HDLC

High Level Data Link Control

HDLC : *High-level Data Link Control*

- It is a bit-oriented data link protocol
- Designed to support both half duplex and full duplex communication over point-to-point and multipoint links.
- It implements the ARQ mechanisms.
- The HDLC protocol embeds information in a data frame that allows devices to control data flow and correct errors

HDLC : *High-level Data Link Control*

- Each piece of data is encapsulated in an HDLC frame by adding a trailer and a header.
- **The header** contains an HDLC address and an HDLC control field.
- **The trailer** is found at the end of the frame, and contains a (CRC) which detects any errors which may occur during transmission.
- The frames are separated by HDLC flag sequences which are transmitted between each frame and whenever there is no data to be transmitted.

HDLC Station Types

- Primary station
  - Controls operation of link
  - Frames issued are called commands
  - Maintains separate logical link to each secondary station
- Secondary station
  - Under control of primary station
  - Frames issued called responses
- Combined station
  - May issue commands and responses

HDLC Link Configurations

- Unbalanced
  - One primary and one or more secondary stations
  - Supports full duplex and half duplex
- Balanced
  - Two combined stations
  - Supports full duplex and half duplex

HDLC Transfer Modes (1)

- Normal Response Mode (NRM)
  - Unbalanced configuration
  - Primary initiates transfer to secondary
  - Secondary may only transmit data in response to command from primary

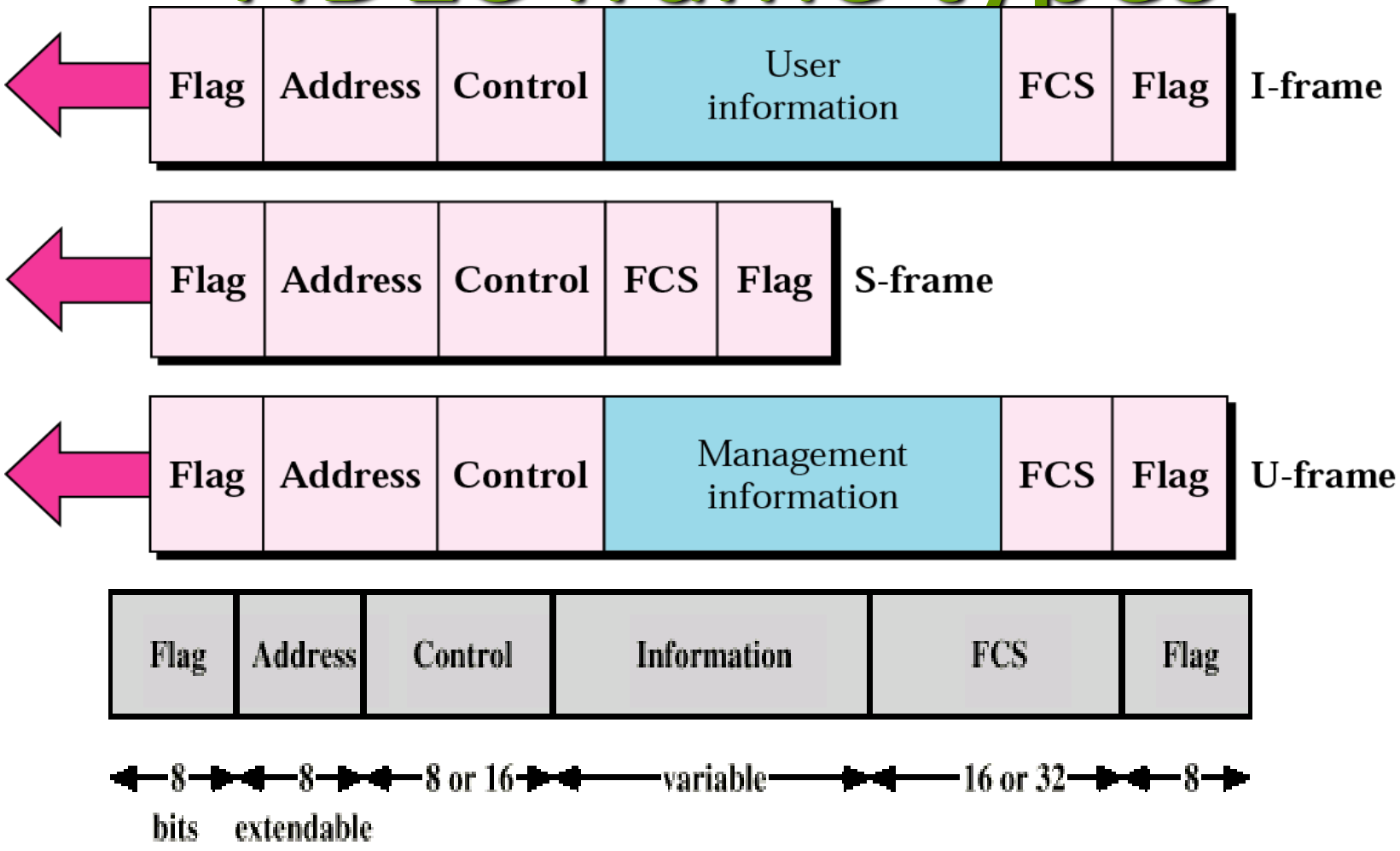
HDLC Transfer Modes (2)

