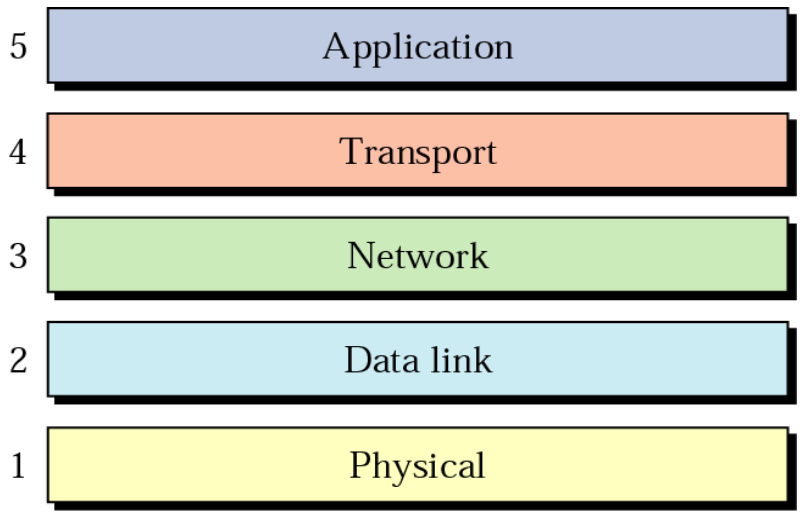
Data Communication & Computer Networks

3. Data Link Control

Data Link Layer

- Responsible for node-to-node (hop-to-hop) communication.
- The two main functions of the data link layer are
  - Data link control
  - Media access control



Data Link Control

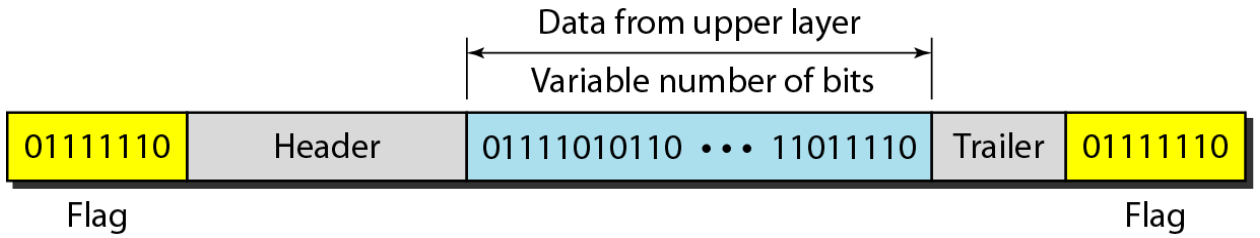
- Deals with the design and procedures for communication between two adjacent nodes (node-to-node communication)
- Data link control functions include
  - framing
  - flow control
  - error control

Framing

- The data link layer packs bits into frames, so that each frame is distinguishable from another.
- The data link layer adds a sender address and a destination address to the frames.

Framing

- Fixed-size framing
  - no need for defining the boundaries of the frames
- Variable-size framing
  - need a way to define the end of the frame and the beginning of the next frame
  - A flag (typically an 8-bit pattern) is used to define frame boundaries.



Flow Control

- Flow control refers to a set of procedures used to restrict the amount of data that the sender can send before waiting for acknowledgment
- Ensuring the sending entity does not overwhelm the receiving entity
  - Preventing buffer overflow (giving ample time to the processor to process)

Error Control

- Error control is both error detection and error correction.
- Error control in the data link layer refers primarily to methods of error detection and retransmission.
- It is often implemented simply:
  - Any time an error is detected in an exchange, concerned frames are retransmitted.

