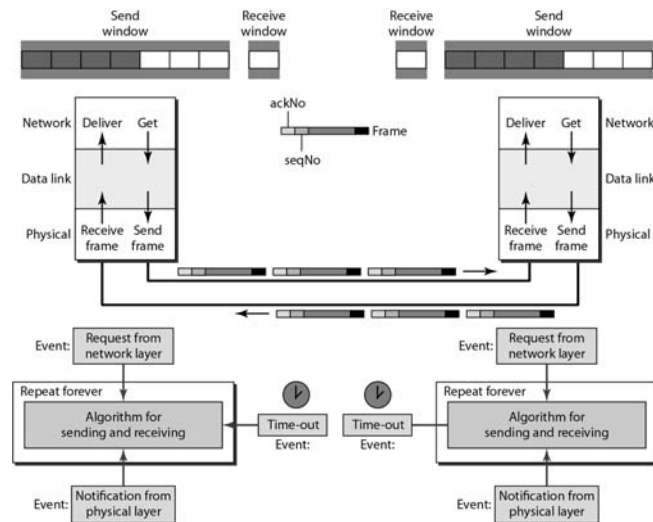


## Piggybacking in Go-Back-N ARQ



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41

## Question

- สาเหตุที่ต้องมีการใช้งาน Protocol ในการจัดการในการส่งข้อมูล (Data link control) สำหรับ node-to-node comm. ?
- ความสำคัญของ Flow control คือ?
- ความสำคัญของ Error control คือ?

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42

## Protocols comparison

| Protocol             | Flow control | Error control | Sender | Receiver |
|----------------------|--------------|---------------|--------|----------|
| Simplest             |              |               |        |          |
| Stop-and-Wait        |              |               |        |          |
| Stop-and-Wait ARQ    |              |               |        |          |
| Go-Back-N ARQ        |              |               |        |          |
| Selective Repeat ARQ |              |               |        |          |

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43

## HDLC

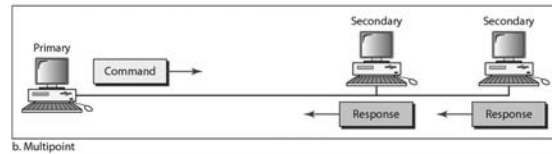
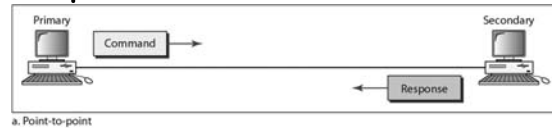
- High-level Data Link Control (HDLC) is a bit-oriented protocol for communication over point-to-point and multipoint links. It implements the ARQ mechanisms we discussed in this chapter.
  - Configurations and Transfer Modes
  - Frames
  - Control Field

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44

## Transfer Modes

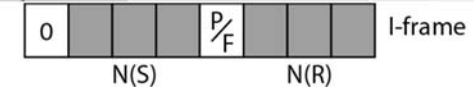
- Normal response mode



- Asynchronous balanced mode



## HDLC frames & Control field format



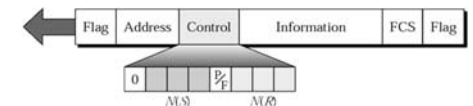
## HDLC frames & Control field format

- Flag (8 bits) : "01111110"
- Address (>= 1 byte)
  - Receiving address
  - Length
    - 1 byte : last bit in address field = '1'
    - > 1 byte : last bit of each byte = '0' except last bit of last address byte = '1'
- FCS (Frame Check Sequence) (2 or 4 byte)
  - Error detection
    - CRC (16-bit CRC-CCITT : 0x1021 or CRC-32 : 0x04C11DB7)\*
    - Error detection for all fields
      - Except Flag



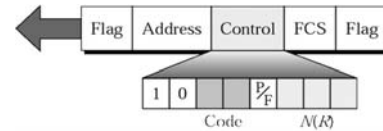
## I-frame control field

- 1<sup>st</sup> bit: '0' : defined type of frame (I-Frame)
- N(S) (3 bits): Transmitting Frame number (0-7)
  - Can extend to 7 bits
- N(R) (3 bits): ACK or NAK Frame number (0-7)
  - When piggybacking is used
  - Can extend to 7 bits
- P/F bit
  - P bit (Poll bit) : Poll Frame from Primary
    - '1': Poll Frame from Primary
    - '0': otherwise
  - F bit (Final bit) : Frame from Secondary
    - '1': Last I-frame from Secondary
    - '0': otherwise



