CS2031
Telecommunications II

High-level Data Link Control (HDLC)

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HDLC

- ISO 33009, ISO 4335, Used initially in X.25

  1979, ISO 3309

- It's old – so, why should we care?
  - Implements framing, addressing
  - Implements flow control mechanisms

- Do we have to learn it by heart?
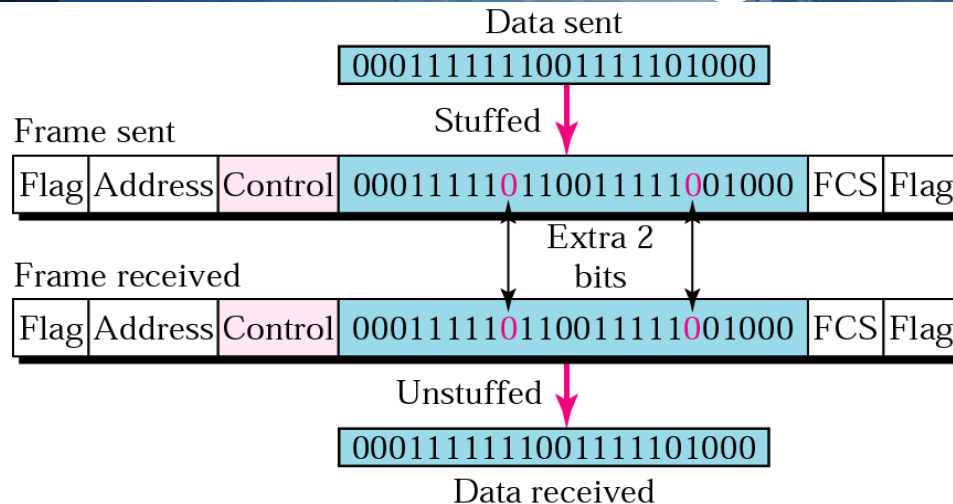 - **No** – learn the principles – not the frames layout!

HDLC frame

Only in I- and U-frames

Flag	Address	Control	Information	FCS	Flag
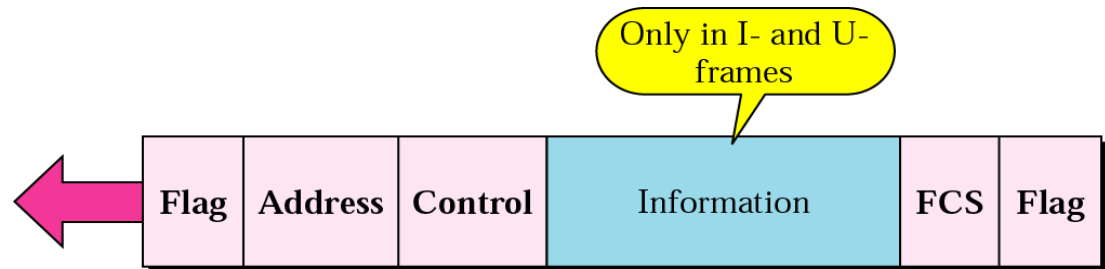
- Flag= 01111110
  - specifies beginning and end of frame

