

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

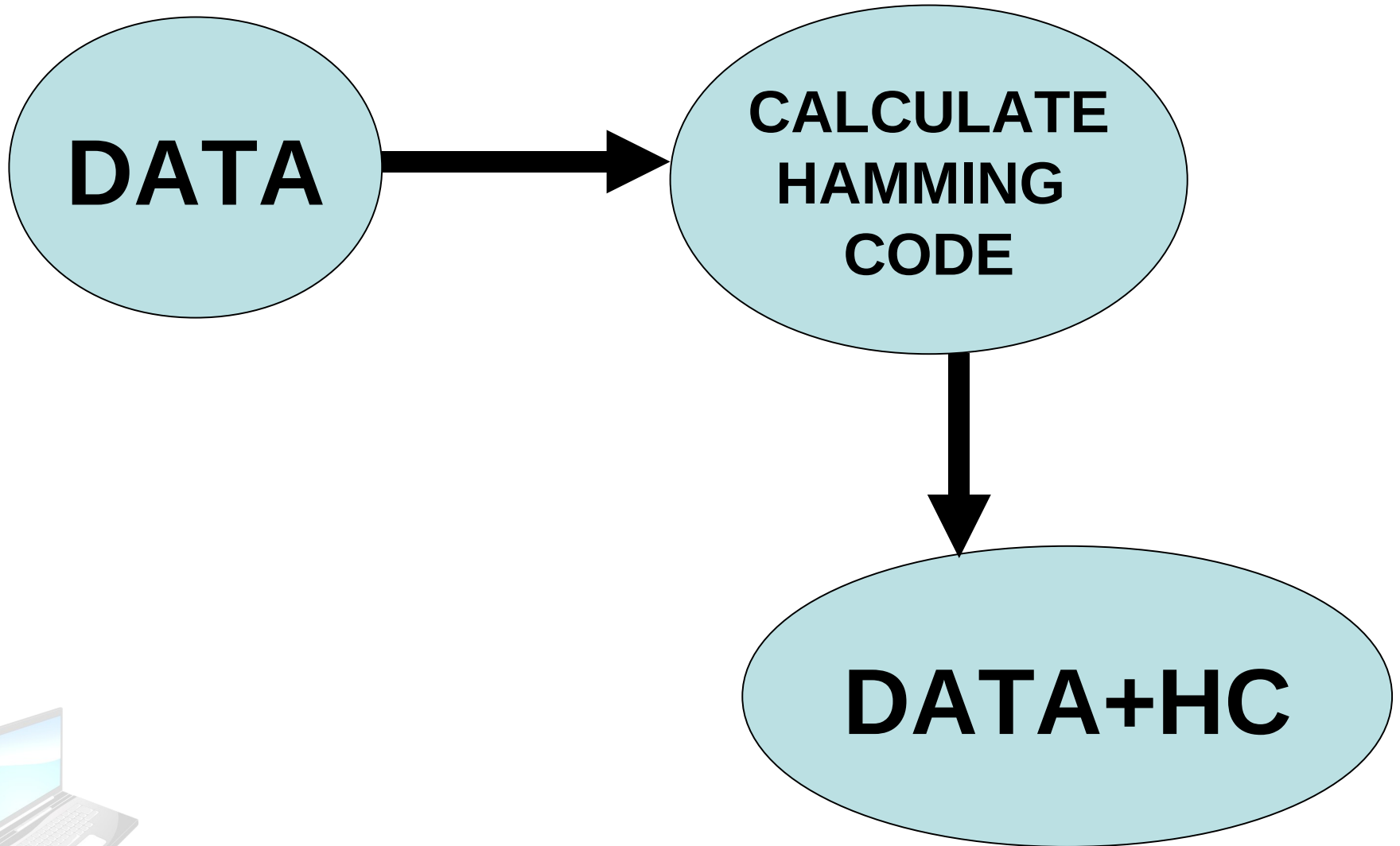


Error Detection

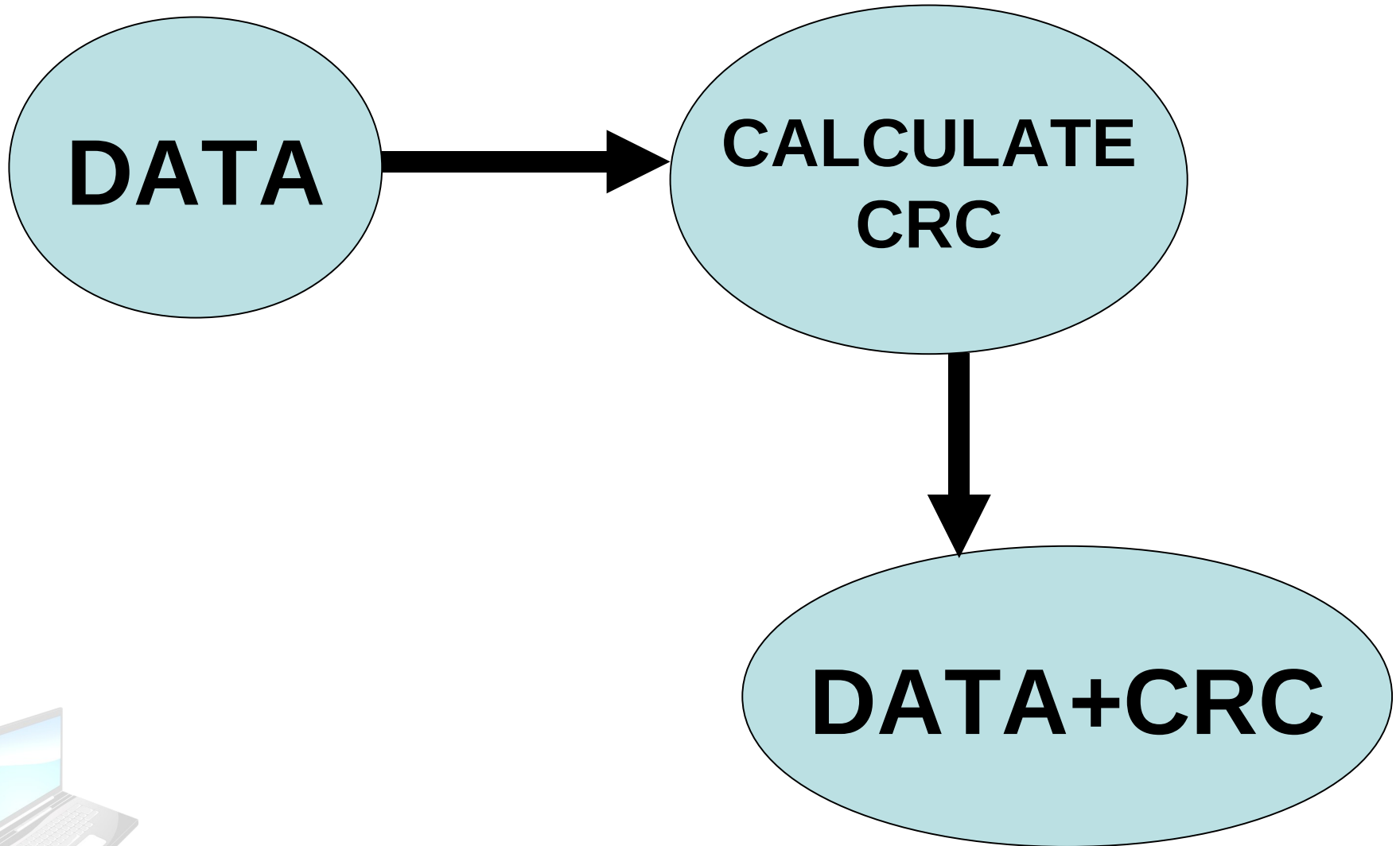
- Parity bits
- Polynomial codes or checksums



Hamming Codes



Cyclic Redundancy Check



HAMMING CODE? CRC?

- **Bagaimana cara kerjanya?**
- **Coba anda cari!!**



