

INTERNATIONAL STANDARD

ISO
8802-2
ANSI/IEEE
Std 802.2

First edition
1989-12-31

Information processing systems — Local area networks —

Part 2 : Logical link control

*Systèmes de traitement de l'information — Réseaux locaux —
Partie 2 : Contrôle de liaison logique*



Reference number
ISO 8802-2 : 1989 (E)
ANSI/IEEE
Std 802.2-1989



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First Printing
December 1989

ISBN 1-55937-019-X
Library of Congress Catalog Card Number 88-46183

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ANSI/IEEE Std 802.2-1989

(Revision of ANSI/IEEE Std 802.2-1985)

Information processing systems— Local area networks—

Part 2: Logical link control

Sponsor

**Technical Committee on Computer Communications
of the
IEEE Computer Society**

Approved August 17, 1989

IEEE Standards Board

Approved January 12, 1990

American National Standards Institute

Approved 1989 by the

International Organization for Standardization



**Adopted as an International Standard by the
International Organization for Standardization**



**Published by
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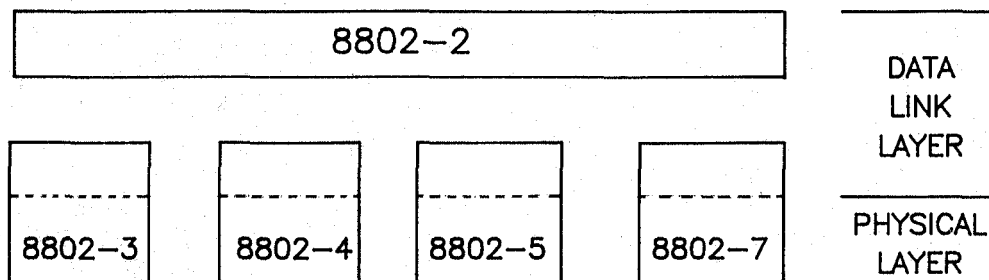
In 1985, ANSI/IEEE Std 802.2-1985 was adopted by ISO Technical Committee 97, *Information processing systems*, as draft International Standard ISO 8802-2. Following the procedures described above, the Standard was subsequently approved by ISO in the form of this new edition, which is published as International Standard ISO 8802-2 : 1989.



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Foreword to International Standard ISO 8802-2 : 1989

This standard is part of a family of standards for Local Area Networks (LANs). The relationship between this standard and the other members of the family is shown below. (The numbers in the figure refer to ISO Standard numbers.)



This family of standards deals with the physical and data link layers as defined by the ISO Open Systems Interconnection Reference Model (ISO 7498 : 1984). The access standards define four types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. The standards defining these technologies are:

- (1) ISO 8802-3 [ANSI/IEEE Std 802.3-1988], a bus utilizing CSMA/CD as the access method,
- (2) ISO 8802-4 [ANSI/IEEE Std 802.4-1985], a bus utilizing token passing as the access method,
- (3) ISO 8802-5 [IEEE Std 802.5-1989], a ring utilizing token passing as the access method,
- (4) ISO 8802-7, a ring utilizing slotted ring as the access method.

ISO 8802-2 [IEEE Std 802.2-1989], Logical Link Control protocol, is used in conjunction with the medium access standards.

The reader of this document is urged to become familiar with the complete family of standards.

The main body of this standard serves for both the ISO 8802-2 : 1989 and IEEE 802.2-1989 standards. ISO and IEEE each have unique foreword sections.

IEEE Std 802.2-1989

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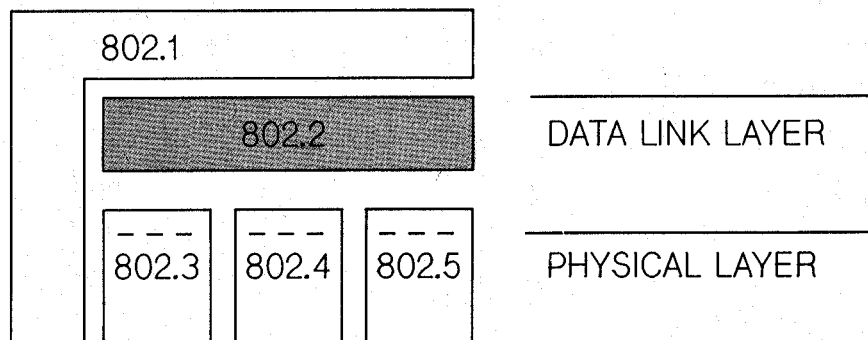
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(This Foreword is not a part of ISO 8802-2 : 1989 or of IEEE Std 802.2-1989.)

This standard is part of a family of standards for Local Area Networks (LANs). The relationship between this standard and other members of the family is shown below. (The numbers in the figure refer to IEEE Standard numbers.)



This family of standards deals with the physical and data link layers as defined by the ISO Open Systems Interconnection Reference Model. The access standards define three types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. The standards defining these technologies are:

- (1) ANSI/IEEE Std 802.3-1988 [ISO 8802-3], a bus utilizing CSMA/CD as the access method,
- (2) ANSI/IEEE Std 802.4-1985 [ISO 8802-4], a bus utilizing token passing as the access method,
- (3) IEEE Std 802.5-1989 [ISO 8802-5], a ring utilizing token passing as the access method.

IEEE Std 802.2-1989 [ISO 8802-2], the Logical Link Control standard, is used in conjunction with the medium access standards.

IEEE P802.1 describes the relationship among these standards and their relationship to the ISO Open Systems Interconnection Reference Model in more detail. This companion document also will contain networking management standards and information on internetworking.

The reader of this standard is urged to become familiar with the complete family of standards.

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Information processing systems— Local area networks—

Part 2: Logical link control

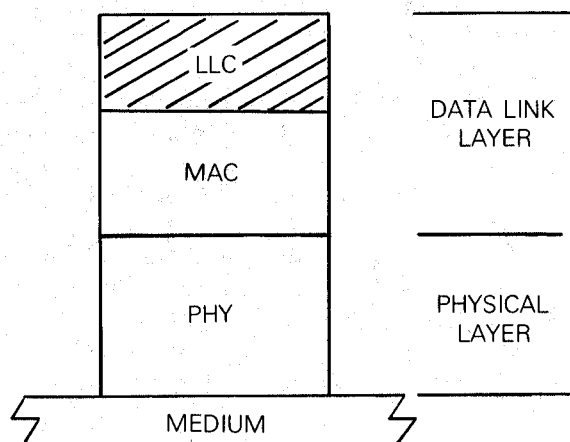
1. Introduction

1.1 Scope and Purpose. This International Standard is one of a set of international standards produced to facilitate the interconnection of computers and terminals on a Local Area Network (LAN). It is related to the other international standards by the Reference Model for Open Systems Interconnection.

