Data and Computer Communications

Chapter 7 – Data Link Control Protocols

High Level Data Link Control (HDLC)

- an important data link control protocol
- specified as ISO 33009, ISO 4335
- station types:
  - Primary - controls operation of link- frames sent by primary are called commands
  - Secondary - under control of primary station- frames sent by secondary are called responses
  - Combined - issues commands and responses
- link configurations
  - Unbalanced - 1 primary, multiple secondary
  - Balanced - 2 combined stations

11.5 HDLC

Configurations and Transfer Modes

Frames

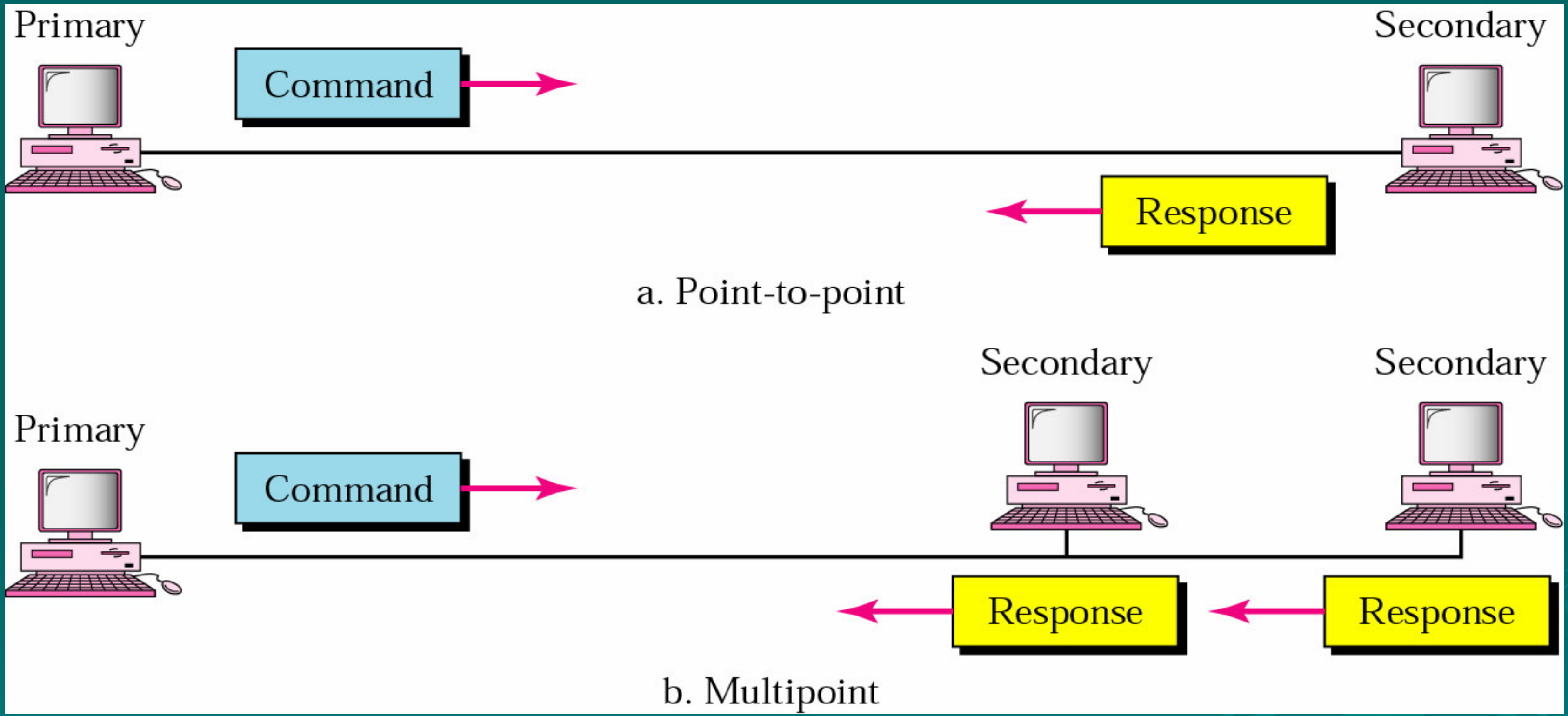
Frame Format

Examples

HDLC Transfer Modes

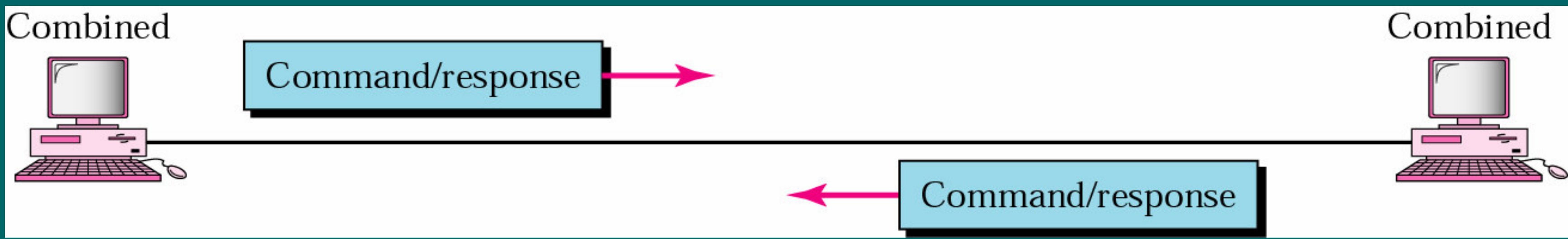
- Normal Response Mode (NRM)
  - unbalanced config, primary initiates transfer
  - used on multi-drop lines, eg host + terminals
- Asynchronous Balanced Mode (ABM)
  - balanced config, either station initiates transmission, has no polling overhead, widely used
- Asynchronous Response Mode (ARM)
  - unbalanced config, secondary may initiate transmit without permission from primary, rarely used