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

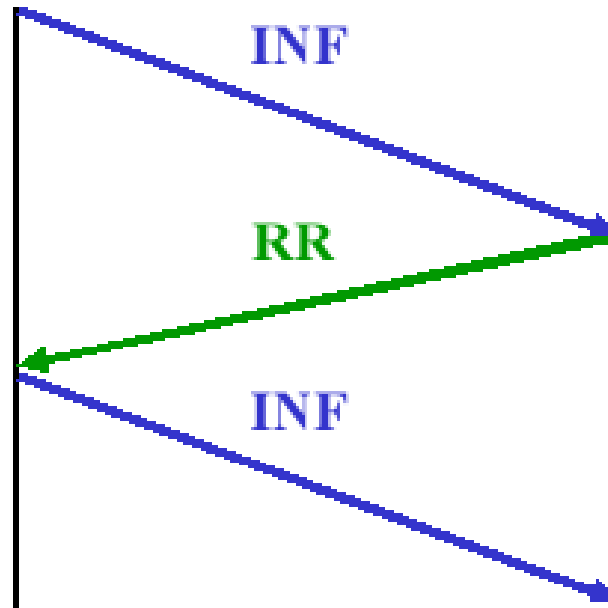


Solution: Stop-and-Wait

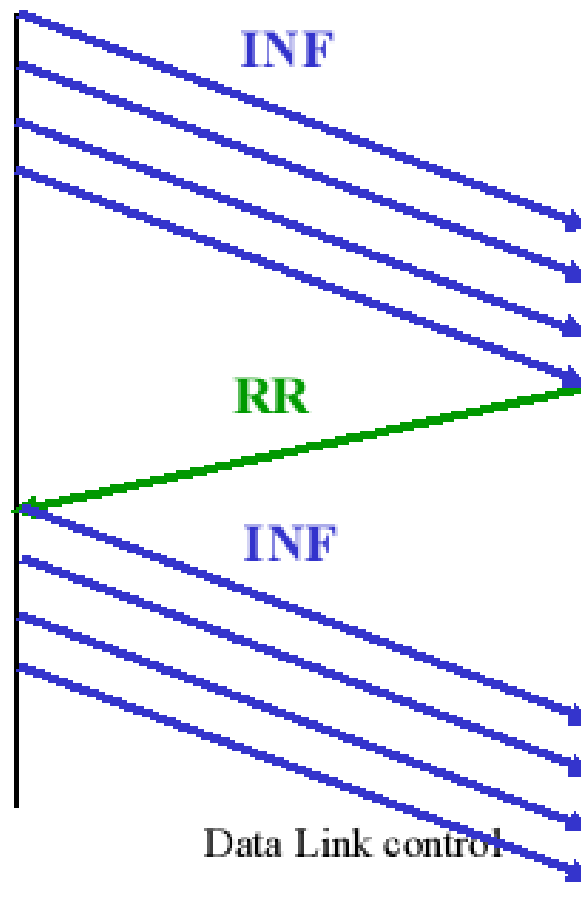
- The receiver sends an acknowledgement frame telling the sender to transmit the next data frame.
- The sender waits for the ACK, and if the ACK comes, it transmits the next data frame.



