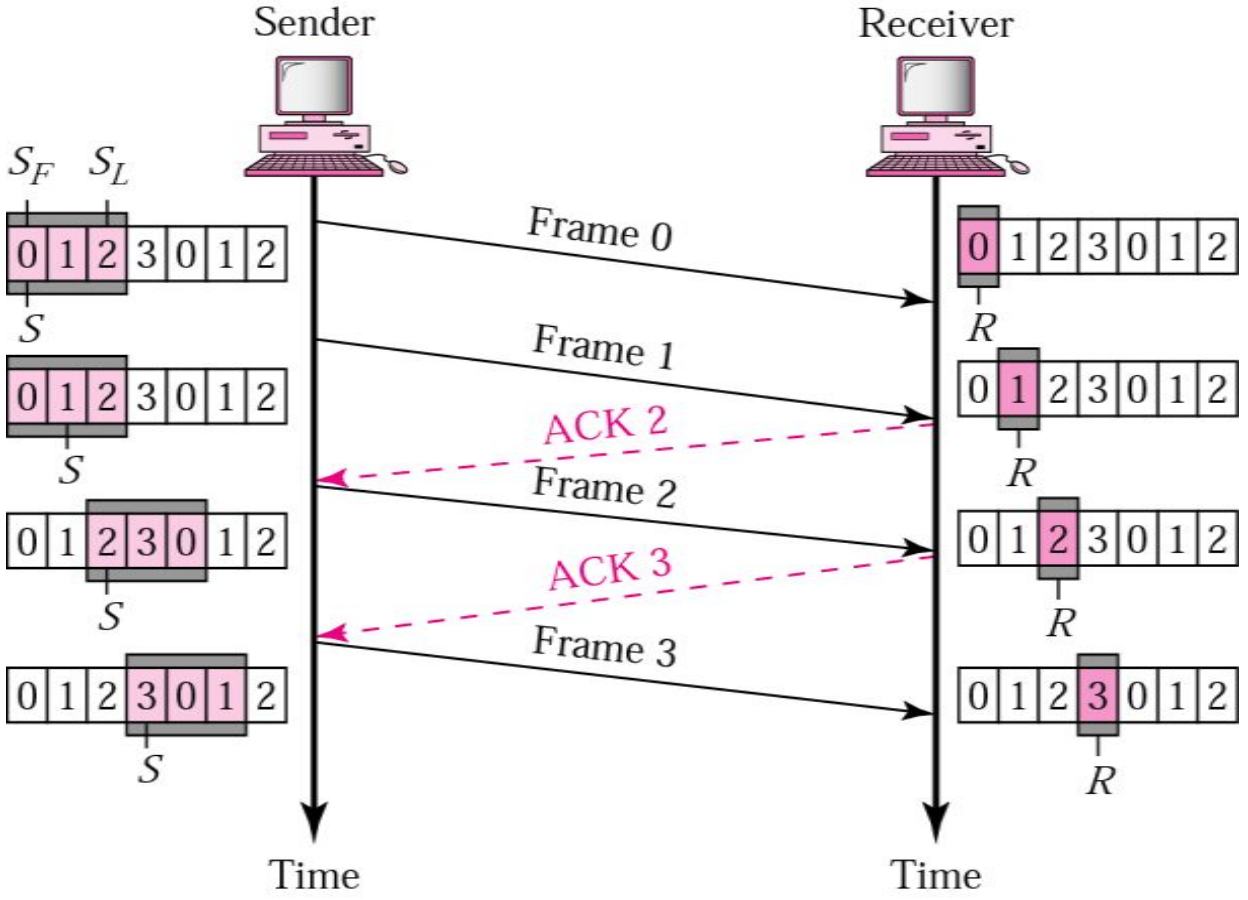


Figure: Normal operation

Go-Back-N Automatic Repeat Request

- Correctly received