- Address
  - specifies secondary station
  - as either sender or receiver

- Control
  - specifies type of frame and seq.&ack. number

- Frame Check Sequence (FCS)
  - either 16- or 32-bit CRC

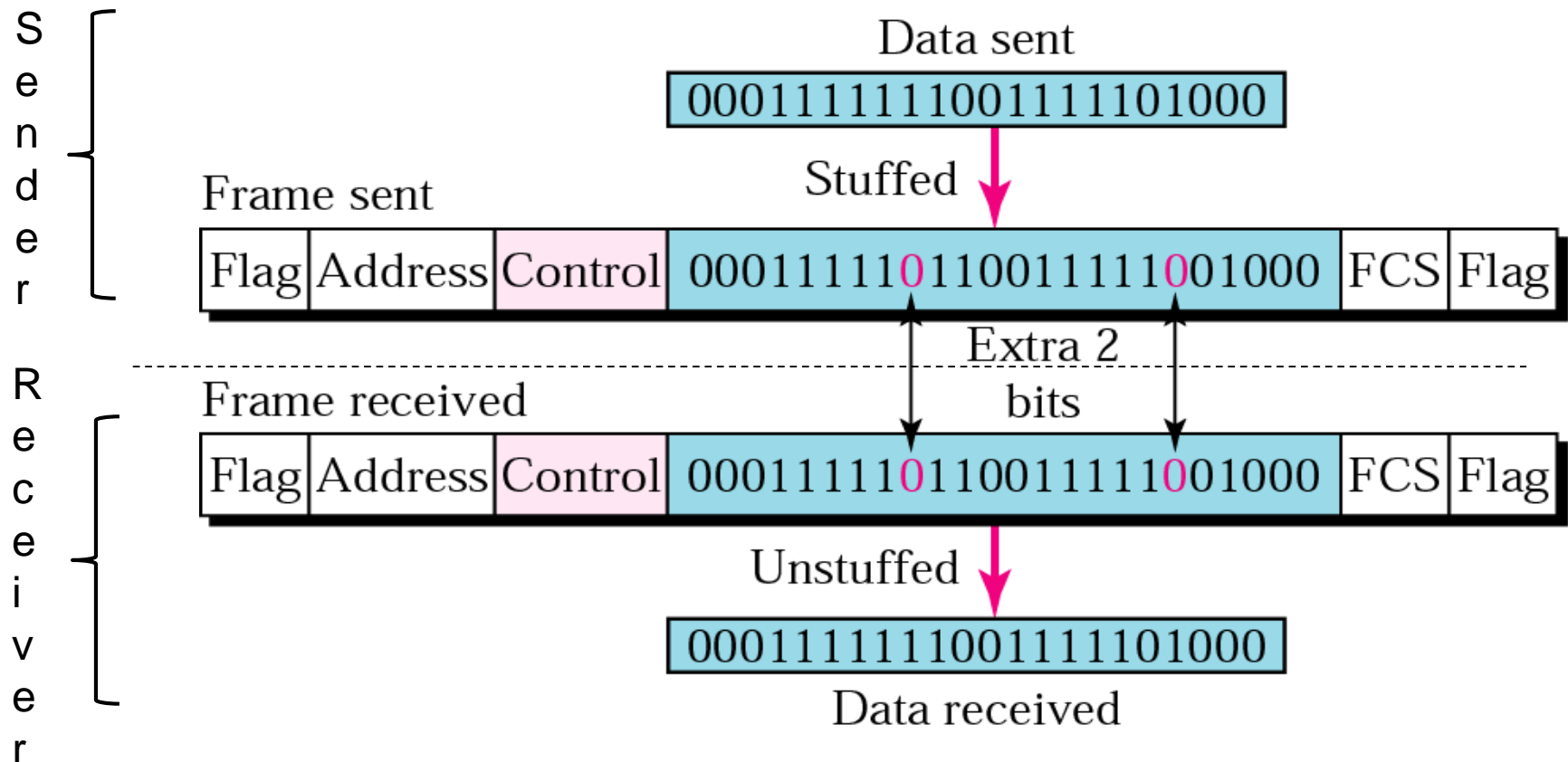* Figure is courtesy of B. Forouzan

Bit-Stuffing

Data sent

`000111111110001111101000`

Frame sent

Stuffed

| Flag | Address | Control | 000111110110011111001000 | FCS | Flag |

Extra 2 bits

Frame received

| Flag | Address | Control | 000111110110011111001000 | FCS | Flag |

Unstuffed

`000111111110001111101000`

Data received

- Bit stuffing used to avoid confusion with data containing same combination as flag 01111110
    - 0 inserted after every sequence of five 1s
    - If receiver detects five 1s
        - it checks next bit
        - If 0, it is deleted
        - If 1 and seventh bit is 0, accept as flag
        - If sixth and seventh bits 1, sender is indicating abort
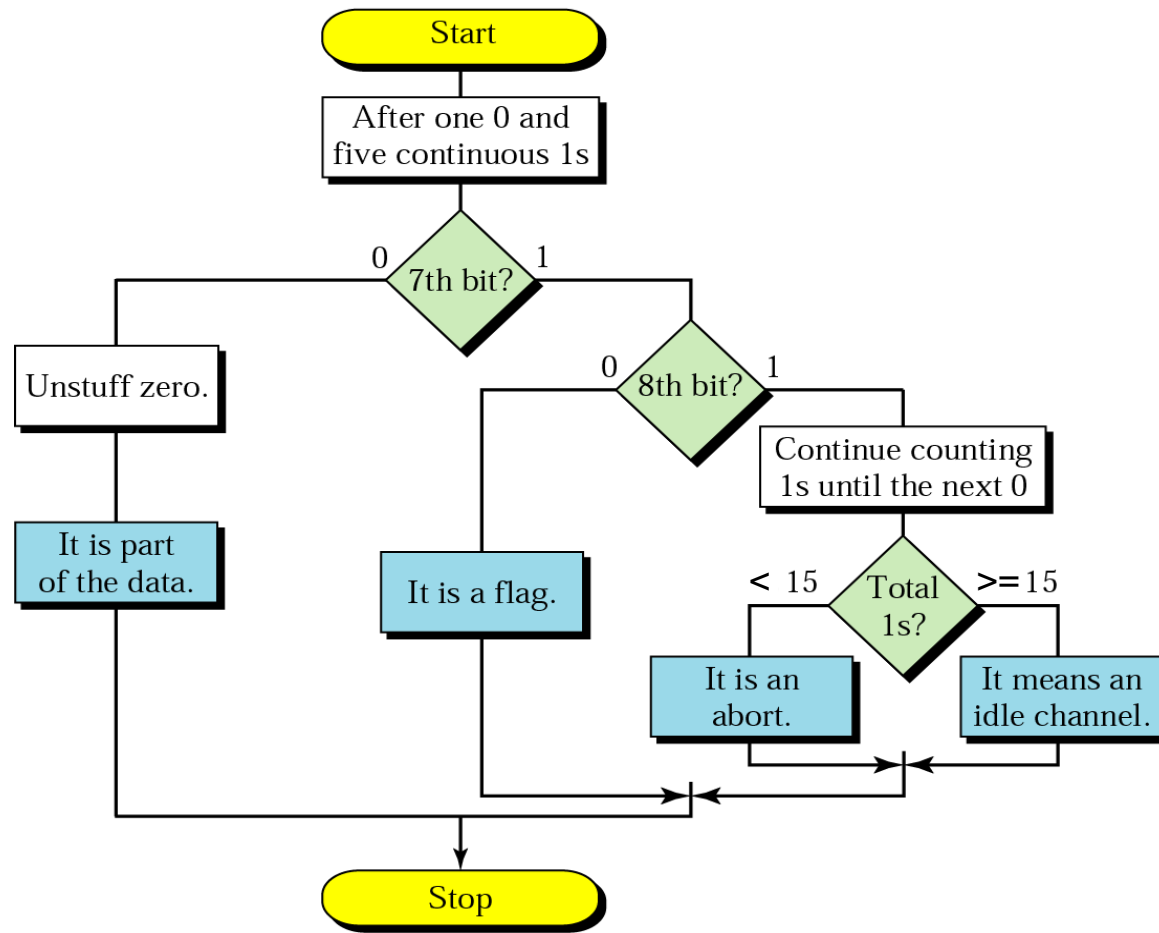
* Figure is courtesy of B. Forouzan

Bit Stuffing

Sender

Data sent
`000111111100111110 1000`

Stuffed

Frame sent

| Flag | Address | Control | `0001111101100111110 01000` | FCS | Flag |

Extra 2 bits

Receiver

Frame received

| Flag | Address | Control | `0001111101100111110 01000` | FCS | Flag |

Unstuffed

Data received
`000111111100111110 1000`

Process of adding 0 whenever there is a flag or escape sequence in the text.

Bit stuffing in HDLC

* Figure is courtesy of B. Forouzan

Bit stuffing in HDLC

* Figure is courtesy of B. Forouzan

Address Field

Flag	Address	Control	Information	FCS	Flag

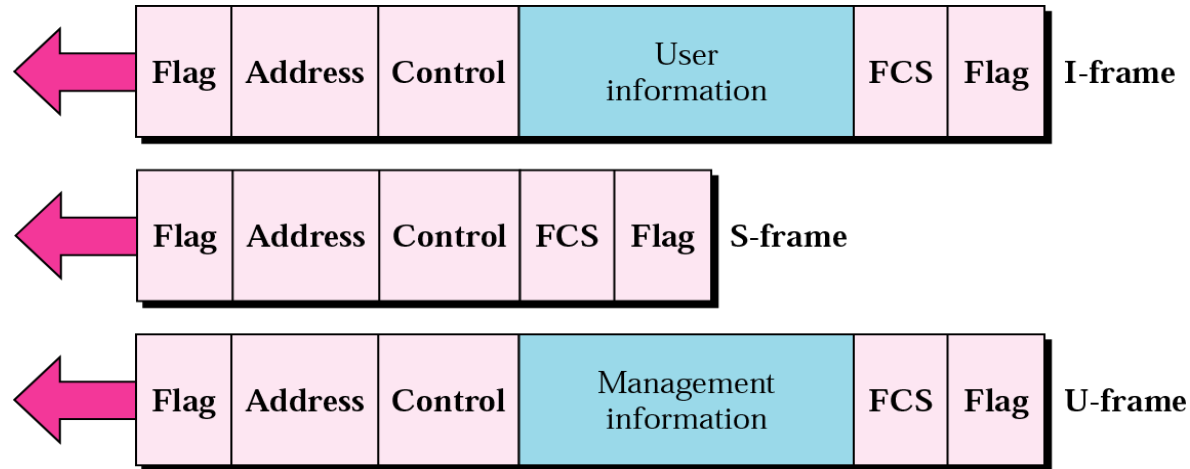←—8—→ ←—8—→ ←—8 or 16—→ ←——variable——→ ←—16 or 32—→ ←—8—→
bits   extendable
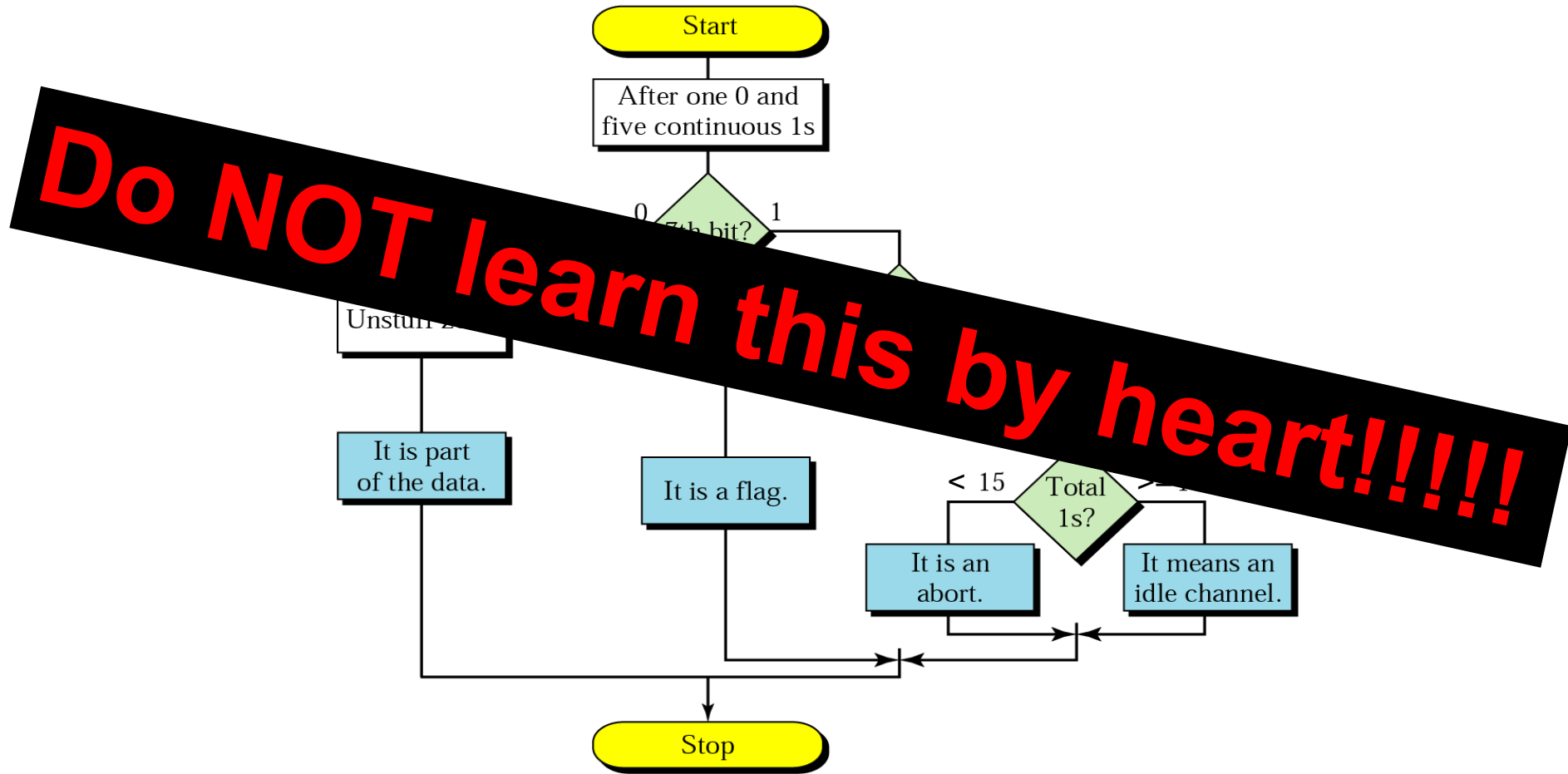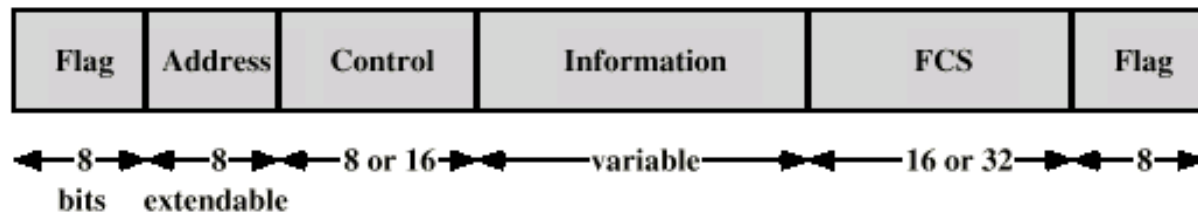
- Usually 8 bits long
- May be extended to multiples of 7 bits
  - LSB of each octet indicates that it is the last octet (1) or not (0)
- All ones (11111111) is broadcast

