Data Link Layer

Data Link Function

- Framing
- Addressing
- Flow Control
- Error Detection
- Error Corection
- Link Initialization

Framing (Flags)

- Bit-2 yang digunakan sebagai tanda awal dan akhir paket
- Contoh:
  - 01111110
  - Muncul tahun 1970 (IBM) => SDLC (Synchronous Data Link Control)
  - Pola 111111 tidak boleh muncul di data

Framing Error

- Parity Check
- CRC

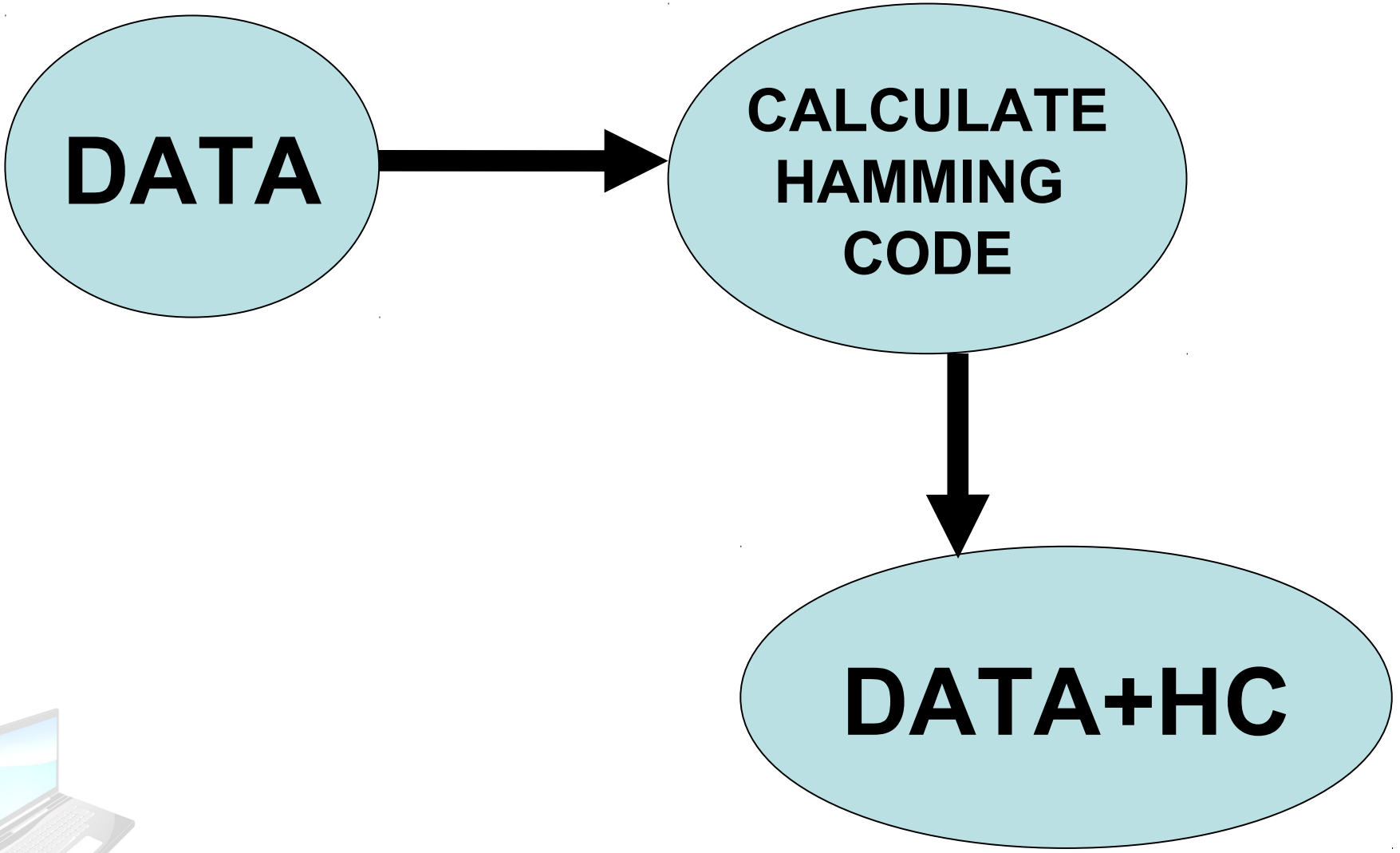
Error Control

- Deteksi error, minta kirim ulang
- Atau betulkan error tanpa retransmisi

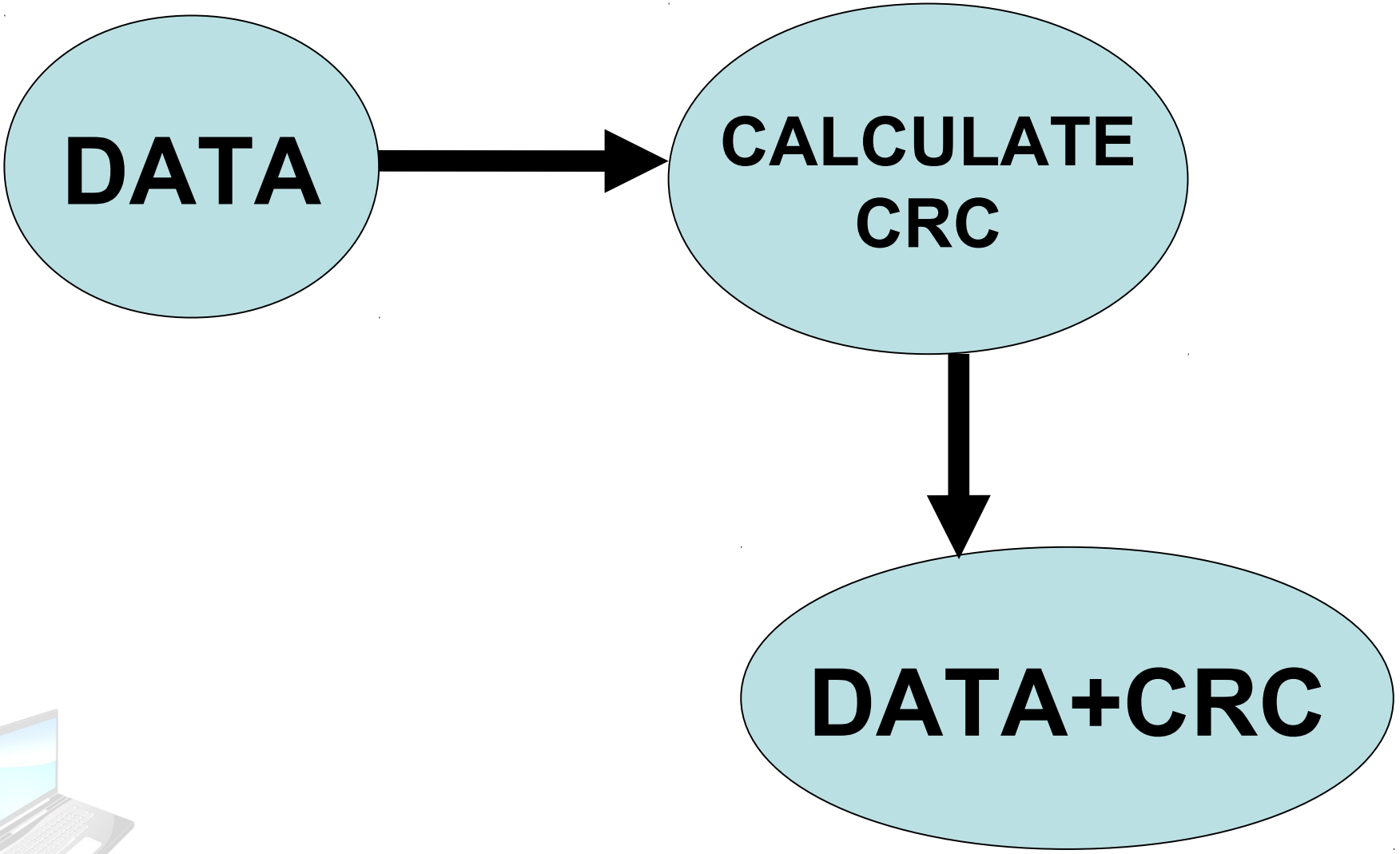
Error Detection

- Parity bits
- Polynomial codes or checksums