Error Control

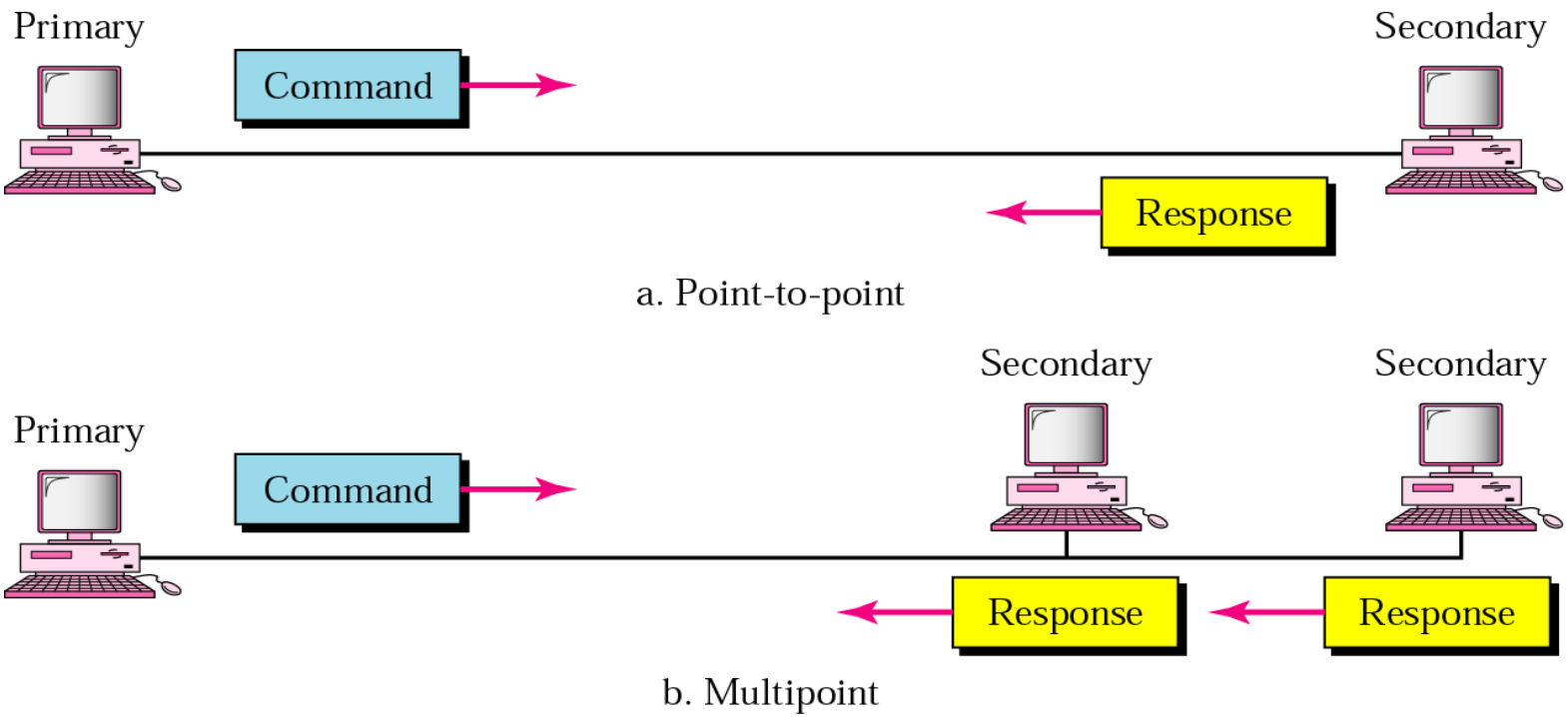
- The retransmission of data in the data link layer is based on automatic repeat request (ARQ)
- An ARQ system is based on:
  - Error detection (Damaged Frames, Lost Frames)
  - Positive acknowledgment
  - Negative acknowledgement and retransmission
  - Retransmission after timeout

HDLC

- High-level Data Link Control
- A bit-oriented protocol for communication over point-to-point and multipoint links.
- It implements the ARQ mechanisms