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 ... 8n

| 0 | | 0 | | ... | 1 | |

* Figure is courtesy of W. Stallings

HDLC Frame Types

| 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 |

- I-Frame: Information Transfer Format
  - Control= | 0 | ? | ? | ? | ? | ? | ? | ? |
- S-Frame: Supervisory Format
  - Control= | 1 | 0 | ? | ? | ? | ? | ? | ? |
- U-Frame: Unnumbered Format
  - Control= | 1 | 1 | ? | ? | ? | ? | ? | ? |

* Figure is courtesy of B. Forouzan

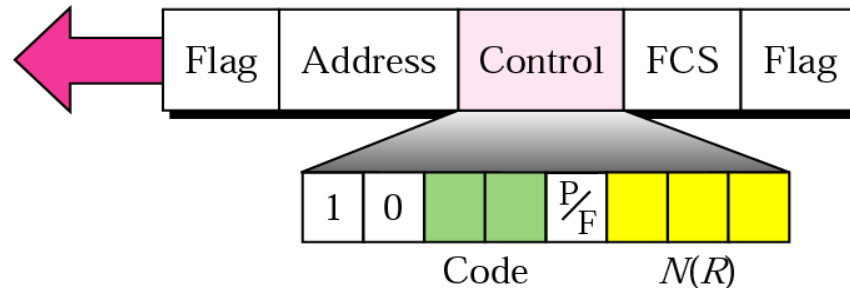# I-Frame
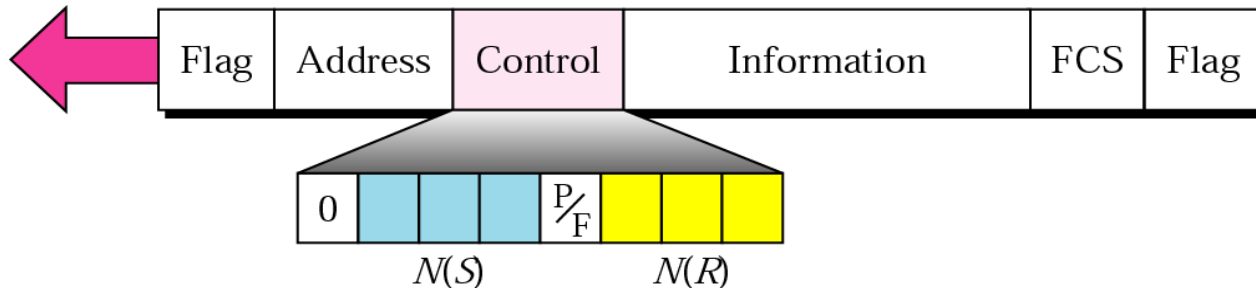
- N(S)
  - Sequence Number of Sender
- N(R)
  - Sequence Number of Receiver
- P/F
  - Poll/Final bit
  - Set by Primary station as request for information
  - Set by Secondary station to signal response or to signal final frame of a transmission
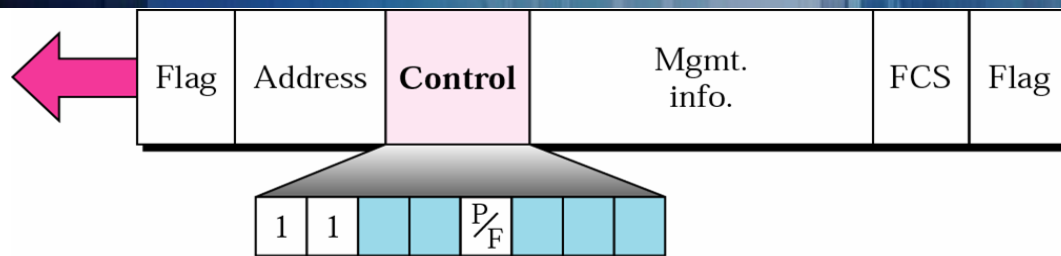
* Figure is courtesy of B. Forouzan

S-Frame Control Field

- ## Code 00 = Receive Ready (RR)

  - Acknowledge frames & waiting for more

- ## Code 10 = Receive Not Ready (RNR)

  - Acknowledge frames & busy right now

- ## Code 01 = Reject (REJ)

  - Go-Back-N NAK

- ## Code 11 = Selective Reject (SREJ)

  - Selective Repeat NAK
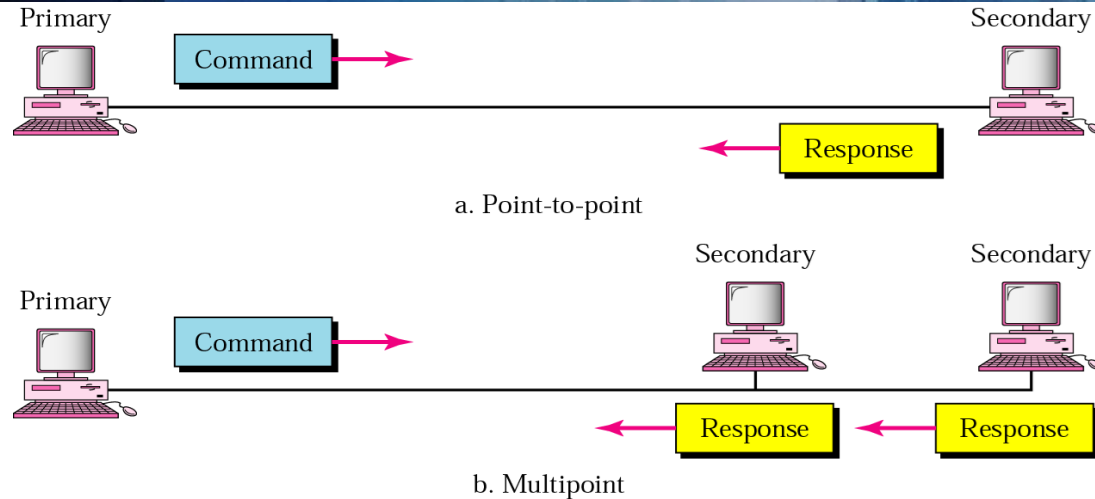
* Figure is courtesy of B. Forouzan

U-Frame Control Field

Code	Command/Response	Meaning
00 001	SNRM	Set normal response mode
11 100	SABM	Set asynchronous balanced mode
00 100	UP	Unnumbered poll
00 000	UI	Unnumbered information
00 110	UA	Unnumbered acknowledgment
00 010	DISC	Disconnect
10 000	SIM	Set initialization mode
11 001	RSET	Reset
11 101	XID	Exchange ID
10 001	FRMR	Frame reject

