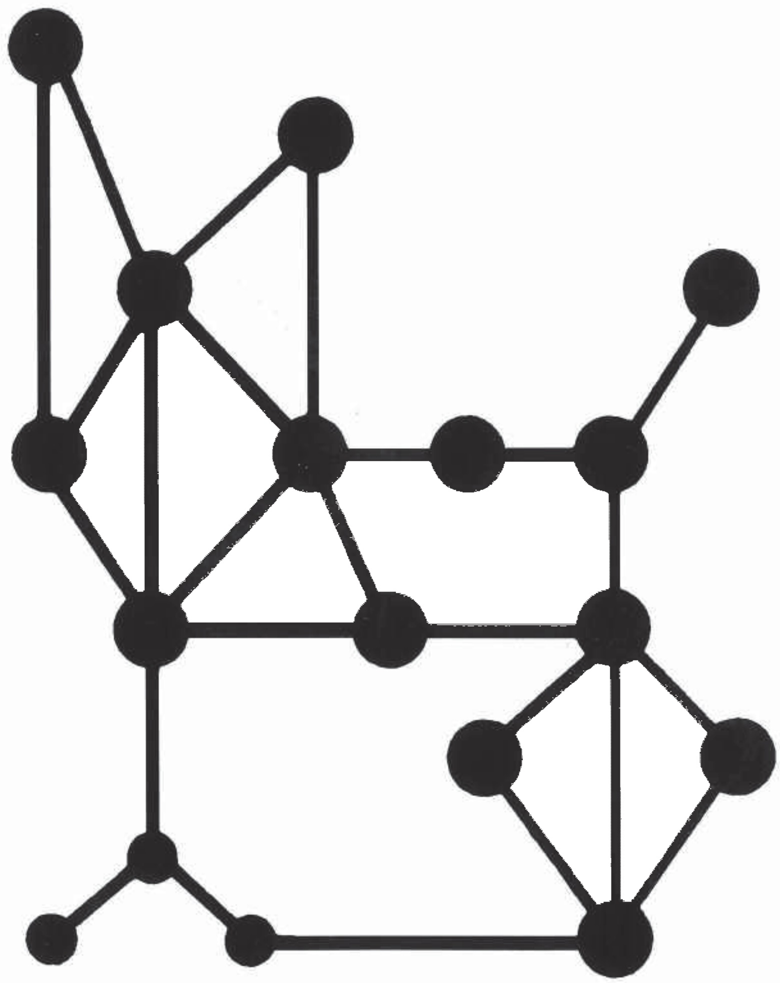
Mischa Schwartz

# Telecommunication Networks

## Protocols, Modeling and Analysis



# Telecommunication Networks: Protocols, Modeling and Analysis

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## 4–3 High-level Data Link Control (HDLC)

We now focus more specifically on the HDLC protocol, which as already noted has fast become an international standard. This protocol followed, and in many respects is based on, the IBM SDLC (synchronous data link control). American standards activities, paralleling the ISO work and interacting with it, resulted in the American National Standards Institute (ANSI) data-link control procedure standard ADCCP (advanced data communication control procedure). HDLC and ADCCP are closely related and will not be distinguished specifically in this discussion [CARLD]. The CCITT X-25-recommended data-link procedures, LAPB (balanced link access procedures), a subset of HDLC, will be described in some detail later. All these protocols and others like them are examples of bit-oriented protocols, in which the frame structure used eliminates a specific dependence on byte or character formatting [SCHW 1977].

In this section we first describe the basic philosophy and operation of HDLC, with reference made to the tutorial paper by Carlson [CARLD]. We then outline a throughput performance analysis of one common mode of operation of HDLC, following the work of Bux, Kummerle, and Truong [BUX 1980]. The analysis is similar to that carried out in the last section for the idealized go-back-$N$ protocol, but because it focuses on a model of a real protocol, it captures the effect of finite sequence numbering and a specific error-control procedure. This enables us to compare the idealized throughput analysis with the analysis for a real protocol.

The standard frame format for HDLC (ADCCP and SDLC have the same format) appears in Fig. 4–9. Note that the number of overhead (control) bits is $\ell' = 48$, just the number used earlier for calculations. The eight-bit flag sequence 01111110 that appears at the beginning and end of a frame is used to establish and maintain synchronization. Because the flag appears at the beginning and end of the frame there is no need to prescribe an information field structure. The information field (packet) delivered from the network layer above can be any desired number of bits. Extended versions of the frame structure of Fig. 4–9 are available as well: The address, control, and block-check fields can all be increased to allow additional addressing, improved error detection, and increased sequence numbers. Since the flags appearing at the

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[CARLD] D. E. Carlson, "Bit-oriented Data Link Control Procedures," *IEEE Trans. on Comm.*, vol. COM-28, no. 4, April 1980, 455–467; reprinted in [GREE].

[BUX 1980] W. Bux, K. Kummerle, and H. L. Truong, "Balanced HDLC Procedures: A Performance Analysis," *IEEE Trans. on Comm.*, vol. COM-28, no. 11, Nov. 1980, 1889–1898.

| F | Address | Control | Information (packet, if transmitted) | Block check | F |
|---|---|---|---|---|---|
| (flag) 01111110 | 8 bits | 8 bits | | 16 bits | (flag) 01111110 |

**Figure 4–9** HDLC standard frame format

beginning and end of a frame contain six consecutive ones, that sequence may not appear anywhere else in the frame. Bit stuffing is used to eliminate this possibility: a zero is inserted at the transmitter any time that five ones appear outside the *F* fields. The zeros are removed at the receiver. If seven ones appear anywhere in the frame (six ones followed by an additional one), the frame is declared in error.

Three types of frames are defined to handle information flow, supervisory and control signals, and responses to all of these:

- I (information transfer) format
- S (supervisory) format
- U (unnumbered) format

S- and U-frames carry no information field. They are used strictly for supervisory and control purposes. The eight-bit control field in the frame determines which type of frame is being transmitted, and, for the S- and U- frames, which specific control signal is being transmitted. Figure 4–10 breaks the eight-bit control field down for the three types of frame. A zero in the first bit of the control field corresponds to an I-frame. The bit pairs 10 and 11 appearing as the first two bits indicate S-frame and U-frame, respectively, as shown. The two *S* bits in bit positions 3 and 4 of the S-frame allow four different S-frames to be transmitted. The five *M* bits in the U-frame allow 32 different U-frames to be transmitted. The three-bit number $N(S)$ in the I-frame represents the sequence number of the I-frame. Mod-8 sequence numbering is thus standard with normal HDLC. Each successive I-frame has its sequence number incremented by one. When the transmitter reaches its maximum sequence number it is forced to stop transmitting until a frame in the reverse direction is received, acknowledging an outstanding packet. The $N(R)$ bits in the I- and S-frames are used to acknowledge I-frames received. The number $N(R)$ acknowledges the receipt of $N(R)$-1 and any frames preceding that number not already acknowledged. $N(R)$ indicates that the receiver is *expecting* I-frame number $N(R)$. Thus $N(R) = 5$ (bit

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