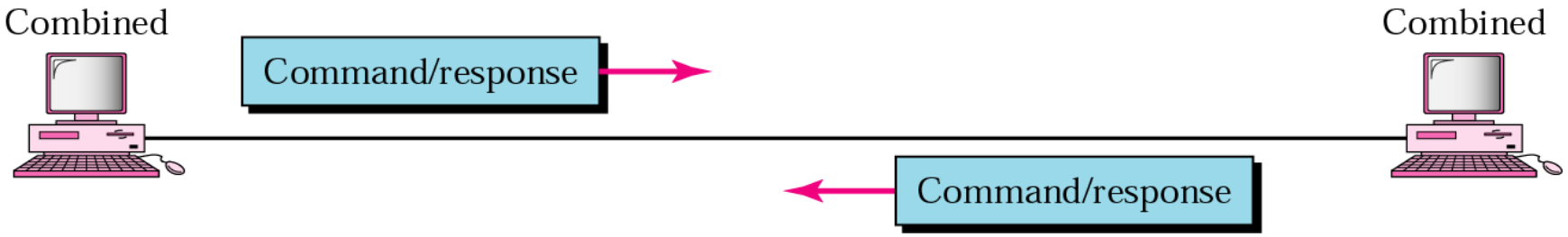
Configurations & Transfer Modes

1. NRM – Normal Response Mode
   - Station configuration is unbalanced



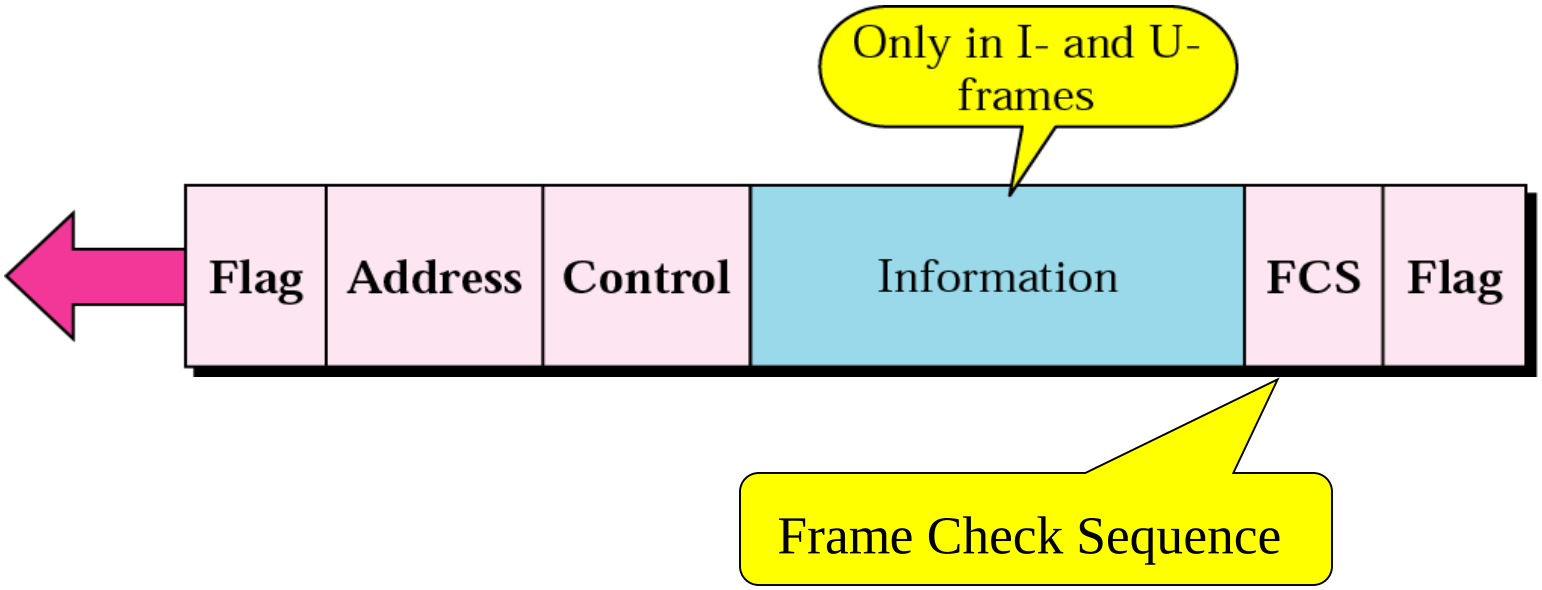
Configurations & Transfer Modes

2. ABM – Asynchronous Balanced Mode
   - Station configuration is balanced
   - Point-to-point link
   - Each station can function as primary and secondary



Frame Format

- Each frame in HDLC may contain up to 6 fields



Frame Format

- Flag Field
  - Contains an 8-bit sequence 01111110
  - Used to identify beginning and end of a frame
  - Serves as a synchronization pattern for the receiver
  - In multiple frame transmissions, the ending flag of one frame can serve as the beginning flag of the next frame