11.15 NRM



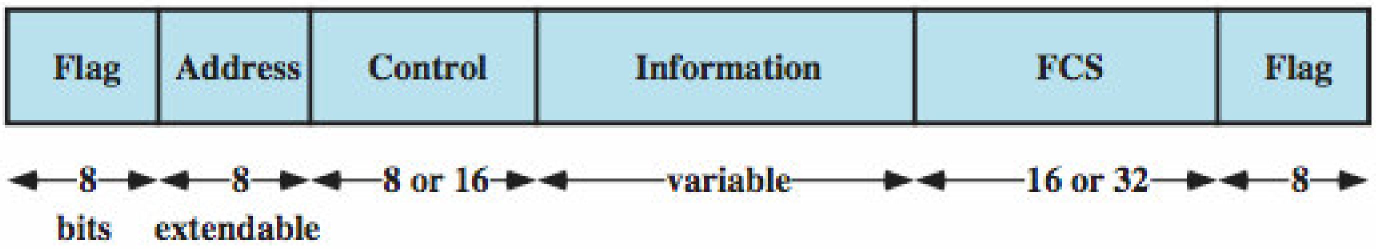
Primary
Command
Secondary
Response
a. Point-to-point
Secondary
Secondary
Primary
Command
Response
Response
b. Multipoint

11.16 ABM



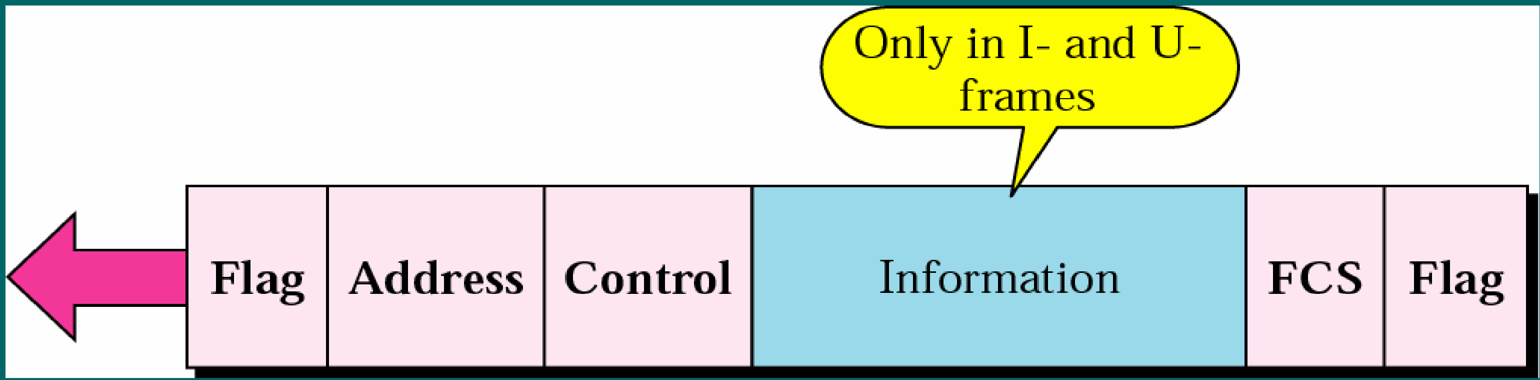
HDLC Frame Structure

- synchronous transmission of frames
- single frame format used



(a) Frame format

11.17 HDLC frame



Flag Fields and Bit Stuffing

- delimit frame at both ends with 01111110 seq
- receiver hunts for flag sequence to synchronize
- bit stuffing used to avoid confusion with data containing flag seq 01111110
  - 0 inserted after every sequence of five 1s
  - if receiver detects five 1s it checks next bit
  - if next bit is 0, it is deleted (was stuffed bit)
  - if next bit is 1 and seventh bit is 0, accept as flag
  - if sixth and seventh bits 1, sender is indicating abort

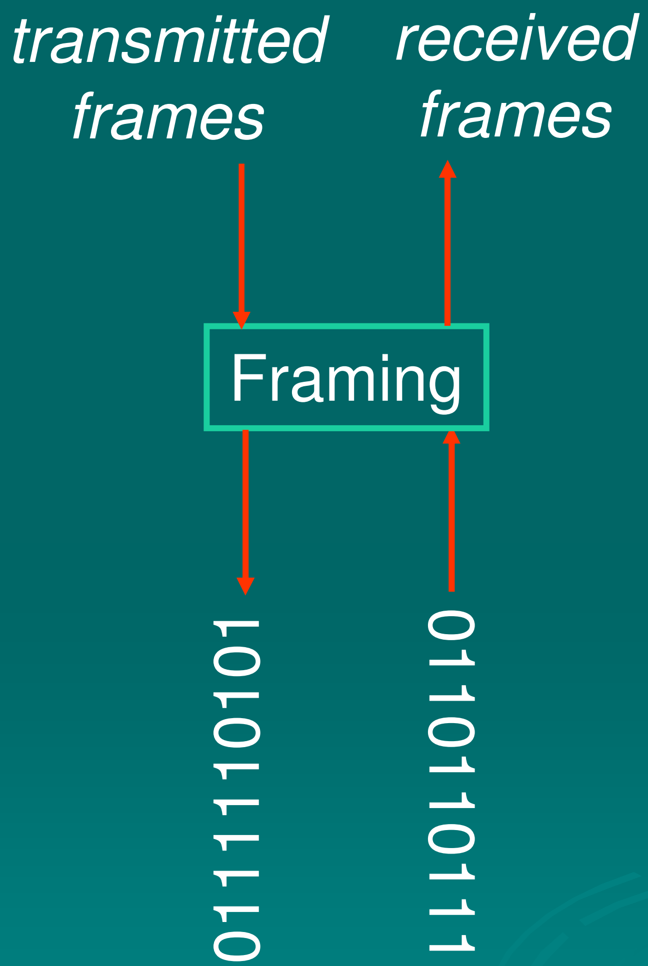
Original Pattern:

111111111111011111101111110

After bit-stuffing

11111011111011011111010111110 10

Framing



- Mapping stream of physical layer bits into frames
- Mapping frames into bit stream
- Frame boundaries can be determined using:
  - Character Counts
  - Control Characters
  - Flags
  - CRC Checks