* Figure is courtesy of B. Forouzan

Normal Response Mode (NRM)

Primary

Command →

Secondary

← Response

a. Point-to-point
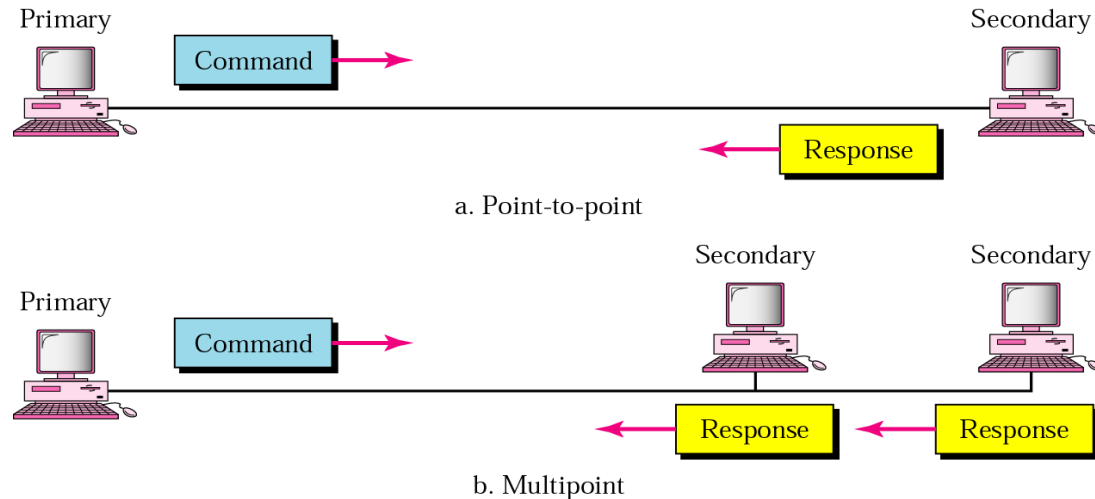
Primary

Command →

Secondary

Secondary

← Response ← Response

b. Multipoint

- Master/Slave architecture
- Unbalanced configuration
- Primary initiates transfer to secondary
- Secondary may only transmit data in response to command from primary
- Used on multi-drop lines

* Figure is courtesy of B. Forouzan

Asynchronous Response Mode (ARM)

a. Point-to-point

b. Multipoint

- Unbalanced configuration
- Secondary may initiate transmission without permission form primary
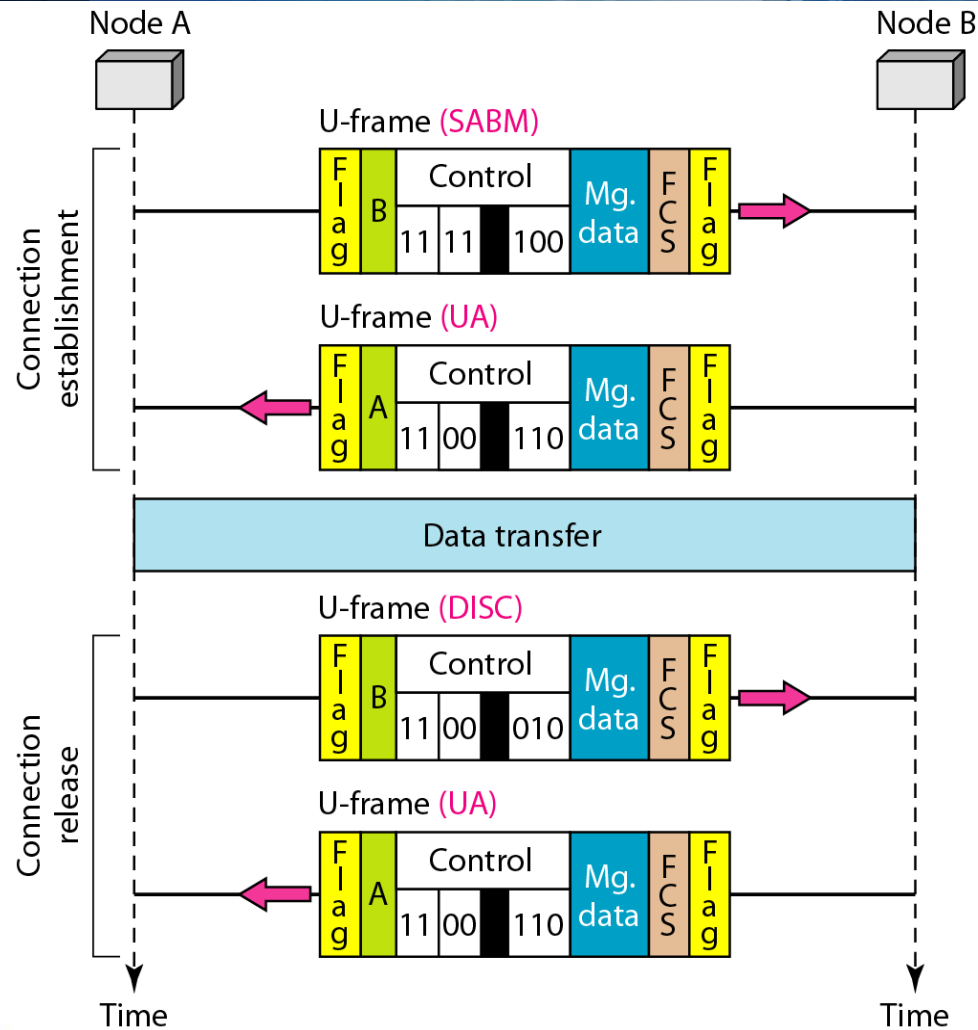- Primary responsible for line
- Rarely used

* Figure is courtesy of B. Forouzan

Asynchronous Balanced Mode (ABM)

Combined — Command/response → ← Command/response — Combined
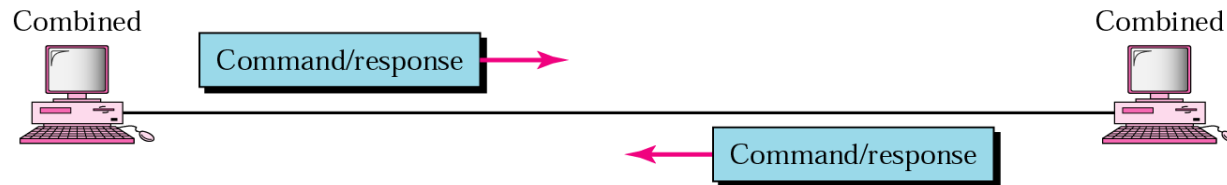
- Balanced configuration
- Either station may initiate transmission without receiving permission
- Most widely used
- No polling overhead