NOTE: The exact relationship of the layers described in this International Standard to the layers defined by the OSI Reference Model is under study.

This International Standard describes the functions, features, protocol, and services of the Logical Link Control (LLC) sublayer in the ISO 8802 Local Area Network Protocol. The LLC sublayer constitutes the top sublayer in the data link layer (see Fig 1-1) and is common to the various medium access methods that are defined and supported by the ISO 8802 activity. Separate international standards describe each medium access method individually and indicate the additional features and functions that are provided by the Medium

Fig 1-1
Relationship to LAN Reference Model



Access Control (MAC) sublayer in each case to complete the functionality of the data link layer as defined in the LAN architectural reference model.

This International Standard describes the LLC sublayer service specifications to the network layer (Layer 3), to the MAC sublayer, and to the LLC sublayer management function. The service specification to the network layer provides a description of the various services that the LLC sublayer, plus underlying layers and sublayers, offer to the network layer, as viewed from the network layer. The service specification to the MAC sublayer provides a description of the services that the LLC sublayer requires of the MAC sublayer. These services are defined so as to be independent of the form of the medium access methodology, and of the nature of the medium itself. The service specification to the LLC sublayer management function provides a description of the management services that are provided to the LLC sublayer. All of the above service specifications are given in the form of primitives that represent in an abstract way the logical exchange of information and control between the LLC sublayer and the identified service function (network layer, MAC sublayer, or LLC sublayer management function). They do not specify or constrain the implementation of entities or interfaces.

This International Standard provides a description of the peer-to-peer protocol procedures that are defined for the transfer of information and control between any pair of data link layer service access points on a local area network. The LLC procedures are independent of the type of medium access method used in the particular local area network.

To satisfy a broad range of potential applications, two types of data link control operation are included (see Section 4). The first type of operation (see Section 6) provides a data-link-connectionless-mode service across a data link with minimum protocol complexity. This type of operation may be useful when higher layers provide any essential recovery and sequencing services so that these do not need replicating in the data link layer. In addition, this type of operation may prove useful in applications where it is not essential to guarantee the delivery of every data link layer data unit. This type of service is described in this International Standard in terms of "logical data links". The second type of operation (see Section 7) provides a data-link-connection-mode service across a data link comparable to existing data link control procedures provided in International Standards such as HDLC (see ISO 4335 : 1987 [1]¹). This service includes support of sequenced delivery of data link layer data units, and a comprehensive set of data link layer error recovery techniques. This second type of service is described in this international standard in terms of "data link connections".

This International Standard identifies two distinct "classes" of LLC operation. Class I provides data-link-connectionless-mode service only. Class II provides data-link-connection-mode service plus data-link-connectionless-mode service. Either class of operation may be supported.

The basic protocols described herein are peer protocols for use in multi-

¹ The numbers in brackets correspond to those of the references listed in 1.3.

station, multiaccess environments. Because of the multistation, multiaccess environment, it shall be possible for a station to be involved in a multiplicity of peer protocol data exchanges with a multiplicity of different stations over a multiplicity of different logical data links and/or data link connections that are carried by a single physical layer (PHY) over a single physical medium. Each unique to-from pairing at the data link layer shall define a separate logical data link or data link connection with separate logical parameters and variables. Except where noted, the procedures described in this chapter shall relate to each data link layer logical data link or data link connection separately and independently from any other logical data link or data link connection that might exist at the stations involved.

1.2 Standards Compatibility. The peer protocol procedures defined in Section 5 utilize some of the concepts and principles, as well as commands and responses, of the balanced data link control procedures known as Asynchronous Balanced Mode (ABM), as defined in ISO 7809 : 1984 [3]. (The ABM procedures provided the basis upon which the CCITT Recommendation X.25 Level 2 LAPB [4] procedures were defined.) The frame structure defined for the data link layer procedures as a whole is defined in part in Section 3 of this international standard and in part in those International Standards that define the various medium access control (MAC) procedures. The combination of a MAC sublayer address and an LLC sublayer address is unique to each data link layer service access point in the local area network.

NOTE: This division of data link layer addressing space into separate MAC and LLC address fields is not presently a part of any present ISO data link layer International Standard.

1.3 References

- [1] ISO 4335 : 1987, Information processing systems, Data communications, High-level data link control elements of procedures.²
- [2] ISO 7498 : 1984, Information processing systems, Open systems interconnection, Basic reference model.
- [3] ISO 7809 : 1984, Information processing systems, Data communications, High-level data link control procedures, Consolidation of classes of procedures.
- [4] CCITT Recommendation X.25, Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.³

² ISO documents are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, USA. ISO documents are also available from the ISO Office, 1 rue de Varembe, Case Postale 56, CH-1211, Genève 20, Switzerland/Suisse.

³ CCITT documents are available in the US from the US Dept. of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161. CCITT documents are also available from CCITT General Secretariat, International Telecommunications Union, Sales Section, Place des Nations, CH-1211, Genève 20, Switzerland/Suisse.

[5] CCITT Recommendation X.200, Reference model on open systems interconnection for CCITT applications.