- Asynchronous Balanced Mode (ABM)
  - Balanced configuration
  - Either station may initiate transmission without receiving permission
  - Most widely used

HDLC Transfer Modes (3)

- Asynchronous Response Mode (ARM)
  - Unbalanced configuration
  - Secondary may initiate transmission without permission form primary
  - Primary responsible for line

HDLC frame types



(a) Frame format

HDLC *Frame Fields*

Flag field

- is 8 bits of a fixed pattern (0111 1110).
- There is one flag at the beginning and one at the end frame.
- The ending flag of one Frame can be used as the beginning flag of the next frame.
- To guarantee that the flag does not appear anywhere else in the frame
- HDLC uses a process called **Bit Stuffing**.
- Every time a sender wants to transmit a bit sequence having more than 6 consecutive 1's, it inserts 1 redundant 0 after the 5_{th} 1

Bit Stuffing

- the process of adding one extra zero whenever there are 5 consecutive 1's in the data, so that the receiver doesn't mistake the data for a flag.

A frame before bit stuffing:

01111110 01111100 101101111 110010

After

011111010 011111000 101101111 10010010

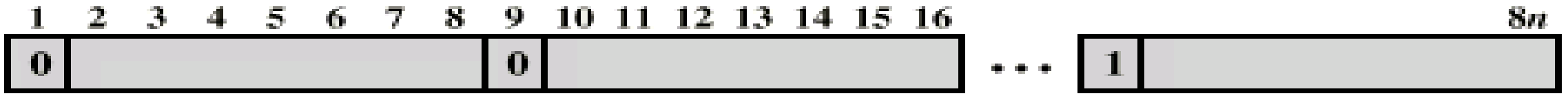
How does the receiver identify a stuffed bit?

- Receiver reads incoming bits and counts 1's.
- When number of consecutive 1s **after** a zero is 5, it checks the next bit (7^{th} bit).
- If **7^{th} bit = zero** → receiver recognizes it as a **stuffed bit**, discard it and resets the counter.
- If the **7^{th} bit = 1** → then the receiver checks the 8^{th} bit; If the **8^{th} bit = 0**, the sequence is recognized as a **flag**.