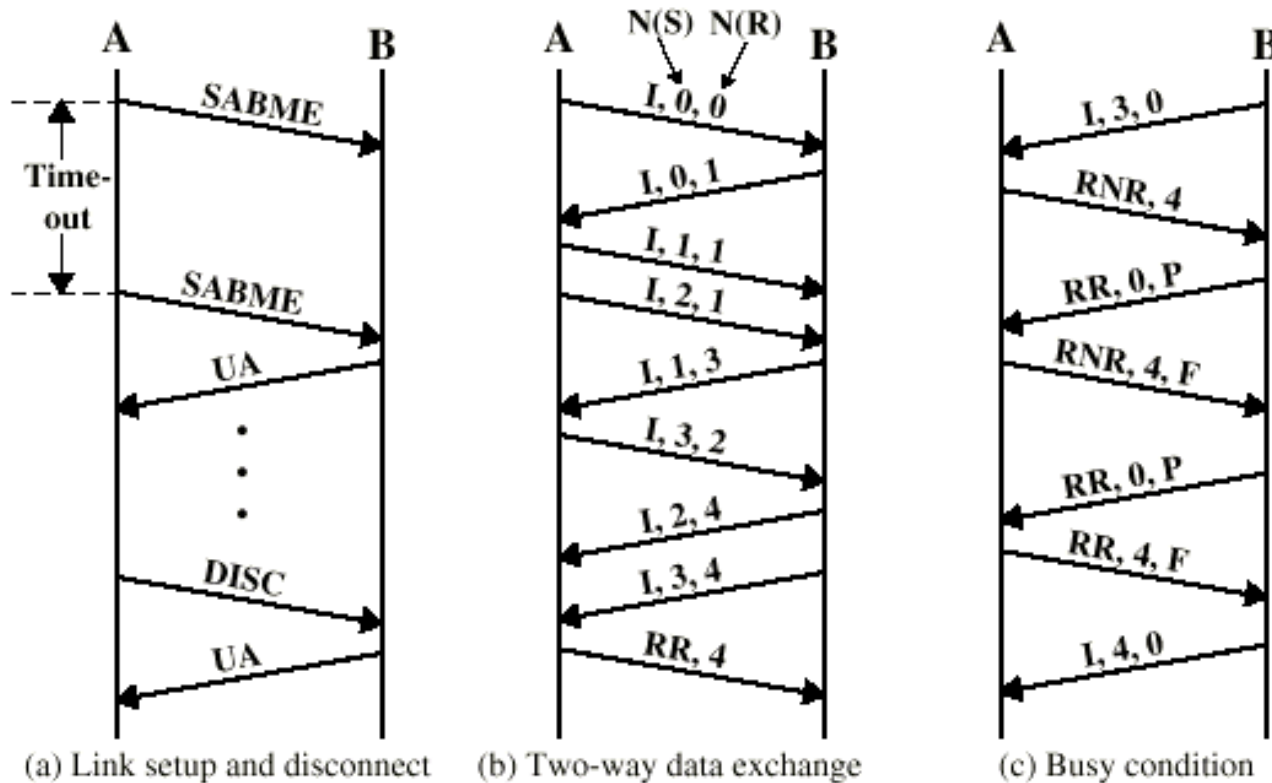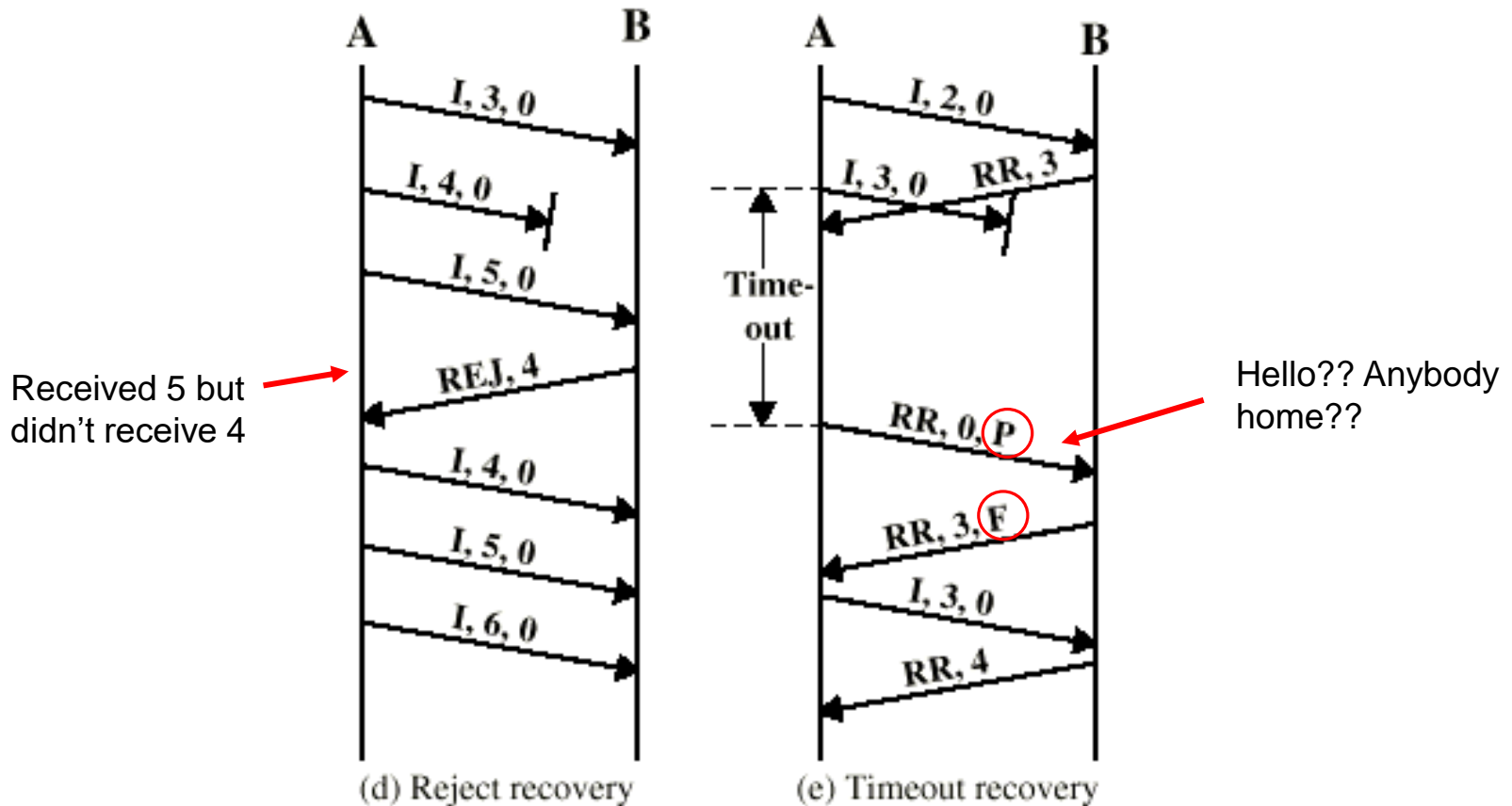# Connection & Disconnection

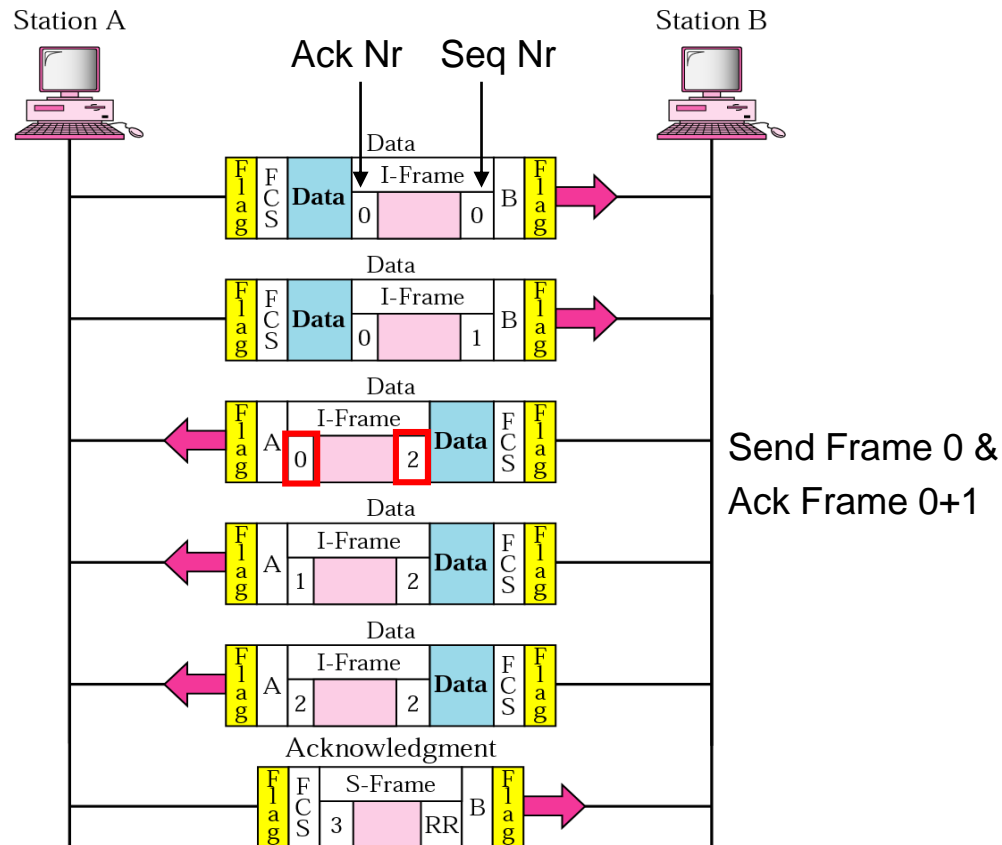* Figure is courtesy of B. Forouzan

Examples of Operation

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

SABME	Set asynchronous balanced mode	RR	Receive Ready
I	Information	RNR	Receive Not Ready
UA	Unnumbered acknowledgment	REJ	Reject
DISC	Disconnect	SREJ	Selective Reject

* Figure is courtesy of W. Stallings

Example

Received 5 but didn't receive 4

Hello?? Anybody home??

