

HDLC Derived Protocols

High Speed Data Link Control Defined

A Tutorial

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HDLC (High speed Data Link Control) is a common reference in most WAN products. The purpose of this paper is to define the variations and uses of protocols derived from HDLC.

The OSI Model

The Open Systems Interconnection (OSI) is a seven-layer protocol stack model used as a reference throughout the computer industry. The ISO was developed as a functional reference

model only. One must note that some well known protocols such as TCP/IP and Signaling System 7 (SS7) were developed before the OSI model, and therefore do not exactly align with the defined OSI boundaries, where protocol stacks like IBM's SNA have a very close relationship. However, when used as a reference, the OSI model gives us a general idea of what to expect from the various layers of a given protocol stack.

The OSI Stack Protocol Model

Layer 7	APPLICATION	Provides application services such as file transfer, remote file access
Layer 6	PRESENTATION	Masks format differences between applications while preserving information content
Layer 5	SESSION	Dialog management. Controls basic communication facility between applications
Layer 4	TRANSPORT	Rules for information exchange and reliable end-to-end data delivery
Layer 3	NETWORK	Procedures for data transfer between computers; routing
Layer 2	DATA LINK	Group bits into frames. Synchronize and provide error checking
Layer 1	PHYSICAL INTERFACE	Convert digital signals into a bit stream. Transmit across physical circuit



Data Link Layer

Since all HDLC derived protocols reside in the Data Link layer (a.k.a. layer 2), we will only concern ourselves with this layer. The Data Link layer is tasked to establish and maintain point-to-point Wide Area Network (WAN) links. Each data link is actually two, and only two, entities communicating at any one time through a physical port. There are two basic types of data link protocols, a master-slave interaction called Normal Response Mode (NRM, also known as Unbalanced), and a peer to peer relationship called Asynchronous Balanced Mode. NRM has all connection initialization, configuration and control done by the designated master (or Primary Station), ABM allows either peer ("Balanced") to initialize and control the link at any time ("Asynchronous"). NRM may have more than one Secondary Station (multidrop, multipoint), but they must communicate by way of the Primary Station.

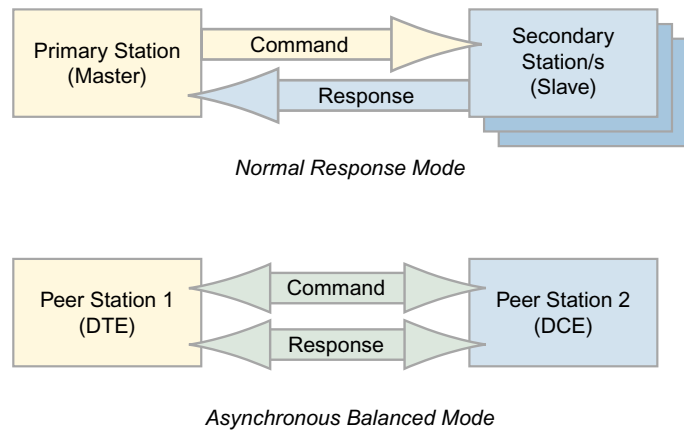
HDLC

There are many non-HDLC protocols that fall within the data link spectrum, from Monosync and Bisync to the IEEE 802.2 LLC and MAC layers. This paper is only concerned with HDLC derived protocols, commonalities and differences. Non-HDLC protocols will be covered in future documentation.

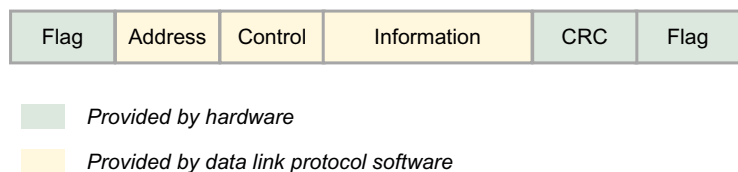
The full HDLC protocol is defined in ISO 3309 and related ISO standards. HDLC was the result of an effort by the international community to develop a standard for data link communication. HDLC has its roots in the ISO protocol stack model, a framework also defined by the international standards bodies.