Hamming Codes



Cyclic Redundancy Check



HAMMING CODE?
CRC?

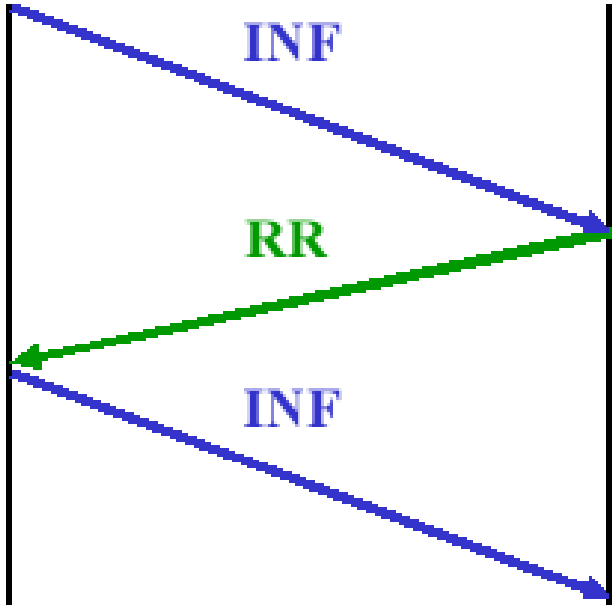
Flow Control

- What happens if the sender tries to transmit faster than the receiver can accept?
- Data will be lost unless flow control is implemented

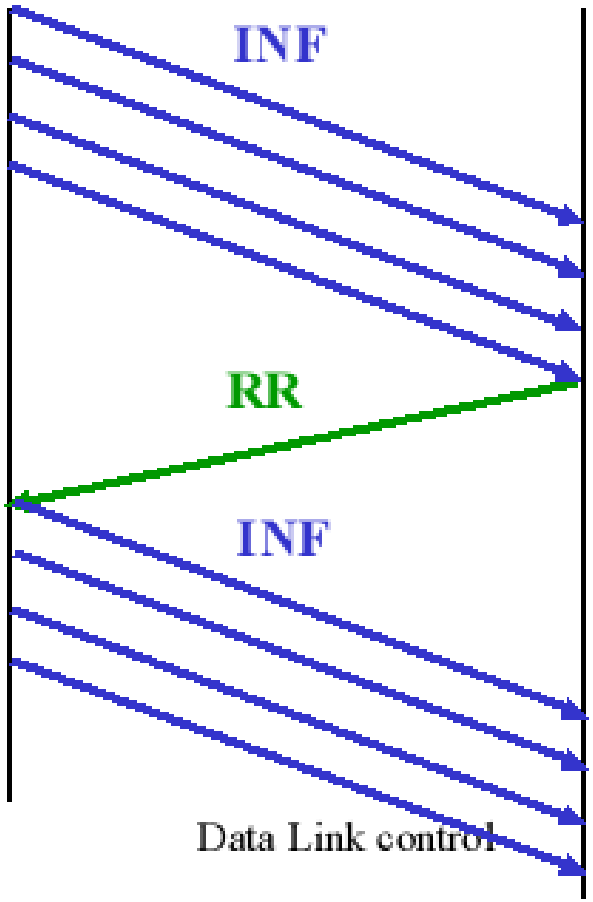
Solution: Stop-and-Wait

- The receiver sends an acknowledgement frame telling the sender to transmit the next data frame.
- The sender waits for the ACK, and if the ACK comes, it transmits the next data frame.

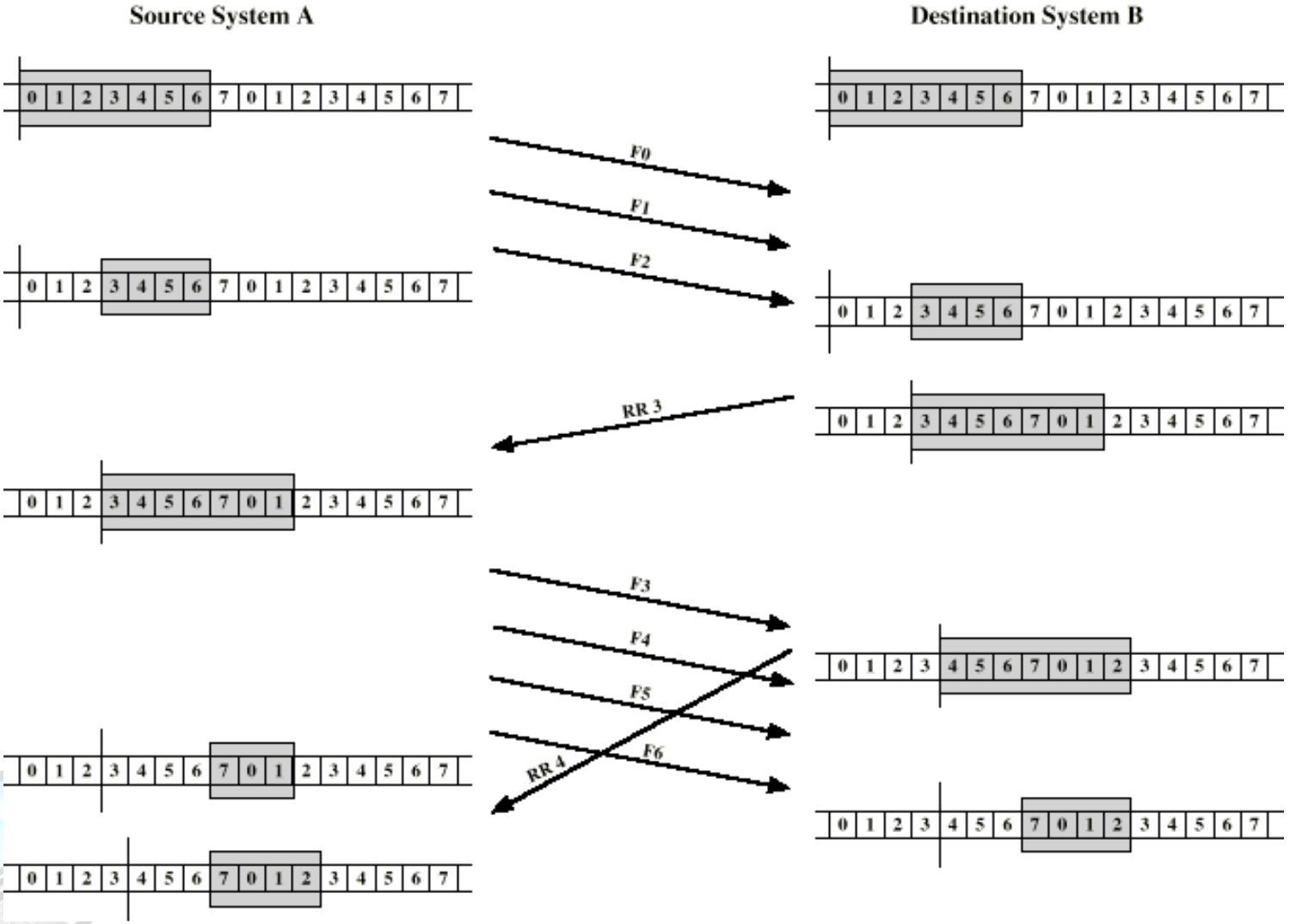
Principle : send a frame and wait for RR to send next frame