1.4 Acronyms and Definitions

1.4.1 Acronyms

ABM	Asynchronous Balanced Mode
ACK	ACKnowledge
ADM	Asynchronous Disconnected Mode
C	Command
CCITT	International Telegraph and Telephone Consultative Committee
C/R	Command/Response
DA	Destination Address
DCE	Data Circuit-terminating Equipment
DIS	Draft International Standard
DISC	DISConnect
DM	Disconnected Mode
DSAP	Destination Service Access Point
DTE	Data Terminal Equipment
F	Final
FCS	Frame Check Sequence
FRMR	FRaMe Reject
HDL	High-level Data Link Control
I	Information
I	Information transfer format
ISO	International Organization for Standardization
LAN	Local Area Network
LAPB	Link Access Procedure, Balanced
LLC	Logical Link Control
LSAP	Link layer Service Access Point
LSB	Least Significant Bit
LSDU	Link layer Service Data Unit
M	Modifier function bit
MAC	Medium Access Control
N(R)	Receive sequence Number
N(S)	Send sequence Number
OSI	Open Systems Interconnection
P	Poll
PDU	Protocol Data Unit
P/F	Poll/Final
PHY	PHYsical
R	Response
REJ	REJect
RNR	Receive Not Ready
RR	Receive Ready
S	Supervisory format

S	Supervisory function bit
SA	Source Address
SABME	Set Asynchronous Balanced Mode Extended
SAP	Service Access Point
SSAP	Source Service Access Point
TEST	TEST
U	Unnumbered format
UA	Unnumbered Acknowledgment
UI	Unnumbered Information
V(R)	Receive state Variable
V(S)	Send state Variable
XID	eXchange IDentification

1.4.2 Definitions. For the purpose of this International Standard the following definitions shall apply:

accept. The condition assumed by an LLC upon accepting a correctly received PDU for processing.

address fields (DSAP and SSAP). The ordered pair of service access point addresses at the beginning of an LLC PDU which identifies the LLC(s) designated to receive the PDU and the LLC sending the PDU. Each address field is one octet in length.

basic status. An LLC's capability to send or receive a PDU containing an information field.

command. In data communications, an instruction represented in the control field of a PDU and transmitted by an LLC. It causes the addressed LLC(s) to execute a specific data link control function.

command PDU. All PDUs transmitted by an LLC in which the C/R bit is equal to "0".

control field (C). The field immediately following the DSAP and SSAP address fields of a PDU. The content of the control field is interpreted by the receiving destination LLC(s) designated by the DSAP address field:

- (a) As a command, from the source LLC designated by the SSAP address field, instructing the performance of some specific function; or
- (b) As a response, from the source LLC designated by the SSAP address field.

data link. An assembly of two or more terminal installations and the interconnecting communications channel operating according to a particular method that permits information to be exchanged; in this context the term *terminal installation* does not include the data source and the data sink.

data link layer. The conceptual layer of control or processing logic existing in the hierarchical structure of a station that is responsible for maintaining

control of the data link. The data link layer functions provide an interface between the station higher layer logic and the data link. These functions include address/control field interpretation, channel access and command PDU/response PDU generation, transmission, and interpretation.

exception condition. The condition assumed by an LLC upon receipt of a command PDU which it cannot execute due to either a transmission error or an internal processing malfunction.

global (broadcasting) DSAP address. The predefined LLC DSAP address (all ones) used as a broadcast (all parties) address. It can never be the address of a single LLC on the data link.

group (multicast) DSAP address. A destination address assigned to a collection of LLCs to facilitate their being addressed collectively. The least significant bit shall be set equal to "1".

higher layer. The conceptual layer of control or processing logic existing in the hierarchical structure of a station that is above the data link layer and upon which the performance of data link layer functions are dependent; for example, device control, buffer allocation, LLC station management, etc.

information field (I). The sequence of octets occurring between the control field and the end of the LLC PDU. The information field contents of I, TEST, and UI PDUs are not interpreted at the LLC sublayer.

invalid frame. A PDU that either

- (a) Does not contain an integral number of octets,
- (b) Does not contain at least two address octets and a control octet, or
- (c) Is identified by the physical layer or MAC sublayer as containing data bit errors.

LLC. That part of a data station that supports the logical link control functions of one or more logical links. The LLC generates command PDUs and response PDUs for transmission and interprets received command PDUs and response PDUs. Specific responsibilities assigned to an LLC include

- (a) Initiation of control signal interchange,
- (b) Organization of data flow,
- (c) Interpretation of received command PDUs and generation of appropriate response PDUs, and
- (d) Actions regarding error control and error recovery functions in the LLC sublayer.

MAC. That part of a data station that supports the medium access control functions that reside just below the LLC sublayer. The MAC procedures include framing/deframing data units, performing error checking, and acquiring the right to use the underlying physical medium.

N-layer. A subdivision of the architecture, constituted by subsystems of the same rank (N).

N-user. An N+1 entity that uses the services of the N-layer, and below, to communicate with another N+1 entity.

octet. A bit-oriented element that consists of eight contiguous binary bits.

peer protocol. The sequence of message exchanges between two entities in the same layer that utilize the services of the underlying layers to effect the successful transfer of data and/or control information from one location to another location.

priority (use in primitives). A parameter used to convey the priority required or desired.

protocol data unit (PDU). The sequence of contiguous octets delivered as a unit from or to the MAC sublayer. A valid LLC PDU is at least 3 octets in length, and contains two address fields and a control field. A PDU may or may not include an information field in addition.

response. In data communications, a reply represented in the control field of a response PDU. It advises the addressed destination LLC of the action taken by the source LLC to one or more command PDUs.

response PDU. All PDUs sent by a LLC in which the C/R bit is equal to "1".

service. The capabilities and features provided by an N-layer to an N-user.

service class (use in primitives). A parameter used to convey the class of service required or desired.