It should be noted that the term "HDLC" can be taken a couple of ways based on the target applications. One interpretation (rare) is a complete ISO documented data link protocol (e.g., ISO 3309, 4335,

Layer 2: Data Link Layer



Basic HDLC Frame¹



Note 1: Except where indicated, all frames shown are transmitted from left most bit first

7809, etc.). A second, more common meaning is some data encapsulated in HDLC framing that includes frame delimiters ("flags"), zero bit insertion ("bit stuffing") and CRC generation. The last is better known because it is a common part of several different data link protocols, and is designed into a wide array of WAN controller chips (hardware implementation). A sample of protocols that use HDLC framing include:

- LAPB** Link Access Protocol (Balanced), Data link level for X.25
- LAPD** Link Access Protocol (D channel) used for ISDN D channel and other telco signaling
- Frame Relay** An independent data link protocol
- SDLC** The template for HDLC, used in IBM's System Network Architecture (SNA) stack
- MTP-2** Data link Signaling layer of SS7
- PPP** Point-to-Point Protocol.

HDLC Derived Protocols

The basic HDLC frame consists of two frame delimiters, address, control and information fields, and a CRC.

- The *frame delimiters* (8 bits), also known as flags, mark the end points of the HDLC frame. The binary flag pattern is always 01111110, or 7E hex.
- The *address* section (8 bits or multiple of 8) of the frame contains the destination address, which is either 01 (DTE) or 03 (DCE). HDLC is a point to point (one on one) link there are only two possibilities.
- The *control* field (8 bits or multiple of 8) is where bits of information about the frame itself and some link status, are passed to the destination. The destination system will take action depending on the value of these bits.
- The *information* field (variable length, not used in some types of frames) is the actual payload of the frame. Usually the I field is an encapsulated upper layer protocol packet (or partial packet), but it may also be raw data.
- The *Cyclic Redundancy Code* (16 or 32 bits), is a mathematical pattern check of the complete frame (sans the flags and CRC). The frame is checked on its way out of the source system, and the CRC is added. At the destination, the same mathematical algorithm is again performed as the frame is received, and is then compared against the transmitted CRC for the sake of data accuracy.
- *Bit stuffing* or zero insertion, is done by the hardware, and can happen anywhere within the frame. The purpose of bit stuffing is to mask any data that may be construed as a frame delimiter (01111110). As the data arrives from the protocol layer (before the flags are added), the frame is monitored for consecutive ones. When five consecutive ones are found in the data stream, a zero is inserted immediately following the fifth one (1). On receive, the stuffed zeros are removed before the data is passed up to the protocol handler.

Address and Control Fields

HDLC Address Field

Primary station issues command frames with secondary station address.
Secondary station issues responses with secondary station address.

X	X	X	X	X	X	X	X
---	---	---	---	---	---	---	---

HDLC Address:
Always secondary station address

HDLC Control Fields

0	N(S)	P/F	N(R)
---	------	-----	------

Information

10	SS	P/F	N(R)
----	----	-----	------

Supervisory

11	MM	P/F	MMM
----	----	-----	-----

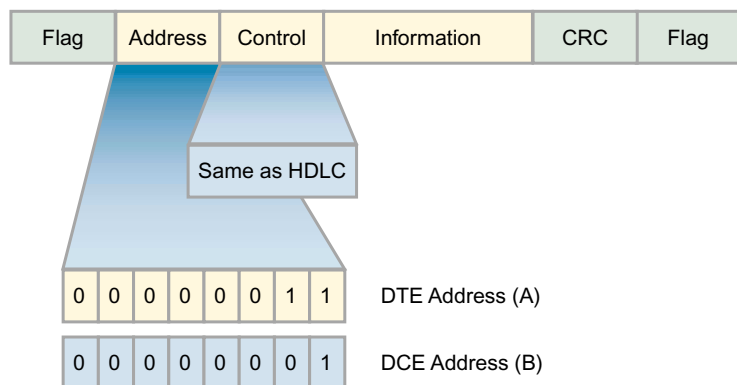
Unnumbered

1 2 3 4 5 6 7 8

N (S) Number of this frame (last frame sent) by source (0-7)
N (R) Number of last frame received by source (0-7)
P/F Poll/Final bit. If Poll, system soliciting a response. If Final, system response frame
S Supervisory function bit
M Modifier function bit

Values for S and M Command/Response bits can be found in ISO 4335.