Framing & Bit Stuffing

HDLC frame

Flag	Address	Control	Information	FCS	Flag

any number of bits

- Frame delineated by flag character
- HDLC uses *bit stuffing* to prevent occurrence of flag 01111110 inside the frame
- Transmitter inserts extra 0 after each consecutive five 1s *inside* the frame
- Receiver checks for five consecutive 1s
  - if next bit = 0, it is removed
  - if next two bits are 10, then flag is detected
  - If next two bits are 11, then frame has errors

Example: Bit stuffing & de-stuffing

(a) Data to be sent

0110111111111100

After stuffing and framing

*01111110*011011111011111000*01111110*

(b) Data received

01111110000111011111011111011001111110

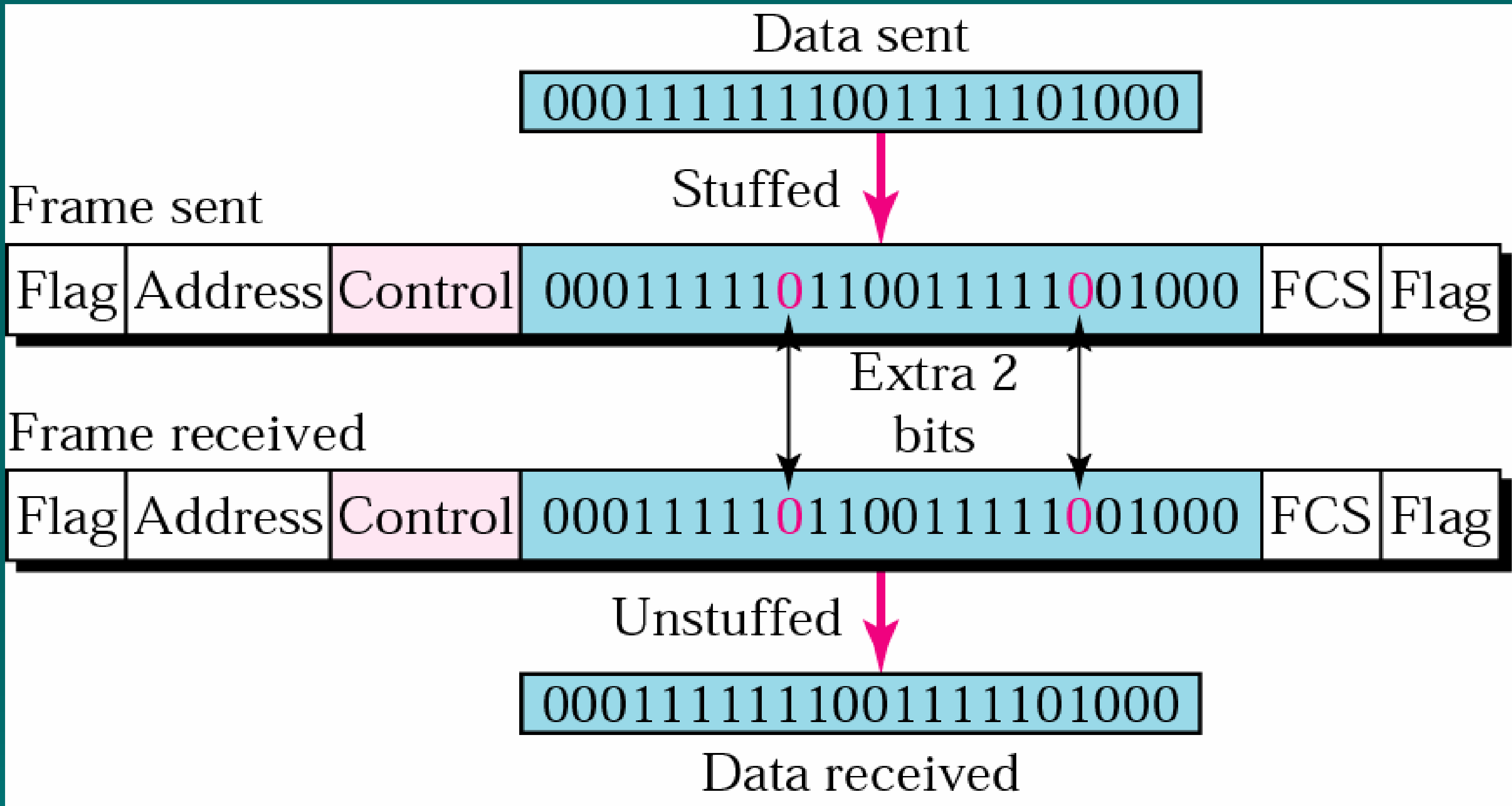
After destuffing and deframing

00011101111-11111-110

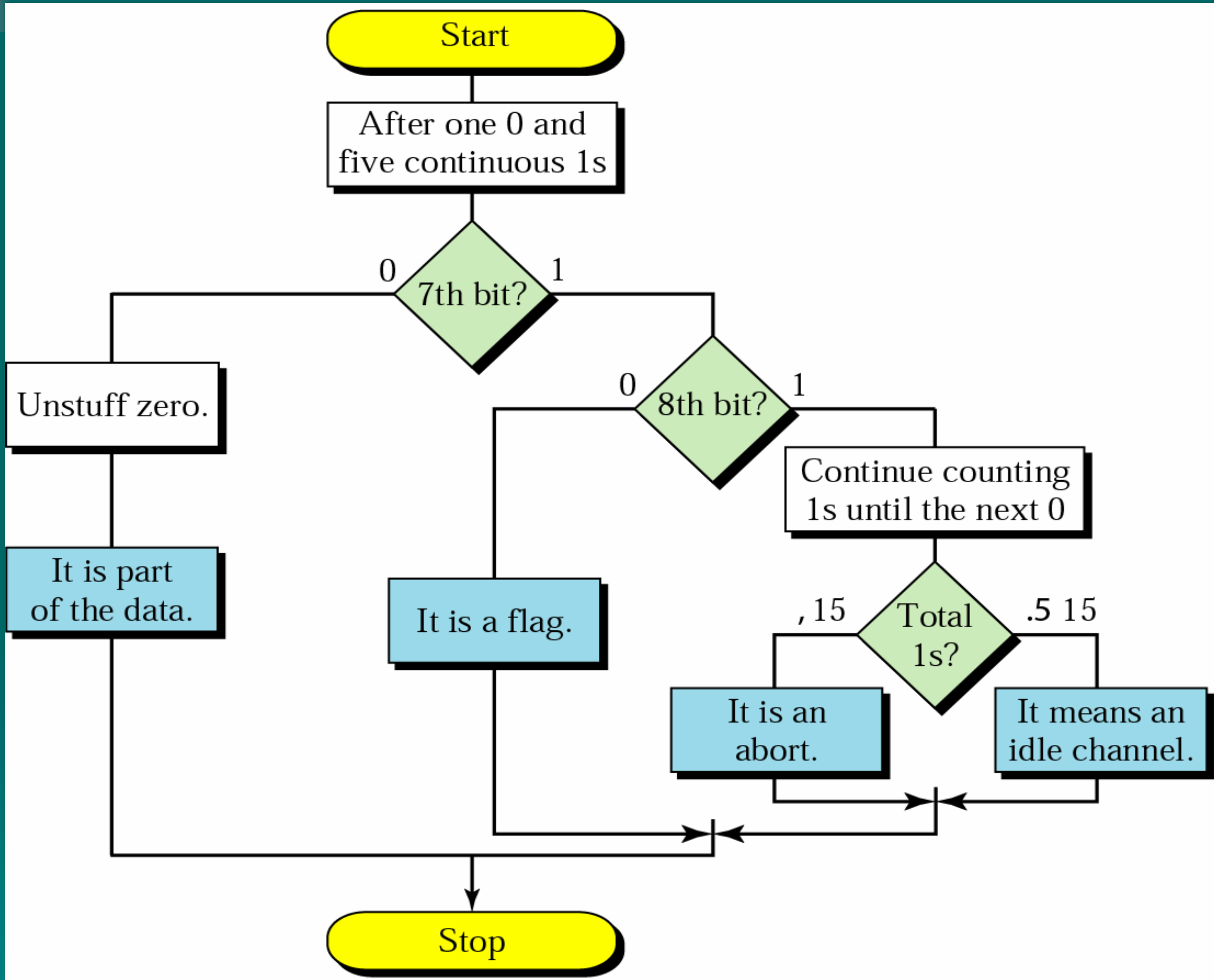
Note:

Bit stuffing is the process of adding one extra 0 whenever there are five consecutive 1s in the data so that the receiver does not mistake the data for a flag.

11.24 Bit stuffing and removal

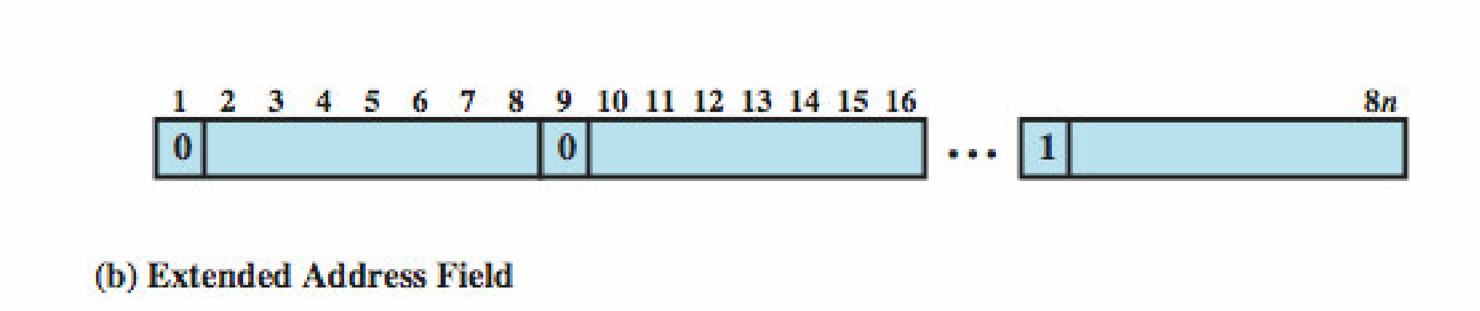


11.25 Bit stuffing in HDLC



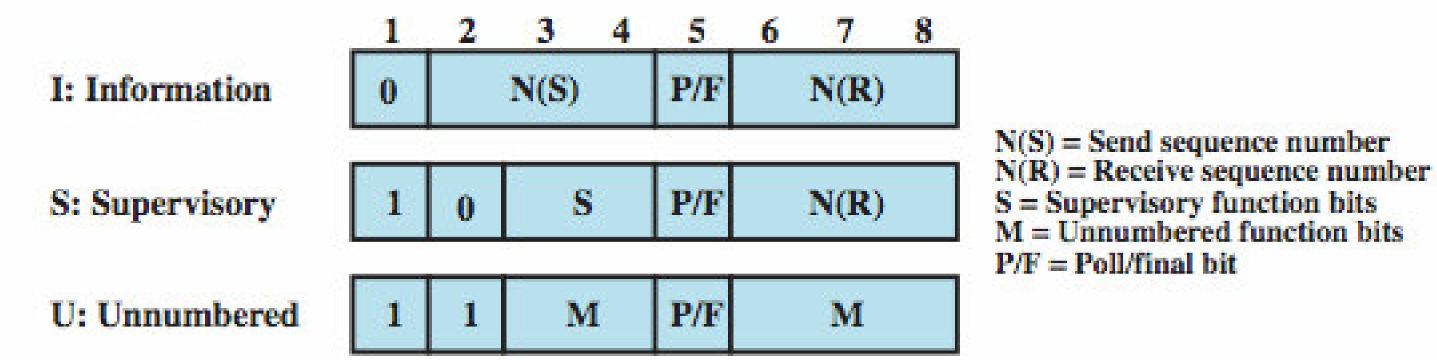
Address Field

- identifies secondary station that sent or will receive frame
- usually 8 bits long
- may be extended to multiples of 7 bits
  - LSB indicates if is the last octet (1) or not (0)
- all ones address 11111111 is broadcast



