# CSc 450/550
# Computer Networks
# Link Layer Protocols

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# Review

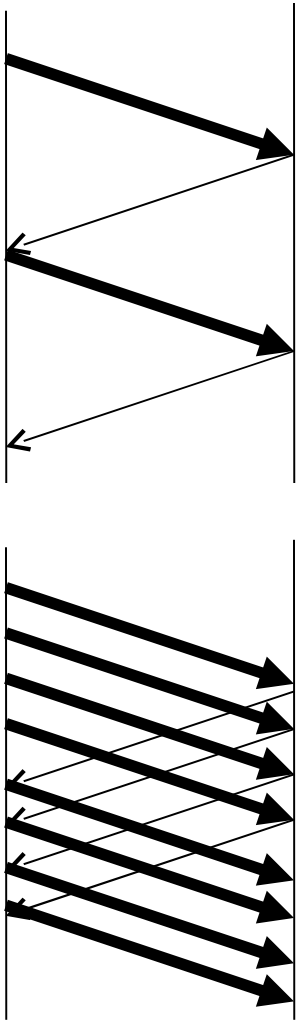
- Application layer: HTTP, DNS
- Transport layer: TCP, UDP
- Network layer: IP/ICMP; RIP, OSPF, BGP
- Link layer
  - frame control
    - byte stuffing, bit stuffing
  - error control
    - error detecting code, error correcting code

# Today's topics

- Link layer
  - flow control
    - sliding-window-based flow control
  - representative link layer protocols
    - HDLC (High-level Data Link Control)
    - SLIP (Serial Line Internet Protocol)
    - PPP (Point-to-Point Protocol)

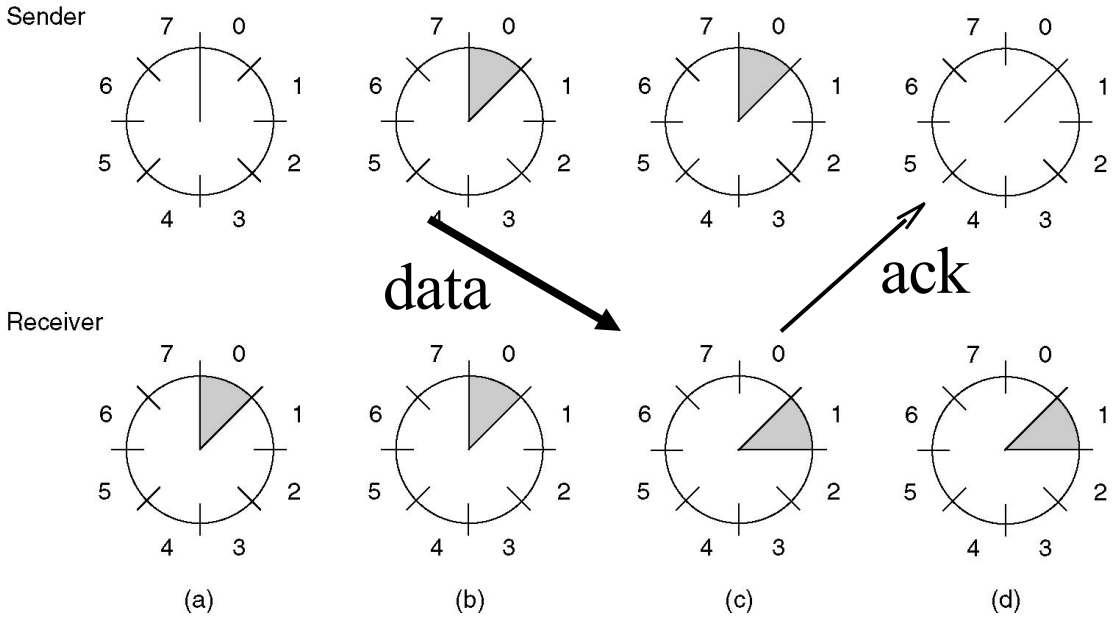
# Transmission control

- Stop-and-wait
  - transmit the next packet
  - wait for its acknowledgment
    - or retransmit if timeout
  - low link utilization
- Pipelining
  - higher link utilization
  - issues at receiver
    - buffer limit? out-of-order packets?