(d) Reject recovery

(e) Timeout recovery

* Figure is courtesy of W. Stallings

Piggybacking without Error

Station A

Station B

Ack Nr   Seq Nr

Send Frame 0 &
Ack Frame 0+1

* Figure is courtesy of B. Forouzan

Piggybacking with Error
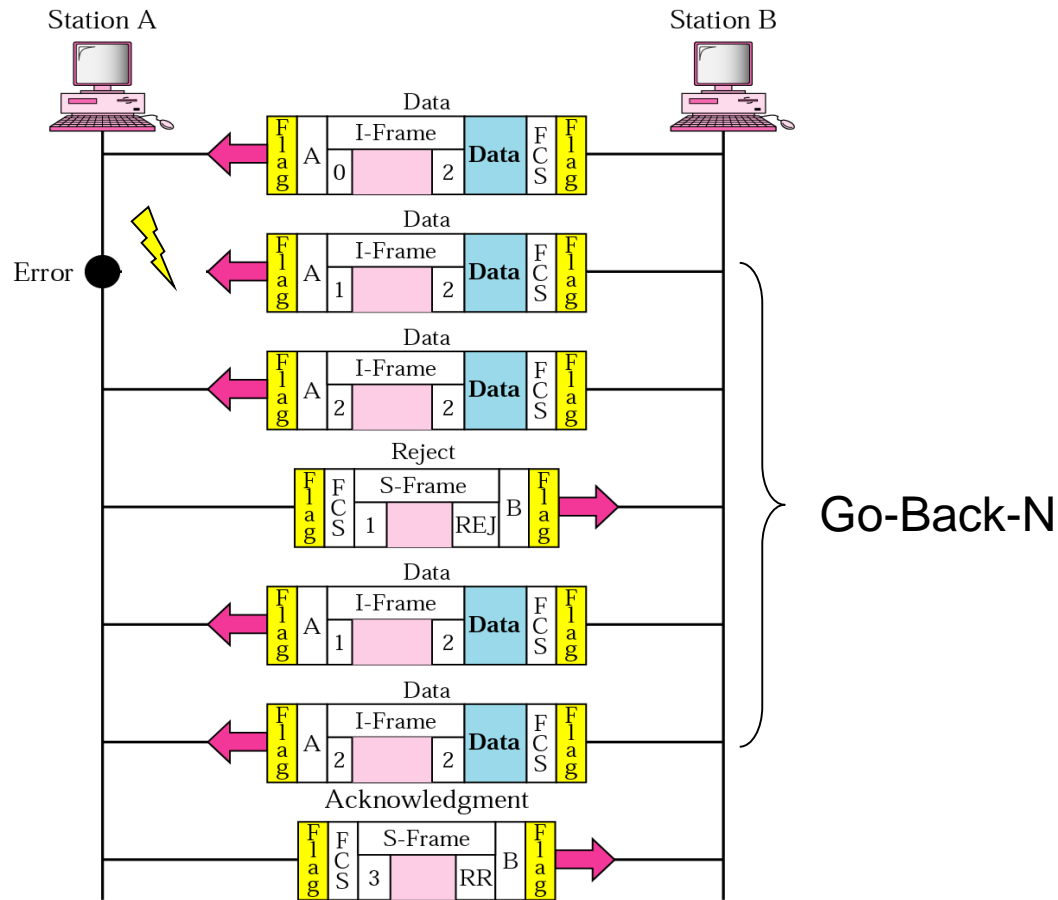
* Figure is courtesy of B. Forouzan

Summary: HDLC

- Three station types
  - Primary station
  - Secondary station
  - Combined station
- Operation modes
  - Normal response mode
  - Asynchronous response mode
- Three frame types
  - I-Frame: Information Transfer Format
  - S-Frame: Supervisory Format – Flow Control
  - U-Frame: Unnumbered Format – Connection setup/term./etc

- Bit-Stuffing - to avoid confusion of data and flag

HDLC – Why?

- 'should give you a feeling for a protocol

- It includes most of the basic mechanisms
  - Framing
  - Addressing
  - Bit-stuffing
  - Flow/Error control

- Once you can run through HDLC in your head, you understand the basics of link layer protocols
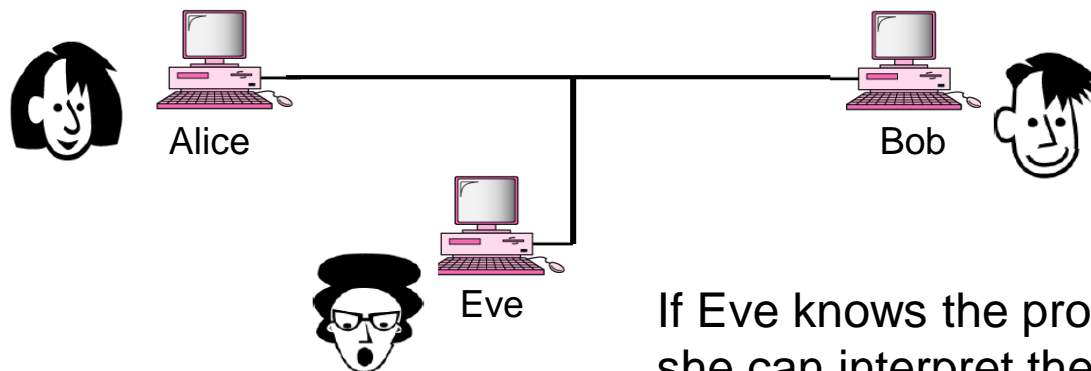
Binary Example

011111100111110001111011010101101011111110

011111100111101011000110111011010111110

011111100111110001100001010111101011111110

011111100111101011000110111011010111110

Alice   Bob

Binary Example

0111111001111100011110110101011010101111110

0111111001111010110001101110110101111110
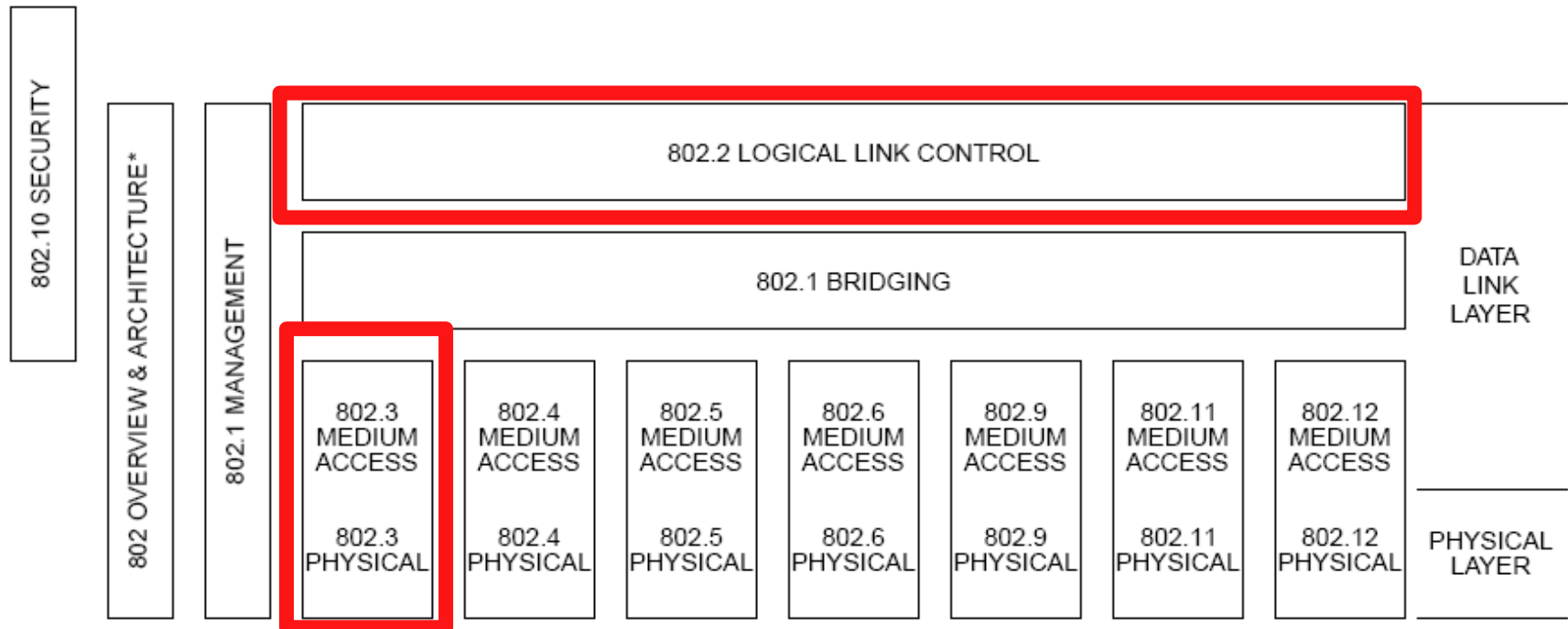
0111111001111100011000010101111010101111110