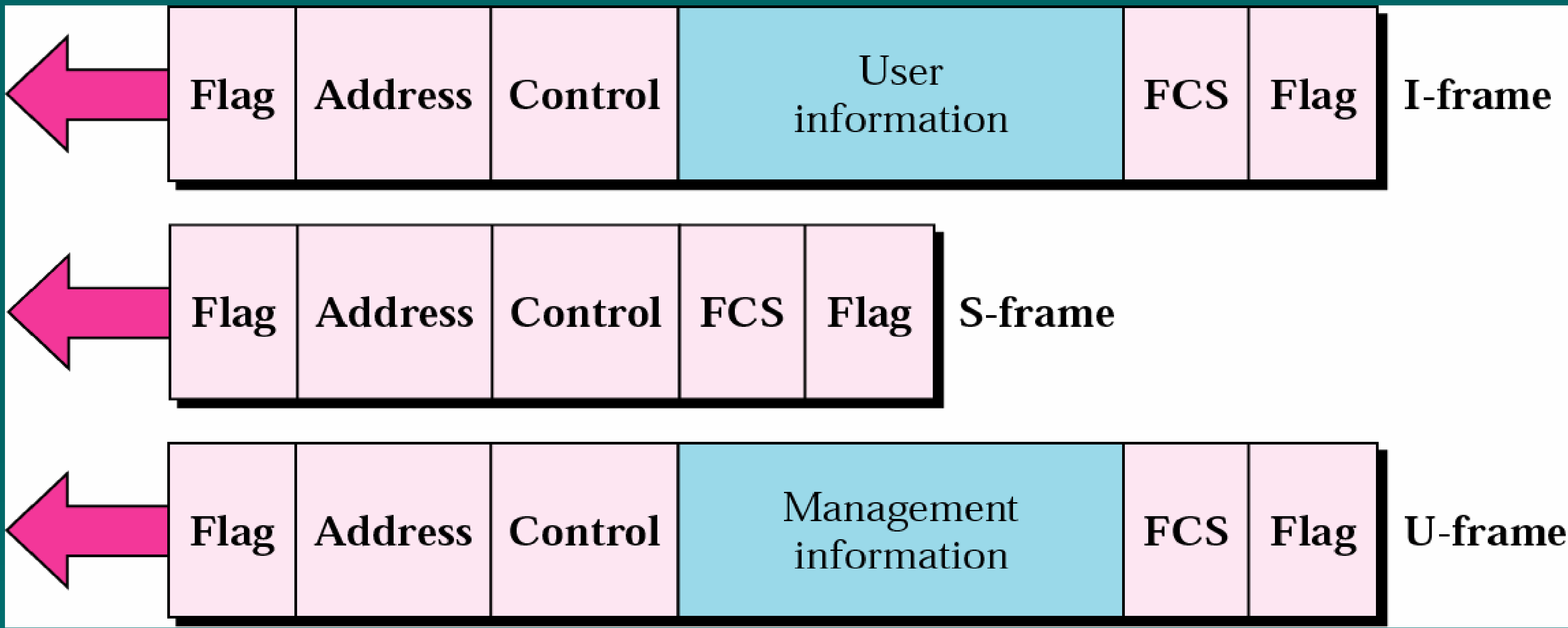
Control Field

- different for different frame type
  - Information - data transmitted to user (next layer up)
    - Flow and error control piggybacked on information frames
  - Supervisory - ARQ when piggyback not used
  - Unnumbered - supplementary link control
- first 1-2 bits of control field identify frame type