01111010 01111100 101101111 10010010

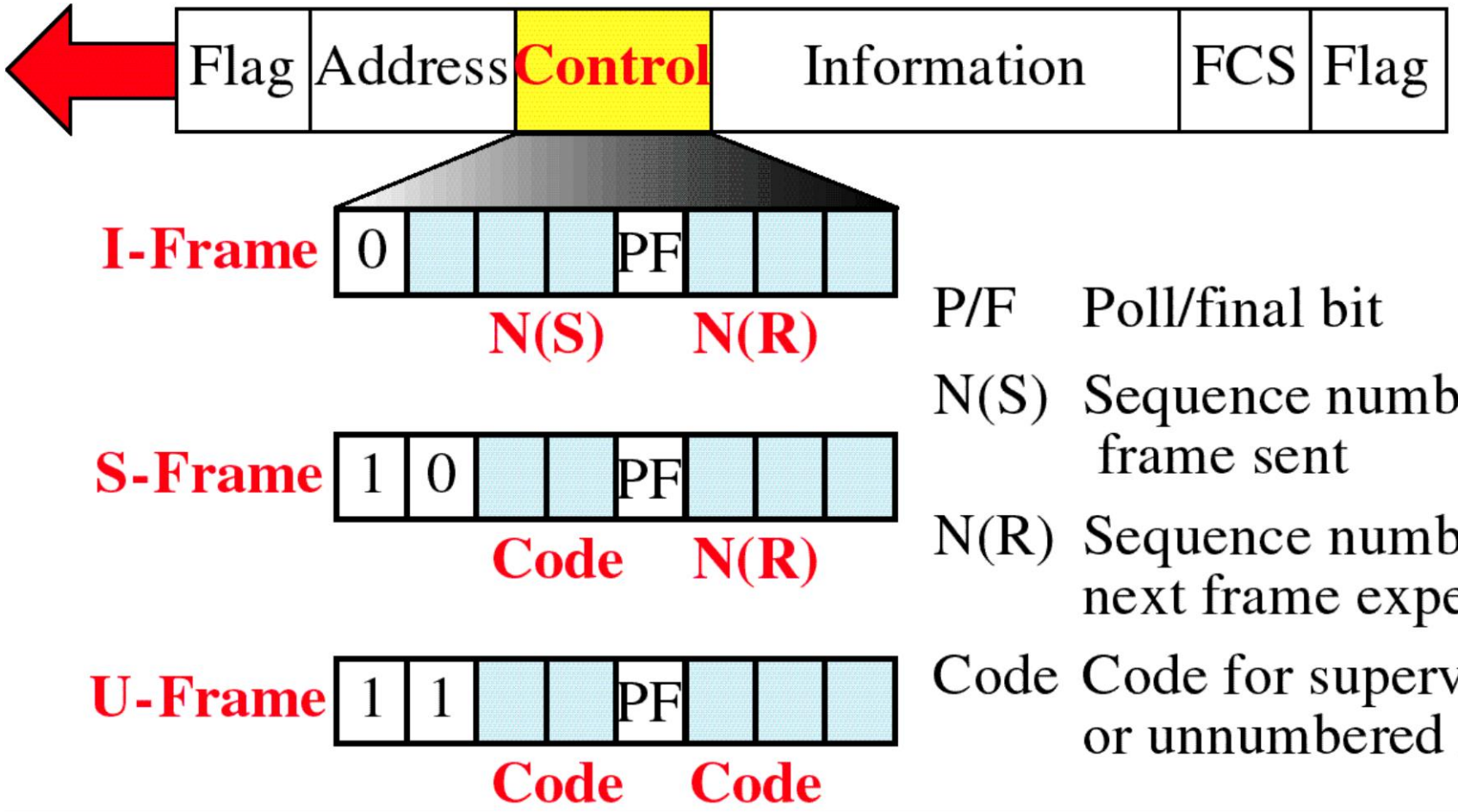
Address Field

- Identifies secondary station that sent or will receive frame
- Usually 8 bits long
- May be extended to multiples of 7 bits
  - LSB of each octet indicates that it is the last octet (1) or not (0)
- All ones (11111111) is broadcast



(b) Extended Address Field

HDLC Control Field



P/F Poll/final bit

N(S) Sequence number of frame sent

N(R) Sequence number of next frame expected

Code Code for supervisory or unnumbered frame

Control Field

- all three types contain a bit called (Poll/Final) P/F bit

I-Frame

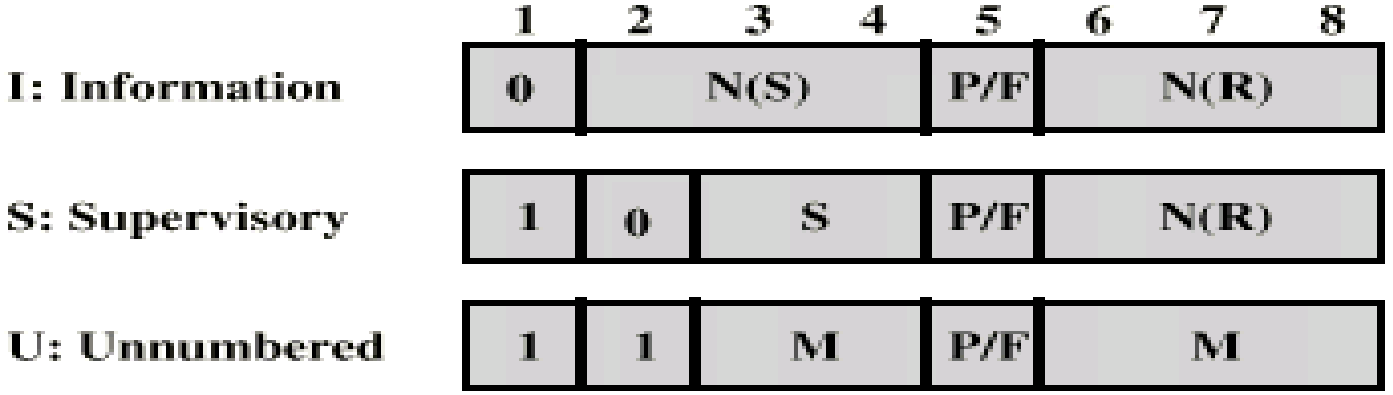
- **N(S)** : sequence # of the **sent frame**
- **N(R)** : sequence # of frame **expected in return**
  - ➔ **N(R)** is ACK field
- If last frame received is error free

➔N(R) number will be the next frame in sequence

- If the frame was not received correctly

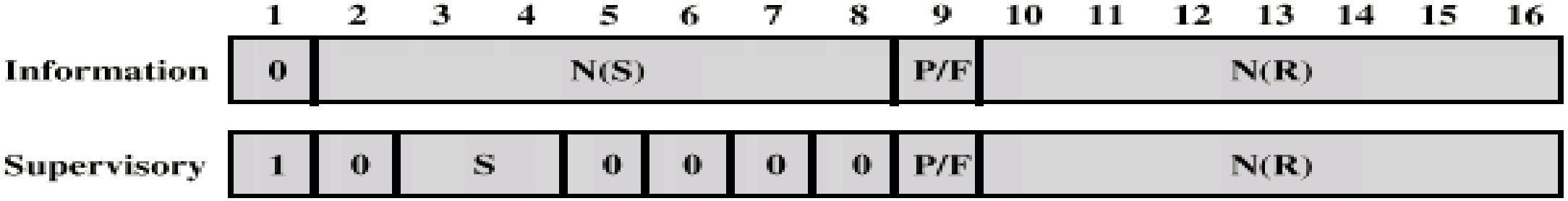
➔ N(R) number will be the number of damaged frame indicating the need for retransmission

Control Field Diagram



N(S) = Send sequence number
N(R) = Receive sequence number
S = Supervisory function bits
M = Unnumbered function bits
P/F = Poll/final bit