out of order packets are not Buffered

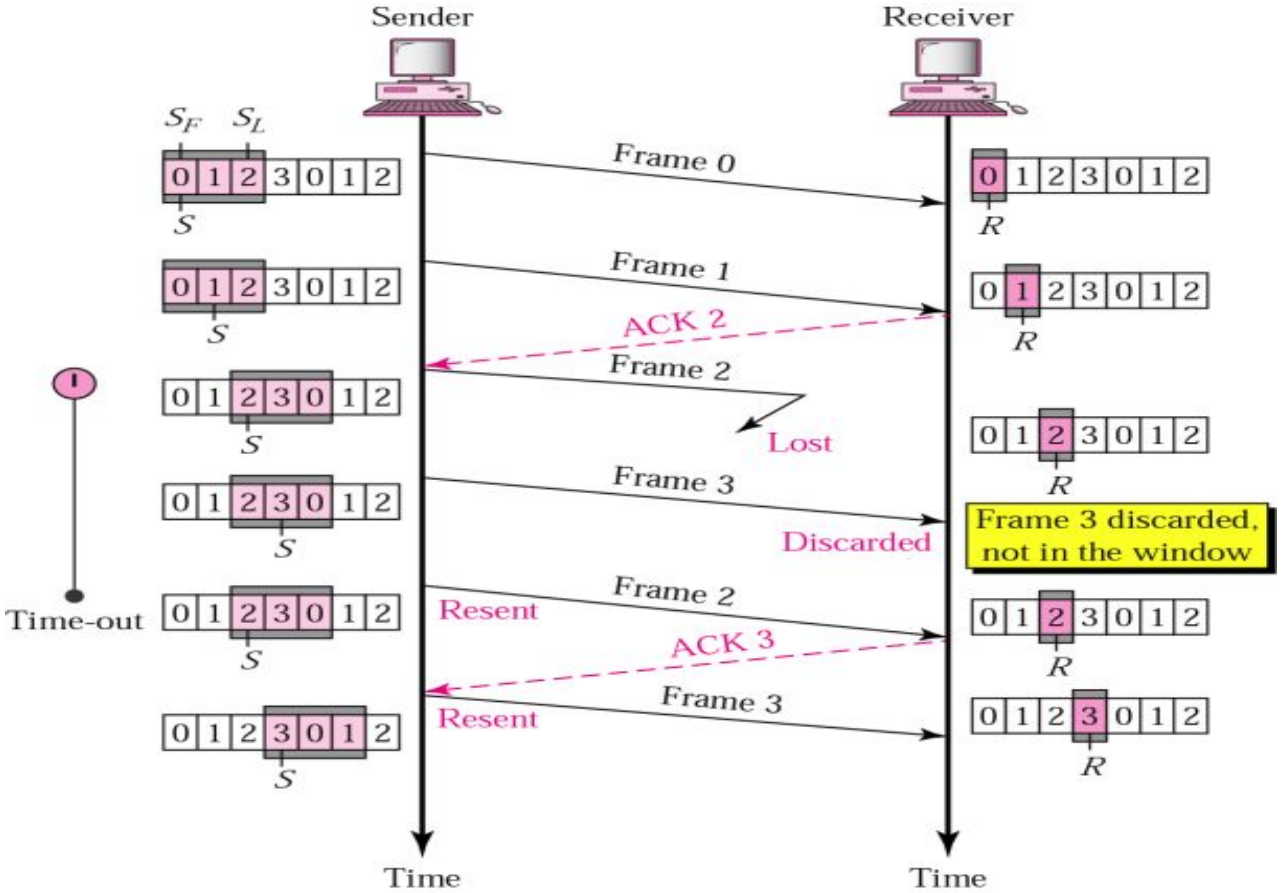
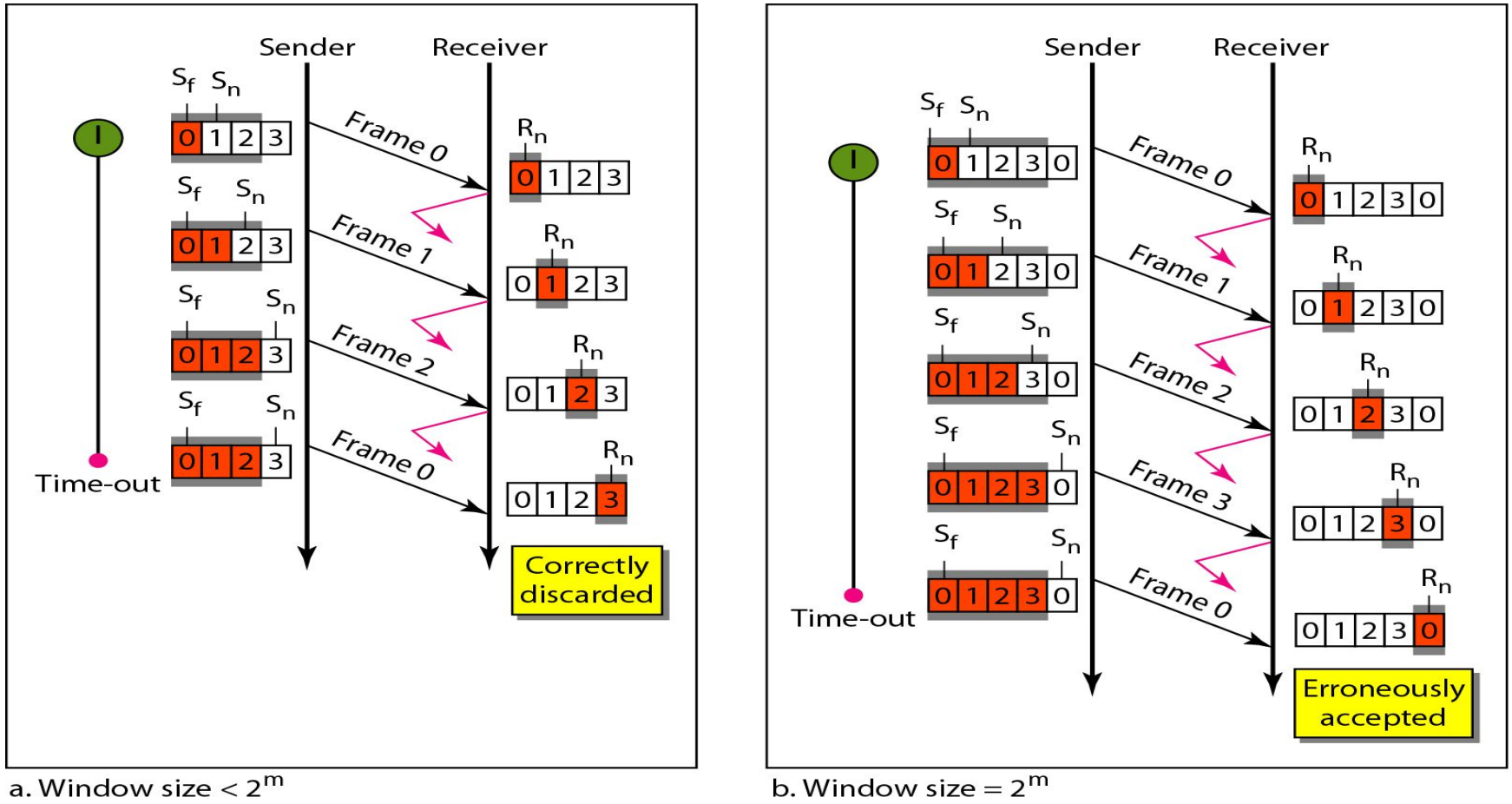