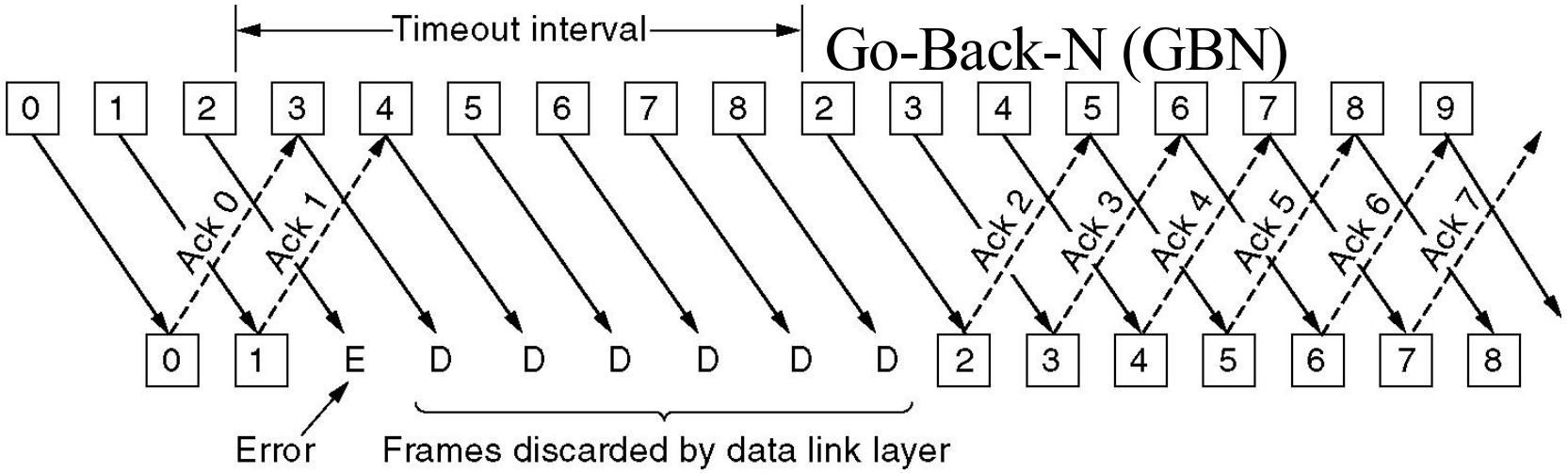
# Flow control

- Sliding window
  - window size < buffer size
  - e.g., window size = 1, i.e., stop-and-wait