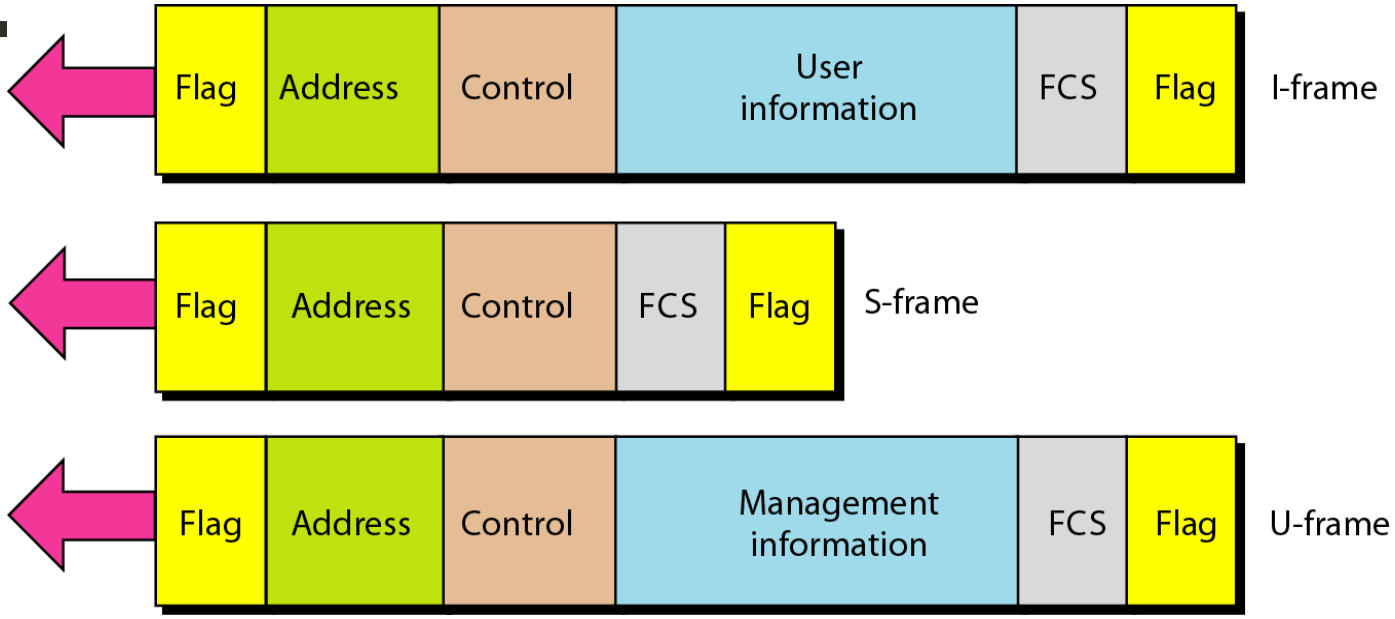
Frame Format

- Address Field
  - When primary/secondary configuration is used, it contains address of the secondary station
  - When primary/secondary configuration is not used, it contains source and destination addresses
  - All address bytes but the last one end with 0, only the last byte ends with 1

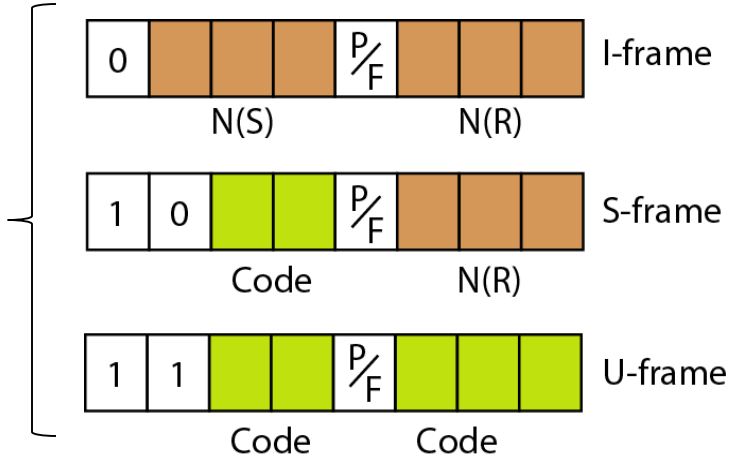
Frame Format

- Control Field
  - 1 or 2 bytes for flow and error control
- Information Field
  - Contains user data from network layer or network management information
- FCS Field
  - Frame Check Sequence
  - Contains 2 or 4 byte ITU-T CRC