\* Cyclic redundancy check. Retrieved January 19, 2017, from wikipedia Web site: [https://en.wikipedia.org/wiki/Cyclic\\_redundancy\\_check](https://en.wikipedia.org/wiki/Cyclic_redundancy_check)

## S-frame control field

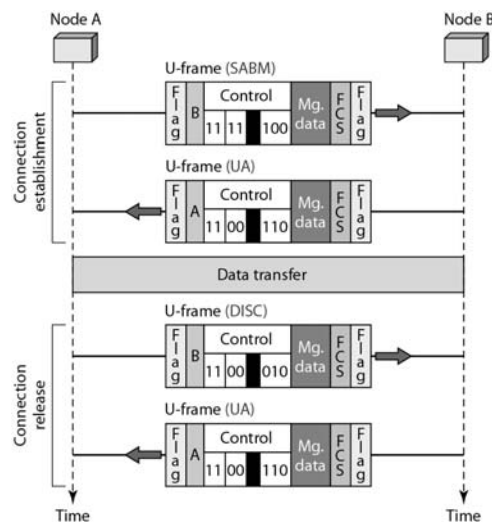


- Code
  - 00: RR (Receive Ready)
    - N(R) - ACK no.
  - 01: REJ (REJect) → NAK for Go-back-N
    - N(R) - NAK no.
  - 10: RNR (Receive Not Ready) : receiver announces that receiver is busy and cannot receive more frame (acts as kind of congestion control mechanism by asking sender to slow down)
    - N(R) - ACK no.
  - 11: SREJ (Selective-REJect) → NAK for Selective-reject ( N(R) - NAK no.)
- P/F bit
  - Depend on the condition of Code field

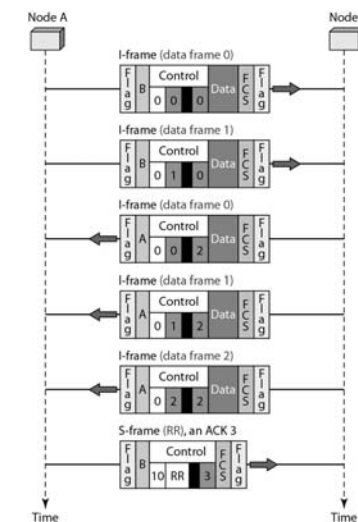
## U-frame control command and response

| Code   | Command | Response | Meaning   |
|--------|---------|----------|---|
| 00 001 | SNRM    |          | Set normal response mode                            |
| 11 011 | SNRME   |          | Set normal response mode, extended                  |
| 11 100 | SABM    | DM       | Set asynchronous balanced mode or disconnect mode   |
| 11 110 | SABME   |          | Set asynchronous balanced mode, extended            |
| 00 000 | UI      | UI       | Unnumbered information                              |
| 00 110 |         | UA       | Unnumbered acknowledgment                           |
| 00 010 | DISC    | RD       | Disconnect or request disconnect                    |
| 10 000 | SIM     | RIM      | Set initialization mode or request information mode |
| 00 100 | UP      |          | Unnumbered poll                                     |
| 11 001 | RSET    |          | Reset   |
| 11 101 | XID     | XID      | Exchange ID   |
| 10 001 | FRMR    | FRMR     | Frame reject  |

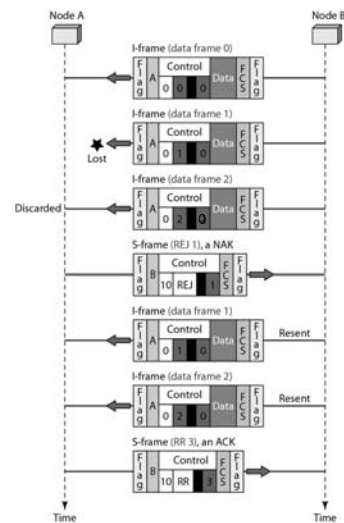
## Example of connection and disconnection



## Example of piggybacking without error



Example of piggybacking with error



HDLC (Activity)

- A

HDLC (Activity)

- B

HDLC (Activity)

- C