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

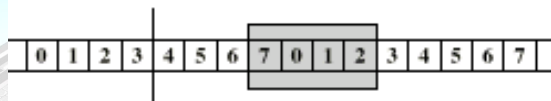
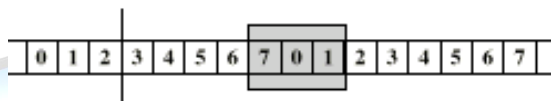
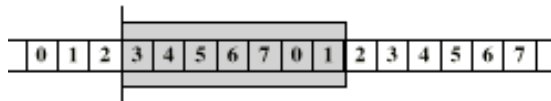
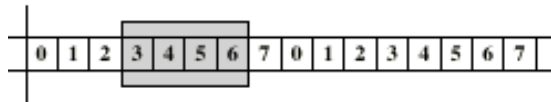
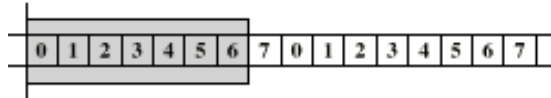


- Principle : send several frames without RR
- RR valid for a number of frames

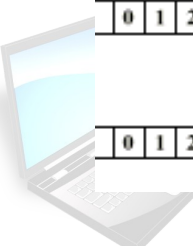
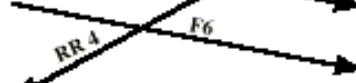
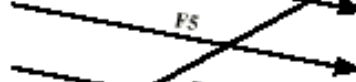
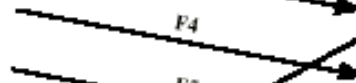
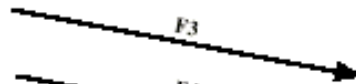
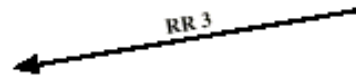
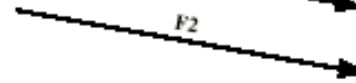
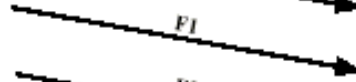
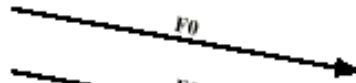
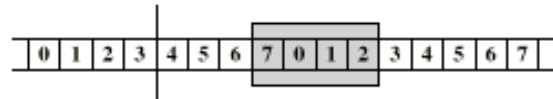
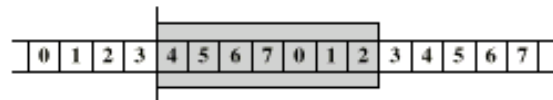
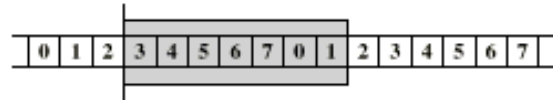
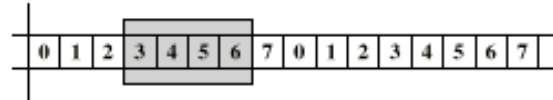
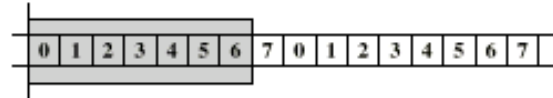


Sliding Windows

Source System A



Destination System B



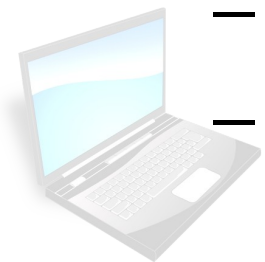
Automatic Repeat Request (ARQ)