(c) 8-bit control field format

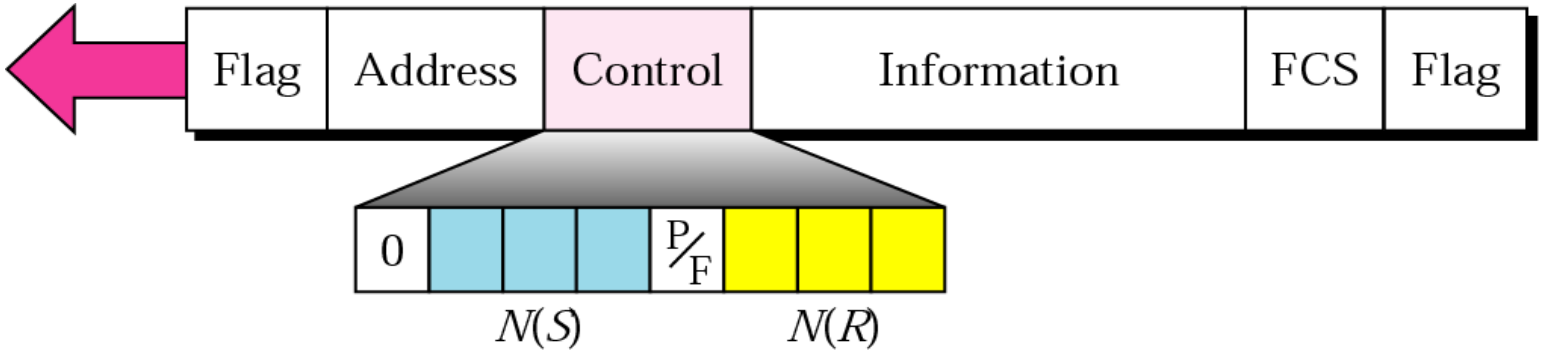


(d) 16-bit control field format

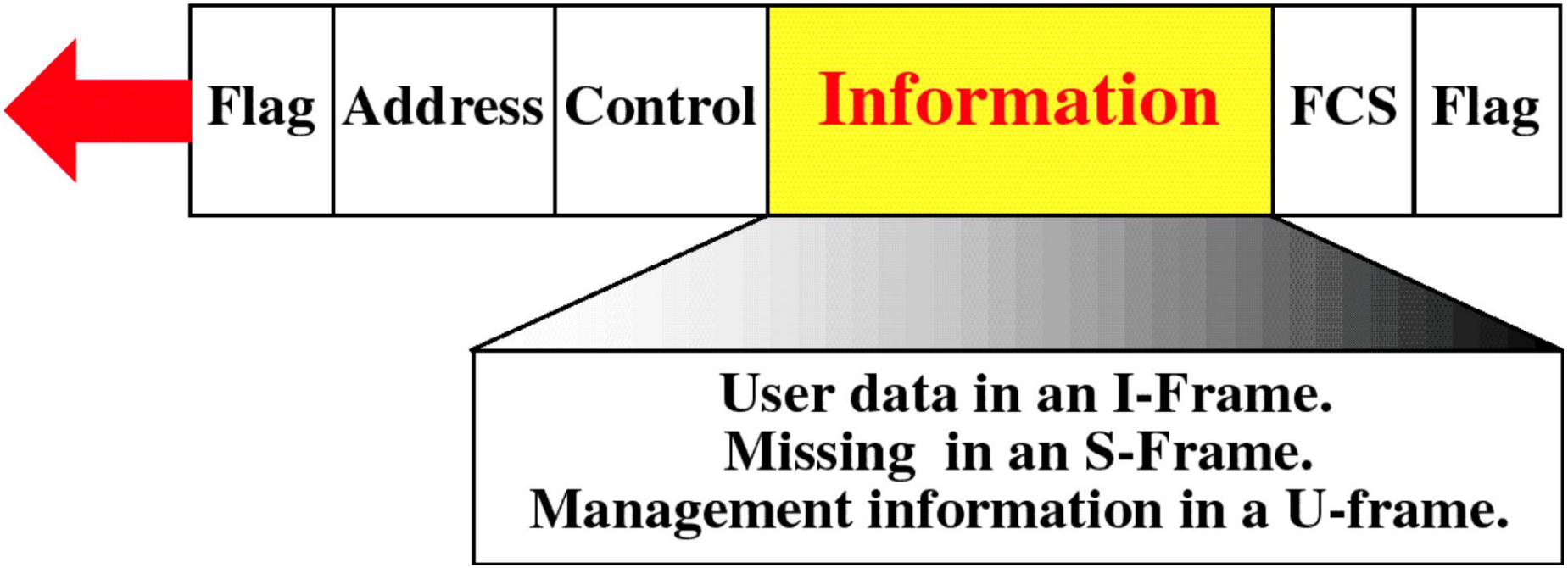
Information Field

- Only in information and some unnumbered frames
- Must contain integral number of octets
- Variable length

