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Draft for Development

Logical link control for local area networks

Part 2. Guidance for implementors

Commande logique de liaison pour réseaux locaux
Partie 2. Guide de mise en oeuvre

Logisches Steuerungsverfahren für lokale Netze
Teil 2. Leitfaden für Anwender



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This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because the application of standardization to LAN technology is rapidly advancing and not yet sufficiently stable, pending the outcome of deliberations in the International Standards Committee (ISO/TC 97/SC 6 Data Transmission).

It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than two years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *BSI News*. Observations which it is felt should receive attention before the official call for comments will be welcomed.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

National foreword

This Draft for Development has been prepared under the direction of the Office and Information Standards Committee.

This Draft for Development complements DD 99 : Part 1 by giving guidance to implementors, and is identical to the Technical Guide on LLC which was previously available from the Department of Trade and Industry as TG 101/1.

Information on related standards and Drafts for Development is given in the national foreword to DD 99 : Part 1.

A brochure giving details of existing and projected British Standard publications for Open Systems Interconnection (OSI) may be obtained from the Sales Department, BSI, Linford Wood, Milton Keynes MK14 6LE, at no charge.

Terminology and conventions. The text of Technical Guide TG 101/1 has been approved as suitable for publication as a Draft for Development without deviation. Some terminology and certain conventions are not identical with those used in Drafts for Development; attention is drawn especially to the following.

Wherever the words 'IEEE Standard 802.2' appear they should be read as 'DD 99 : Part 2'.

TECHNICAL GUIDE TO IEEE-802.2 LLC1) General Overview of LLC

How does the LLC fit into the OSI Reference Model?

The LLC and the MAC are the two sub-layers which in combination provide the functionality of the OSI Reference Model 'Data Link Layer' (ref.1). The Data Link Layer is responsible for permitting communication between two different stations on the LAN. The MAC (as discussed elsewhere) solves issues of contention for the medium, and its implementation is specific to the type of medium used. It also provides the first level of address matching. The LLC sub-layer is common to all media access methods. All information transfer between the Network Layer and lower layers passes via the LLC.

What function does the LLC perform?

The LLC builds on the capabilities of the MAC, to provide eight additional functions which are not present in the MAC. These functions are:

- Additional Address Selection
- Connectionless ('Datagram') Service
- Connection-Oriented Service (optional)
- (with error correction)
- Acknowledge Connectionless Service (optional)
- Polled Response Service (optional)
- Exchanging ID with other LLCs (and optional duplicate address check)
- Downline Loading (optional)
- Loop-back Test

(Where the optional features are not implemented in a particular configuration, the LLC must ignore those commands.)

Let's look at each of these functions in turn.

Additional Address Selection

The LLC may contain interfaces to more than one Network Layer entity. These interfaces are known as Link-layer Service Access Points (LSAPs), and each has associated with it an LSAP address. The LSAP address may be regarded as a switch to permit selection of various Network Layer interfaces. More than one Network Layer interface will be needed if more than one network layer protocol is supported, or if the station is providing both a local communications capability and a gateway to a WAN. Other applications might be in a multi-user system where a number of users wish to access the LAN simultaneously, or in a terminal concentrator (though these splits for multiple use might be better placed at higher layer boundaries).

Each of the four types of service outlined below requires a different method of communicating with the network layer, so there will need to be a different LSAP for each type supported.

IEEE-802.2 caters for optional Types by defining Classes of LLC. To date, only two classes have been defined; Class I LLCs will support Type I service only, whereas Class II will support Types I and II. Thus, one may be sure that every LLC will, as a minimum support Type I. Further classes will be defined as Types III, IV are fully incorporated in the standard.

LLC Service Specification

The service which the IEEE 802 Medium Access Techniques provide to the Logical Link Control Sub Layer is essentially a datagram, ie individual MAC frames are regarded as unrelated to any previously transmitted MAC frames or to any other MAC frames that may subsequently be transmitted. In order to build a useful communication mechanism additional functionality has to be added to the MAC service and the Logical Link Control sub-layer represents, the first level of enhancement to the services offered by the Medium Access techniques. LLC offers various classes of enhancement and the choice of the appropriate class of LLC must be seen in the context of the total networking and communications requirements of the potentially communicating systems.