LAPB Frame



DTE issues command frames with address B, response frames with address A
DCE issues command frames with address A, response frames with address B

Address and Control Fields

The address and control fields are where most HDLC derived protocols differ. Even in a standard HDLC frame the address octet(s) may differ depending on the configuration of the link. In unbalanced or NRM mode, the address always contains the secondary station address. In Balanced Mode where either end point can control the link, the address field contains the destination address. The control field also differs within HDLC depending on the frame type, Information, Supervisory, or Unnumbered.

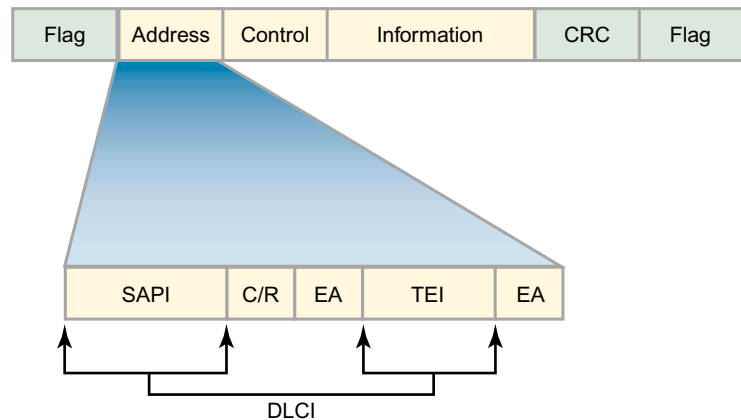
LAPB Frame

Linked Access Protocol (Balanced) is the data link layer used with X.25. The address field can contain only one of two fixed (DTE or DCE) addresses. The control fields are identical with HDLC.

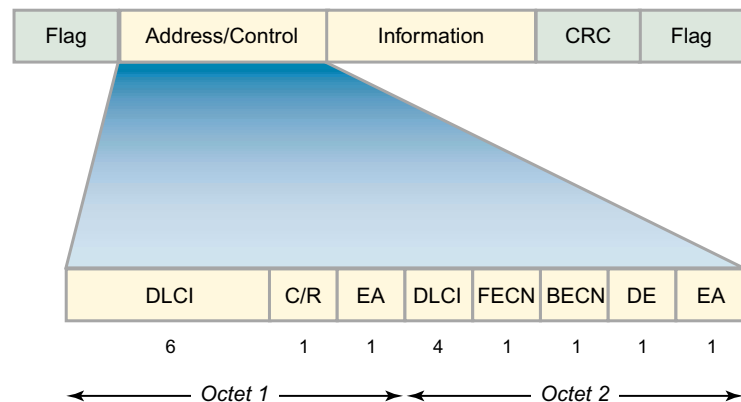
LAPD Frame

Linked Access Protocol (D Channel) is the data link layer used with ISDN. The control field is identical to HDLC, but the address field differs. The address field contains the Service Access Point Identifier (SAPI), Terminal Endpoint Identifier (TEI), a Command/Response bit and two address field extender bits. The SAPI and TEI together make up the Data Link Connection Identifier (DLCI). The SAPI identifies the type of service (Signaling, Packet Data, or Management) required of the layer 3 (Network Layer) protocol. The TEI is the address of the remote endpoint.

LAPD Frame



Frame Relay



DLCI Data Link Connection Identifier
 C/R Not used in Frame Relay
 EA Extended Address bit
 FECN Forward Explicit Congestion Notification
 BECN Backward Explicit Congestion Notification
 DE Discard Eligibility bit