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

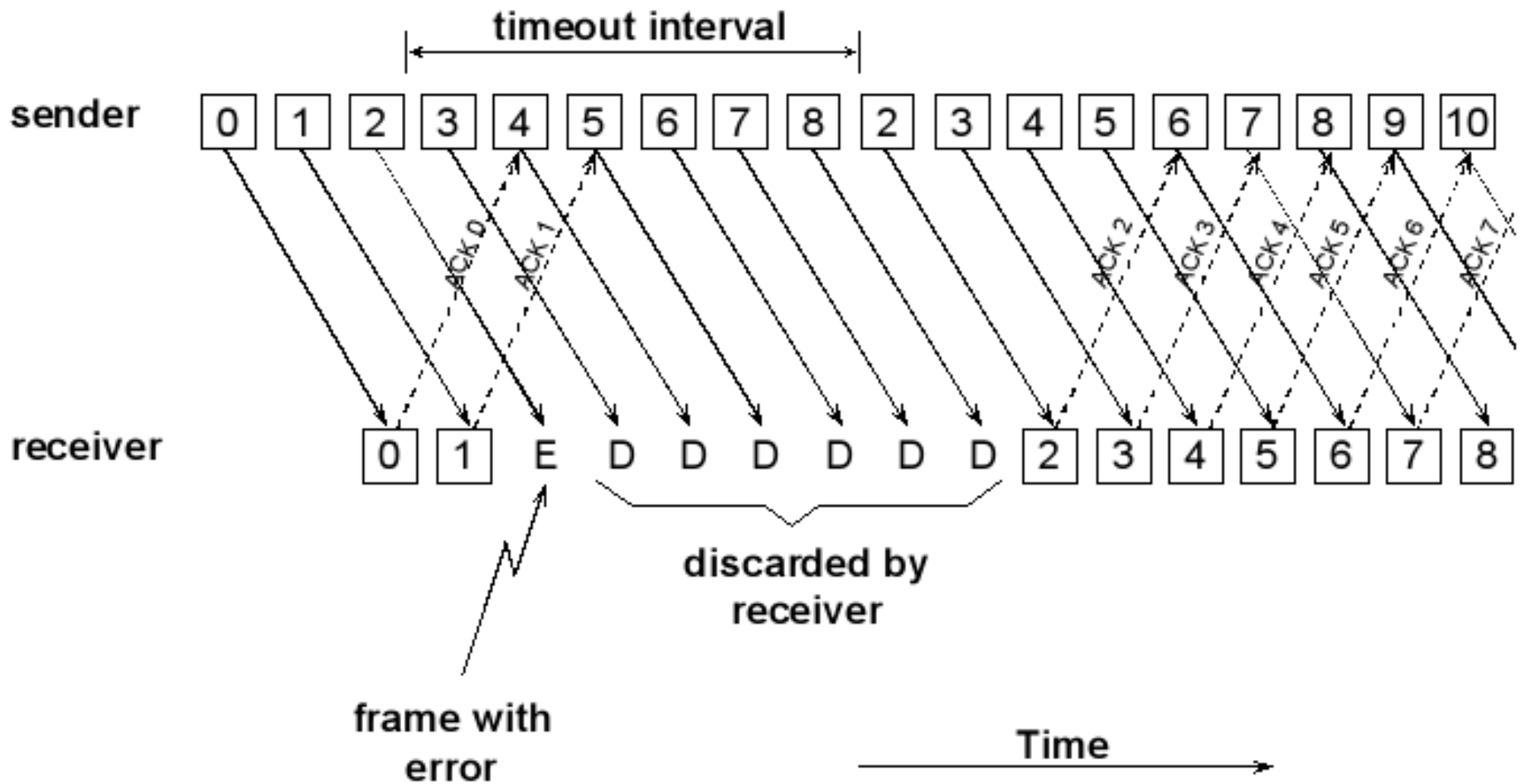


Stop and Wait

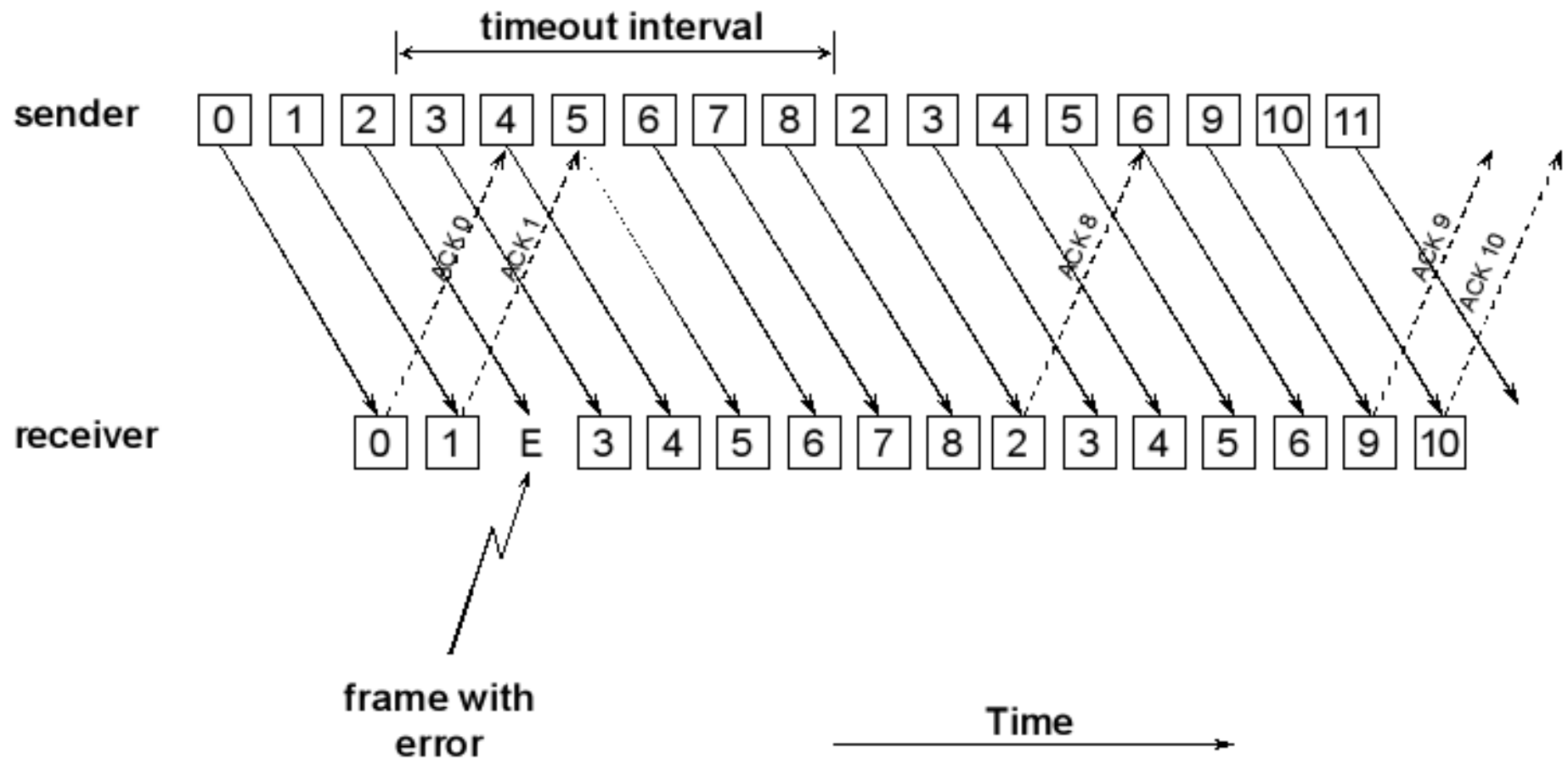
- **Source transmits single frame**
- **Wait for ACK**
- **If received frame damaged, discard it**
 - Transmitter has timeout
 - If no ACK within timeout, retransmit
- **If ACK damaged, transmitter will not recognize it**
 - Transmitter will retransmit
 - Receiver gets two copies of frame
 - Use ACK0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