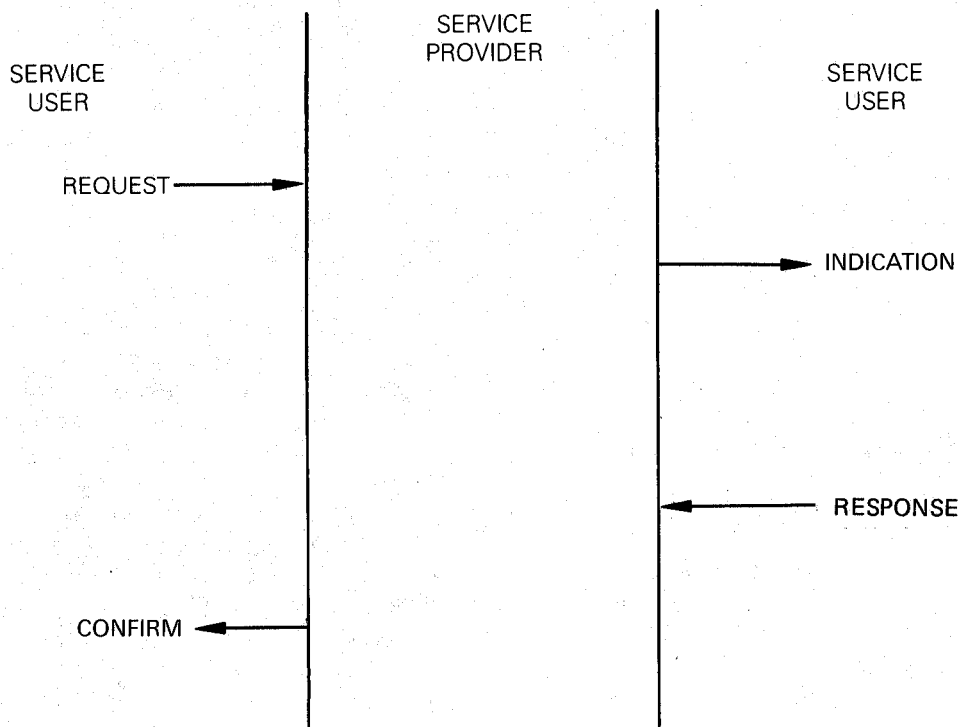


2. LLC Sublayer Service Specifications

This section covers the services required of, or by, the LLC sublayer at the logical interfaces with the network layer, the MAC sublayer, and the LLC sublayer management function.

In general, the services of a layer (or sublayer) are the capabilities which it offers to a user in the next higher layer (or sublayer). In order to provide its service, a layer (or sublayer) builds its functions on the services which it requires from the next lower layer (or sublayer). Fig 2-1 illustrates this notion of service hierarchy and shows the relationship of the two correspondent N-users and their associated N-layer (or sublayer) peer protocol entities.

Fig 2-1
Service Primitives



Services are specified by describing the information flow between the N-user and the N-layer (or sublayer). This information flow is modeled by discrete, instantaneous events, which characterize the provision of a service. Each event consists of passing a service primitive from one layer (or sublayer) to the other through an N-layer (or sublayer) service access point associated with an N-user. Service primitives convey the information required in providing a particular service. These service primitives are an abstraction in that they specify only the service provided rather than the means by which the service is provided. This definition of service is independent of any particular interface implementation.

Services are specified by describing the service primitives and parameters that characterize each service. A service may have one or more related primitives that constitute the activity that is related to the particular service. Each service primitive may have zero or more parameters that convey the information required to provide the service.

Primitives are of four generic types:

- | | |
|-------------------|--|
| REQUEST | The request primitive is passed from the N-user to the N-layer (or sublayer) to request that a service be initiated. |
| INDICATION | The indication primitive is passed from the N-layer (or sublayer) to the N-user to indicate an internal N-layer (or sublayer) event which is significant to the N-user. This event may be logically related to a remote service request, or may be caused by an event internal to the N-layer (or sublayer). |
| RESPONSE | The response primitive is passed from the N-user to the N-layer (or sublayer) to complete a procedure previously invoked by an indication primitive. |
| CONFIRM | The confirm primitive is passed from the N-layer (or sublayer) to the N-user to convey the results of one or more associated previous service request(s). |

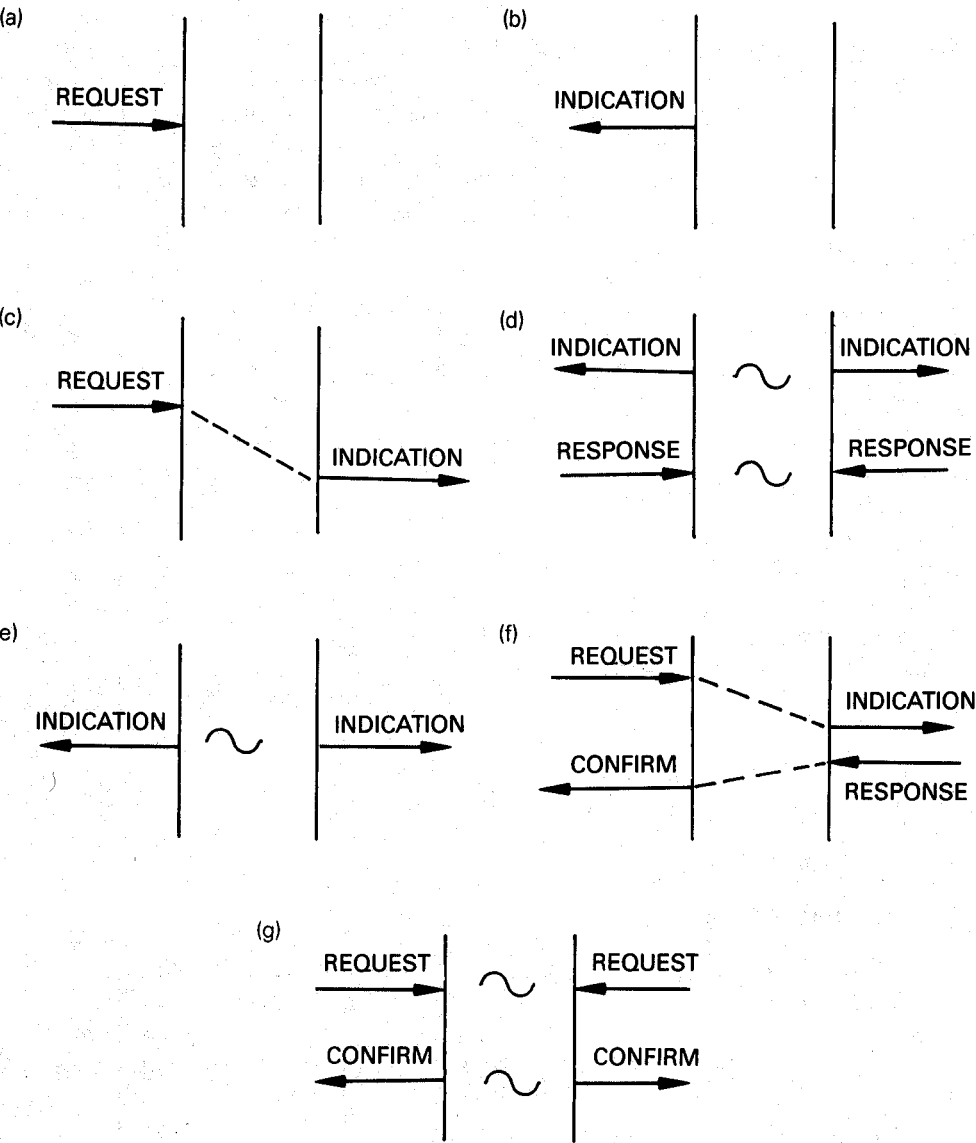
Possible relationships among primitive types are illustrated by the time-sequence diagrams shown in Fig 2-2. The figure also indicates the logical relationship of the primitive types. Primitive types that occur earlier in time and are connected by dotted lines in the diagrams are the logical antecedents of subsequent primitive types.