One basic choice offered by LLC is that between a connectionless and connection oriented service i.e the choice between Type 1 (Connectionless) and Type 2 (Connection Oriented) LLC. Where the connection oriented operation is a requirement it must be recognised that the connection function can be implemented at layers 2, 3 or 4 of the OSI model. It is possible to implement a connection oriented network service (layer 3) on top of LLC type 1. It is also possible to implement a connection oriented network service by suitable enhancement to LLC 2. In certain circumstances connection oriented operation can be implemented in the transport layer on top of connectionless link (LLC 1) operation and connectionless network operation. Thus it can be seen that the appropriate choice of LLC cannot be made in isolation and needs to take account of user requirements and design options at other layers. This topic is treated further in the Technical Guide TG 100/1 for the Network Layer.

Connectionless (CL) 'Datagram' Service (Type I)

In this communication method, each frame of information has added into it all the information needed to determine where it is to go. In this respect, it is like a letter in an envelope. The advantage of this method is that no initial handshaking is required with the destination, and no information needed be retained about the transmission after it is complete. This makes for a simple LLC implementation. Additionally, multi-cast and broadcast messages are possible.

Connection - Oriented (CO) Service (Type II)

In this communication method, an initial command frame (CONNECT) causes the remote end to initialise a counter for the frames to follow. In a system with gateways to WANs or other LANs, it may also cause any intermediate routing equipment to select the path for the data to use. Once this process is complete, data may be sent securely, in numbered frames. If corrupted frames are received, the receiver may request retransmission of the frame by number, thus ensuring integrity for the data received. Because this numbered information has to be time-division-multiplexed with other data on the PHYSICAL medium, it does still require the complete SA and DA addresses to be present in every frame. In any case, the MAC doesn't know about connections created by the LLC, and so must handle all frames for transmission alike.) The advantage of this scheme is that positive confirmation of delivery of the data is received in the same order that it is sent. However, for Connected-Oriented operation to be successful, the LLC must respond to received data within a predefined time (because of the existence of response timers), and it must also be able to keep track of the incoming information. Furthermore, the sending LLC must retain the information that it has sent in a buffer until a positive acknowledgement has been received, in case a retransmission is called for. (Saving pointers to the data is less costly than actually buffering the data, but if this approach is adopted, the operating system must prevent anyone changing the data between transmission and retransmission.) Implementation of a CO LLC is much more difficult and costly than the CL type. For this reason, the CO capability may be omitted from the LLC.

Acknowledged Connectionless Service (Type III)

In certain real-time applications, it is not possible to set up a connection prior to sending the data, but nevertheless, some acknowledgement is required that it did indeed get there. This service provides that capability. Note that were a number of such frames to be sent before the acknowledgements were received, it would be impossible to relate the acknowledgement to a particular frame. For this reason, this service is really a half-duplex service (though a spare bit has been used to indicate alternate frames, allowing one frame's acknowledgement to be outstanding at any time). Assumptions have to be made about the speed of response when a frame is received, and these assumptions will vary from system to system.

It seems likely that a special control field code will be used for the U-format PDU containing Type III information. The receiver will respond with a similar frame (less the information), and the P/F bit set to the same value as it received. The transmitter may optionally toggle the P/F bit, and wait for the echo before proceeding.

(This type is still under study.)

Polled Response (Type IV)

For interfacing slowly-changing data input devices to a LAN (such as keyboards, and sensing devices), a low-cost master-slave arrangement is adequate. A special service type to perform this has considerable advantages in token-passing systems, where a polled station has no requirement to accept the token, only sending its information when requested by the master, during the master's ownership of the token. Even in CSMA/CD systems, it is likely that a slight cost reduction may be achieved for nodes that only support Type IV, (though there will be no difference in the MAC sub-layer and the PHYSICAL layer).

The most probable arrangement for Type IV will be a new U-format PDU, known as UP (Un-numbered Poll), which will be a single frame with the P/F bit set to one. It will cause a UI frame to be returned, also with the P/F bit set to one. There is no guarantee that the response, (or indeed the request) will reach its destination, but usually this will not be a problem, as there are likely to be many polls for each meaningful response.