Go Back N



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

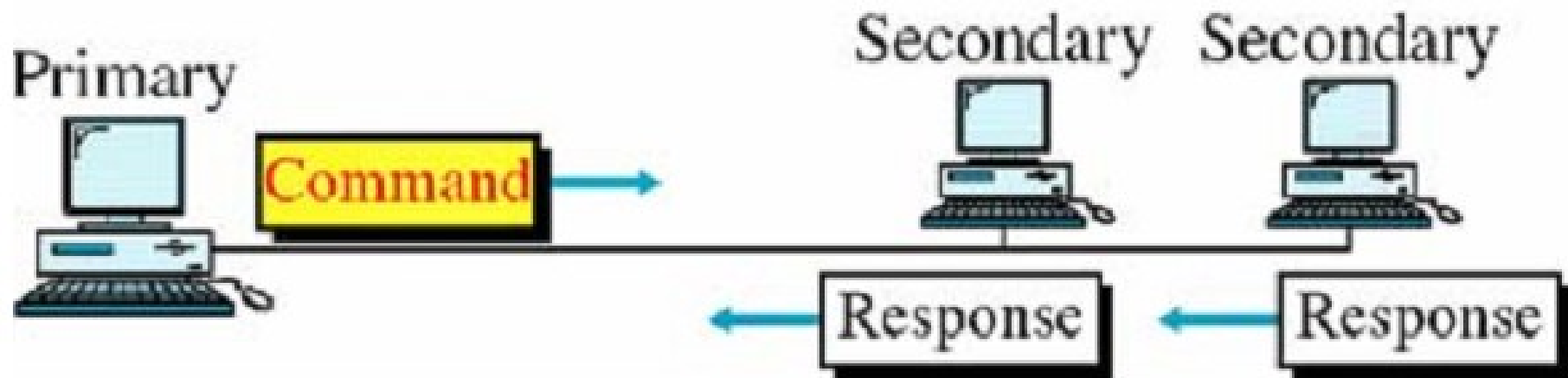


HDLC configurations

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

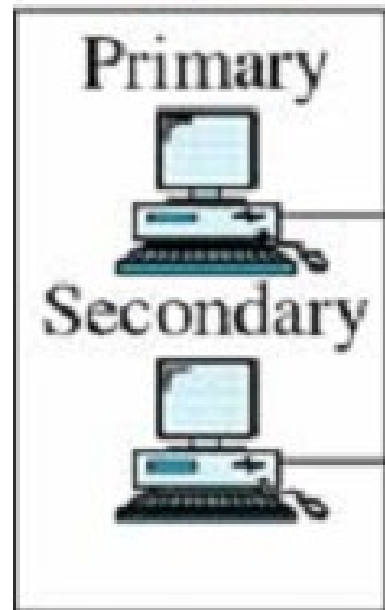


HDLC Configurations: Unbalanced (master/slave)