HDLC Frame Types

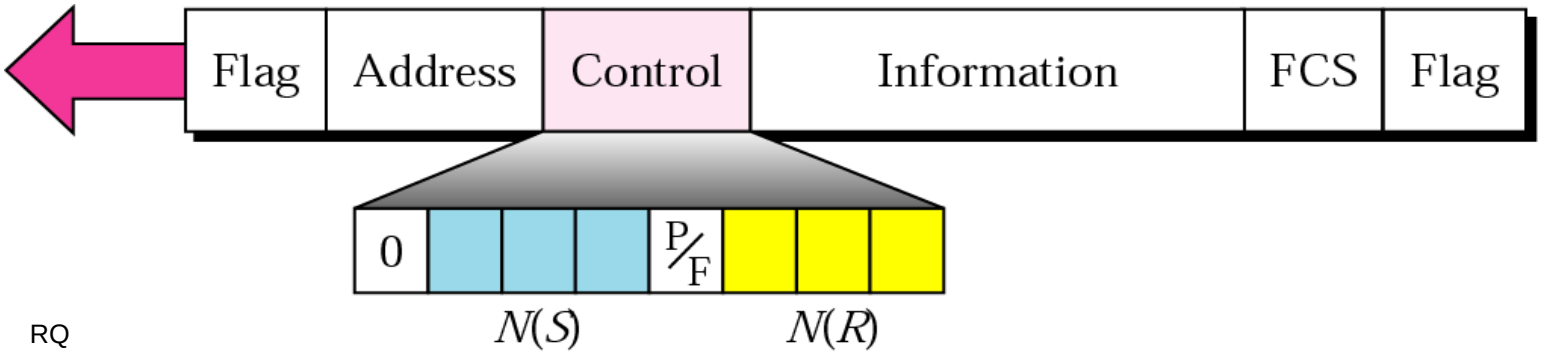


Control field format for the different frame types



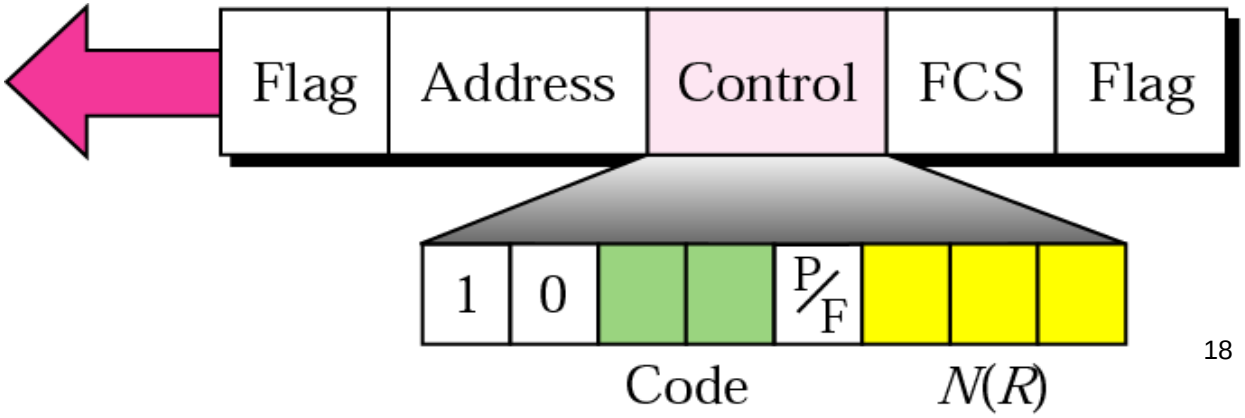
I-frame (Information)

- Carries user data from network layer
- Can carry flow and error control information (piggybacking)
  - N(S) = the sequence number
  - N(R) = the ack number when piggybacking is used



S-frame (Supervisory)