- Principle : send several frames without RR
- RR valid for a number of frames



Sliding Windows

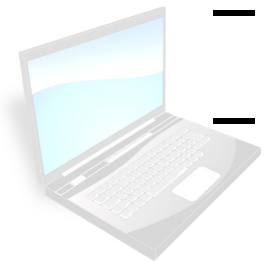


Automatic Repeat Request (ARQ)

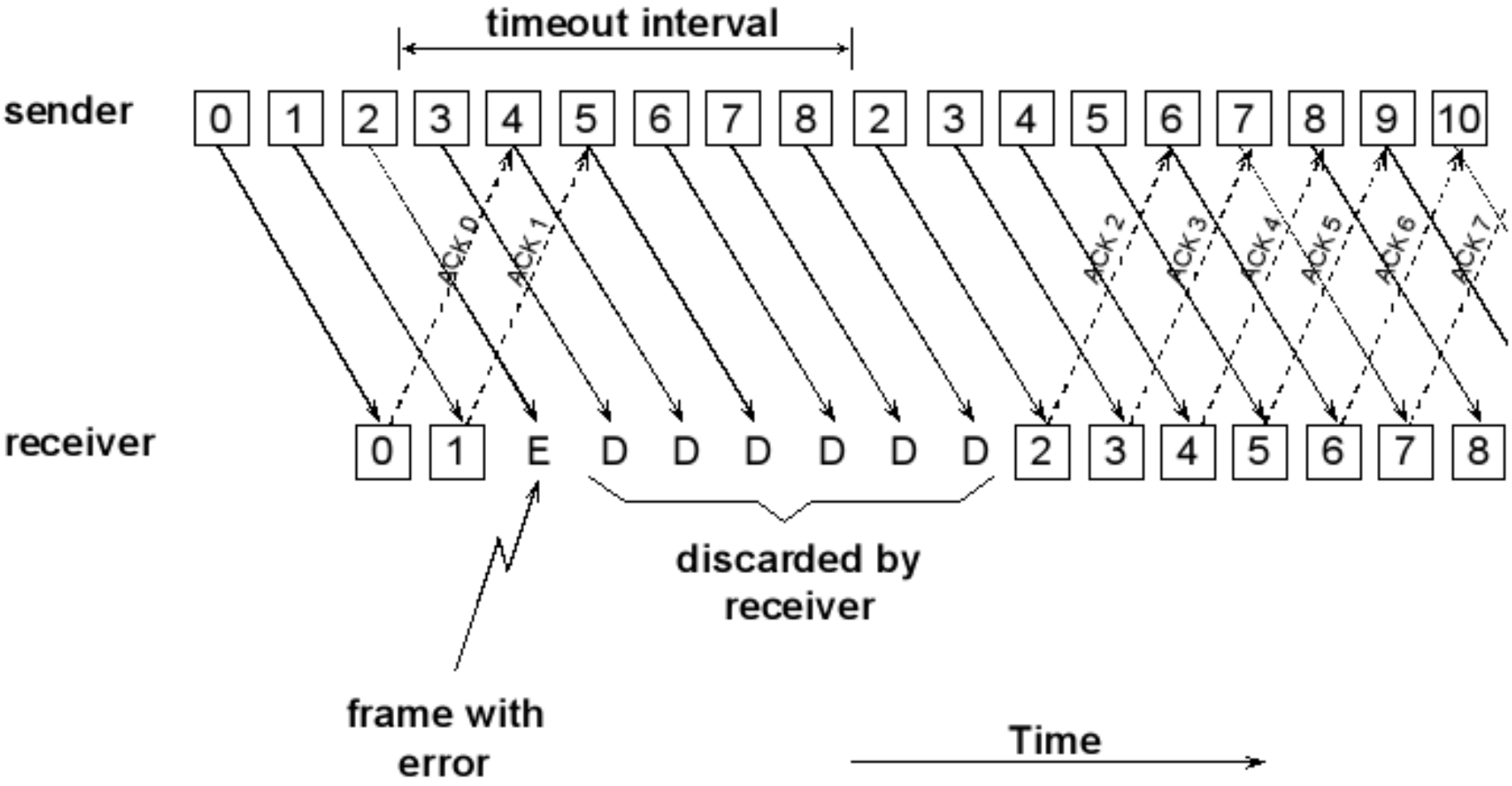
- Stop and wait
- Go back N
- Selective reject (selective retransmission)