2.1 Network Layer/LLC Sublayer Interface Service Specification. This section specifies the services required of the LLC sublayer by the network layer, as viewed from the network layer, to allow a local network layer entity to exchange packets with remote peer network layer entities. The services are described in an abstract way and do not imply any particular implementation or any exposed interface.

Two forms of service are provided—*unacknowledged connectionless-mode* and *connection-mode*:

Unacknowledged Connectionless-Mode Service. The data transfer service that provides the means by which network entities can exchange link service data units (LSDUs) without the establishment of a data link level connection. The data transfer can be point-to-point, multicast, or broadcast.

Fig 2-2
Time-Sequence Diagram



Connection-Mode Services. This set of services provides the means for establishing, using, resetting, and terminating data link layer connections. These connections are point-to-point connections between LSAPs.

The connection establishment service provides the means by which a network entity can request, or be notified of, the establishment of data link layer connections.

The connection-oriented data transfer service provides the means by which a network entity can send or receive LSDUs over a data link layer connection. This service also provides data link layer sequencing, flow control, and error recovery.

The connection reset service provides the means by which established connections can be returned to the initial state.

The connection termination service provides the means by which a network entity can request, or be notified of, the termination of data link layer connections.

The connection flow control service provides the means to control the flow of data associated with a specified connection, across the network layer/data link layer interface.

2.1.1 Overview of Interactions

2.1.1.1 Unacknowledged Connectionless-Mode Services

2.1.1.1.1 Unacknowledged Connectionless-Mode Data Transfer. The primitives associated with unacknowledged connectionless-mode data transfer are

DL-UNITDATA request

DL-UNITDATA indication

The DL-UNITDATA request primitive is passed to the LLC sublayer to request that an LSDU be sent using unacknowledged connectionless-mode procedures. The DL-UNITDATA indication primitive is passed from the LLC sublayer to indicate the arrival of an LSDU.

2.1.1.2 Connection-Mode Services

2.1.1.2.1 Connection Establishment. The service primitives associated with connection establishment are

DL-CONNECT request

DL-CONNECT indication

DL-CONNECT response

DL-CONNECT confirm

The DL-CONNECT request primitive is passed to the LLC sublayer to request that a data link connection be established between a local LSAP and a remote LSAP. The DL-CONNECT indication primitive is passed from the LLC sublayer to indicate the request by a remote entity to establish a connection to a local LSAP. The DL-CONNECT response primitive is passed to the LLC sublayer to signal acceptance of a connection. The DL-CONNECT con-

firm primitive is passed from the LLC sublayer to convey the results of the previous associated DL-CONNECT request primitive.

2.1.1.2.2 Connection-Mode Data Transfer. The primitives associated with connection-mode data transfer are

DL-DATA request

DL-DATA indication

The DL-DATA request primitive is passed to the LLC sublayer to request that an LSDU be sent using connection-mode procedures. The DL-DATA indication primitive is passed from the LLC sublayer to indicate the arrival of an LSDU.

2.1.1.2.3 Connection Termination. The primitives associated with connection termination are

DL-DISCONNECT request

DL-DISCONNECT indication

The DL-DISCONNECT request primitive is passed to the LLC sublayer to request the immediate termination of a data link connection. The DL-DISCONNECT indication primitive is passed from the LLC sublayer to indicate to the network layer that a connection has been terminated.

2.1.1.2.4 Connection Reset. The primitives associated with connection resetting are

DL-RESET request

DL-RESET indication

DL-RESET response

DL-RESET confirm

The DL-RESET request primitive is passed to the LLC sublayer to request that a connection be immediately reset to the initial state. The DL-RESET indication primitive is passed from the LLC sublayer to indicate a connection reset attempt by either a remote entity or the local LLC sublayer. The DL-RESET response primitive is passed to the LLC sublayer to signal acceptance of the reset condition. The DL-RESET confirm primitive is passed from the LLC sublayer to convey the results of the previous associated DL-RESET request primitive.

2.1.1.2.5 Connection Flow Control. The primitives associated with connection flow control are

DL-CONNECTION-FLOWCONTROL request

DL-CONNECTION-FLOWCONTROL indication

The DL-CONNECTION-FLOWCONTROL request primitive is passed to the LLC sublayer to control the flow from the LLC sublayer of DL-DATA indication primitives related to a connection. The DL-CONNECTION-FLOW-

CONTROL indication primitive is passed from the LLC sublayer to control the flow from the network layer of DL-DATA request primitives related to a connection.

2.1.2 Detailed Service Specifications. This section describes in detail the primitives and parameters associated with the identified services. Note that the parameters are specified in an abstract sense. The parameters specify the information that must be available to the receiving entity. A specific implementation is not constrained in the method of making this information available.

The "source_address" and "destination_address" parameters provide at a minimum the logical concatenation of the MAC address field (SA and/or DA) and the LLC address field (SSAP and/or DSAP). An implementation of connection-mode services may make use of a locally significant connection identifier to imply source and destination address parameters. The "data" parameter may be provided by actually passing the link service data unit, by passing a pointer, or by other means. The "priority" parameter provides the priority associated with the data unit transfer. The "priority" parameter is passed transparently to the underlying MAC sublayer via the appropriate LLC/MAC primitives, see 2.2. The "reason" parameter provides an explanation of the disconnection, including a request by the remote entity, or an error internal to the LLC sublayer. The "amount" parameter provides information regarding the amount of data that the LLC entity is allowed to pass.

2.1.2.1 DL-UNITDATA request

2.1.2.1.1 Function. This primitive is the service request primitive for the unacknowledged connectionless-mode data transfer service.