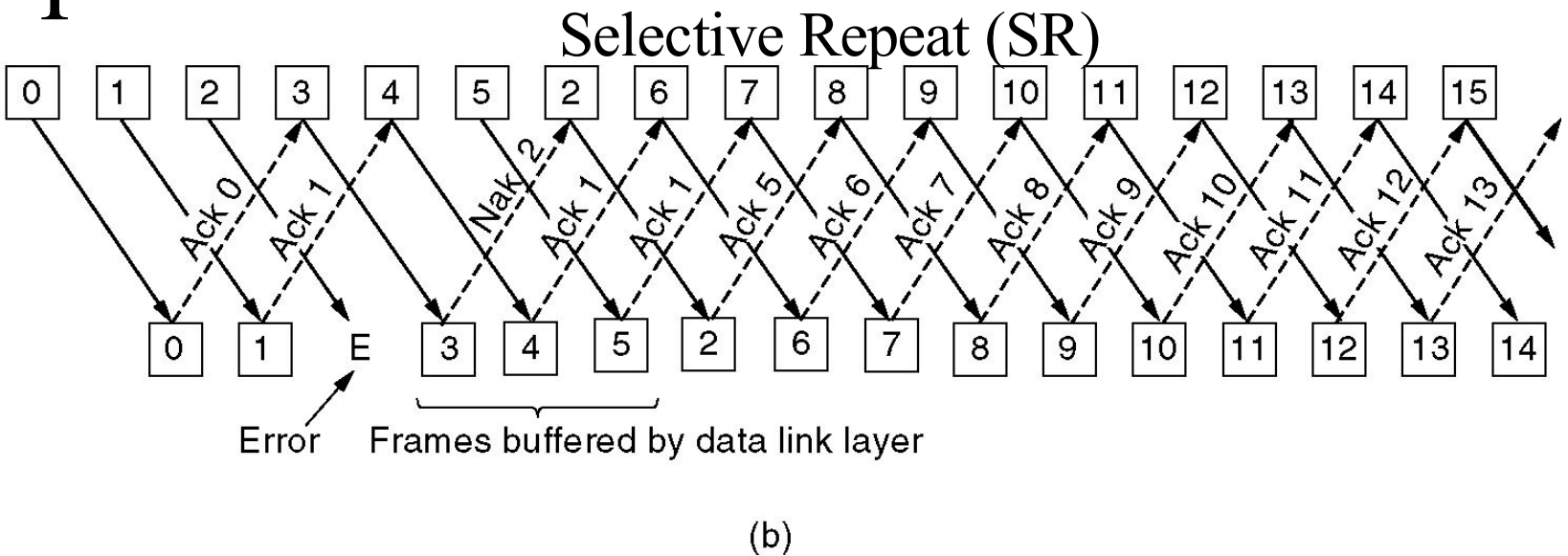





Q: window size vs sequence space?

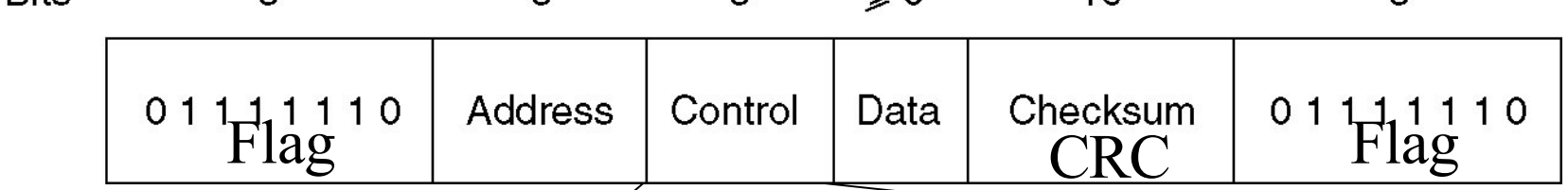



# Out-of-order packets

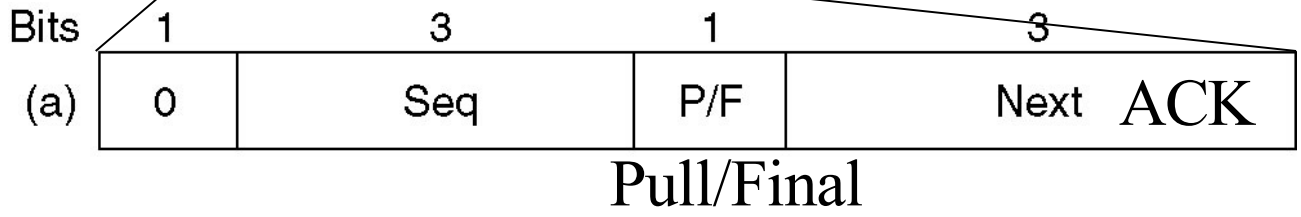


# High-level Data Link Control

- HDLC (bit-stuffing) derived from SDLC




- Information




- Supervisory


- Unnumbered



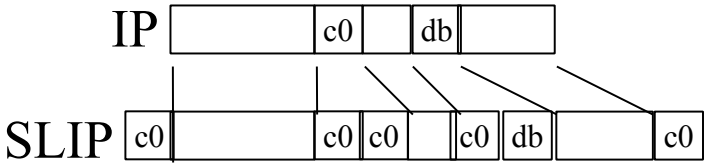

Q: flow, error control?

# HDLC frames

- Information
  - sequence number
  - acknowledgment number
- Supervisory
  - acknowledgment number
  - Ready, Not Ready; Reject, Selective Reject
- Unnumbered
  - control frames
  - connectionless, unreliable service