Stop and Wait

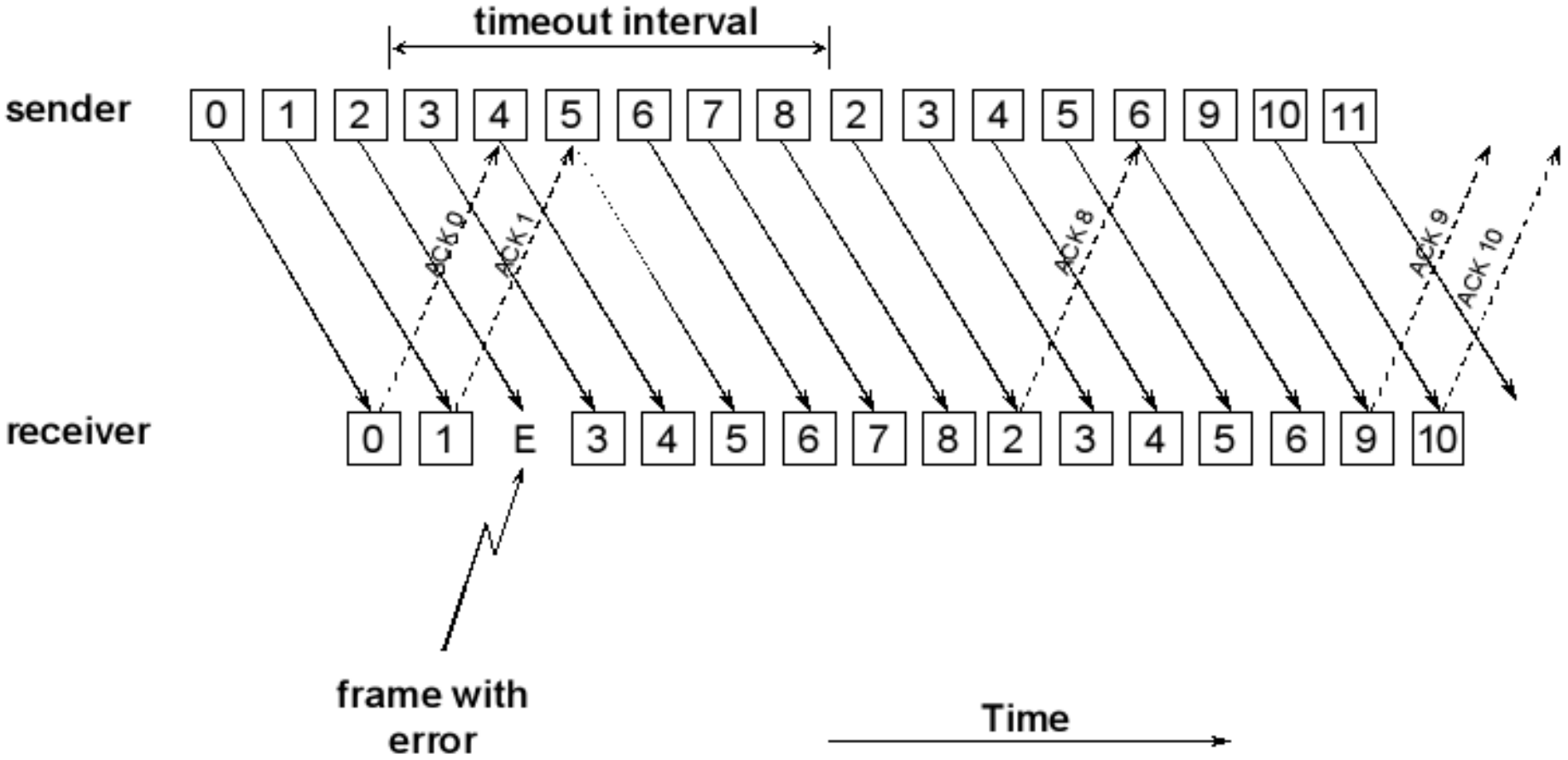
- **Source transmits single frame**
- **Wait for ACK**
- **If received frame damaged, discard it**
  - **Transmitter has timeout**
  - **If no ACK within timeout, retransmit**
- **If ACK damaged,transmitter will not recognize it**
  - **Transmitter will retransmit**
  - **Receive gets two copies of frame**
  - **Use ACK0 and ACK1**



Go Back N


timeout interval
sender
receiver
0 1 2 3 4 5 6 7 8 2 3 4 5 6 7 8 9 10
ACK 0
ACK 1
ACK 2
ACK 3
ACK 4
ACK 5
ACK 6
ACK 7
0 1 E D D D D D D 2 3 4 5 6 7 8
discarded by receiver
frame with error
Time

Selective Repeat



HDLC

- Support half/full – duplex over point-to-point and multipoint links
- HDLC system characterization
  - Station types
  - Configurations
  - Communication modes
- Frames

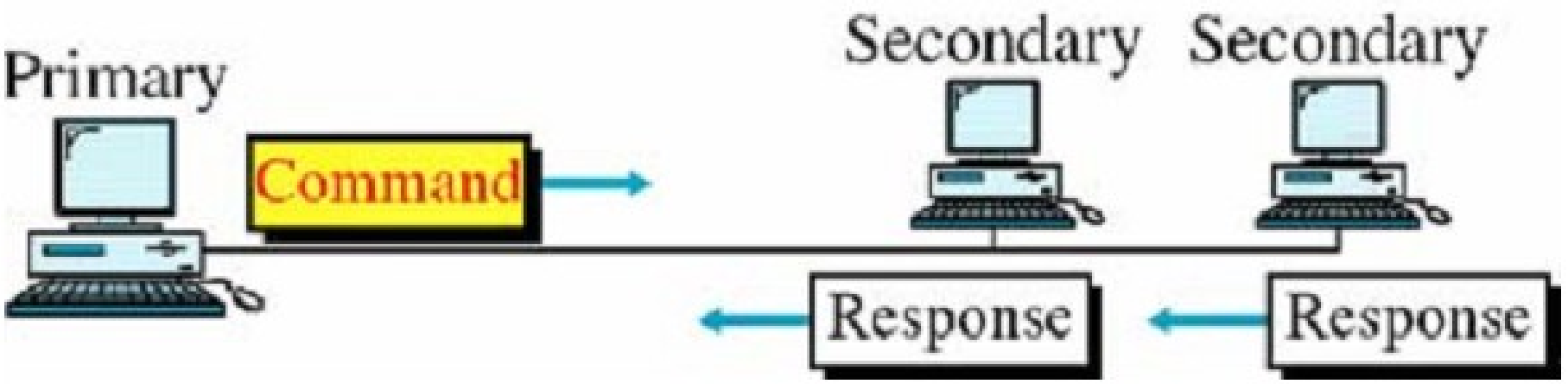
HDLC station types

- Primary station
  - The station that controls the medium by sending "command"
- Secondary station
  - The station that "response" to the primary station
- Combined station
  - The station that can both command and response