I *frame*



Information Field



Information Field

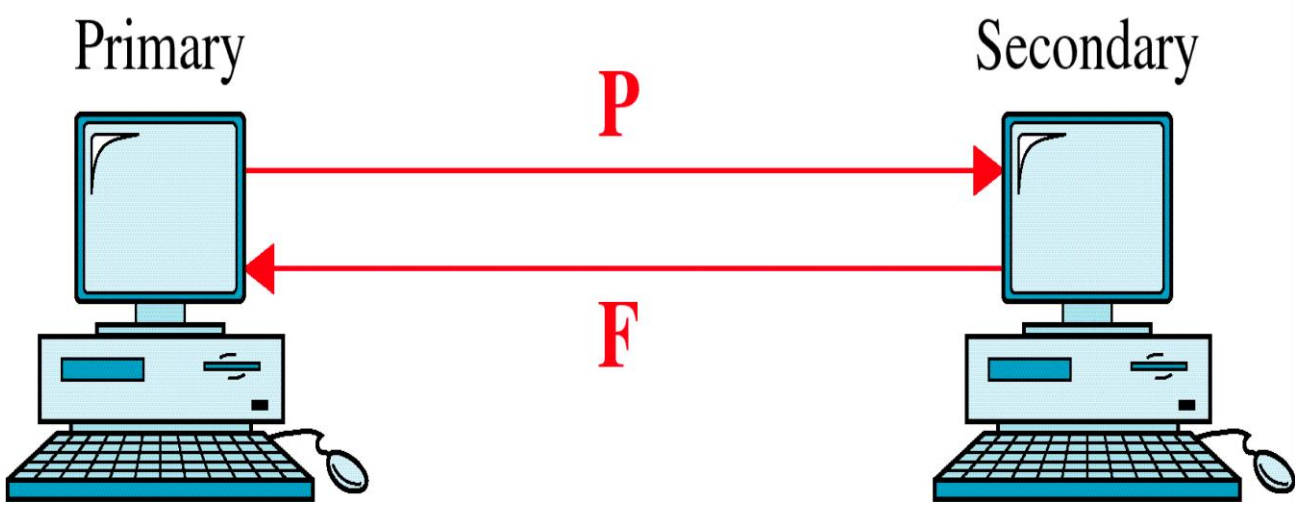
- Contains **user data** in **I**-frame and **network management information** in a **U**-frame.
- It is possible to include flow and error control information in an I-frame that also contains data.
- In 2-way exchange of data (full-duplex), the 2nd station can ACK receipt of data from the 1st station in the control field of its own data frame rather than sending a separate frame just for ACK.
- Combining data to be sent & ACK of the frame received in one single frame is called **PIGGYBACKING**.

Poll/Final Bit

- Use depends on context
- Command frame
  - P bit
  - 1 to solicit (poll) response from peer
- Response frame
  - F bit
  - 1 indicates response to soliciting command

Poll/Final

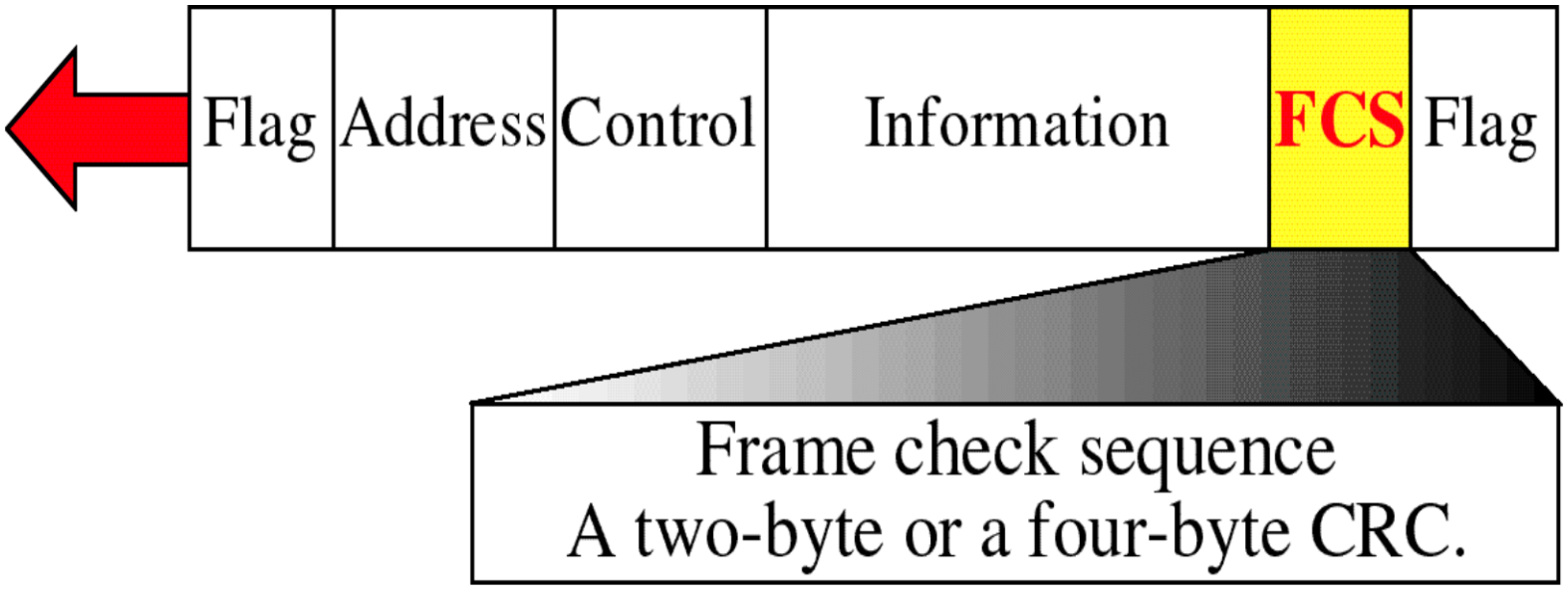
- P/F = 1 ➔POLL or Final
  - **Poll** if frame is sent by the primary
  - **Final** if frame is sent by the secondary