Frame Relay

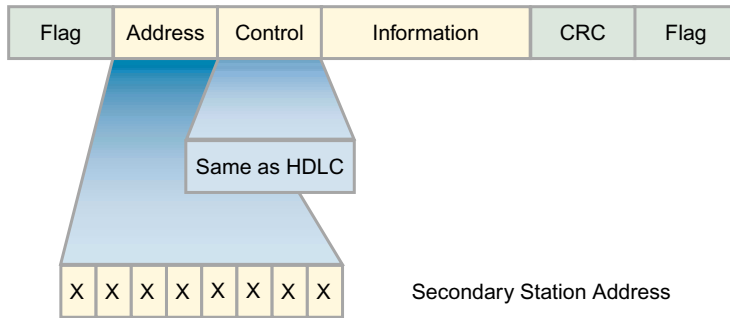
Frame Relay was developed to overcome the multiple layer handshaking overhead used in X.25. Frame Relay takes advantage of the fact that phone lines in North America are relatively error free. Frame Relay relies on some upper layer protocol to provide the necessary data transport

confirmation. Frame Relay is similar to other HDLC protocols, but it does not have a separate address and control fields. The address and control fields are combined. ISPs will often use Frame Relay over a clear channel T1 for high speed WAN connections.

Frame Relay does not have a designated upper level protocol. It is often used by Internet Service Providers (ISPs) to encapsulate

HDLC Derived Protocols

SDLC



TCP/IP, but is also defined by ITU-T and ANSI as part of the ISDN Control and User planes. See *ITU-T Q.921, Q.922 and Q.931, and ANSI T1.601, and T1.602, for additional information.*

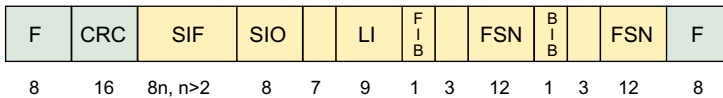
SDLC

Synchronous Data Link Control (SDLC) is the data link protocol designated by IBM's System Network Architecture (SNA), and is very closely related to HDLC. SDLC is primarily an unbalanced NRM protocol using Primary Stations connected to Secondary Stations in various configurations such as Point to Point, Multipoint, Loop (ring), and Hub Go-ahead.

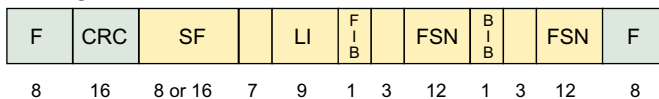
MTP-2

Bit transmission order →

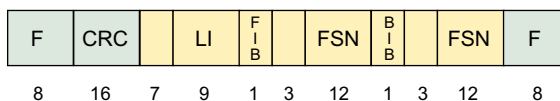
Message Signal Unit



Link Status Signal Unit



Fill-in Signal Unit



Blank Spaces are spare or reserved. Numbers show bits count for each field.

BIB	Backward Indicator Bit	LI	Length Indicator
BSN	Backward Sequence Number	n	Number of octets in SIF
CRC	Cyclic Redundancy Code	SF	Status Field
F	Flag	SIF	Signaling Information Field
FIB	Forward Indicator Bit	SIO	Service Information Octet
FSN	Forward Sequence Number		

MTP-2

Message Transfer Part 2 (MTP-2) is the data link layer for Signaling System 7 (SS7) the protocol stack that is the mainstay of the public telephone network. MTP-2 is a point-to-point data link protocol in the same genre as HDLC although not a direct derivative. Similarities include flags, a checksum, frame sequence numbering, and status. MTP-2 is unique in that it has three distinct frame types, Fill In Signal Unit (FISU), Link Status Signal Unit (LSSU), and Message Transfer Unit (MSU). ITU-T Q.703 (07-96) describes MTP-2 and the frame formats.