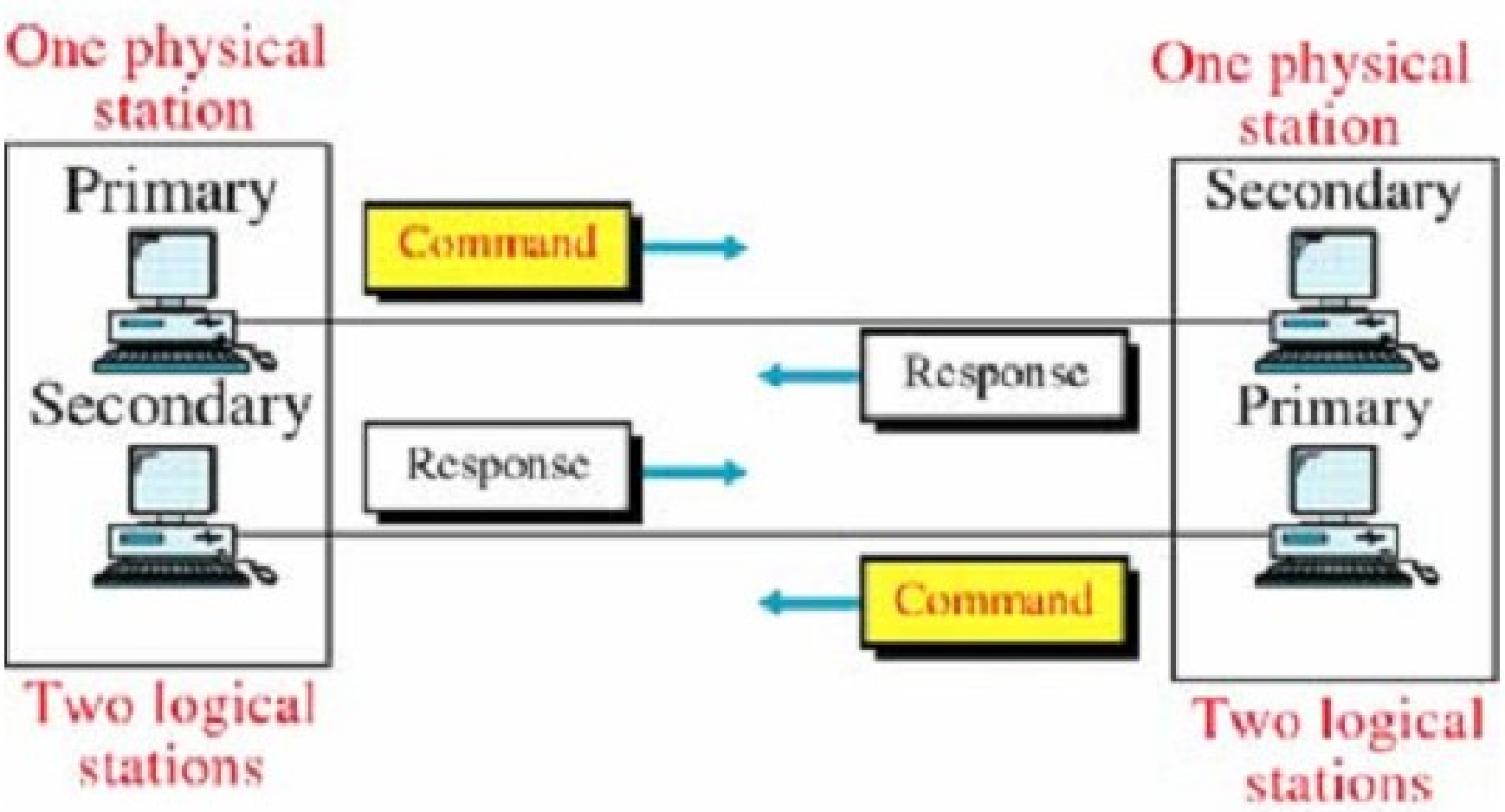
HDLC configurations

- The relationship of hardware devices on a link
- 3 configurations of all stations (primary/secondary/combined)
  - Unbalanced
  - Symmetrical
  - Balanced

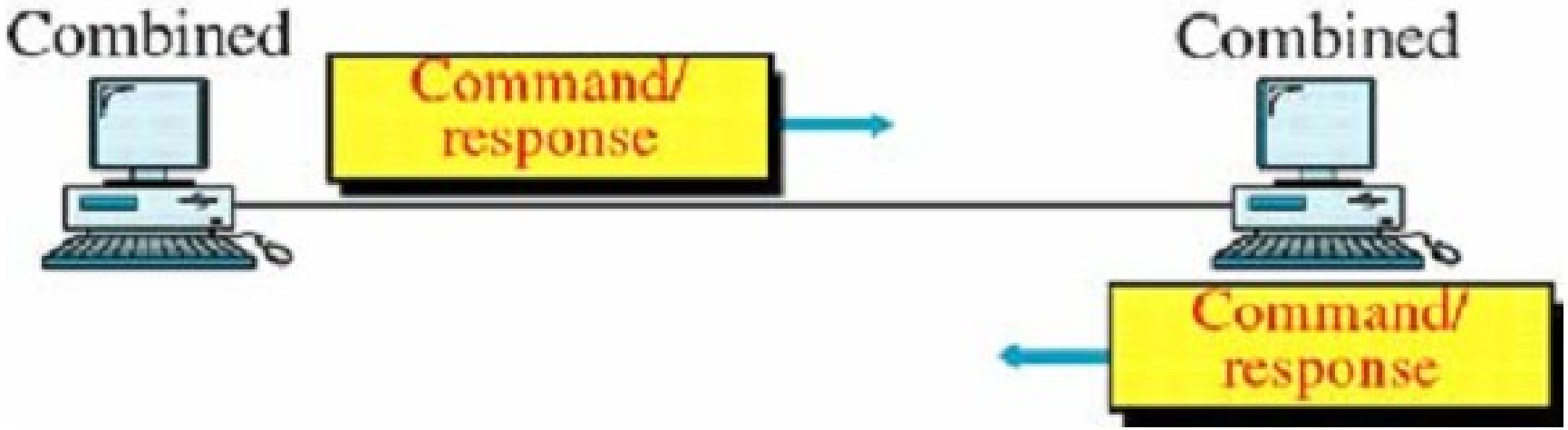
HDLC Configurations: Unbalanced (master/slave)



HDLC Configurations: Symmetrical



HDLC Configurations: Balanced



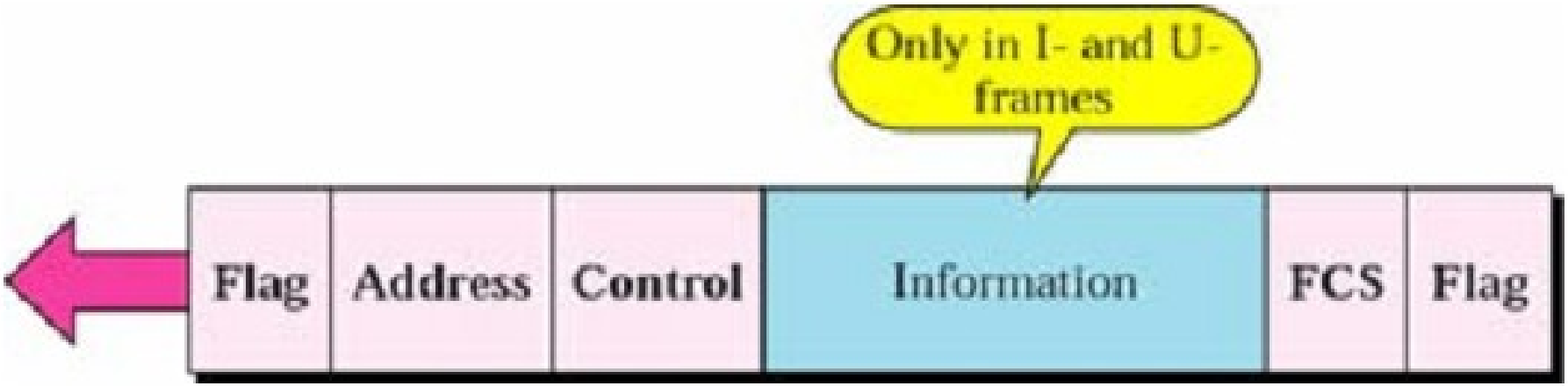
HDLC frame

- 3 frame types
  - Information frame (I-frame)
  - Supervisory frame (S-frame)