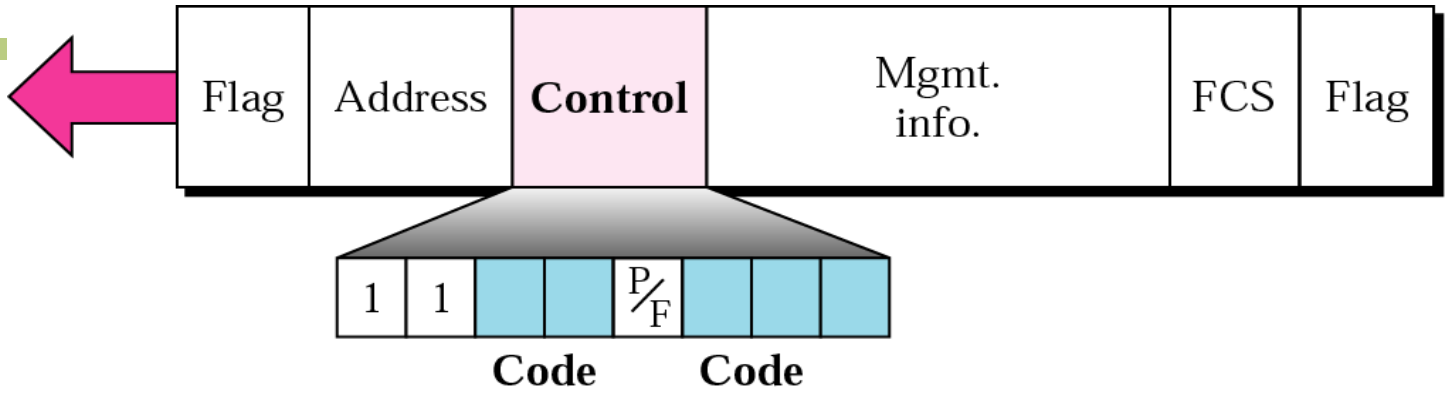
- Used for flow and error control whenever piggybacking can not be used
- Code field defines whether
  - Receive ready (RR)
  - Receive not ready (RNR)
  - Reject (REJ)
  - Selective reject (SREJ)



U-frame (Unnumbered)

- Used to exchange session management and control information between connected devices.
- Much of the information is contained in codes included in the control field.
- Contains an information field, but used for system management information, not user data

U-frame (Unnumbered)