2.1.2.1.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-UNITDATA request(  
    source_address,  
    destination_address,  
    data,  
    priority  
)
```

The source_address and destination_address parameters specify the local and remote LSAPs involved in the data unit transfer. The destination_address may specify either an individual or group address. The data parameter specifies the link service data unit to be transferred by the data link layer entity. The priority parameter specifies the priority desired for the data unit transfer.

2.1.2.1.3 When Generated. This primitive is passed from the network layer to the LLC sublayer to request that a LSDU be sent to one or more remote LSAP(s) using unacknowledged connectionless-mode procedures.

2.1.2.1.4 Effect on Receipt. Receipt of this primitive causes the LLC sublayer to attempt to send the LSDU using unacknowledged connectionless-mode procedures.

2.1.2.1.5 Additional Comments. This primitive is independent of any connection with the remote LSAP.

A possible logical sequence of primitives associated with successful unacknowledged connectionless-mode data unit transfer is illustrated in Fig 2-2 (c).

2.1.2.2 DL-UNITDATA indication

2.1.2.2.1 Function. This primitive is the service indication primitive for the unacknowledged connectionless-mode data unit transfer service.

2.1.2.2.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-UNITDATA indication(  
    source_address,  
    destination_address,  
    data,  
    priority  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs involved in the data unit transfer. The source address may be the address of a local LSAP, or may be a group address specifying multiple LSAPs, including a local LSAP. The data parameter specifies the link service data unit which has been received by the LLC sublayer entity. The priority parameter specifies the priority desired for the data unit transfer.

2.1.2.2.3 When Generated. This primitive is passed from the LLC sublayer to the network layer to indicate the arrival of an LSDU from the specified remote entity.

2.1.2.2.4 Effect on Receipt. The effect of receipt of this primitive by the network layer is unspecified.

2.1.2.2.5 Additional Comments. This primitive is independent of any connection with the remote LSAP.

In the absence of errors, the contents of the data parameter are logically complete and unchanged relative to the data parameter in the associated DL-UNITDATA request primitive.

2.1.2.3 DL-CONNECT request

2.1.2.3.1 Function. This primitive is the service request primitive for the connection establishment service.

2.1.2.3.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-CONNECT request(  
    source_address,  
    destination_address,  
    priority  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs that are to be connected. The `priority` parameter specifies the priority desired for the connection.

2.1.2.3.3 When Generated. This primitive is passed from the network layer to the LLC sublayer when the network layer entity wishes to establish a logical link connection, of a given priority, to a remote LSAP.

2.1.2.3.4 Effect on Receipt. The receipt of this primitive by the LLC sublayer causes the local LLC entity to initiate the establishment of a connection with the remote LLC entity.

2.1.2.3.5 Additional Comments. A possible logical sequence of primitives associated with successful connection establishment is illustrated in Fig 2-2 (f).

2.1.2.4 DL-CONNECT indication

2.1.2.4.1 Function. This primitive is the service indication primitive for the connection establishment service.

2.1.2.4.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-CONNECT indication(  
    source_address,  
    destination_address,  
    priority  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs that are to be connected. The `priority` parameter indicates the priority desired for the connection.

2.1.2.4.3 When Generated. This primitive is passed from the LLC sublayer to the network layer to indicate that a connection of a certain priority is being requested.

2.1.2.4.4 Effect on Receipt. The network layer entity shall issue either a DL-CONNECT response primitive to accept the connection, or a DL-DISCONNECT request primitive to refuse the connection.

2.1.2.4.5 Additional Comments. None.

2.1.2.5 DL-CONNECT response

2.1.2.5.1 Function. This primitive is the service response primitive for the connection establishment service.

2.1.2.5.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-CONNECT response(  
    source_address,  
    destination_address,  
    priority  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs that are to be connected. The `priority` parameter indicates the priority provided for the connection.

2.1.2.5.3 When Generated. This primitive is passed from the network layer to the LLC sublayer to indicate acceptance of the requested connection.

2.1.2.5.4 Effect on Receipt. The receipt of this primitive by the LLC sublayer causes the local LLC entity to accept a connection with the remote LLC entity.

2.1.2.5.5 Additional Comments. The network layer entity can return the same priority as given in the DL-CONNECT indication primitive or it may select a lower priority. After returning a DL-CONNECT response primitive, the network layer entity assumes that the connection is established.

2.1.2.6 DL-CONNECT confirm

2.1.2.6.1 Function. This primitive is the service confirm primitive for the connection establishment service.

2.1.2.6.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-CONNECT confirm(  
    source_address,  
    destination_address,  
    priority  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs that are to be connected. The `priority` parameter indicates the priority provided for the connection.

2.1.2.6.3 When Generated. This primitive is passed by the LLC sublayer to the network layer to convey the results of the previous associated DL-CONNECT request primitive. The results indicate that the connection attempt was successful and specify the priority obtained.

2.1.2.6.4 Effect on Receipt. The network layer entity may use this connection for data unit transfer.

2.1.2.6.5 Additional Comments. This primitive indicates that the remote network layer entity received and accepted the connection attempt.

2.1.2.7 DL-DATA request

2.1.2.7.1 Function. This primitive is the service request primitive for the connection-mode data unit transfer service.

2.1.2.7.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-DATA request(  
    source_address,  
    destination_address,  
    data  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection. The data parameter specifies the link service data unit to be transferred by the LLC sublayer entity.

2.1.2.7.3 When Generated. This primitive is passed from the network layer to the LLC sublayer to request that a LSDU be transferred to a remote LSAP over an existing connection.

2.1.2.7.4 Effect on Receipt. The receipt of this primitive by the LLC sublayer causes the LLC sublayer to transfer the LSDU over the specified connection using connection-mode procedures.

2.1.2.7.5 Additional Comments. The DL-DATA request primitive does not contain a priority parameter because priority must be uniform for all DL-DATA requests in a particular connection.

A possible logical sequence of primitives associated with successful connection-mode data unit transfer is illustrated in Fig 2-2(c).

2.1.2.8 DL-DATA indication

2.1.2.8.1 Function. This primitive is the service indication primitive for the connection-mode data unit transfer service.

2.1.2.8.2 Semantics of the Service Primitive. The primitive shall provide parameters, as follows:

```
DL-DATA indication(  
    source_address,  
    destination_address,  
    data  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection. The data parameter specifies the link service data unit which has been received by the LLC sublayer entity.

2.1.2.8.3 When Generated. This primitive is passed by the LLC sublayer to the network layer to indicate the arrival of an LSDU from the specified remote network layer entity over a particular connection.