Figure: Damage or Lost Frame

Go-Back-N Automatic Repeat Request



a. Window size $< 2^m$

b. Window size $= 2^m$

Figure: Window Size

Selective Repeat Automatic Repeat Request

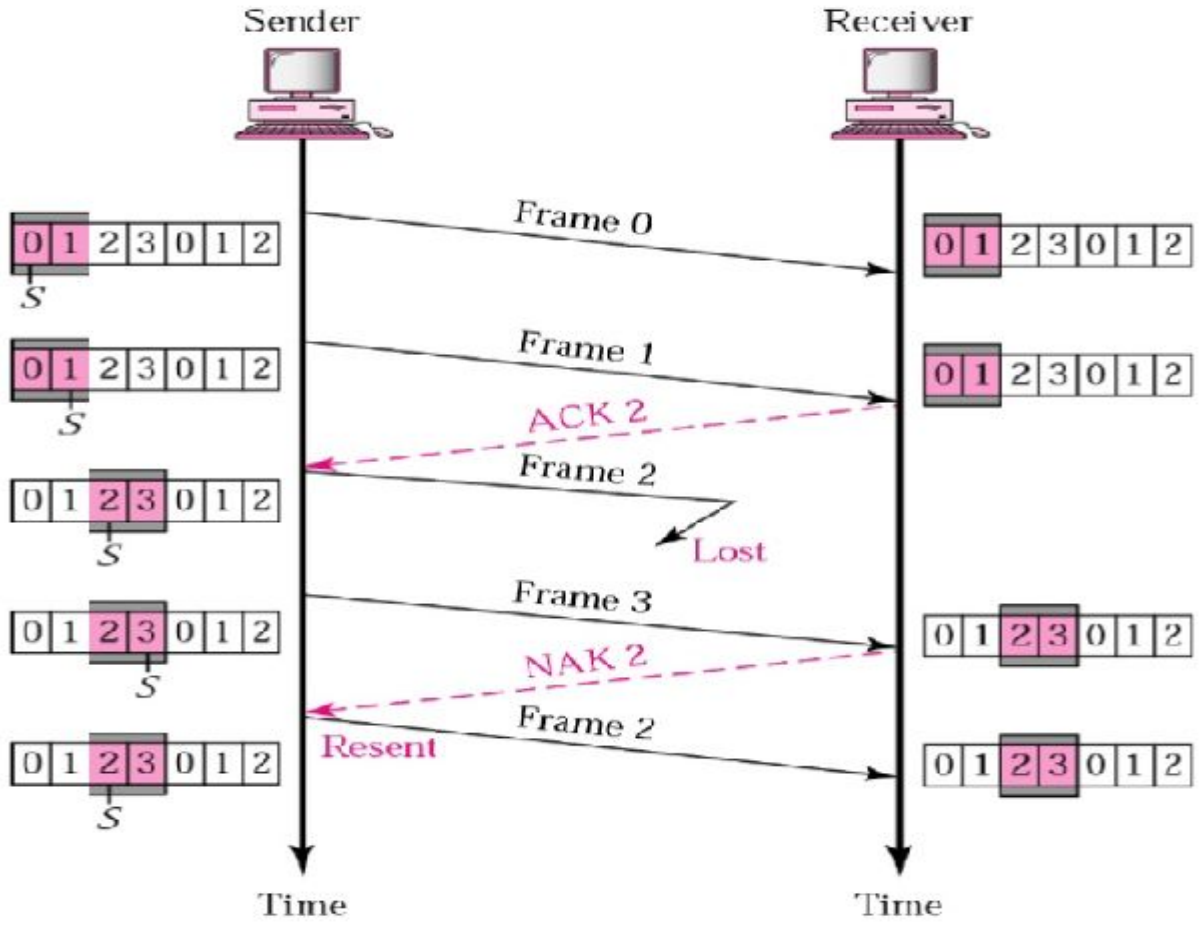


Figure: Selective Repeat ARQ, lost frame

Selective Repeat Automatic Repeat Request

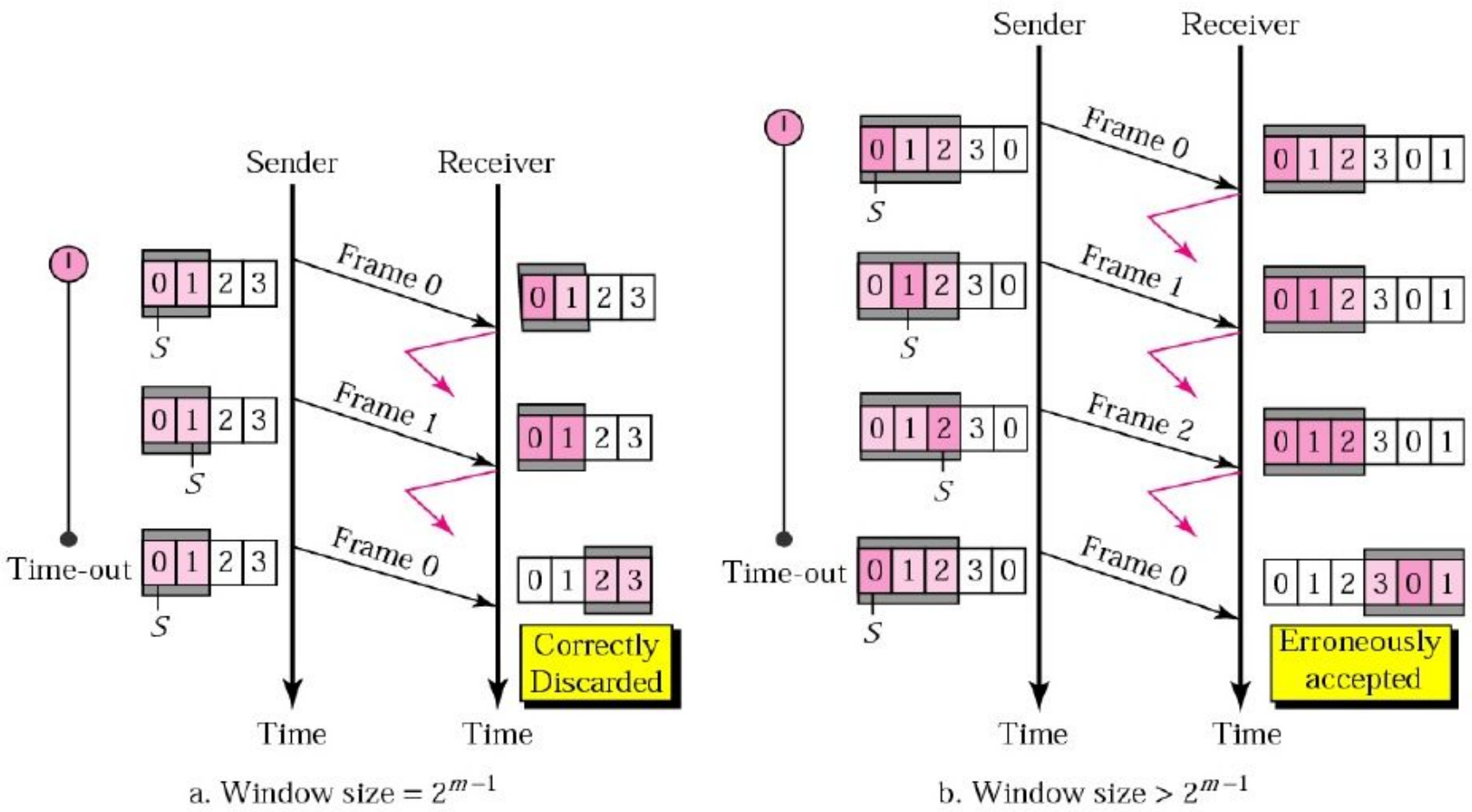


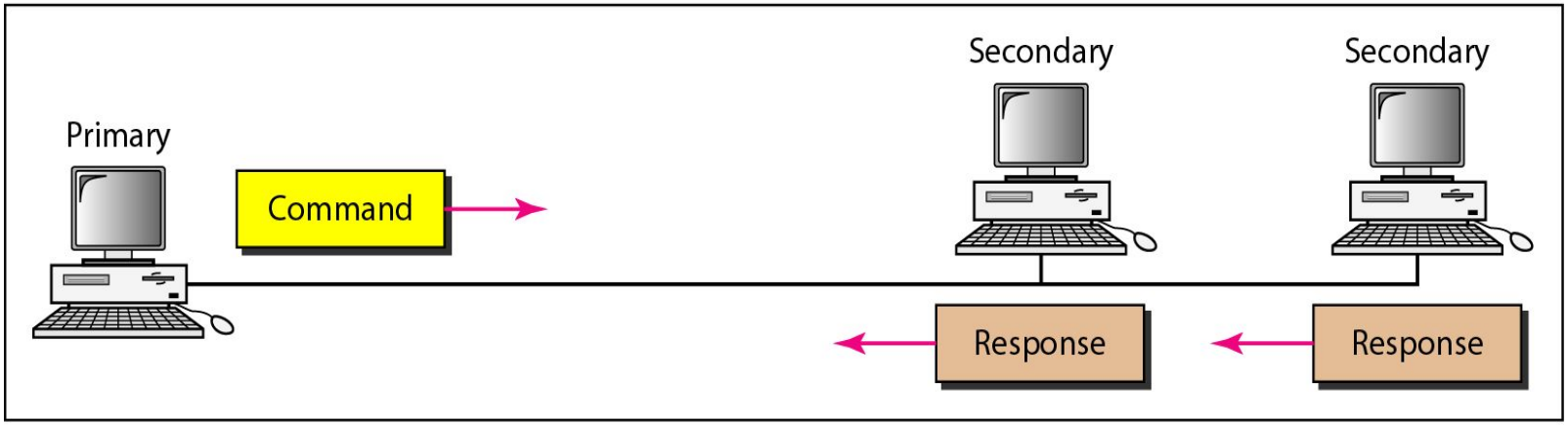
Figure: Selective Repeat ARQ, sender window size

High-level Data Link Control (HDLC)

- HDLC is a bit-oriented protocol for communication over point-to-point and multi-point links. It implements the ARQ mechanisms
- Two modes
  - Normal mode (NRM)
    - Primary station can send commands and secondary stations can only respond
  - Asynchronous balanced mode (ABM)
    - The link is point-to-point i.e each station can function as primary and secondary station