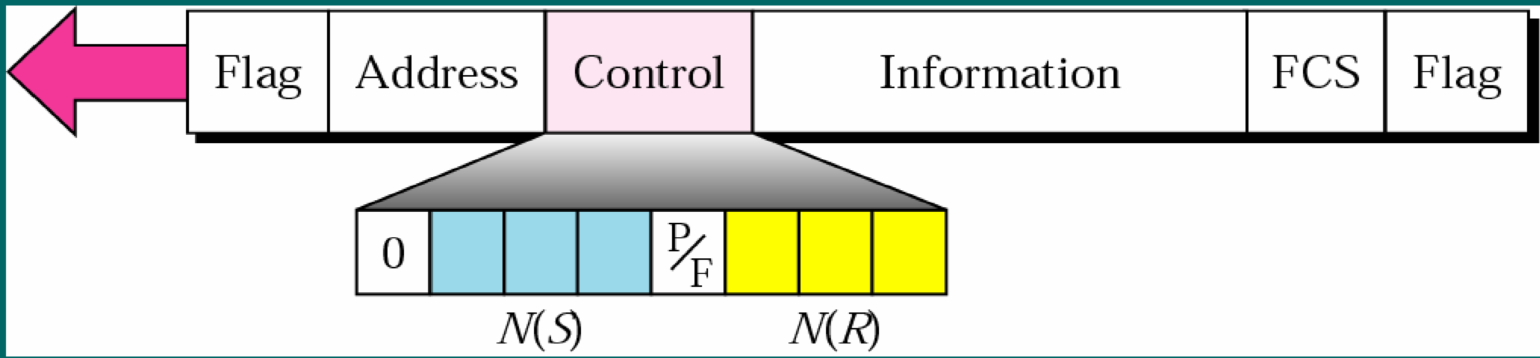


(c) 8-bit control field format

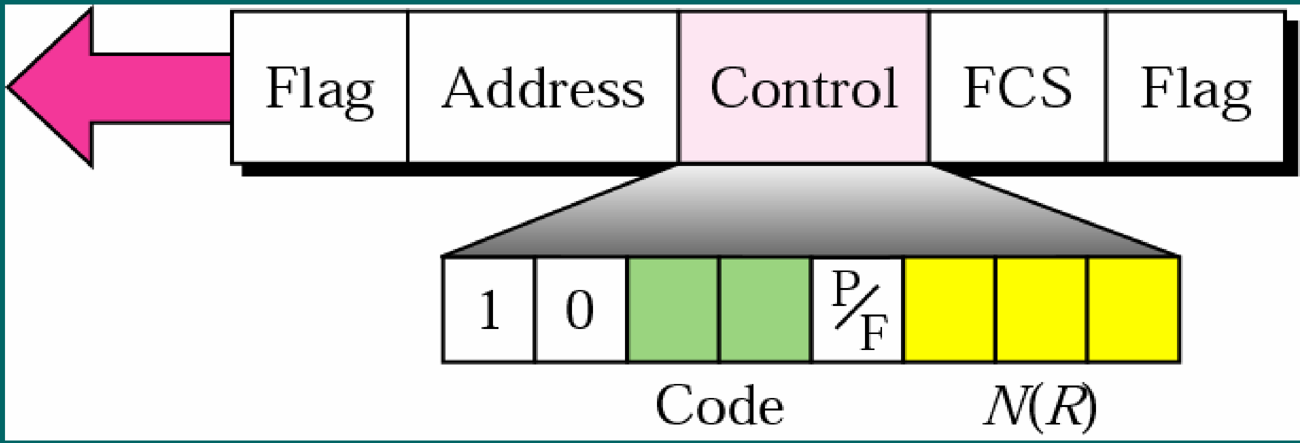
11.18 HDLC frame types



11.19 I-frame



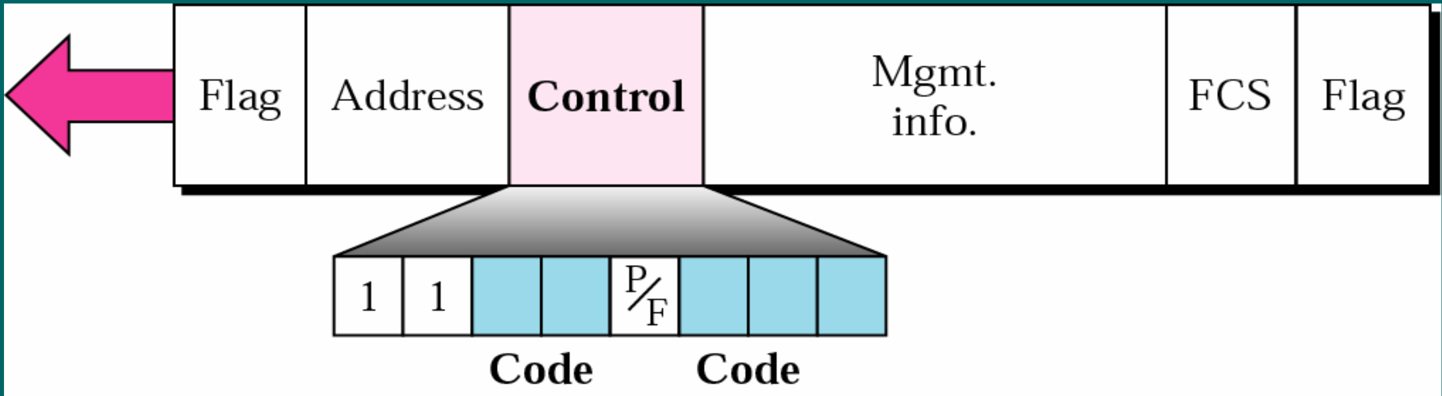
11.20 S-frame control field in HDLC



Code

RR
RNR
REJ
SREJ

11.21 U-frame control field in HDLC



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

Table 11.1 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

Control Field

- use of Poll/Final bit depends on context
- in command frame is P bit set to1 to solicit (poll) response from peer
- in response frame is F bit set to 1 to indicate response to soliciting command
- seq number usually 3 bits
  - can extend to 8 bits as shown below

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Information	0	N(S)							P/F	N(R)						
Supervisory	1	0	S		0	0	0	0	P/F	N(R)						