2.1.2.8.4 Effect on Receipt. The effect of receipt of this primitive by the network layer is unspecified.

2.1.2.8.5 Additional Comments. In the absence of errors, the contents of the data parameter are logically complete and unchanged relative to the data parameter in the associated DL-DATA request primitive.

2.1.2.9 DL-DISCONNECT request

2.1.2.9.1 Function. This primitive is the service request primitive for the connection termination service.

2.1.2.9.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-DISCONNECT request(  
    source_address,  
    destination_address  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection to be terminated.

2.1.2.9.3 When Generated. This primitive is passed from the network layer to the LLC sublayer when the network layer entity wishes to terminate a connection.

2.1.2.9.4 Effect on Receipt. Receipt of this primitive causes the LLC sublayer to immediately terminate the connection.

2.1.2.9.5 Additional Comments. All unacknowledged LSDUs are discarded. The connection termination service is an abortive service. That is, no guarantee of delivery can be assumed about data that is not yet acknowledged at a higher layer. Thus, graceful disconnection (i.e., without loss of data) is the responsibility of a higher layer protocol.

A possible logical sequence of primitives associated with successful connection termination is illustrated in Fig 2-2(c).

2.1.2.10 DL-DISCONNECT indication

2.1.2.10.1 Function. This primitive is the service indication primitive for the connection termination service.

2.1.2.10.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-DISCONNECT indication(  
    source_address,  
    destination_address,  
    reason  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the terminated connection. The `reason` parameter specifies the reason for the disconnection. The reasons for disconnection may include a request by the remote entity, or an error internal to the LLC sublayer.

2.1.2.10.3 When Generated. This primitive is passed from the LLC sublayer to the network layer to inform the network layer that a connection has been terminated.

2.1.2.10.4 Effect on Receipt. The network entity may no longer use this connection for data unit transfer.

2.1.2.10.5 Additional Comments. All unacknowledged LSDUs are discarded. The connection termination service is an abortive service. That is, no guarantee of delivery can be assumed about data that is not yet acknowledged at a higher layer. Thus, graceful disconnection (i.e., without loss of data) is the responsibility of a higher layer protocol.

2.1.2.11 DL-RESET request

2.1.2.11.1 Function. This primitive is the service request primitive for the connection reset service.

2.1.2.11.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-RESET request(  
    source_address,  
    destination_address  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection to be reset.

2.1.2.11.3 When Generated. This primitive is passed from the network layer to the LLC sublayer to request that a connection be reset to the initial state.

2.1.2.11.4 Effect on Receipt. Receipt of this primitive causes immediate resetting of the connection.

2.1.2.11.5 Additional Comments. All unacknowledged LSDUs are discarded. The connection reset service is an abortive service. That is, no guarantee of delivery can be assumed about data that is not yet acknowledged at a higher layer. Thus, graceful reset (i.e., without loss of data) is the responsibility of a higher layer protocol.

A possible logical sequence of primitives associated with successful connection reset is illustrated in Fig 2-2(f).

2.1.2.12 DL-RESET indication

2.1.2.12.1 Function. This primitive is the service indication primitive for the connection reset service.

2.1.2.12.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-RESET indication(  
    source_address,  
    destination_address,  
    reason  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection affected. The `reason` parameter specifies the cause for the reset indication primitive. One of the reason codes indicates that a reset was requested by a remote network layer entity or a remote LLC sublayer peer (as shown in Fig 2-2, parts (f) and (d), respectively). All other codes indicate that the local LLC sublayer has detected the need for a connection reset (as shown in Fig 2-2(b)).

2.1.2.12.3 When Generated. This primitive is passed from the LLC sublayer to the network layer to indicate either that a connection reset has been requested by the remote network layer entity or remote LLC sublayer peer, or that the local LLC sublayer has determined that the data link connection is in need of reinitialization (as shown in Fig 2-2 (d)).

2.1.2.12.4 Effect on Receipt. For remote reset request, the network layer entity shall issue either a DL-RESET response primitive to signal acceptance of the connection reset, or a DL-DISCONNECT request primitive to terminate

the connection. For local reset condition indication, the network layer entity shall issue either a DL-RESET request primitive to reinitialize the connection, or a DL-DISCONNECT request primitive to terminate the connection.

2.1.2.12.5 Additional Comments. The reasons for the reset may include a request by the remote entity, or an error condition detected by the local LLC sublayer. All unacknowledged LSDUs are discarded. The connection reset service is an abortive service. That is, no guarantee of delivery can be assumed about data that is not yet acknowledged at a higher layer. Thus, graceful reset (i.e., without loss of data) is the responsibility of a higher layer protocol.

2.1.2.13 DL-RESET response

2.1.2.13.1 Function. This primitive is the service response primitive for the connection reset service.

2.1.2.13.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-RESET response(  
    source_address,  
    destination_address  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection affected.

2.1.2.13.3 When Generated. This primitive is passed by the network layer to the LLC sublayer to indicate acceptance of the connection reset.

2.1.2.13.4 Effect on Receipt. The receipt of this primitive by the LLC sublayer causes the local LLC sublayer entity to complete the connection reset.

2.1.2.13.5 Additional Comments. All unacknowledged LSDUs are discarded. The connection reset service is an abortive service. That is, no guarantee of delivery can be assumed about data that is not yet acknowledged at a higher layer. Thus, graceful reset (i.e., without loss of data) is the responsibility of a higher layer protocol.

2.1.2.14 DL-RESET confirm

2.1.2.14.1 Function. This primitive is the service confirm primitive for the connection reset service.

2.1.2.14.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-RESET confirm(  
    source_address,  
    destination_address  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection affected.

2.1.2.14.3 When Generated. This primitive is passed from the LLC sub-

layer to the network layer to inform the network layer that a connection reset has been completed.

2.1.2.14.4 Effect on Receipt. The network layer entity may use this connection for data unit transfer.

2.1.2.14.5 Additional Comments. This primitive indicates that the remote LLC sublayer entity has acknowledged the reset.

2.1.2.15 DL-CONNECTION-FLOWCONTROL request

2.1.2.15.1 Function. This primitive is the service request primitive for the connection flow control service.

2.1.2.15.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-CONNECTION-FLOWCONTROL request(  
    source_address,  
    destination_address,  
    amount  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection to be flow controlled. The `amount` parameter specifies the amount of data the LLC sublayer entity is permitted to pass.