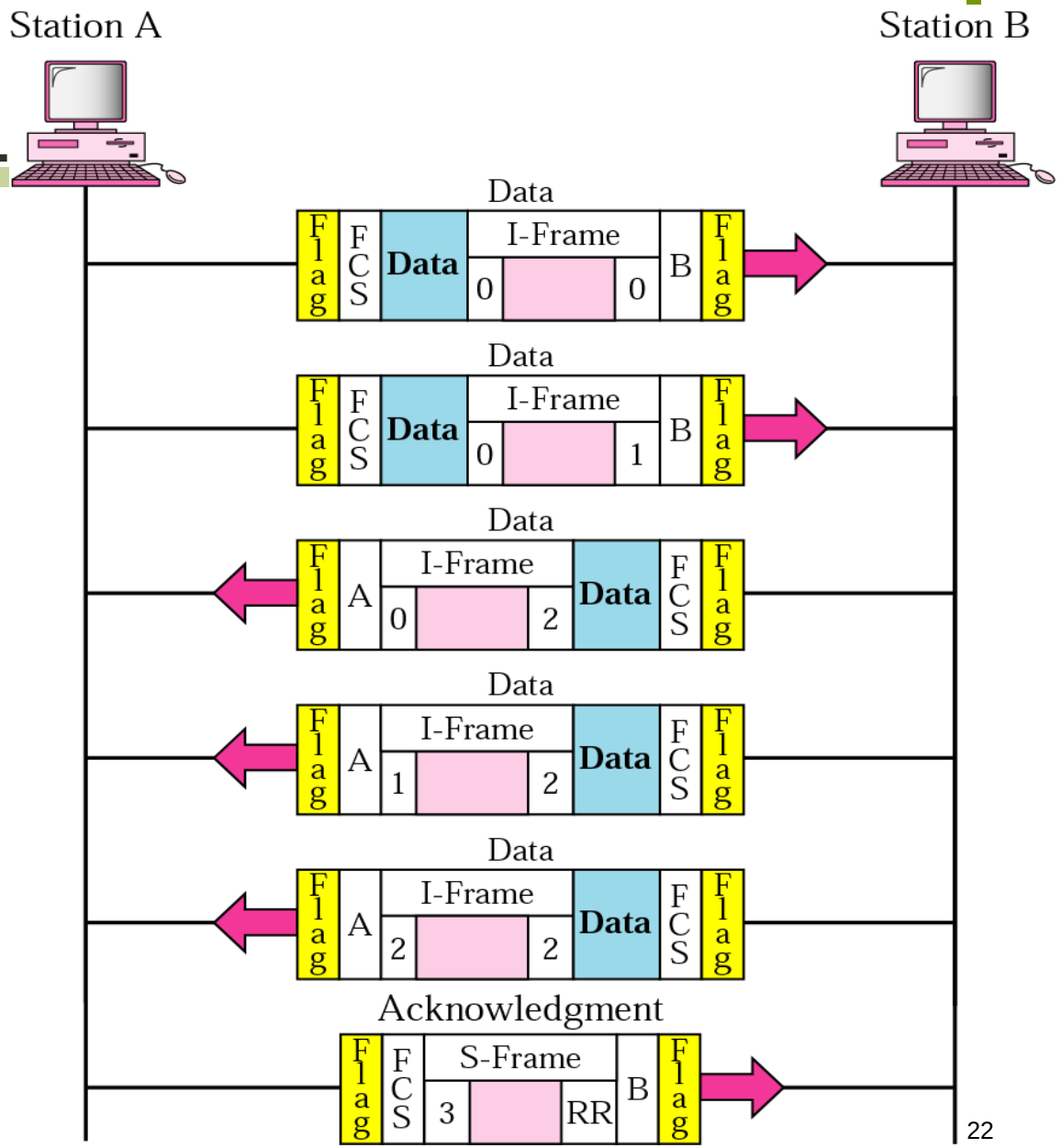


Code		Command	Response
00	001	SNRM	
11	011	SNRME	
11	100	SABM	DM
11	110	SABME	
00	000	UI	UI
00	110		UA
00	010	DISC	RD
10	000	SIM	RIM
00	100	UP	
11	001	RSET	
11	101	XID	XID
10	001		FRMR

U-frame control command and response

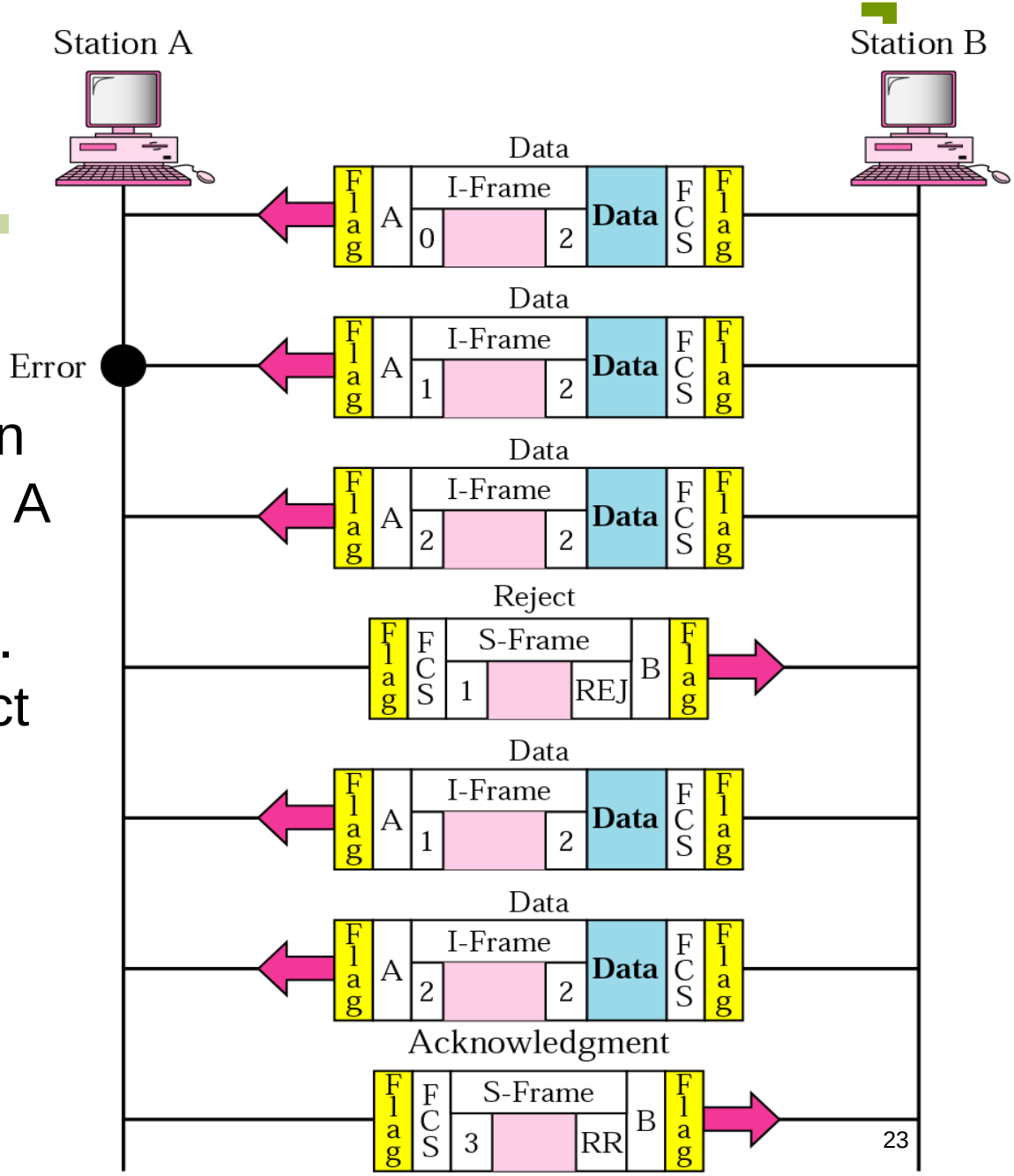
Command/response	Meaning
SNRM	Set normal response mode
SNRME	Set normal response mode (extended)
SABM	Set asynchronous balanced mode
SABME	Set asynchronous balanced mode (extended)
UP	Unnumbered poll
UI	Unnumbered information
UA	Unnumbered acknowledgment
RD	Request disconnect
DISC	Disconnect
DM	Disconnect mode
RIM	Request information mode
SIM	Set initialization mode
RSET	Reset
XID	Exchange ID
FRMR	Frame reject