HDLC transfer modes

a. Point-to-point



b. Multipoint

Figure: HDLC in point to point and multi-point scenario in NRM

HDLC transfer modes

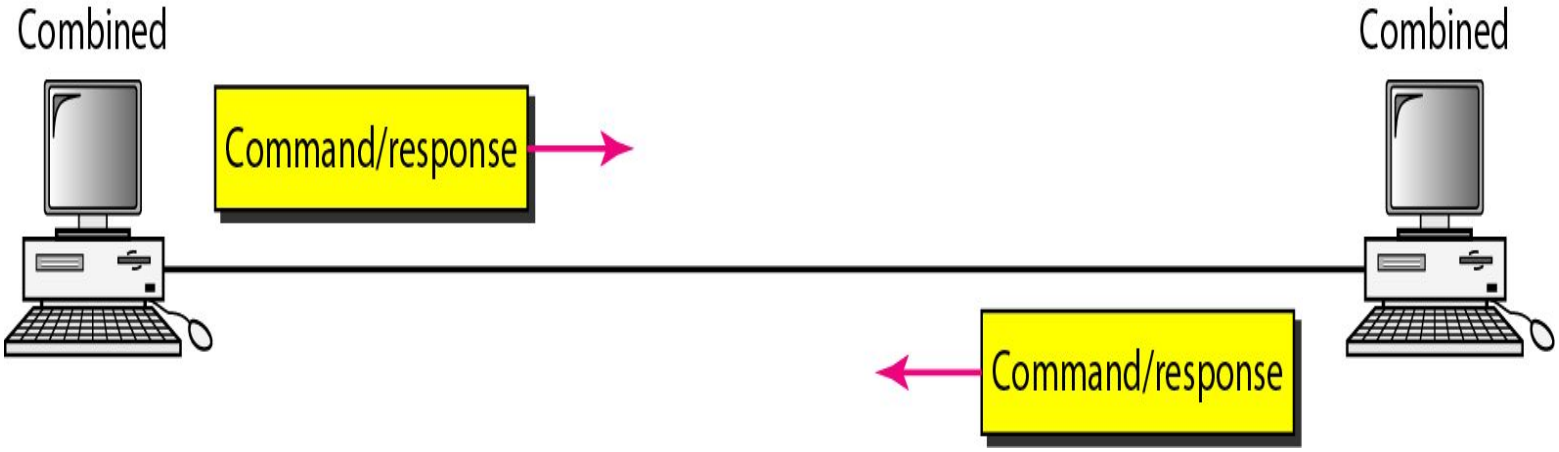
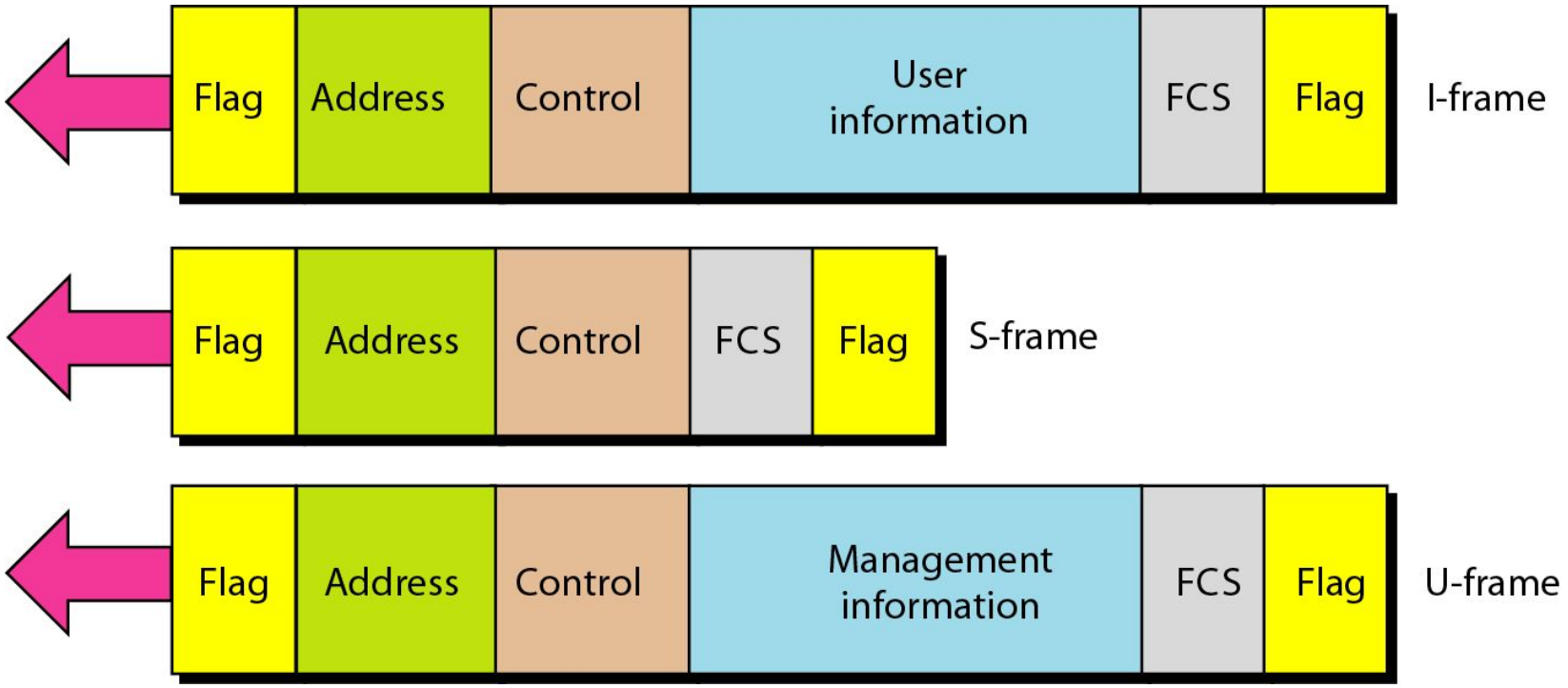


Figure: HDLC in point to point and multi-point scenario in ABM

HDLC frames

- Information frames (I-frame)
- Supervisory frames (S-frame)
- Unnumbered frames (U-frame)



Point-to-Point Protocol (PPP)

- Mostly used on internet communication at data-link layer
- It is byte oriented protocol