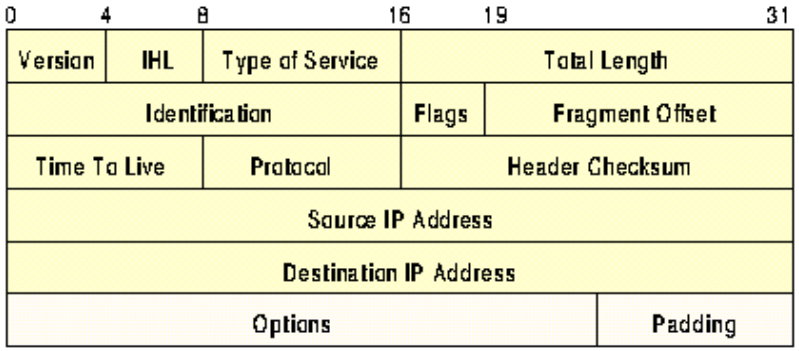
# Serial-Line Internet Protocol

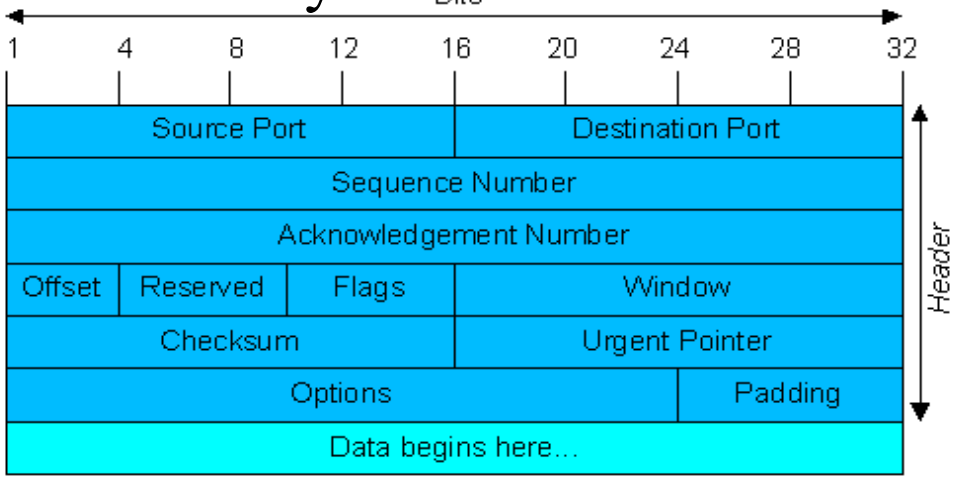
- SLIP/PLIP
  - very simple encapsulation for IP only
  - byte stuffing
    - flag: END (0xc0), escape: ESC (0xdb)
  - no flow/error control



# Compressed SLIP

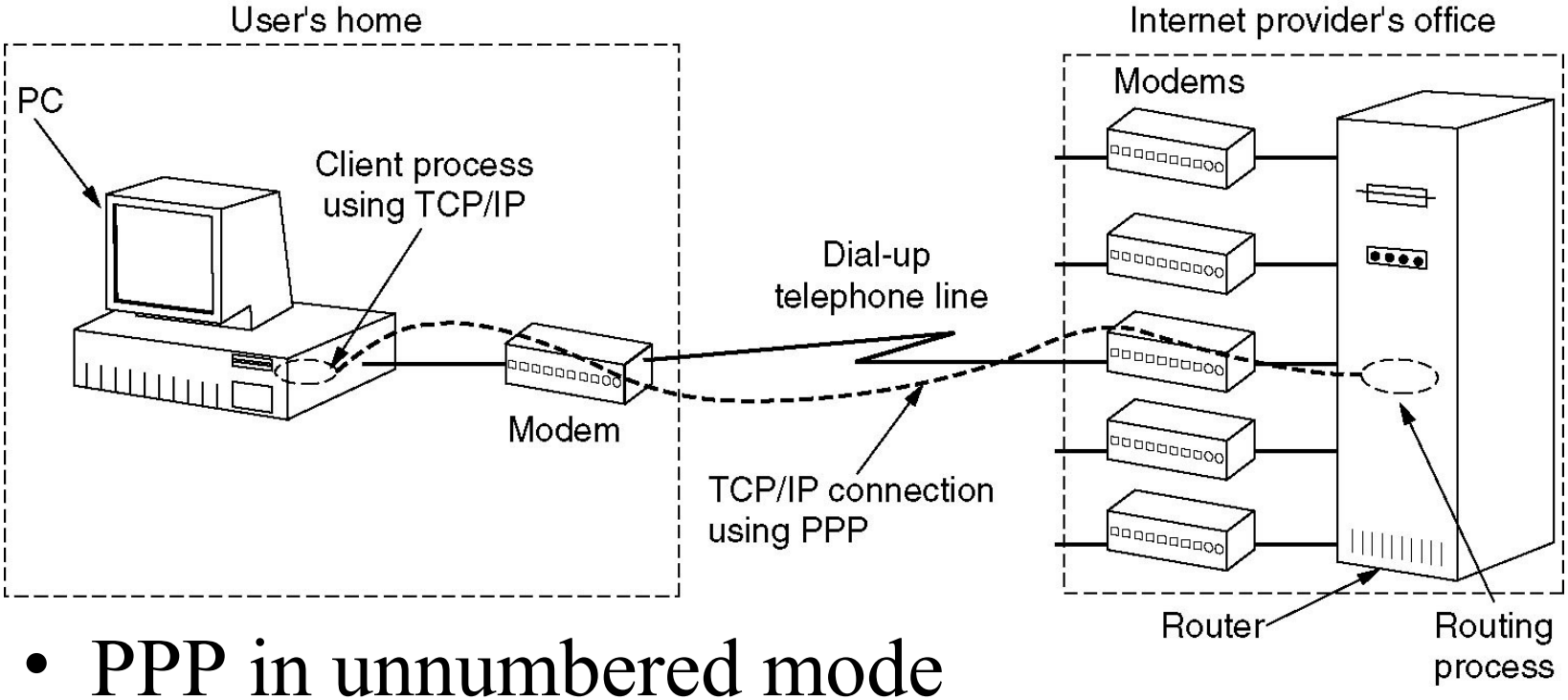
- Compressed SLIP (CSLIP)
  - TCP/IP header: at least 20+20 bytes
    - some static, some predictable
  - Telnet data payload: 1 byte
  - delta encoding
    - Von Jacobson compression to 3 bytes