Example 1


Station A
Station B
Data
Flag
FCS
Data
I-Frame
0
0
B
Flag
Data
Flag
FCS
Data
I-Frame
0
1
B
Flag
Data
Flag
A
I-Frame
0
2
Data
FCS
Flag
Data
Flag
A
I-Frame
1
2
Data
FCS
Flag
Data
Flag
A
I-Frame
2
2
Data
FCS
Flag
Acknowledgment
Flag
FCS
S-Frame
3
RR
B
Flag

Example 2

In previous example, suppose frame 1 sent from station B to station A has an error. Station A informs station B to resend frames 1 and 2. Station A sends a reject supervisory frame to announce the error in frame 1.

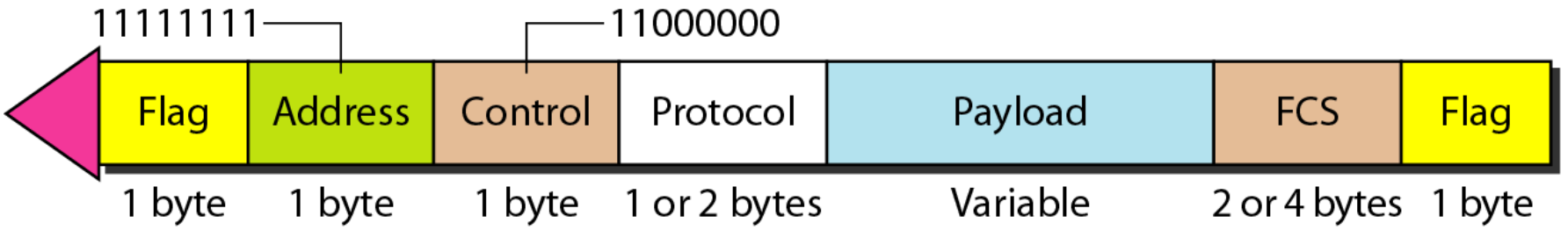


PPP

- Point-to-Point Protocol
- A byte-oriented protocol
  - data to be carried are 8-bit blocks (bytes)
- One of the most common protocols for point-to-point access

PPP Framing

- Flag: frame starts and ends with the bit pattern 01111110
- Address: a constant value and set to 11111111 (broadcast address)
- Control: set to the constant value 11000000 (imitating unnumbered



PPP

- PPP uses set of other protocols to establish the link, authenticate the parties, and carry the network layer data
- Three sets of protocols are defined:
  - The Link Control Protocol (LCP)
  - Two Authentication Protocols (APs)
    - Password Authentication Protocol (PAP)
    - Challenge Handshake Authentication Protocol (CHAP)
  - Several Network Control Protocols (NCPs)
    - Internet Protocol Control Protocol (IPCP)