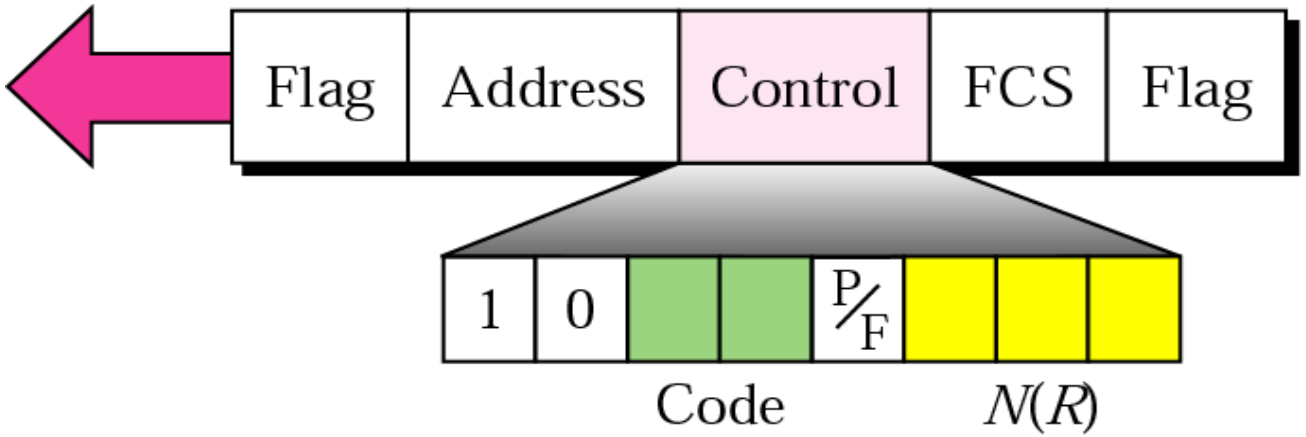
Frame Check Sequence Field

- FCS
- Error detection
- 16 bit CRC
- Optional 32 bit CRC

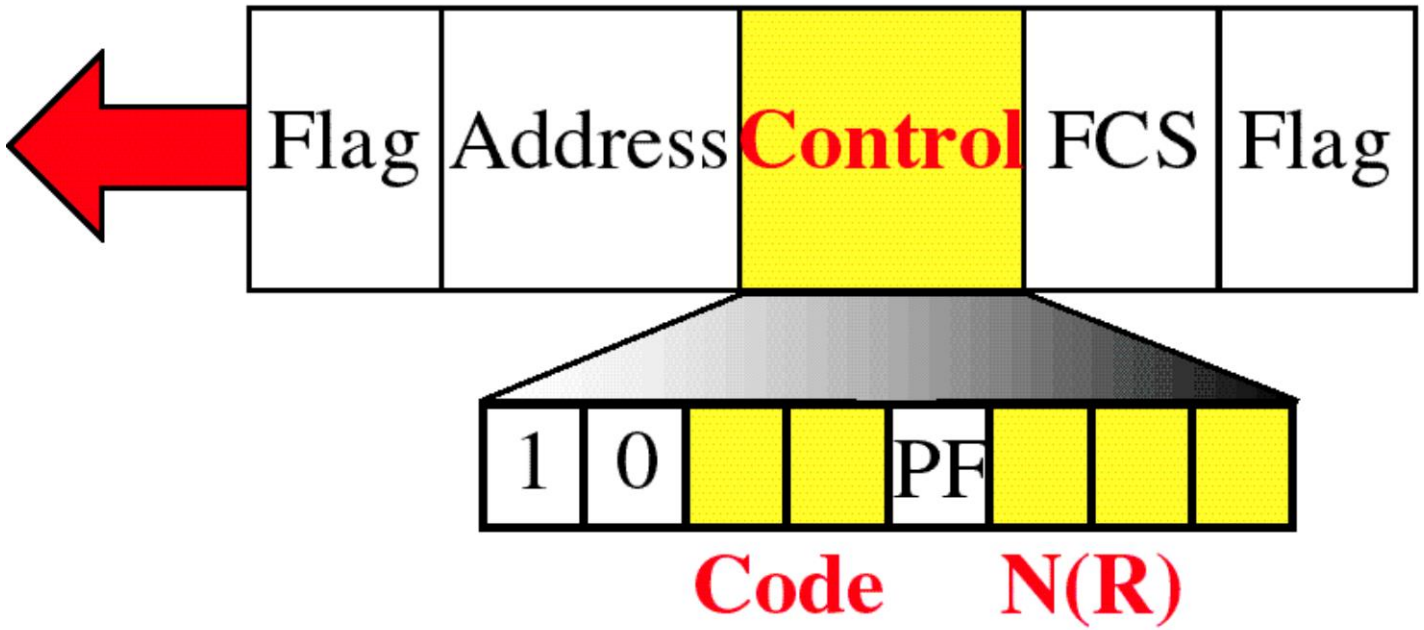
HDLC FCS Field



S-frame control field in HDLC



S-Frame



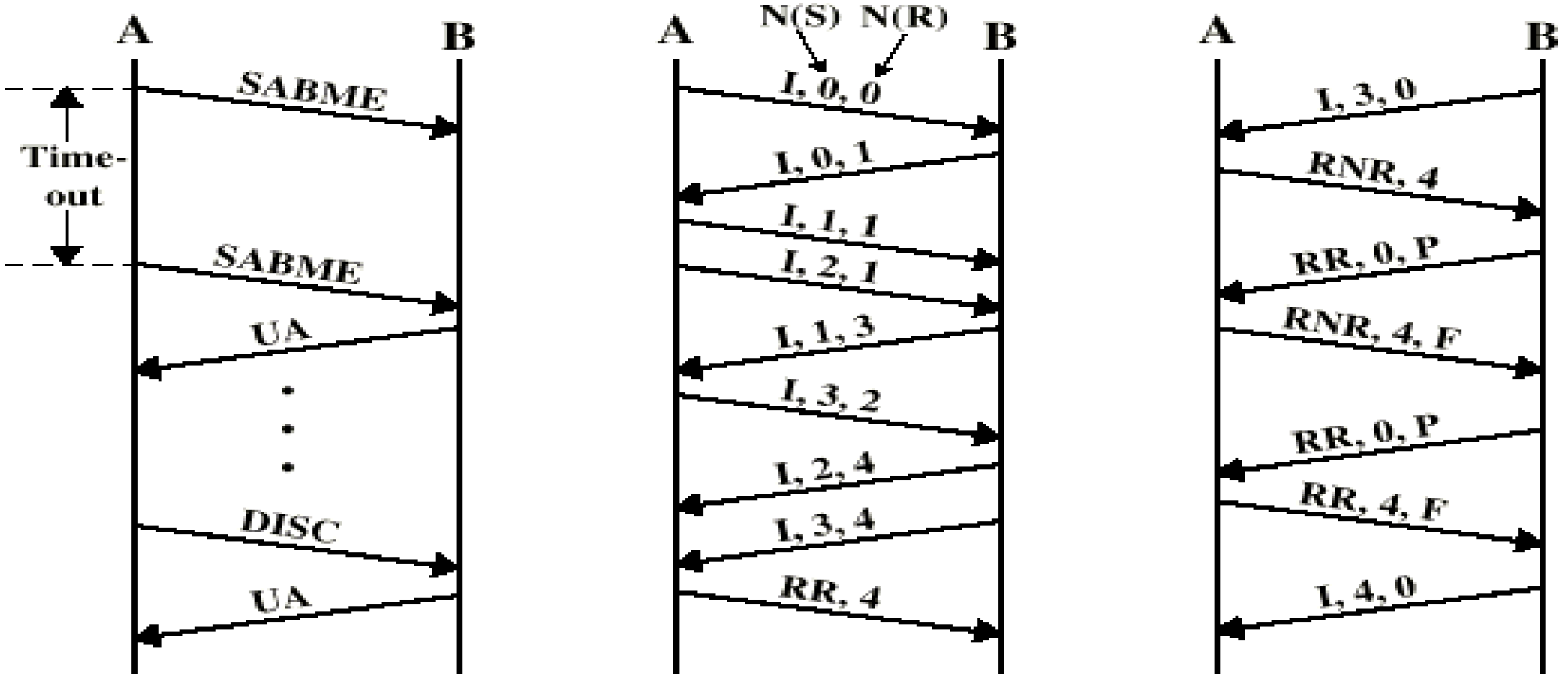
Code	Command	
00	RR	Receive ready
01	REJ	Reject
10	RNR	Receive not ready
11	SREJ	Selective-reject

- **Receive Ready (RR)**
  - Positive ACK of a received I- frame
- **Receive Not Ready (RNR)**
  - Is RR frame with additional duties
  - It Ack the receipt of a frame and announces that the receiver is busy
- **Reject (REJ)**
  - This is a NAK frame that can be used in Go-back-n
- **Selective reject (SREJ)**
  - This is a NAK frame used in Selective Repeat ARQ