(d) 16-bit control field format

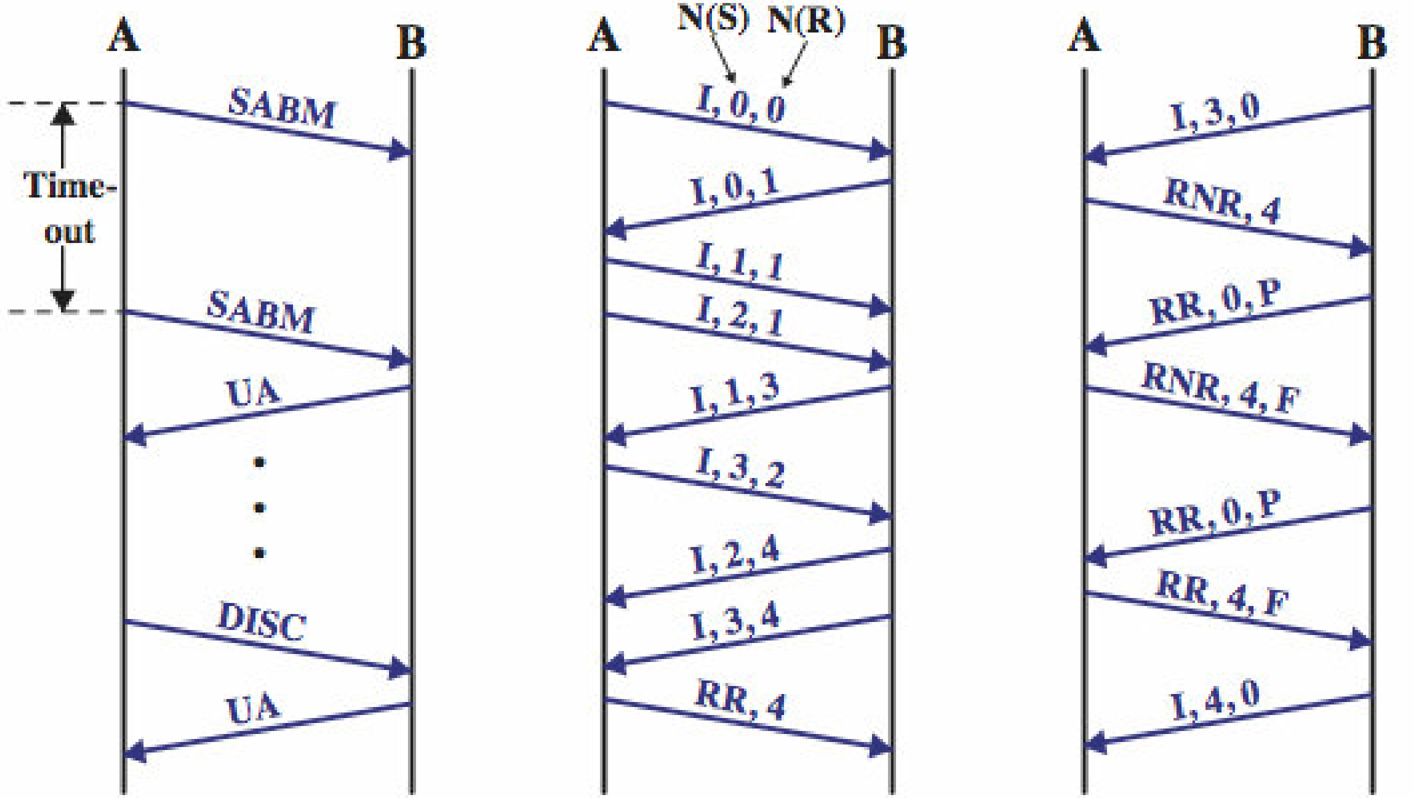
Information & FCS Fields

- Information Field
  - in information and some unnumbered frames
  - must contain integral number of octets
  - variable length
- Frame Check Sequence Field (FCS)
  - used for error detection
  - either 16 bit CRC or 32 bit CRC

HDLC Operation

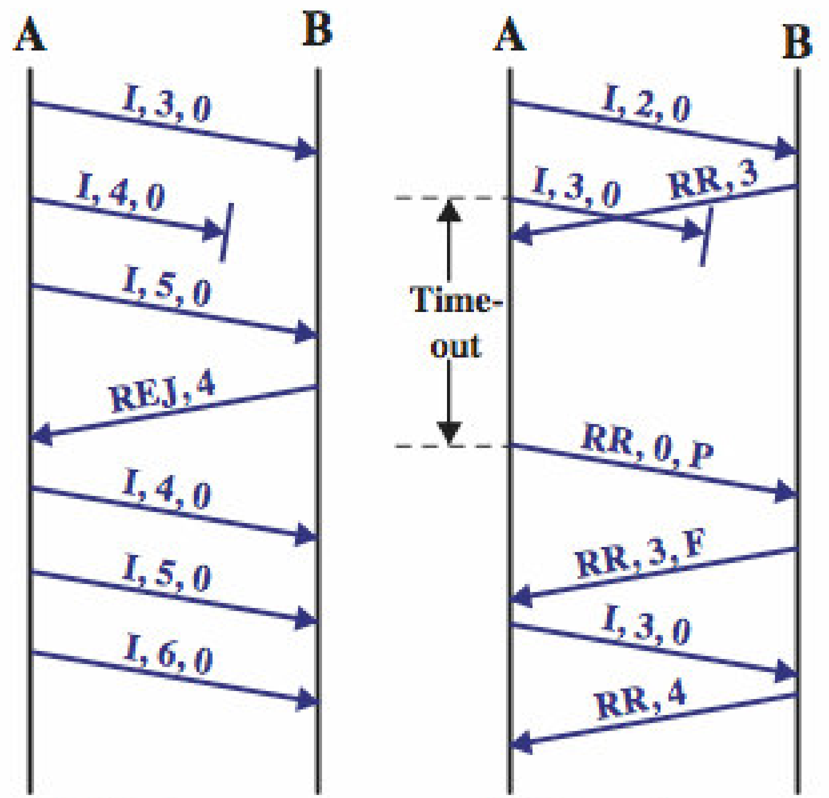
- consists of exchange of information, supervisory and unnumbered frames
- have three phases
  - initialization
    - by either side, set mode & seq
  - data transfer
    - with flow and error control
    - using both I & S-frames (RR, RNR, REJ, SREJ)
  - disconnect
    - when ready or fault noted