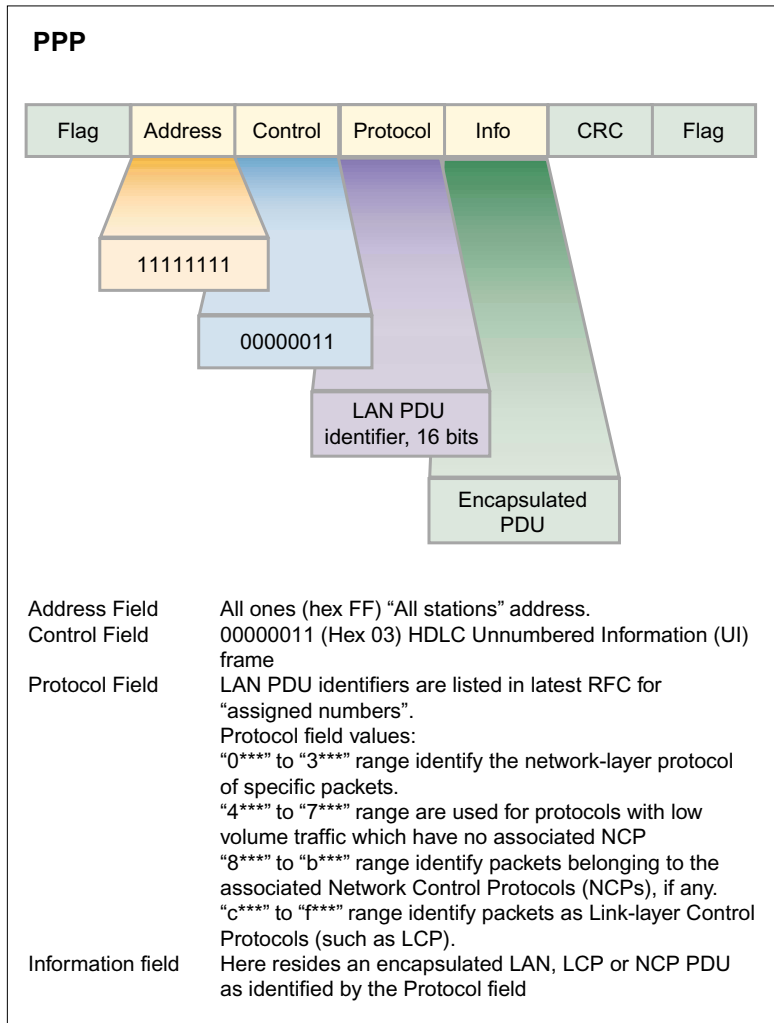
PPP

Point to Point Protocol (PPP) is found most often in the internet world. PPP, defined in RFC 1661, is often used to encapsulate TCP/IP or some other LAN Protocol Data Unit (PDU) for transmission over Wide Area Networks for the purposes of linking networks (LAN to LAN), remote workstations to a corporate LAN (Remote Access), and internet access to an ISP. Open source OSs such as Linux,

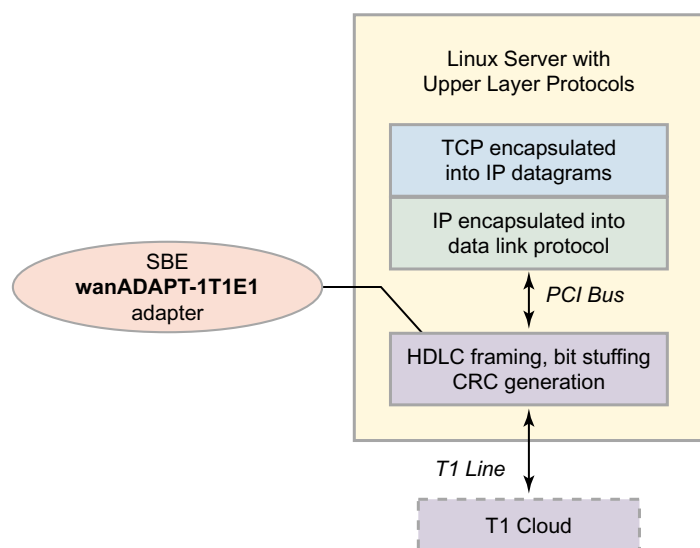
FreeBSD, and NetBSD, all offer PPP as a WAN protocol, as does Solaris. PPP differs slightly from the basic HDLC frame. The flags and CRC are the same, but the address bits are all set to 1 (hex FF), the control field is fixed at hex 03 (HDLC UI frame), and a protocol field is added to identify the data contained in the information field (a specific LAN PDU, link control PDU, or network control PDU).

Summary

HDLC is the basis for a wide variety of data link layer protocols. Regardless of the data link protocol, most HDLC framing, bit stuffing, and CRC generation is performed by the serial controller chips with the specific protocol stack software supplying the rest of the necessary fields (see Layer 2 diagram on page two). This means that most WAN cards can be adapted to any HDLC derived protocol. All that is needed is a little study of the desired protocol to see if it fits within the HDLC ISO 3309 framing rules, and a look at the serial controller chip attributes for HDLC support. ■



HDLC Protocols with a WAN Adapter



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