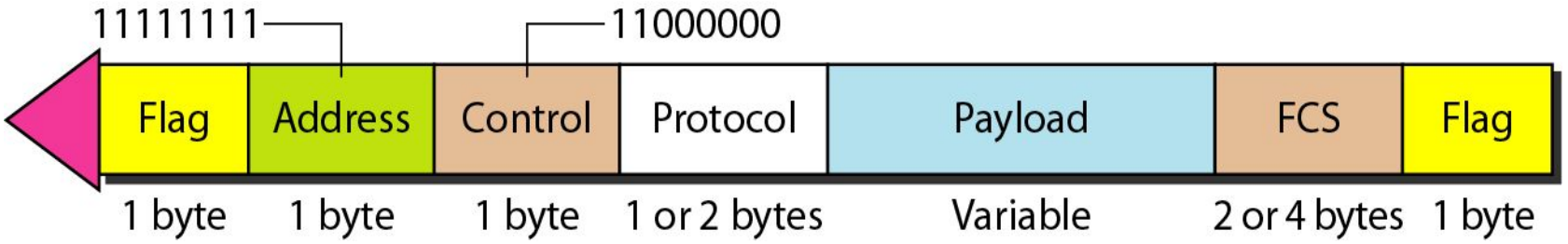
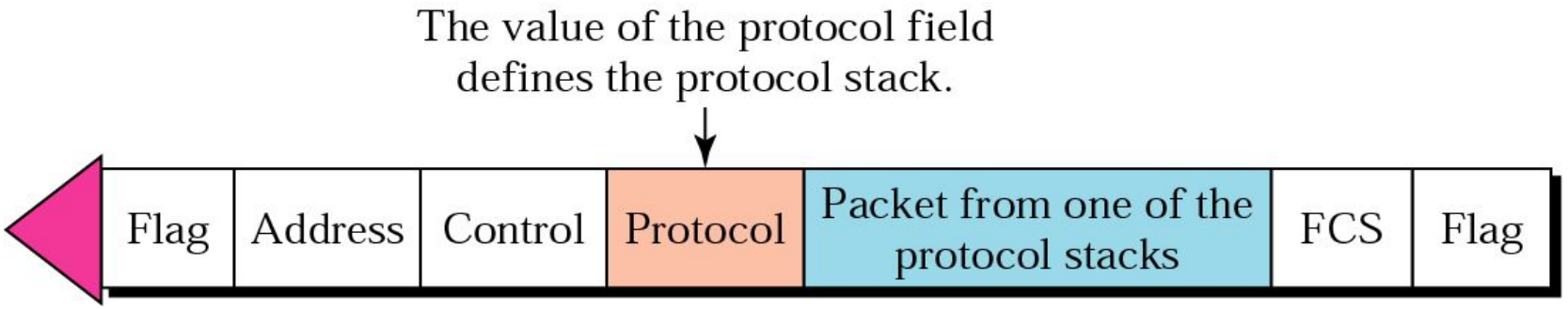


Figure: PPP frame

PPP Layers

- The Data field carries the packets from one of three other protocols - Link Control Protocol, authentication protocols, and Network Control Protocol

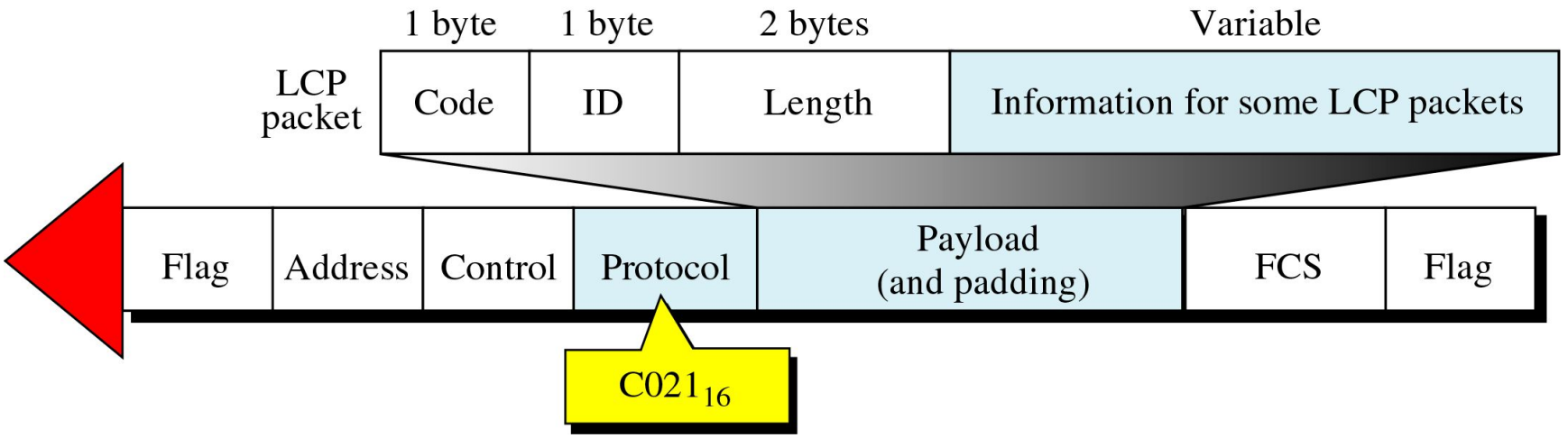

The value of the protocol field defines the protocol stack.
Flag
Address
Control
Protocol
Packet from one of the protocol stacks
FCS
Flag

Link Control Protocol (LCP)

- Responsible for establishing, maintaining, configuring, terminating link, and negotiation
- All LCP packets are carried in payload field of PPP frame – PPP field Protocol = hex C021