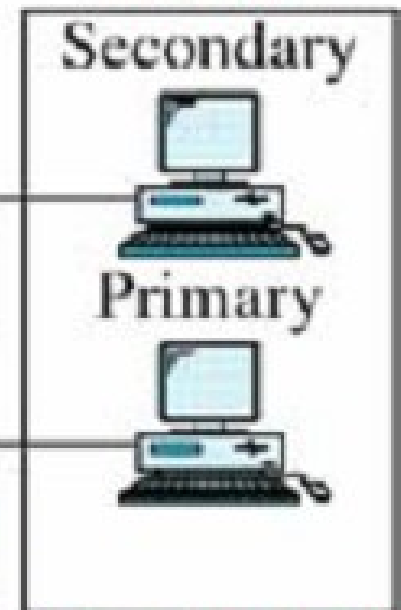
HDLC Configurations: Symmetrical

One physical station



Two logical stations

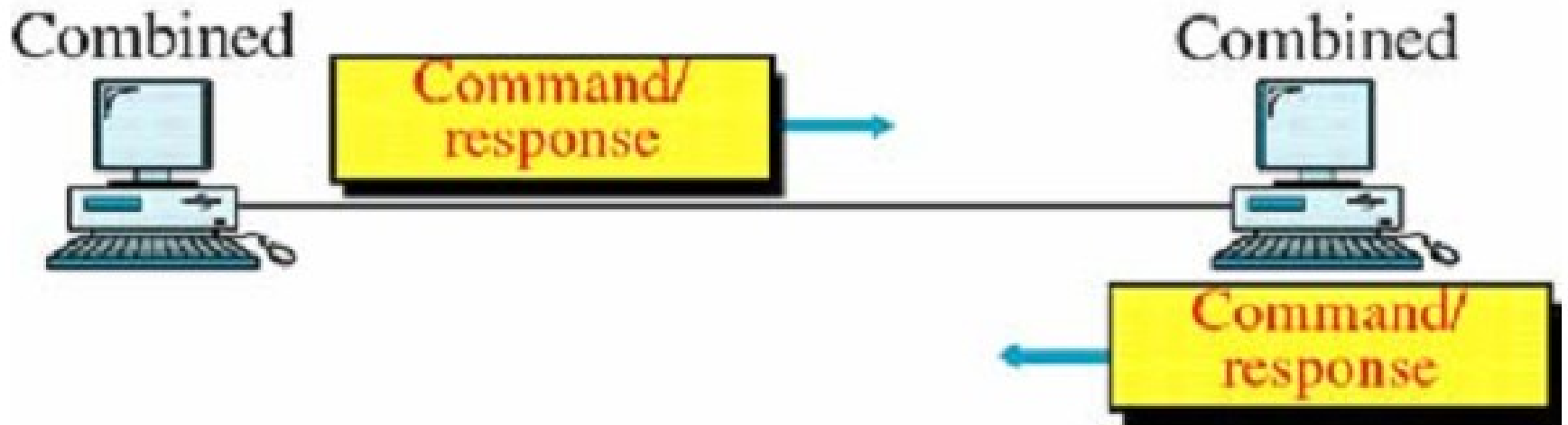
One physical station



Two logical stations



HDLC Configurations: Balanced

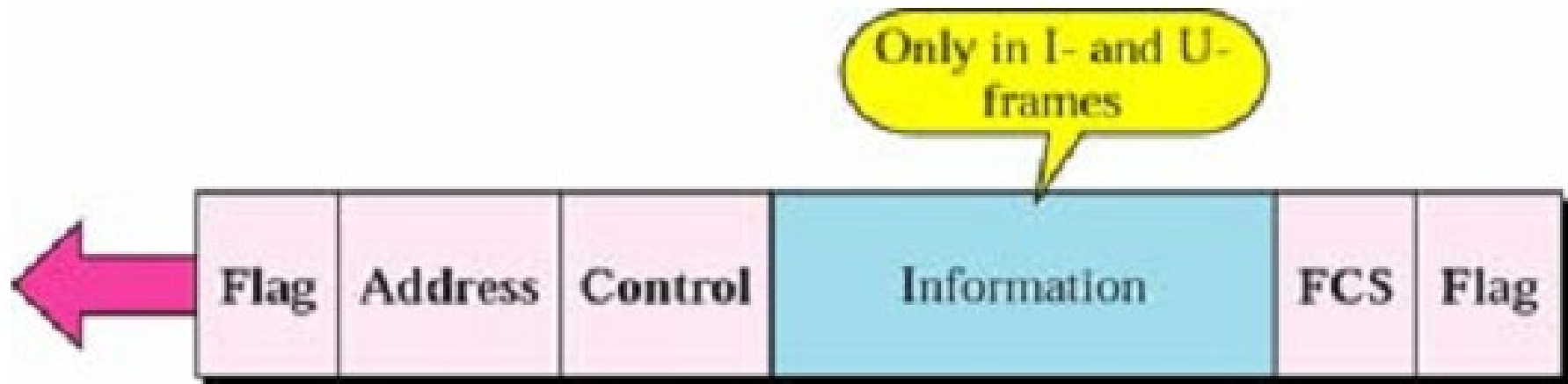


HDLC frame

- 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

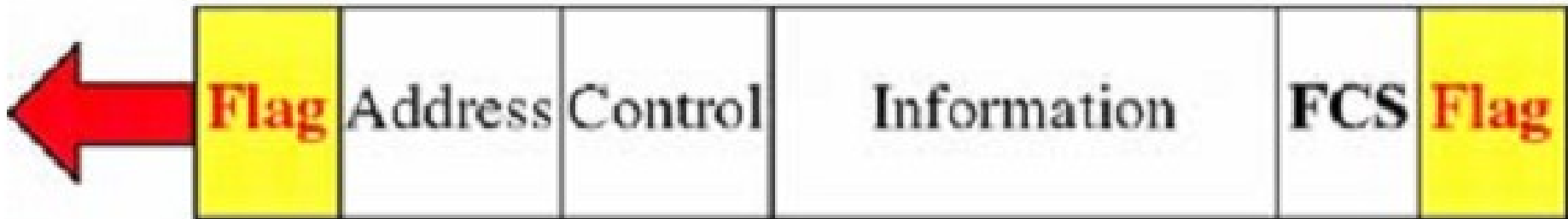


HDLC Frame