(This type is still under study)

The requirements for LLC Types 3 and 4 essentially derive from the possible application of Local Area Networks in a process control environment and have been strongly influenced by the work of the PROWAY committee. As stated above both LLC types 3 and 4 are still under study. Their application is primarily seen in conjunction with the token passing bus medium access techniques and consideration is also being given to an alternative method of providing these functions namely by suitable enhancement to token passing bus protocol.

Station Protocols

The following features are not part of any particular communication protocol, but are rather a function of the station as a whole. Therefore, they are referred to using the special Station LSAP (00000000).

Exchange ID with other LLCs (XID)

XID allows a station to establish which other stations are active on the network, and the level of features that they support. Every station that complies with IEEE-802 must support XID.

The format of the XID response allows a station to tell which data formats it supports, which LLC protocol Types (I-IV), and the maximum frame size that can be accepted.

The process of exchanging station IDs requires one station to send an XID Command Frame, containing its own address, and the address of a station it wishes to hear from. The other station responds with an XID Response frame, giving additional information about its capabilities. A station should respond with an XID_R if addressed, even if it originated the initial XID_C. In this way,

a station may perform a duplicate address check, by sending XID_C with itself as Source and Destination. If it gets more than one response (from itself), it can assume that there are other stations with the same address.

Downline Loading

Where programs to implement the Reference Model reside in Read-Only Memory in each station, updating the programs can be a time-consuming business, especially when the stations are widely dispersed. Downline Loading is an optional capability which may be provided, whereby only the programs to implement the MAC and the station component of the LLC reside permanently in the station. When the SIM (Select Initialisation Mode) frame is received, the station component treats subsequent frames as program information to be loaded into its own memory, until the RIM (Reset IM) frame is received. By this method, communications protocol programs may be kept centrally, and loaded into RAM in the station on power up. Of course, the actual program information sent will be highly specific to the LAN configuration in use.

Loopback Test

This is a simple test, whereby an LLC, on receiving a TEST_C frame, responds with a TEST_R frame, (optionally echoing any information received from the incoming TEST_C frame.) This may be used as a test of the integrity of the link and underlying media, for example to establish bit-error rates, or to exercise part of the system.

2) A User's View of the LLC

In general, the system user will not be aware of the existence of the LLC, as all commands to the LLC will come from higher layers. These higher layers use the lower layers as a means of providing the service that the user has requested, but the only indication that the user gets of what is going on is whether his service is satisfactorily completed. It should not be necessary for the user to have any understanding of the workings of the LLC. Such an understanding may, however, enable him to make better use of his resources, by, for example, suggesting when he should specify connectionless and when connection-oriented service.

Provided that the necessary functions are performed, there is no requirements in IEEE-802.2 for each layer (or sub-layer) interface to be viewable independently. It is expected that in some cases, manufacturers will not document the interface between the LLC and the network layer (they might even integrate them both into one program), and consequently the interface may not be available to applications programmers.

The LLC - Network Layer Interface

Were the LLC-Network layer interface to be viewable, the user would see the following primitives:

		Type
L_DATA	(CL data)	I
L_CONNECT	(set up connection)	II
L_DATA_CONNECT	(CO data)	II
L_DISCONNECT	(clear connection)	II
L_RESET	(async clear)	II
L_CONNECTION_FLOWCONTROL	(limit data rate)	II

(The primitives for Types III, IV are not yet defined).

Each primitive will have associated with it a method of passing the parameters associated with the primitive between the layers. In the case of L_DATA and L_DATA_CONNECT, one of those parameters will be a pointer to the data area containing the information transmitted.

These primitives generally exist in three forms:

L_PRIMITIVE.request	This indicates a command from the local Network layer, or information for the LLC to transmit.
L_PRIMITIVE.indicate	This indicates to the Network layer that the LLC has information for it, usually because it has received a transmission.
L_PRIMITIVE.confirm	This indicates to the Network layer the extent to which the service previously requested was successfully executed.