HDLC Operation

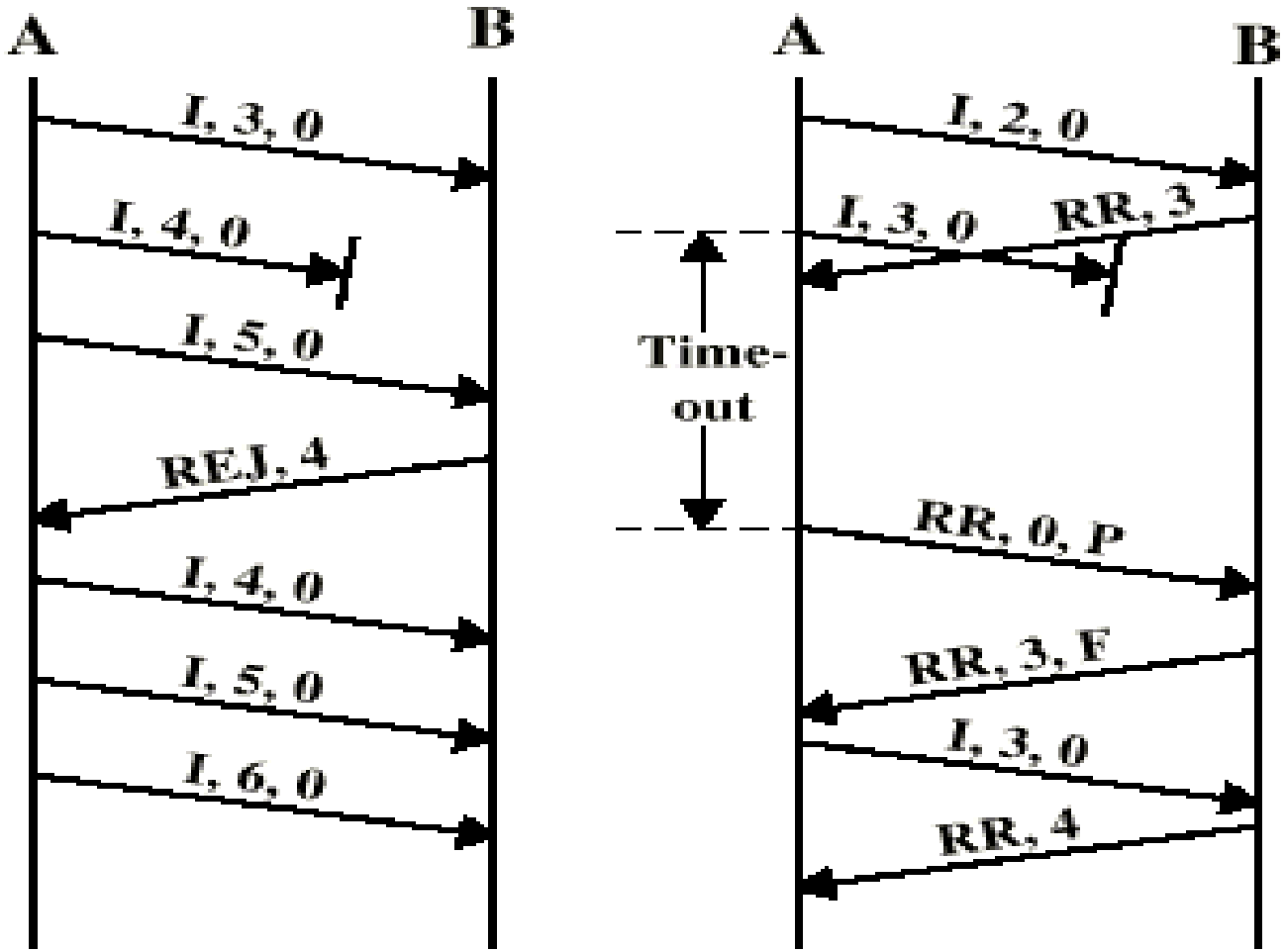
- Exchange of information, supervisory and unnumbered frames
- Three phases
  - Initialization
  - Data transfer
  - Disconnect

Examples of Operation (1)



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

Examples of Operation (2)



(d) Reject recovery

(e) Timeout recovery

Name	Command/ Response	Description
Information (I)	C/R	Exchange user data
Supervisory (S)		
Receive ready (RR)	C/R	Positive acknowledgment; ready to receive I-frame
Receive not ready (RNR)	C/R	Positive acknowledgment; not ready to receive
Reject (REJ)	C/R	Negative acknowledgment; go back N
Selective reject (SREJ)	C/R	Negative acknowledgment; selective reject
Unnumbered (U)		
Set normal response/extended mode (SNRM/SNRME)	C	Set mode; extended = 7-bit sequence numbers
Set asynchronous response/ extended mode (SARM/SARME)	C	Set mode; extended = 7-bit sequence numbers
Set asynchronous balanced/ extended mode (SABM, SABME)	C	Set mode; extended = 7-bit sequence numbers
Set initialization mode (SIM)	C	Initialize link control functions in addressed station
Disconnect (DISC)	C	Terminate logical link connection
Unnumbered Acknowledgment (UA)	R	Acknowledge acceptance of one of the set-mode commands
Disconnected mode (DM)	R	Responder is in disconnected mode
Request disconnect (RD)	R	Request for DISC command
Request initialization mode (RIM)	R	Initialization needed; request for SIM command
Unnumbered information (UI)	C/R	Used to exchange control information
Unnumbered poll (UP)	C	Used to solicit control information
Reset (RSET)	C	Used for recovery; resets N(R), N(S)
Exchange identification (XID)	C/R	Used to request/report status
Test (TEST)	C/R	Exchange identical information fields for testing
Frame reject (FRMR)	R	Report receipt of unacceptable frame