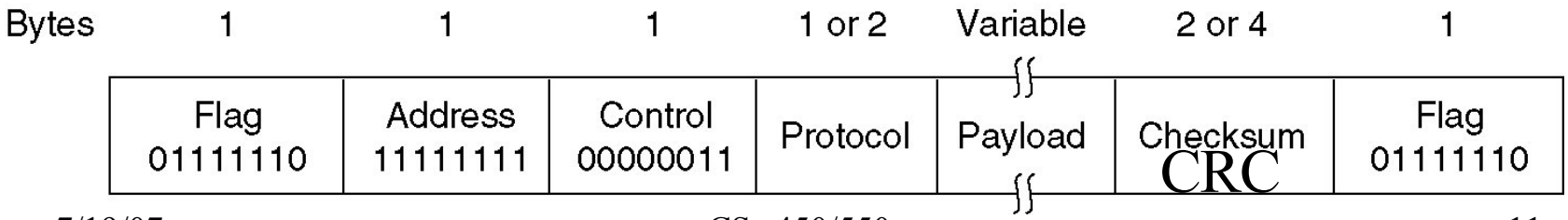



# Point-to-Point Protocol

- PPP, PPPoE




- PPP in unnumbered mode

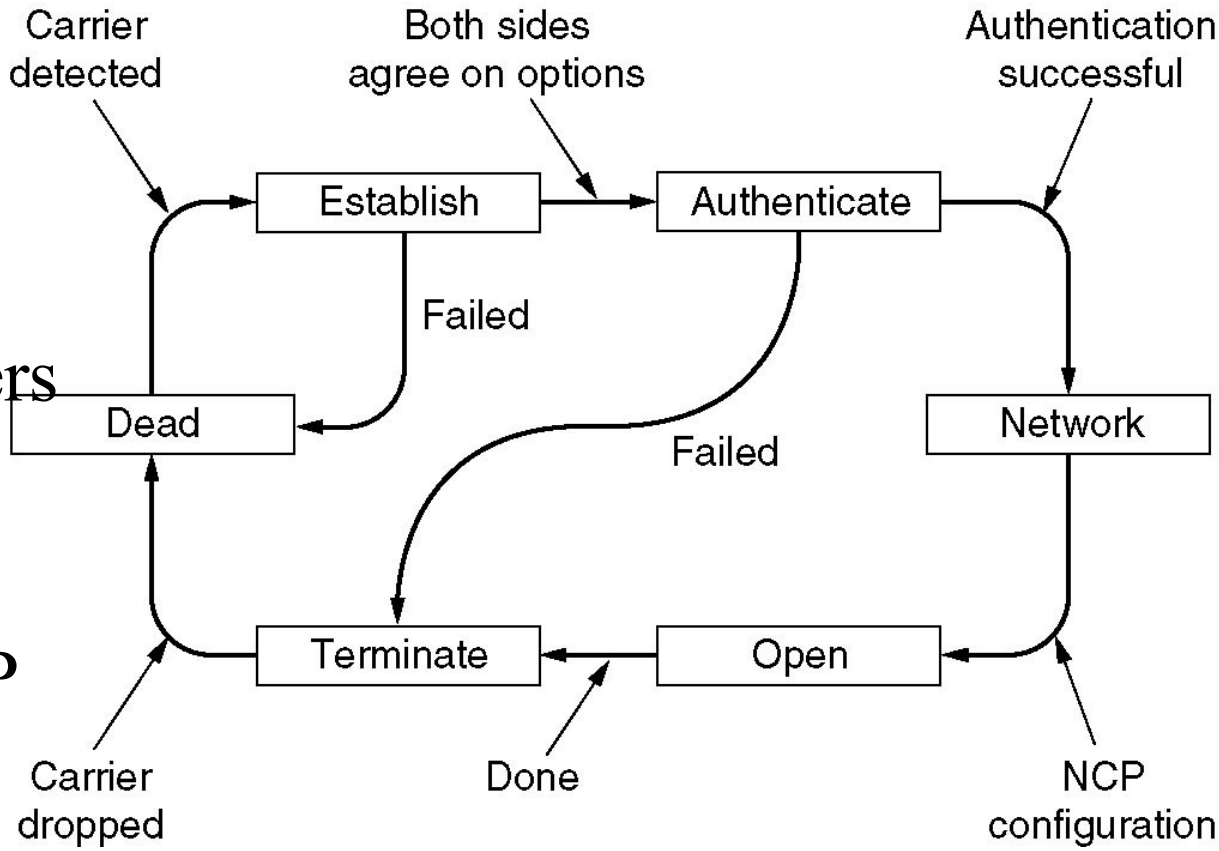





Q: flow, error control?

# PPP state diagram

- LCP
  - link parameters
- NCP
  - network parameters
- Authentication
  - PAP, CHAP, EAP



# LCP frame types

| Name | Direction | Description |
|---|---|---|
| Configure-request | I → R | List of proposed options and values |
| Configure-ack | I ← R | All options are accepted |
| Configure-nak | I ← R | Some options are not accepted |
| Configure-reject | I ← R | Some options are not negotiable |
| Terminate-request | I → R | Request to shut the line down |
| Terminate-ack | I ← R | OK, line shut down |
| Code-reject | I ← R | Unknown request received |
| Protocol-reject | I ← R | Unknown protocol requested |
| Echo-request | I → R | Please send this frame back |
| Echo-reply | I ← R | Here is the frame back |
| Discard-request | I → R | Just discard this frame (for testing) |

# LCP negotiation

- Maximum-Receiver-Unit (MRU)
- Authentication-Protocol