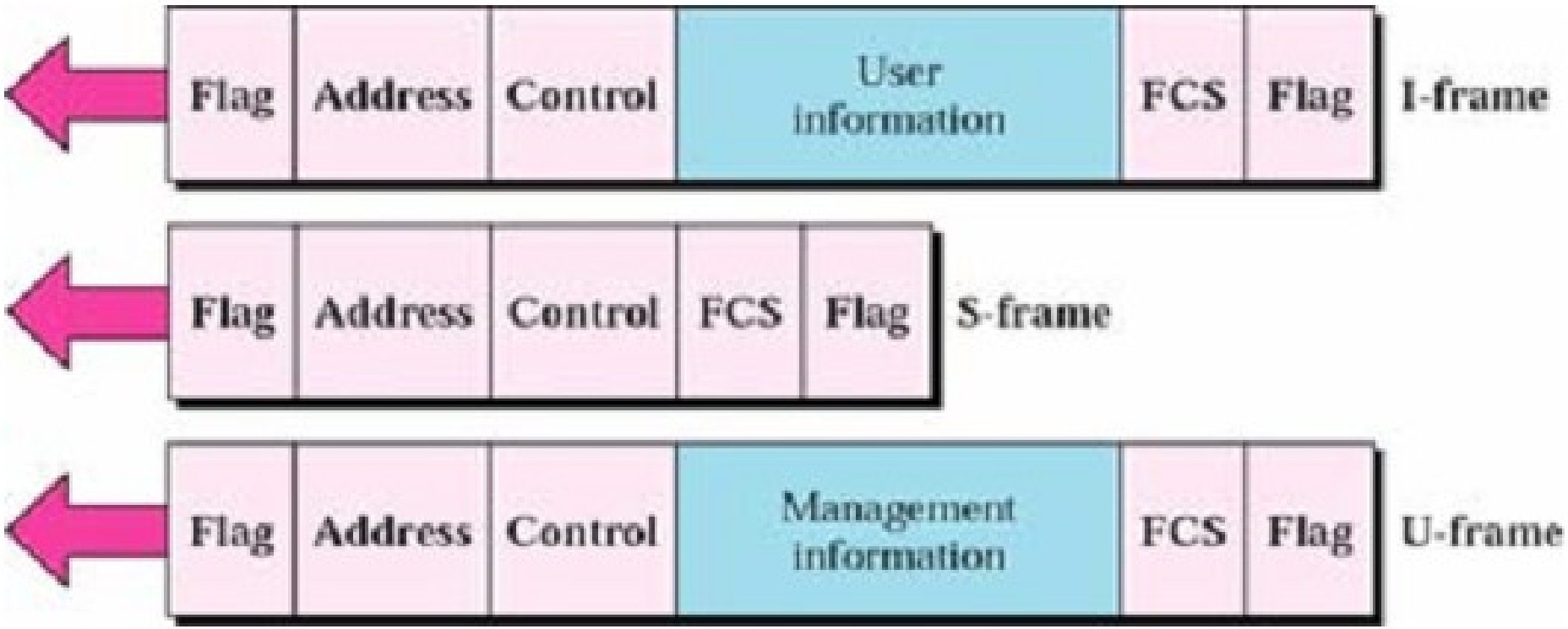
    For ACK, Flow/Error controls
  - Unnumbered frame (U-frame)

    For Mode setting, Initialize, Disconnect

HDLC Frame

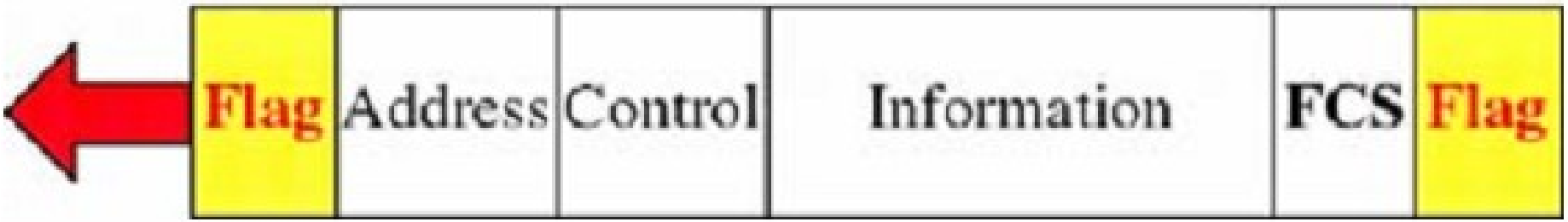

Only in I- and U-frames
Flag
Address
Control
Information
FCS
Flag

HDLC Frame


Flag
Address
Control
User information
FCS
Flag
I-frame
Flag
Address
Control
FCS
Flag
S-frame
Flag
Address
Control
Management information
FCS
Flag
U-frame