Figure 15-5

LCP Packet Encapsulated in a Frame



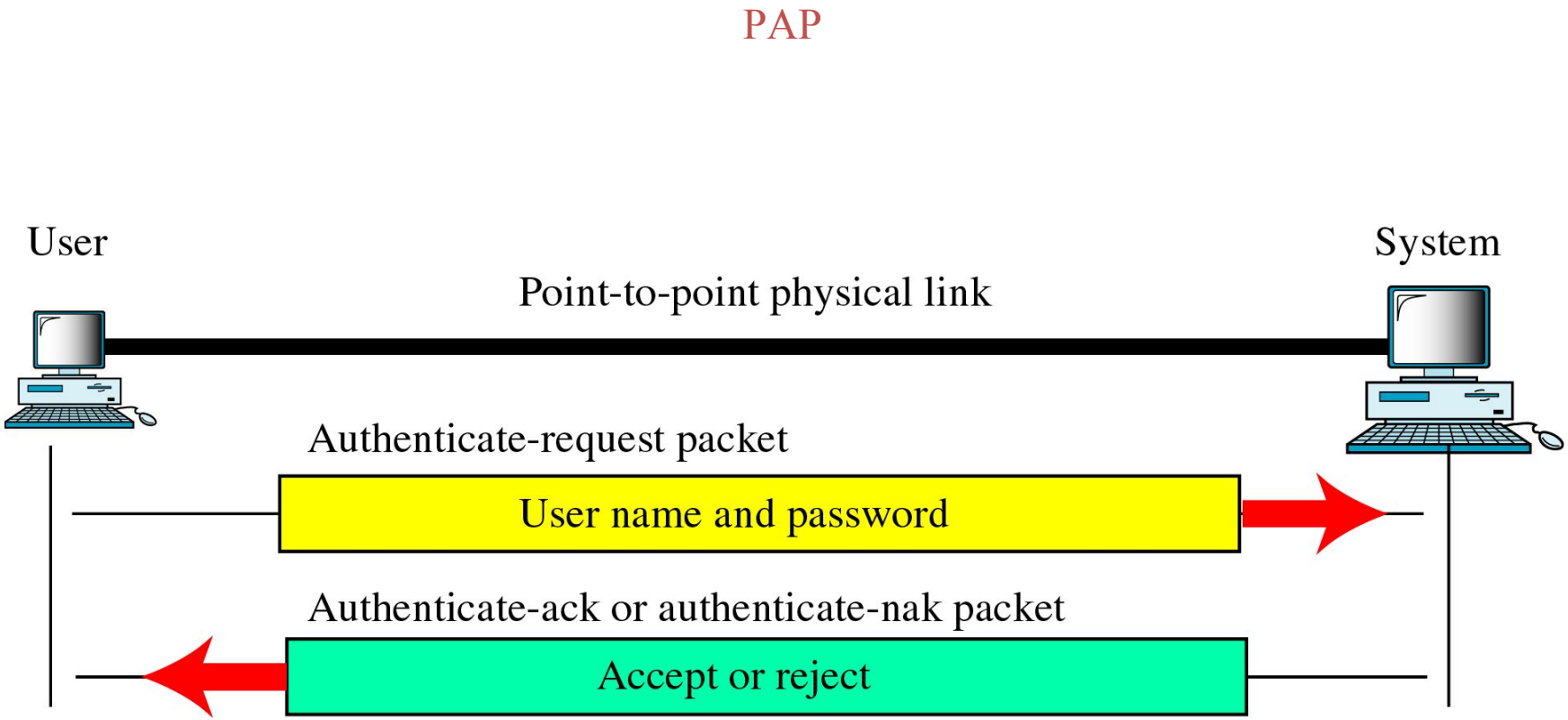
Authentication

- Potentially important since this is dial-up communication
- Two possible protocols for authentication:
  - Password Authentication Protocol (PAP
  - Challenge Handshake Authentication Protocol (CHAP)

Authentication – PAP

- Two-step process
  - User sends ID and password
  - System verifies
- PAP packets are encapsulate in a PPP frame
- There are 3 types of PAP packets (see the next two slides)