- Quality-Control
- Magic-Number (loop-back detection)
- Protocol-Field-Compression (PFC)
- Address-and-Control-Field-Compression

# IPCP

- Protocol
  - 0x8021: IPCP, i.e., NCP for IP
  - 0x0021: IP
- IPCP frame types
  - Configure-*, Terminate-*, Code-Reject
- Negotiation
  - compression: VJ compression (0x002d)
  - IP address: indicate or request one

# PPP is more than just dialup

- PPPoA: PPP over ATM [RFC 2364]
  - some ADSL ISPs using ATM transport
- PPPoE: PPP over Ethernet [RFC 2516]
  - often used by DSL and cable modem ISPs
- Packet over SONET/SDH
  - mostly point-to-point backbone links
- L2TP: Layer-2 *Tunneling* Protocol (PPP/IP)
- PPTP: Point-to-Point TP (PPP+GRE)

# This lecture

- Link layer
  - flow control
    - sliding window
  - HDLC, SLIP, PPP
    - frame, error and flow control
- Explore further
  - PPP: RFC 1661, 1332
  - http://www.cs.uvic.ca/~pan/csc450f05/ppp.pdf

# Next lectures

- July 23 and 26: Medium access control
  - IEEE 802.3: Ethernet
  - IEEE 802.11: wireless Ethernet
- July 30: Interworking

- August 2: 3rd in-class midterm exam