HDLC Frame: Flag field

01111110



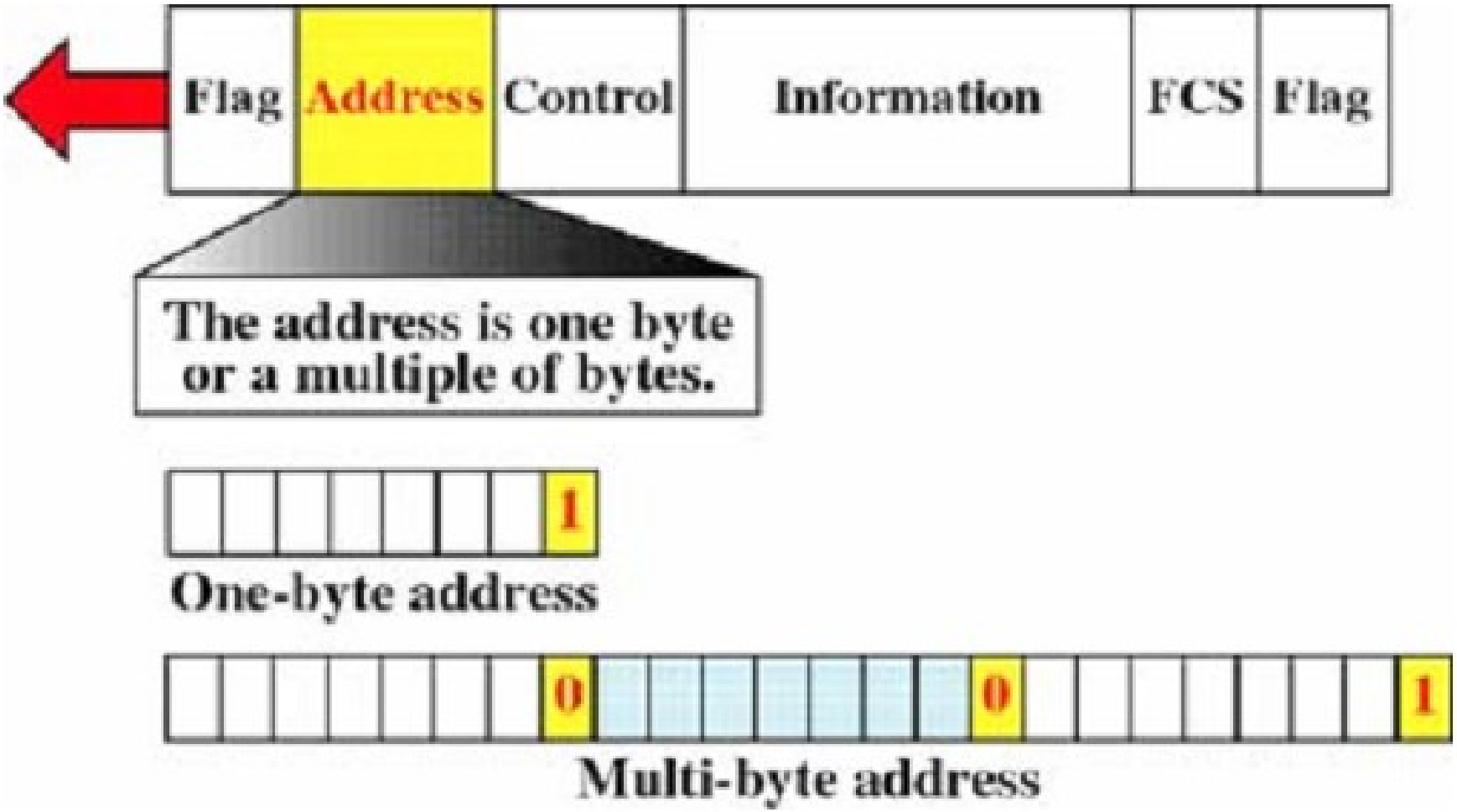
Bit Stuffing

- How to differentiate data and flag?
- Adding one extra 0 whenever there are five consecutive 1s in the data

