Previously

- Finite State Machine Models
- Petri Nets Models

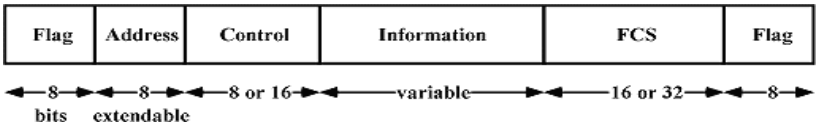
Example Data Link Protocols

- HDLC: High Level Data Link Control
- PPP: Point to Point Protocol

HDLC

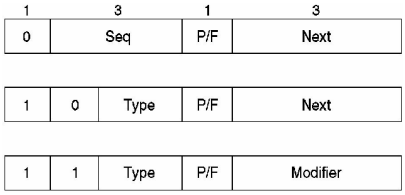
- Widely used to this day: e.g. in
  - X25 (LAPB) Link Access Procedure Balanced
  - IEEE 802.2 *LLC* Logical Link Control
  - ISDN (LAP-D) Link Access Protocol – Channel D
- All of these protocols are based on the same principles:
  - All are bit-oriented,
  - Use bit-stuffing for transparency
- They only differ in minor ways but irritating ways.

Frame Format



- Flag Fields
  - Used to delimit the frame at both ends with the unique bit pattern 01111110,
  - Stations continually hunt for the flag sequence to synchronize on the start of a frame,
  - Bit Stuffing is used to prevent the flag occurring in the data
- Address Field
  - Important when used on lines with multiple terminals,
    - Used to identify one of the terminals
  - On point-to-point lines this is not required,
    - Can be used to distinguish commands from responses on point-to-point lines,

Protocol & Control Field



- 3 Frame Types:
  - *Information*
  - *Supervisory*
  - *Unnumbered*
- Protocol
  - Sliding window with a 3-bit sequence number
    - *Seq* is the sequence number of the frame,
    - *Next* the next frame expected,
  - There can be up to 7 un-acknowledged frame outstanding at any one time,
- *P/F* bit is used when
  - a computer is polling a number of terminals

1. Information Frames

- Purpose:
  - To carry data transmitted for the user
  - To do flow- and error- control by piggybacking data onto the information frame,
- Data Field
  - Contains arbitrary information, present only in *I*- and some *U*- frame.
- FCS Field
  - Frame Checksum Sequence
  - Uses CRC-CCITT as the generator polynomial

2. Supervisory Frames

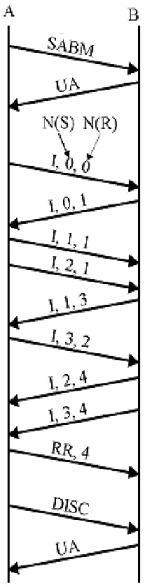
- Type = 00 (*RR*) Receive Ready
  - Used to indicate that that the next frame is expected. Ack frame
- Type = 01 (*REJ*) Reject
  - Used to indicate that a transmission error has occurred,
  - *Next* specifies the frame in sequence not received correctly
  - Retransmission is done using a Go-back-N scheme.
- Type = 10 (*RNR*) Receive Not Ready
  - Used to indicate that sender should stop sending
  - Also acknowledges frames up to but not including *Next*
- Type = 11 (*SREJ*) Selective Reject
  - Used to indicate that the retransmission of only 1 frame,
  - *Next* specifies the frame to be retransmitted,
  - Retransmission is done using a selective-repeat scheme.

3. Unnumbered Frames

- Can be used to carry User Data
  - For unreliable data link protocols
- Also provides up to 32 control functions:
  - DISC Disconnect from the network (e.g., maintenance)
  - SNRM Set Normal Response Mode, it's an asymmetric master-slave connection (from the old mainframe days),
  - SABM Set Asynchronous Balanced Mode, resets the line and declares the partners as equals,
  - FRMR FRaMe Reject, correct FCS but impossible semantics,
  - UA *U*nnumbered *A*cknowledgement to acknowledge supervisory frames

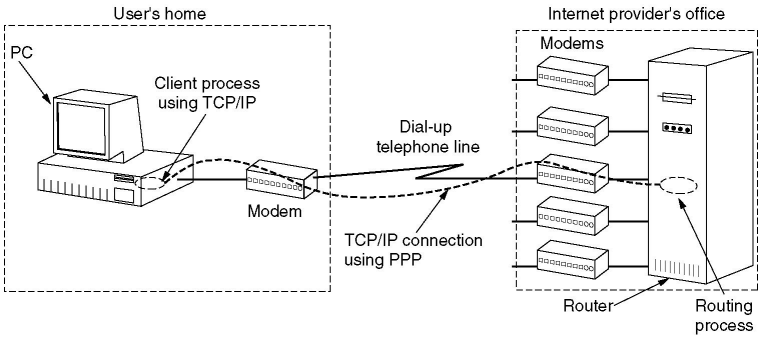
Basic HDLC Operation

- Phase 1
  - Initialises the Data Link
  - Agree on the options that are to be used
    - e.g. length of sequence numbers (3-7bits)
- Phase 2
  - Exchange of data frames and control information to exercise flow and error control
- Phase 3
  - DISC One of the 2 sides signals termination of the process
  - UA Other side accepts disconnect by replying with *UA*



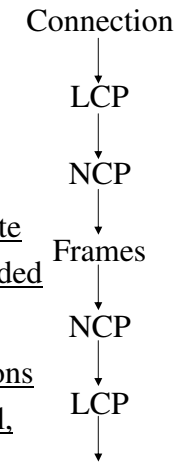
PPP

- Mainly used in two situations:
  - Between routers in a communication subnet
  - Between a home user and an ISP
- Used in the Internet



PPP Features

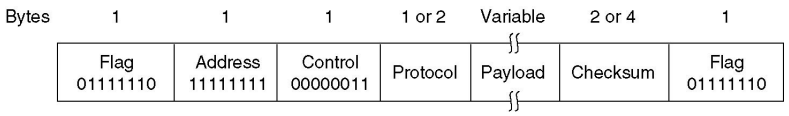
- Provides a framing method which
  - Unambiguously delineates the end of one frame and the start of the next.
  - Handles error detection.
- LCP Link Control Protocol
  - Used to bring up lines, test them, negotiate options and bring them down when not needed
- NCP Network Control Protocol
  - A way of negotiating network-layer options independently of the network layer protocol,
  - A different NCP for each network layer supported (e.g. IP, IPX, AppleTalk).



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)

Frame Format



- Format is very much like HDLC…
- However it is character oriented rather than bit-oriented
- The address is fixed to 11111111 (all stations), P2P after all
- Control field defaults to unreliable transmission (no seq,ack)
  - Can be negotiated through LCP
  - Can negotiate dropping of fixed bytes (address & control bytes)
- Protocol fields allow us to specify the type of the packet in payload.
  - IP, IPX, OSI CLNP, XNS Network Layer packet (start with 0)
  - LCP, NCP Control packet (start with 1)
- Payload length is negotiated using LCP, defaults to 1500 bytes