HDLC Operation Example



(a) Link setup and disconnect (b) Two-way data exchange (c) Busy condition

HDLC Operation Example

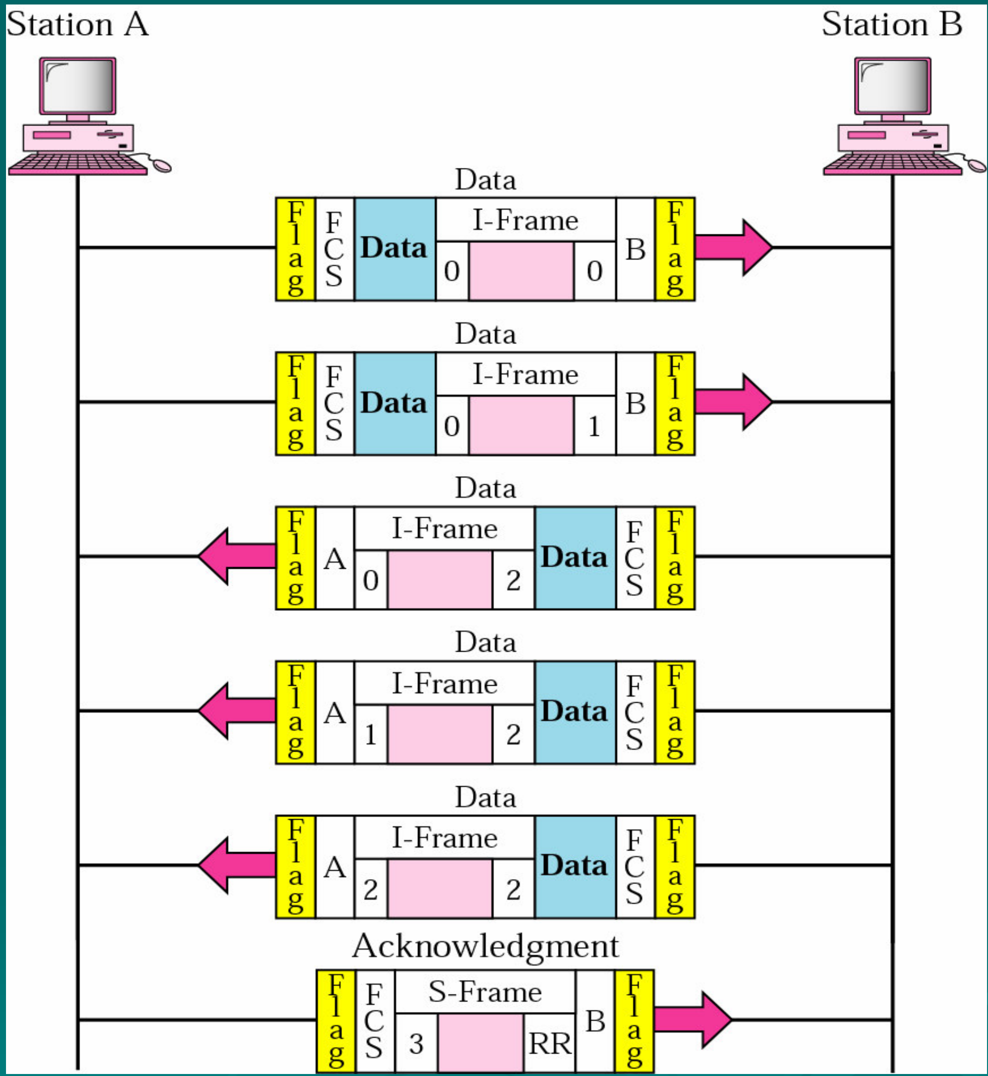


(d) Reject recovery
(e) Timeout recovery

Example 3

Figure 11.22 shows an exchange using piggybacking where there is no error. Station A begins the exchange of information with an I-frame numbered 0 followed by another I-frame numbered 1. Station B piggybacks its acknowledgment of both frames onto an I-frame of its own. Station B's first I-frame is also numbered 0 [N(S) field] and contains a 2 in its N(R) field, acknowledging the receipt of A's frames 1 and 0 and indicating that it expects frame 2 to arrive next. Station B transmits its second and third I-frames (numbered 1 and 2) before accepting further frames from station A. Its N(R) information, therefore, has not changed: B frames 1 and 2 indicate that station B is still expecting A frame 2 to arrive next.

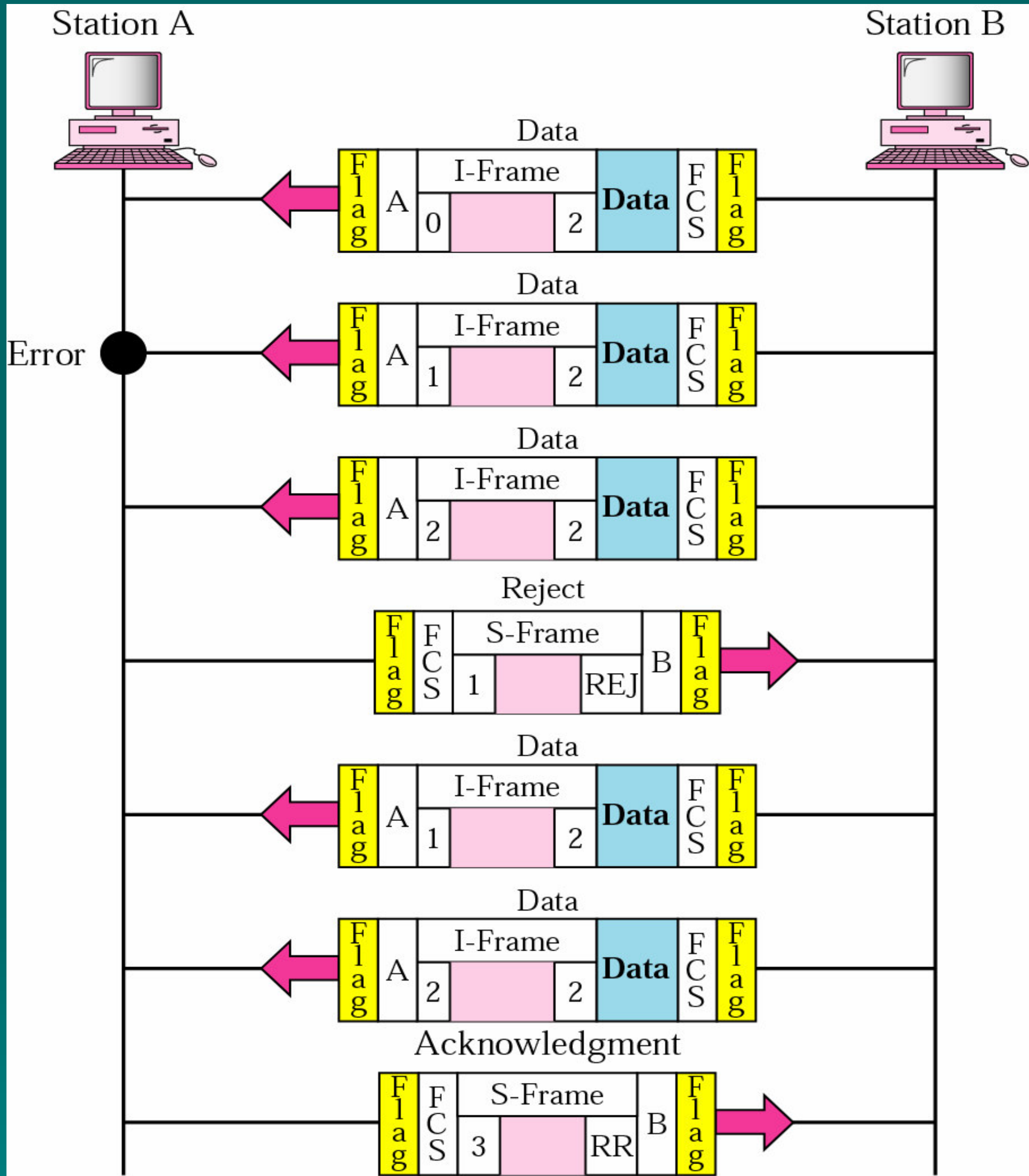
11.22 Example 3



Example 4

In Example 3, suppose frame 1 sent from station B to station A has an error. Station A informs station B to resend frames 1 and 2 (the system is using the Go-Back-N mechanism). Station A sends a reject supervisory frame to announce the error in frame 1. Figure 11.23 shows the exchange.

11.23 Example 4



Summary

- introduced need for data link protocols
- flow control
- error control
- HDLC