0111111001111010110001101110110101111110

Alice

Bob

Eve

If Eve knows the protocol,
she can interpret the information

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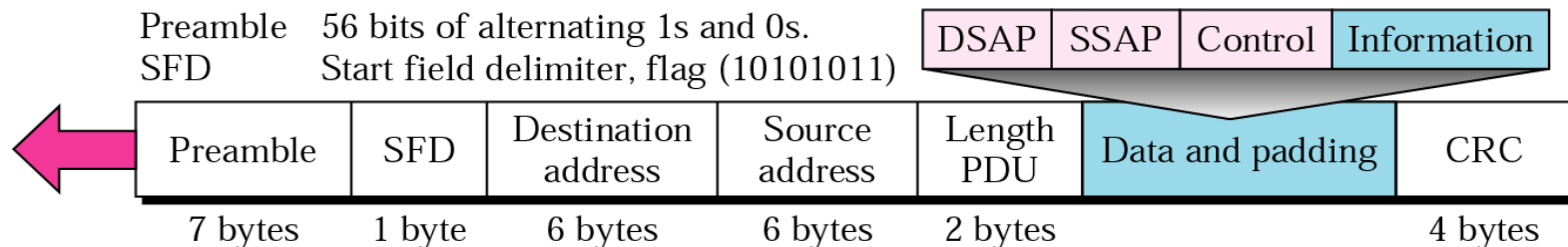THE UNIVERSITY OF DUBLIN

IEEE 802

* 802.3: Ethernet
* 802.11: Wifi
* 802.16: WiMAX
* 802.20: Mobile Broadband Wireless Access (MBWA)
* 802.15.1: Bluetooth
* 802.15.4: ZigBee

* Figure is courtesy of ANSI/IEEE Std 802.11

802.3 MAC Frame

Preamble	SFD	Destination address	Source address	Length PDU	Data and padding	CRC
7 bytes	1 byte	6 bytes	6 bytes	2 bytes		4 bytes

Preamble   56 bits of alternating 1s and 0s.
SFD   Start field delimiter, flag (10101011)

DSAP	SSAP	Control	Information

- 64-bit frame preamble (10101010) used to synchronize reception
  – 7 bit preamble (10101010) + 1 start flag (10101011)

- Maximum frame length: 1518 bytes
  ⇨ max 1500 bytes payload
- Minimum frame length: 64 bytes
  ⇨ min 46 bytes payload

* Figure is courtesy of B. Forouzan

802.2 LLC Control Fields

LLC PDU control field bits

	1	2	3	4	5	6	7	8	9	10–16
Information transfer command/response (I-format PDU)	0				N(S)				P/F	N(R)
Supervisory commands/responses (S-format PDUs)	1	0	S	S	X	X	X	X	P/F	N(R)
Unnumbered commands/responses (U-format PDUs)	1	1	M	M	P/F	M	M	M		

N(S) = sender send sequence number (Bit 2=lower-order-bit)
N(R) = sender receive sequence number (Bit 10=lower-order-bit)
S = supervisory function bit
M = modifier function bit
X = reserved and set to zero
P/F = poll bit—command LLC PDUs
final bit—response LLC PDUs
(1=poll/final)

m = 7
2^m = 128
max w-size= 64 frames

Figure 9—LLC PDU control field formats

IEEE 802.2: Logical Link Control (LLC)
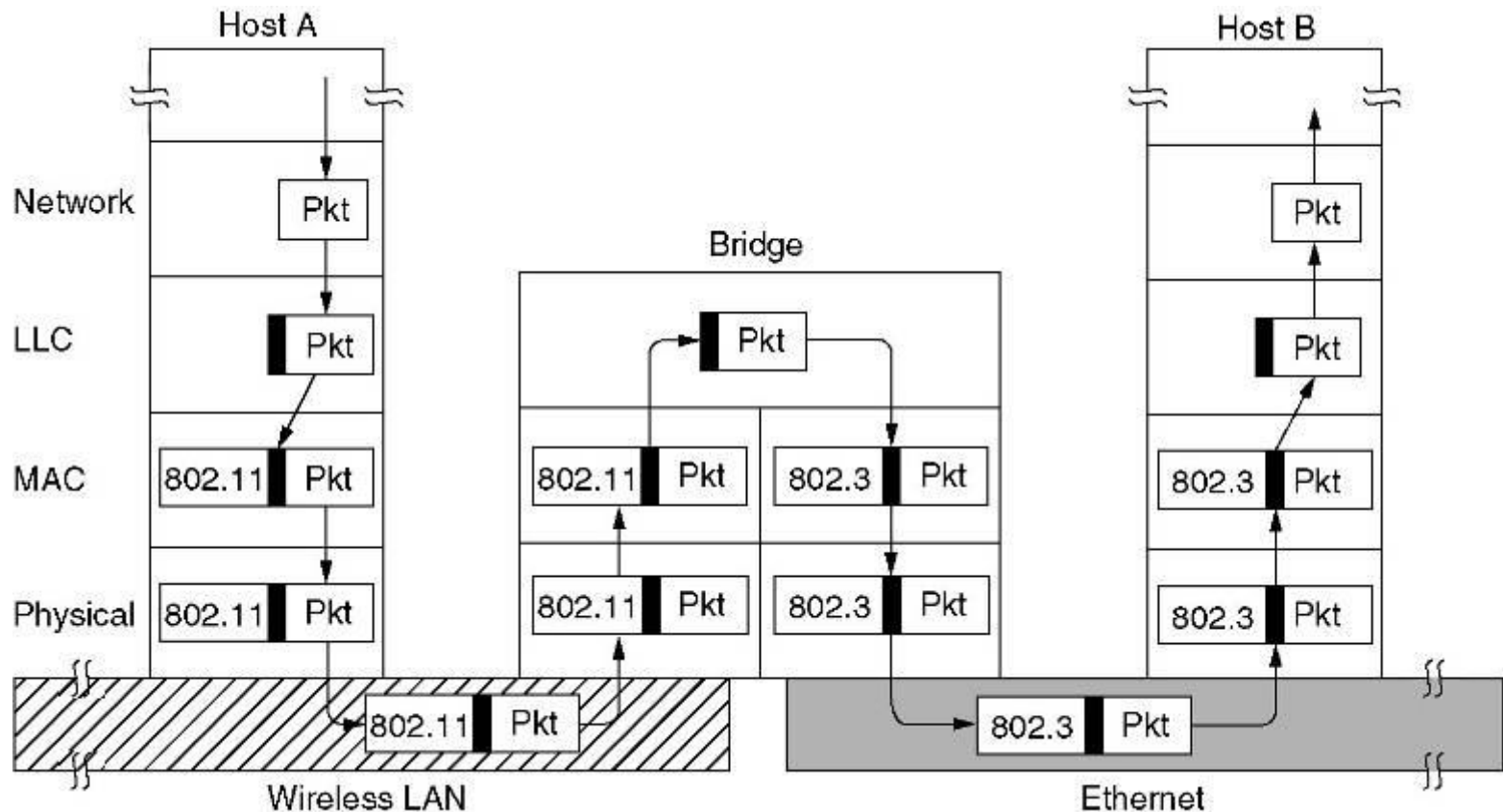

* Figure is courtesy of A. Tanenbaum
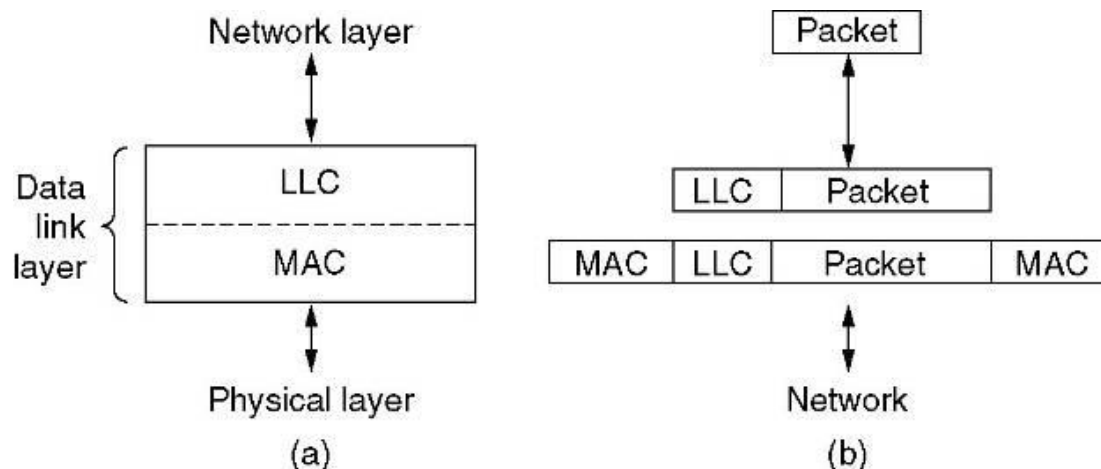
- LLC provides three HDLC services:
  - 1. Unacknowledged connectionless service, recall HDLC has unnumbered frames;
  - 2. Reliable connection-oriented service in the form of HDLC ABM mode;
  - 3. Acknowledged connectionless service, need to add two unnumbered frames to HDLC frame set.