3) Organisation of the IEEE-802.2 Standards Document

The IEEE-802.2 chapters have the following objectives:

1. Introduction

This shows briefly how LLC fits into the ISO RM, and refers to the earlier standards from which much of IEEE-802.2 has been derived.

2. Interface Service Specifications

The primitives used to communicate with the Network layer above are specified in 2.1, and to the MAC Sub-layer below in 2.2. The primitives are defined qualitatively in terms of the information that should be passed in a given situation. No attempt is made to specify the form of the information, which may thus be

whatever is most convenient in the circumstances. Of course, by adopting this approach, the standard does not provide any degree of interconnectability between layers. If the interface is to be exposed, additional details will need to be defined.

3. LLC Protocol Data Unit Structure

In order that any remote LLC may correctly interpret control information generated by the local LLC, the format of the control information must be part of the LLC standard. This chapter specifies how the Source and Destination LSAPs (SSAP and DSAP) and the control information will be formatted, and their position in the frame. It also discusses briefly the assignment of LSAP code points for various situations. Figs 3.1a and 3.1b in Annex 1 shows how the LLC PDU relates to the transmission process, for a typical frame.

4. LLC Types and Classes of Procedure

This chapter discusses the available types of data transmission, and the standard subsets of these that may be supported. The current document (July '83) only discusses Types I, II.

5. LLC Elements of Procedure

Here, the LLC PDU control field formats are defined, and the use of a modulo-128 sequencing scheme for connection-oriented data transfer. The formats for the LLC-to-LLC commands and responses are defined.

6. Description of Type I Procedures

A description, in prose, of the purpose and use of each of the LLC PDU frame formats available for Type I (Connectionless) communication.

7. Description of Type II Procedures

A description, in prose, of the purpose and use of each of the LLC PDU frame formats available for Type II (Connection-Oriented) communication. Because Type II requires both ends to keep track of what has been sent successfully, state-machines are defined, indicating the various states each end can get into, and the conditions necessary for a transition between one state and the next. A 'Connection Component' is defined, which is a state machine associated with a particular connection. An LSAP may have a number of connection components, and hence support multiple simultaneous connections.

(There will in due course be chapters corresponding to chapters 6, 7 for Types III, IV)

4) Relationship of IEEE-802.2 to existing standards

The IEEE-802.2 document has been extensively derived from the widely-used 'High-level Data Link Control Procedures' (HDLC) standard published by ISO (refs. 2-5). Certain features have changed, and where HDLC defines a number of options, IEEE-802.2 usually only chooses one of them. The distinction between HDLC and LLC is that the data delimiting functions (Flags 0 bit insertion) and error detection (Frame Check Sequence) capabilities defined in HDLC are performed by the medium access sub layer in Local Area Networks.

Although HDLC does define an unnumbered frame format as used by LLC for sending connectionless 'Datagram' frames, it uses these unnumbered frames exclusively for sending link control information. The connectionless service (which computer manufacturers currently prefer for LANs) is not currently supported on WANS that adhere to X.25, and use a connection-oriented mode of HDLC (LAP-B) to support this.

5) Is the LLC really necessary?

If you intend to build a LAN which only supports Connectionless operation, it is possible to omit the LLC sub-layer. Indeed, some LANs are available which, whilst claiming IEEE-802.3/4/5 compliance, do indeed omit the LLC. Although such a strategy does reduce the cost of the product, and apparently doesn't forsake anything in functionality, as time passes, and the system grows, difficulties will become apparent.

The minimum price to pay now for interconnectability later is a sublayer which automatically attaches unchanging SSAP, DSAP and Control Fields to the beginning of every (connectionless) transmitted frame, and strips them on receipt. Any received frame which does not contain the Unnumbered Information (UI) control field or the correct DSAP is ignored. If this is done, subsequent system enhancements may be made to support XID, TEST and CO protocols while still remaining downward-compatible. (XID and TEST will be required before IEEE-802.2 compliance can be claimed.)

System Conformance within the definition of the IEEE 802 standards requires the implementation of a class of LLC as well as an associated MAC. The LLC class structure potentially allows inter communication between terminals implementing different levels of functionality at LLC as class 2 LLC includes the ability to support both type 1 and type 2 operation.