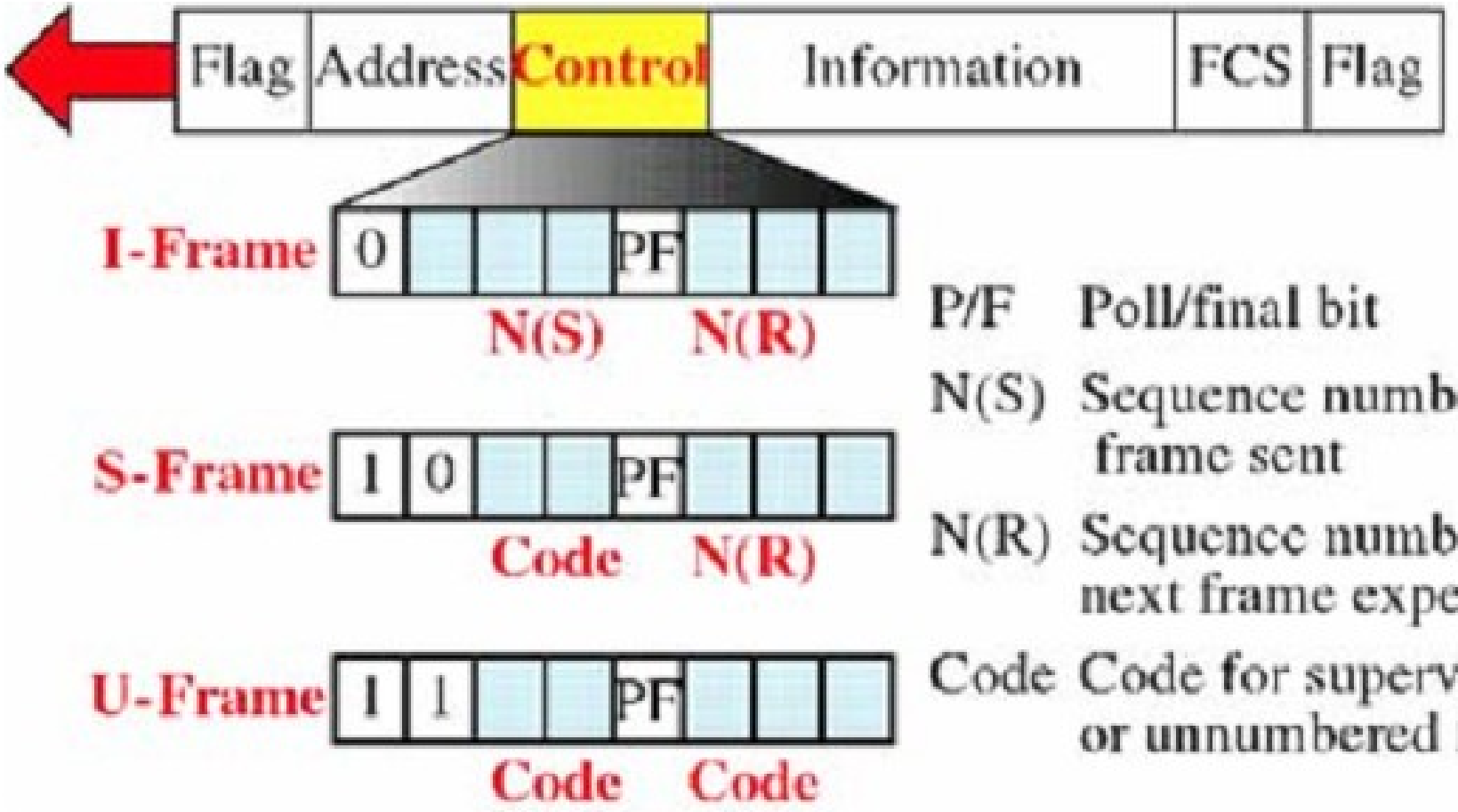
0001111111001111101000

000111110**11001111**0**01000**

HDLC Frame: Address field



HDLC Frame: Control field



P/F Poll/final bit

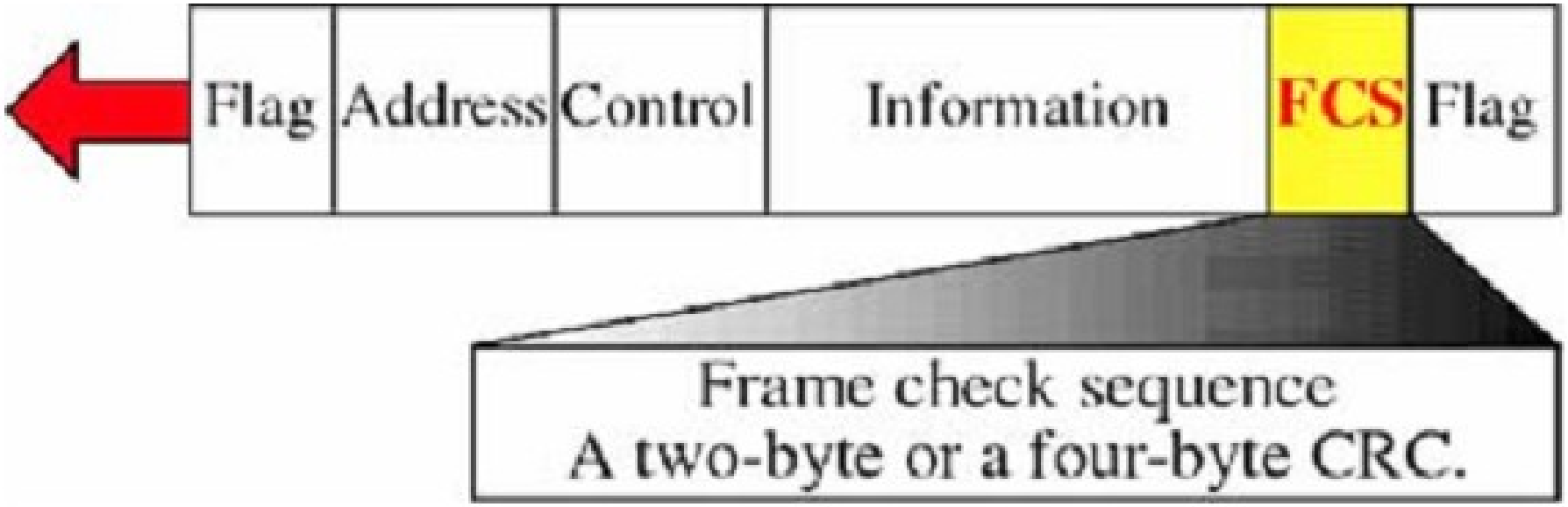
N(S) Sequence number of frame sent

N(R) Sequence number of next frame expected

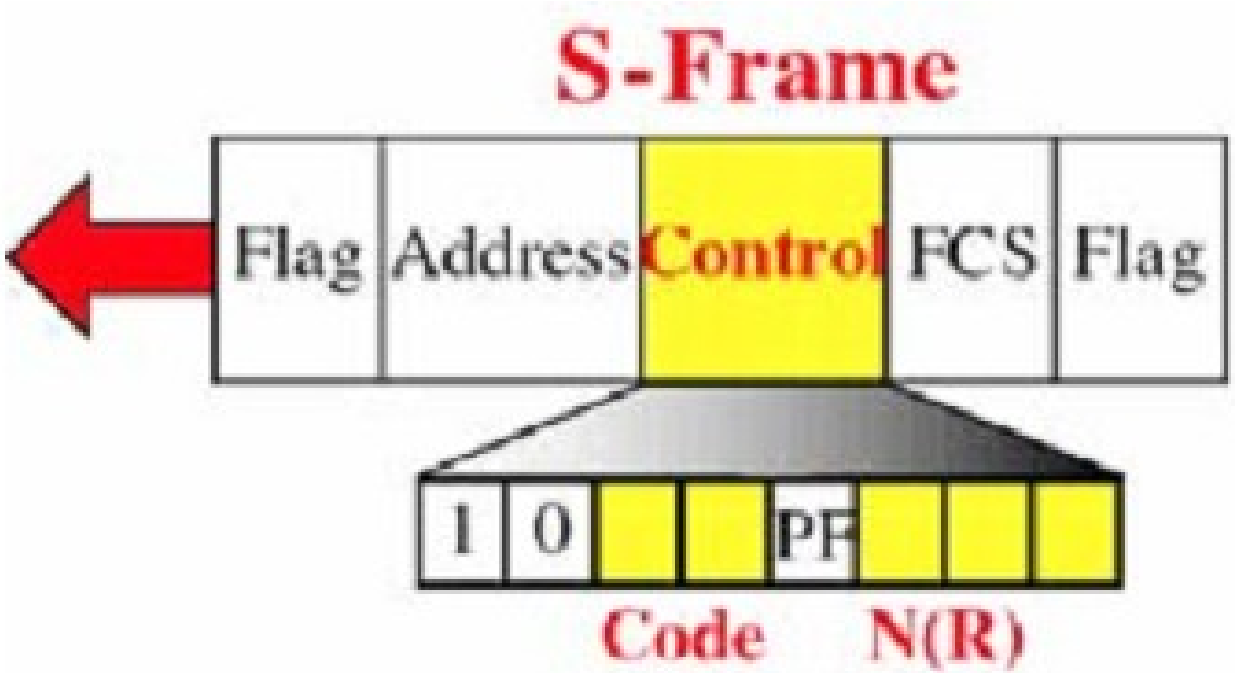
Code Code for supervisory or unnumbered frame

HDLC Frame: Information field

HDLC Frame: FCS field

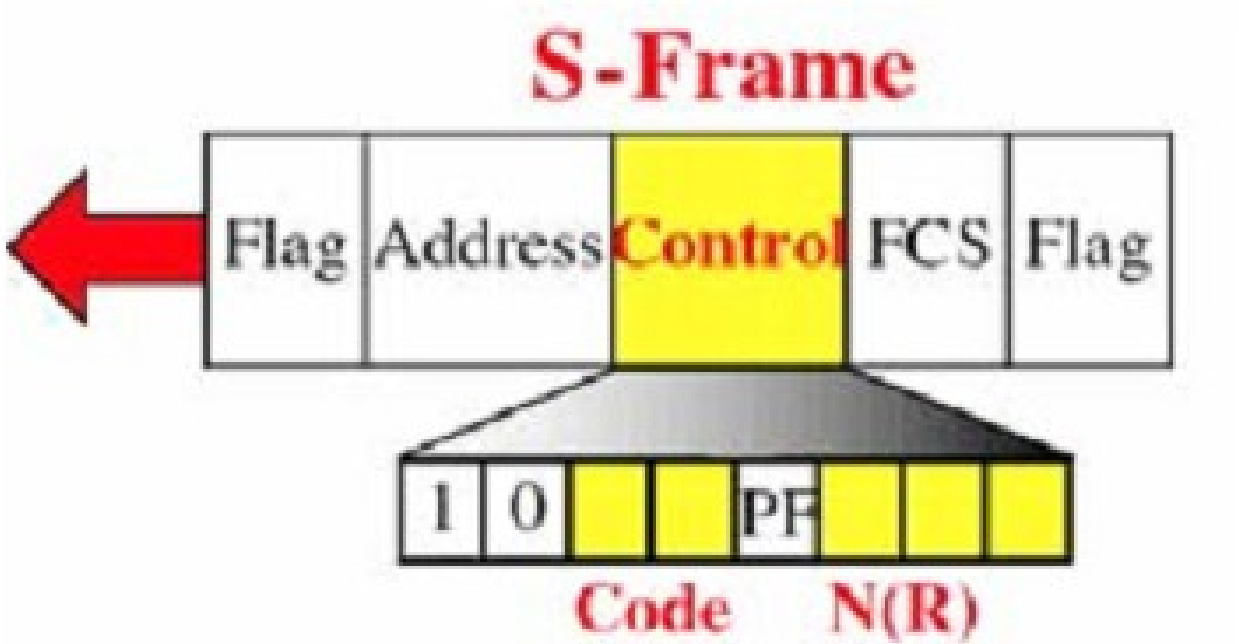


HDLC: S-Frame



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

HDLC: S-Frame Acknowledgement



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

HDLC: S-Frame
Positive Acknowledgement

- RR
  - Receiver sends "Positive Ack" (no data to send)
  - N(R) = seq of next frame
- RNR
  - Receiver sends "Positive Ack"
  - N(R) = seq of next frame
  - Receiver tells sender that sender cannot send any frame until 'RR' frame is received

HDLC: S-Frame
Negative Acknowledgement

- Reject (REJ)
  - Go-back-n ARQ
  - N(R) = # of damage frame (and follow)
- Selective-Reject (SREJ)
  - N(R) = # of damage frame