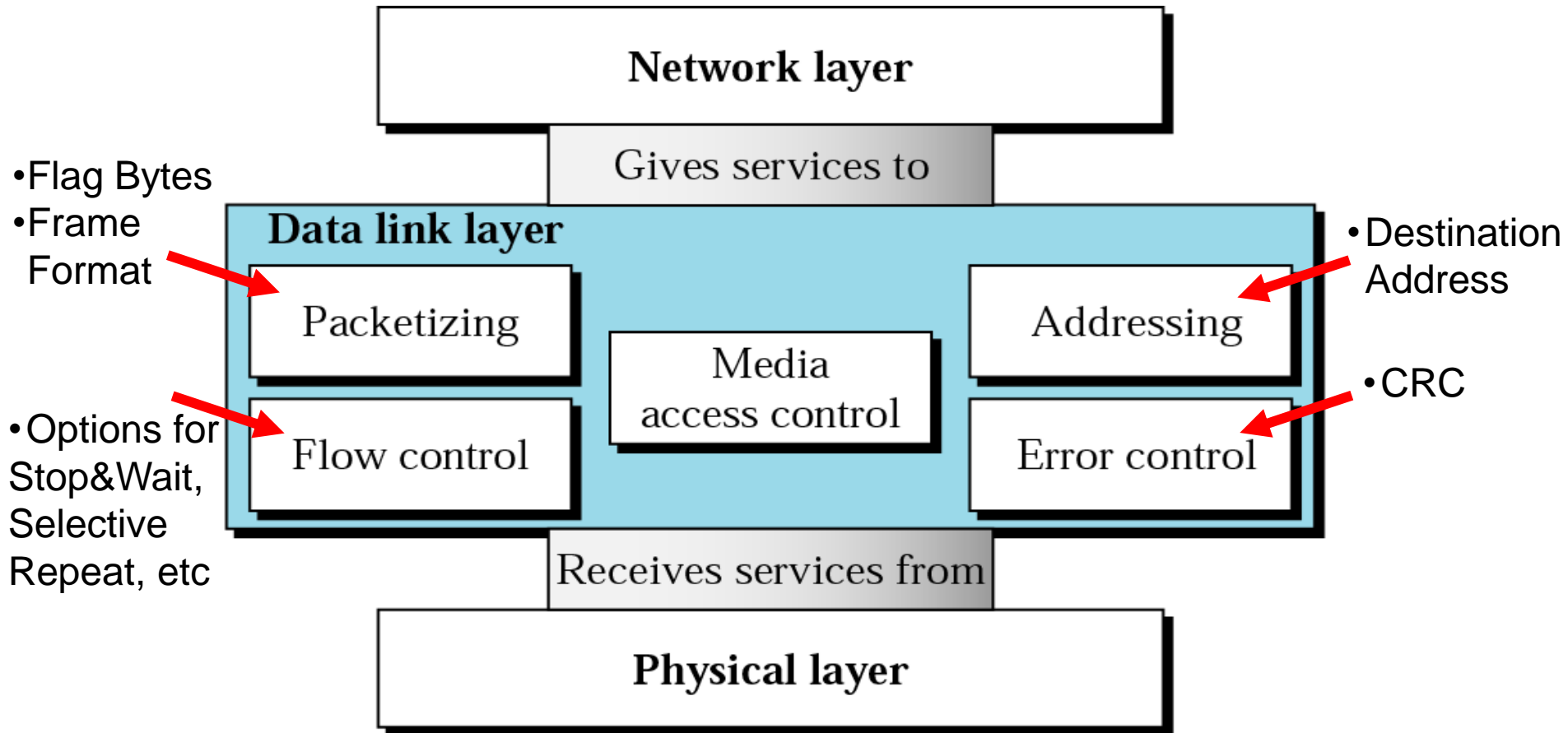- LLC can provide reliable packet transfer service

Bridges from 802.x to 802.y

Operation of a LAN bridge from 802.11 to 802.3.

* Figure is courtesy of A. Tanenbaum

Link Layer

•Flag Bytes
•Frame Format
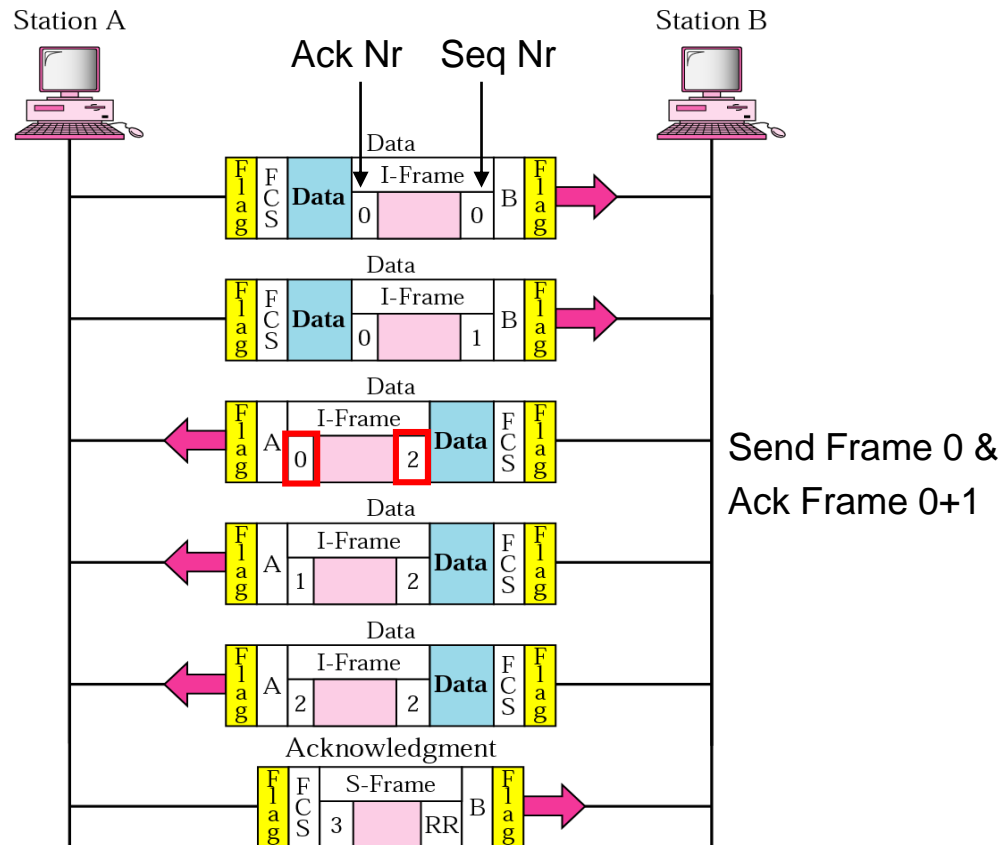
•Destination Address

•CRC

•Options for Stop&Wait, Selective Repeat, etc

Connection & Disconnection

* Figure is courtesy of B. Forouzan

Piggybacking without Error

Station A

Ack Nr   Seq Nr

Station B

Send Frame 0 &
Ack Frame 0+1

* Figure is courtesy of B. Forouzan

Goal

Wifi

Access
Point

Ethernet

ADSL Router

PPP

Internet Service Provider

Irish Internet Exchange

TCD

Ethernet

HEANET