HDLC Frame: Flag field

01111110



Bit Stuffing

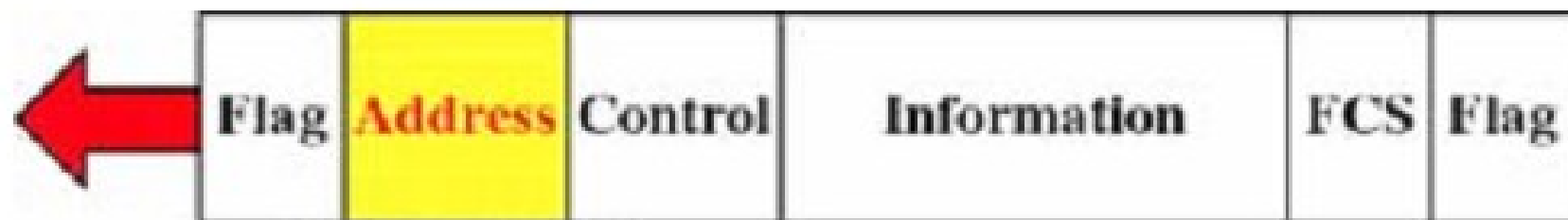
- How to differentiate data and flag?
- Adding one extra 0 whenever there are five consecutive 1s in the data

0001111111001111101000

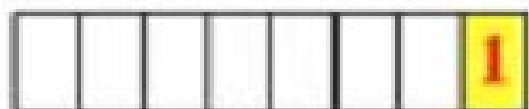
00011111**0**110011111**0**01000



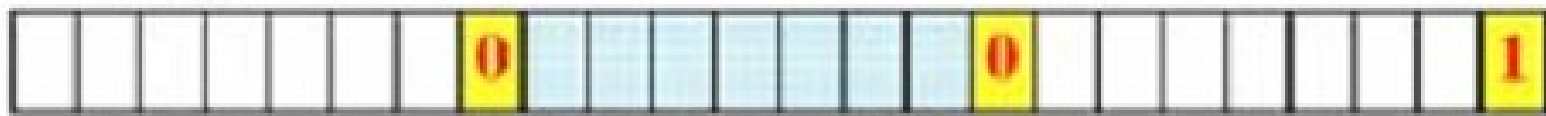
HDLC Frame: Address field



The address is one byte or a multiple of bytes.