Figure 12-5

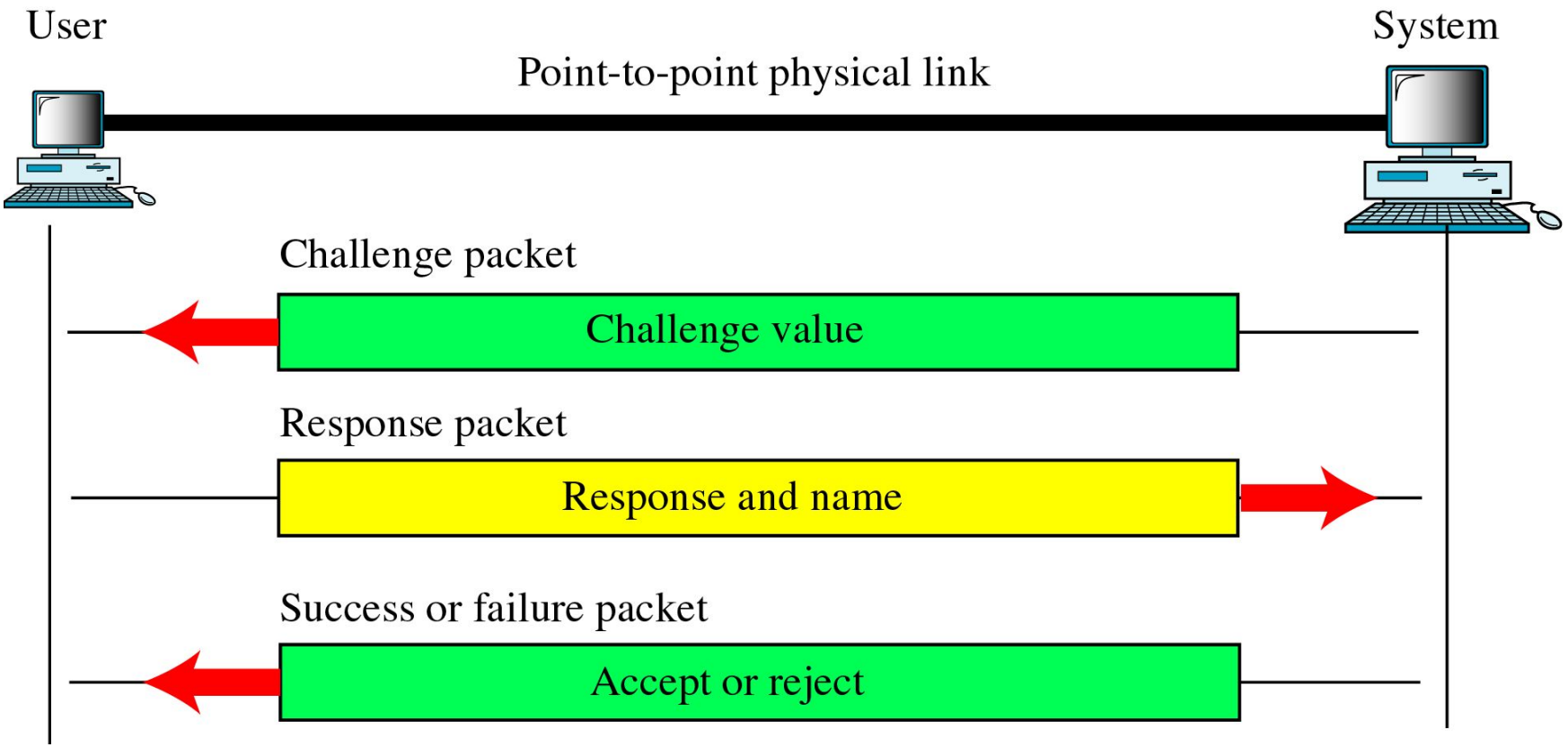

PAP
User
System
Point-to-point physical link
Authenticate-request packet
User name and password
Authenticate-ack or authenticate-nak packet
Accept or reject

Authentication – CHAP

- Three-way handshake
  - System sends a challenge packet
  - User applies a predefined function that takes the challenge value and the user's own password and creates a result
  - System does the same; then compares its result to user's result

Figure 12-7

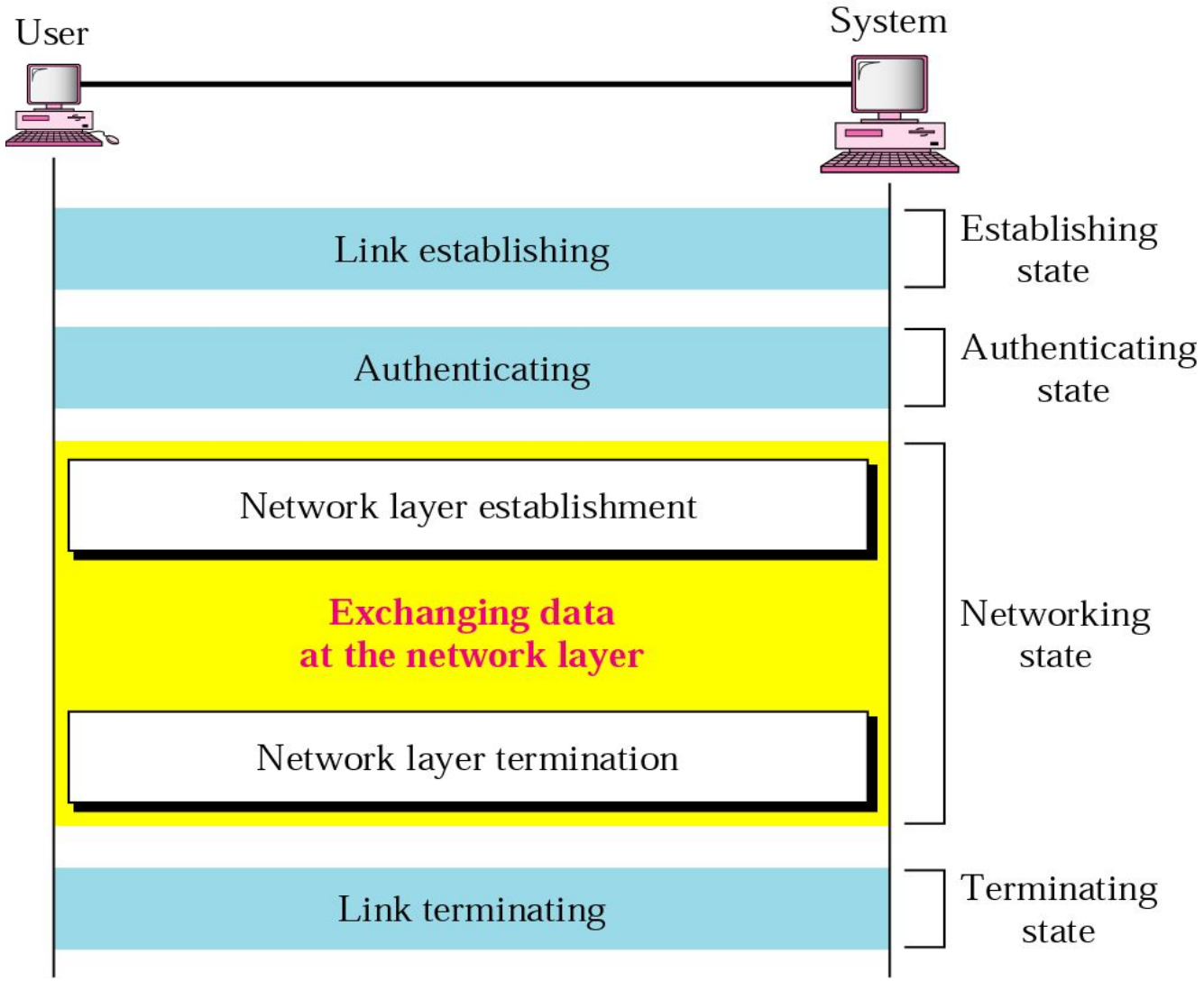
CHAP



IPCP (An NCP Protocol)

- Now that a link has been established and optional security has been established, we need to establish a *network layer connection*
- IPCP, or Internetwork Protocol Control Protocol, is an NCP (Network Control Protocol)

IPCP

- Seven packet types:
  - Configure-request (01)
  - Configure-ACK (02)
  - Configure-NAK (03)
  - Configure-reject (04)
  - Terminate-request (05)
  - Terminate-ACK (06)
  - Code-reject (07)

12.10 An example