One-byte address



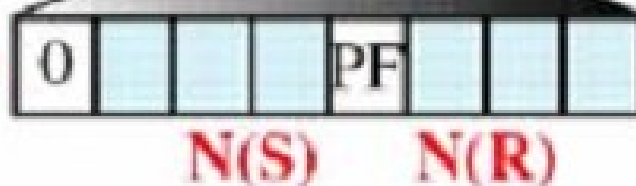
Multi-byte address



HDLC Frame: Control field



I-Frame



P/F Poll/final bit

N(S) Sequence number of frame sent

S-Frame



N(R) Sequence number of next frame expected

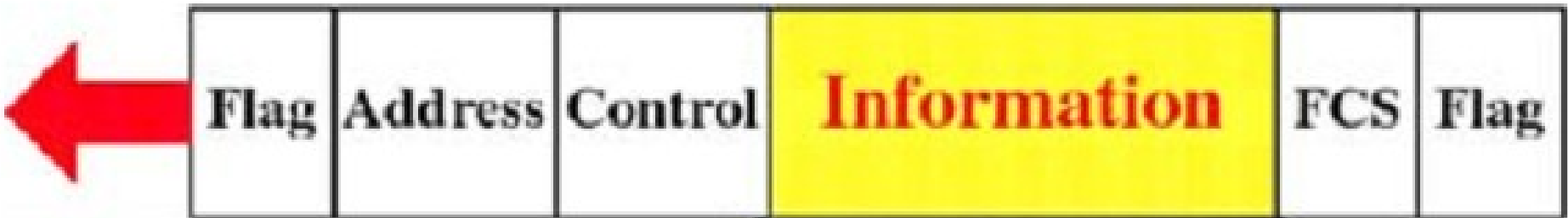
U-Frame



Code Code for supervisory or unnumbered frame



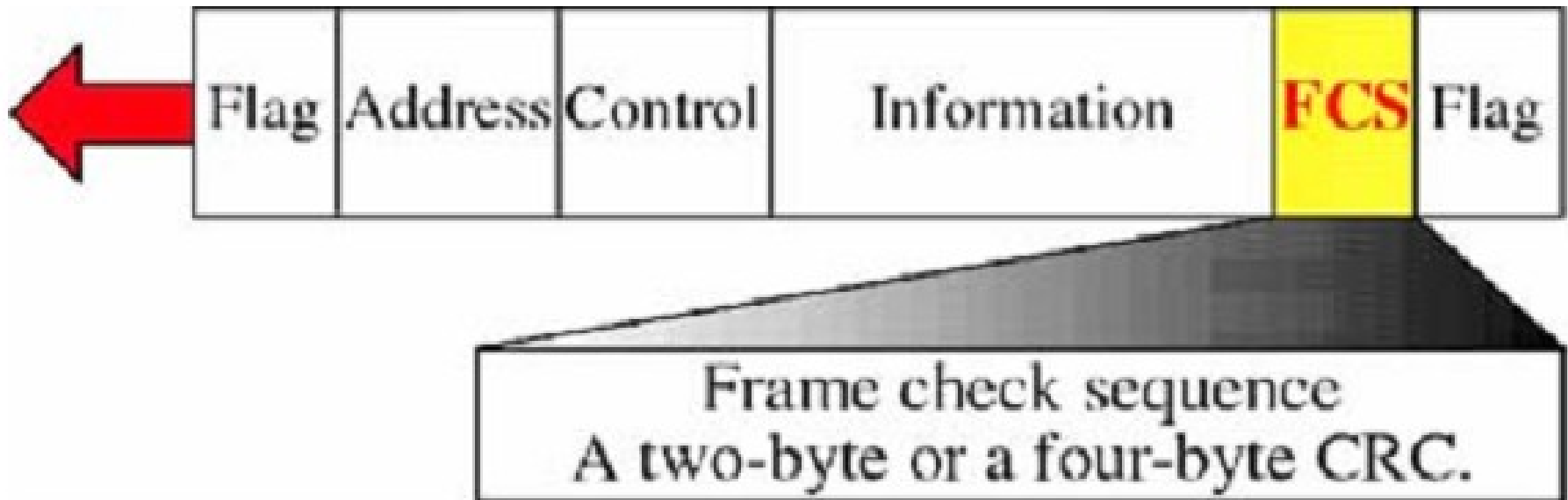
HDLC Frame: Information field



**User data in an I-Frame.
Missing in an S-Frame.
Management information in a U-frame.**

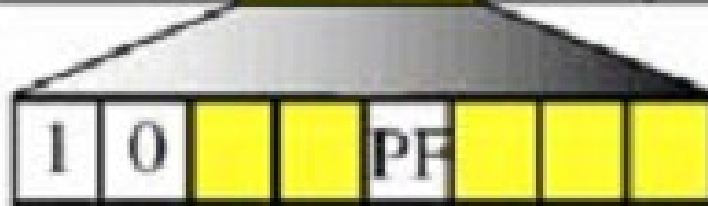


HDLC Frame: FCS field



HDLC: S-Frame

S-Frame

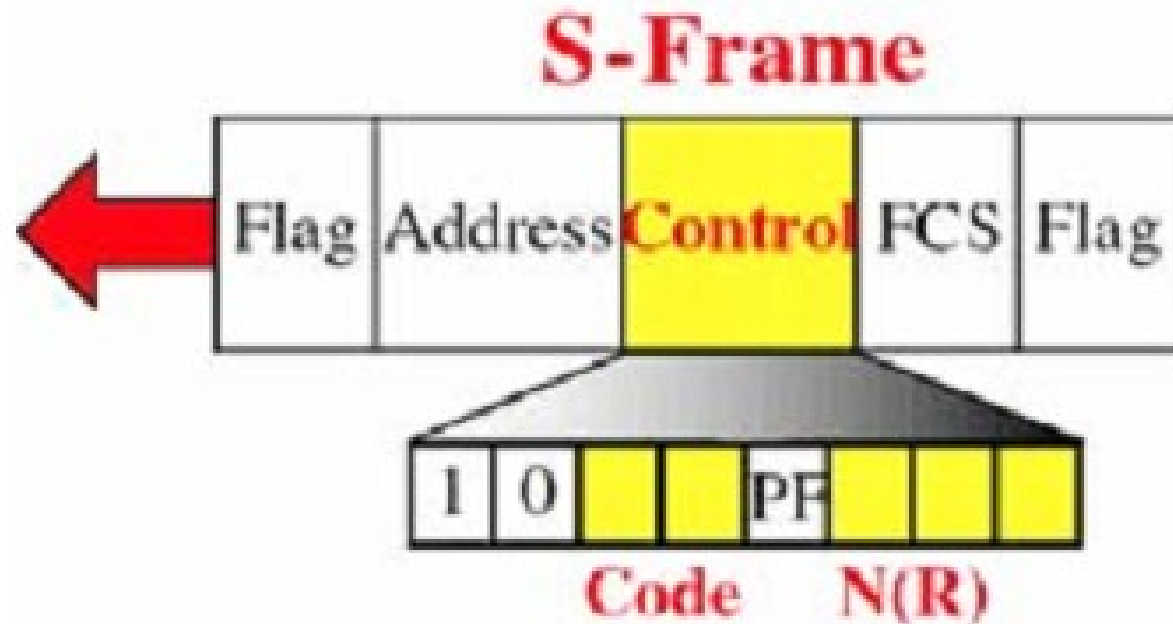


Code N(R)

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



HDLC: S-Frame Acknowledgement



<u>Code</u>	<u>Command</u>
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