2.1.2.15.3 When Generated. This primitive is passed from the network layer to the LLC sublayer to request control of the flow of DL-DATA indication primitives associated with a connection from the LLC sublayer.

2.1.2.15.4 Effect on Receipt. Receipt of this primitive causes the LLC sublayer to adjust the amount of data that may be passed to the network layer.

2.1.2.15.5 Additional Comments. Control of the flow of data on a connection is independent of control of the flow on other connections. The amount of data permitted to be passed is dynamically updated by each request. If amount is specified as zero, then the associated flow is stopped. Specific implementations may allow amount to be specified in implementation specific units, and may allow amount to be specified as "infinite."

A possible logical sequence of primitives associated with a DL-CONNECTION-FLOWCONTROL request is illustrated in Fig 2-2 (a).

2.1.2.16 DL-CONNECTION-FLOWCONTROL indication

2.1.2.16.1 Function. This primitive is the service indication primitive for the connection flow control service.

2.1.2.16.2 Semantics of the Service Primitive. The primitive shall provide parameters as follows:

```
DL-CONNECTION-FLOWCONTROL indication(  
    source_address,  
    destination_address,  
    amount  
)
```

The `source_address` and `destination_address` parameters specify the local and remote LSAPs of the connection to be flow controlled. The amount parameter specifies the amount of data that the network layer entity is permitted to pass to avoid data loss.

2.1.2.16.3 When Generated. This primitive is passed from the LLC sublayer to the network layer to request control of the flow of DL-DATA request primitives associated with a connection from the network layer.

2.1.2.16.4 Effect on Receipt. Receipt of the primitive causes the network layer to adjust the amount of data that it is allowed to pass without data loss.

2.1.2.16.5 Additional Comments. Control of the flow of data on a connection is independent of control of the flow on other connections. The amount of data permitted to be passed is dynamically updated by each indication. If amount is specified as zero, then the associated flow is stopped. Specific implementations may allow amount to be specified in implementation-specific units, and may allow amount to be specified as "infinite."

A possible logical sequence of primitives associated with a DL-CONNECTION-FLOWCONTROL indication is illustrated in Fig 2-2 (b).

2.2 LLC Sublayer/MAC Sublayer Interface Service Specification. This section specifies the services required of the MAC sublayer by the LLC sublayer to allow the local LLC sublayer entity to exchange LLC data units with peer LLC sublayer entities. The services are described in an abstract way and do not imply any particular implementation or any exposed interface.

NOTE: Work is in progress to produce a single service specification that is common to all the MAC sublayers; when this is available, it will be referenced in this document instead of the current MAC service text.

2.2.1 Overview of Interactions

MA-UNITDATA request

MA-UNITDATA indication

MA-UNITDATA-STATUS indication

2.2.2 Detailed Service Specification

2.2.2.1 MA-UNITDATA request

2.2.2.1.1 Function. This primitive defines the transfer of a MSDU from a local LLC sublayer entity to a single peer LLC sublayer entity, or multiple peer LLC sublayer entities in the case of group addresses.

2.2.2.1.2 Semantics of the Service Primitive. The semantics of the primitive are as follows:

```
MA-UNITDATA request(  
    source_address,  
    destination_address,  
    data,  
    priority,  
    service_class  
)
```

The `source_address` parameter shall specify an individual MAC sublayer entity address. The `destination_address` parameter shall specify either an individual or a group MAC sublayer entity address. Together they must contain sufficient information to create the SA and DA fields that are appended to the frame by the local MAC sublayer entity as well as any physical layer address information (e.g., transmit frequency in broadband applications). The `data` parameter specifies the MAC service data unit to be transmitted by the MAC sublayer entity, which includes the DSAP, SSAP, C, and information (if present) fields as specified in Section 3, as well as sufficient information for the MAC sublayer entity to determine the length of the data unit. The `priority` parameter specifies the priority desired for the data unit transfer. The `service_class` parameter specifies the class of service desired for the data unit transfer.

2.2.2.1.3 When Generated. This primitive is generated by the LLC sublayer entity whenever a MSDU must be transferred to a peer LLC sublayer entity or entities. This can be as a result of a request from higher layers of protocol, or from a MSDU generated internally to the LLC sublayer, such as required by Type 2 operation.

2.2.2.1.4 Effect of Receipt. The receipt of this primitive shall cause the MAC sublayer entity to append all MAC specified fields, including DA, SA, and any fields that are unique to the particular medium access method, and pass the properly formatted frame to the lower layers of protocol for transfer to the peer MAC sublayer entity or entities.

2.2.2.1.5 Additional Comments. A possible logical sequence of primitives associated with successful MAC service data unit transfer is illustrated in Fig 2-2 (c).

2.2.2.2 MA-UNITDATA indication

2.2.2.2.1 Function. This primitive defines the transfer of a MSDU from the MAC sublayer entity to the LLC sublayer entity, or entities in the case of group addresses. In the absence of errors, the contents of the `data` parameter are logically complete and unchanged relative to the `data` parameter in the associated MA-UNITDATA request primitive.

2.2.2.2.2 Semantics of the Service Primitive. The semantics of the primitive are as follows:

```
MA-UNITDATA indication(  
    source_address,  
    destination_address,  
    data,  
    reception_status,  
    priority,  
    service_class  
)
```

The `source_address` parameter must be an individual address as specified by the SA field of the incoming frame. The `destination_address` parameter shall be either an individual or a group address as specified by the DA field of

the incoming frame. The data parameter specifies the MAC service data unit as received by the local MAC entity. The reception_status parameter indicates the success or failure of the incoming frame. The priority parameter specifies the priority desired for this data unit transfer. The service_class parameter specifies the class of service desired for the data unit transfer.

2.2.2.2.3 When Generated. The MA-UNITDATA indication primitive is passed from the MAC sublayer entity to the LLC sublayer entity or entities to indicate the arrival of a frame at the local MAC sublayer entity. Frames are reported only if at the MAC sublayer they are validly formatted, received without error, and their destination address designates the local MAC sublayer entity.

2.2.2.2.4 Effect of Receipt. The effect of receipt of this primitive by the LLC sublayer is dependent on the validity and content of the frame.

2.2.2.2.5 Additional Comments. If the local MAC sublayer entity is designated by the destination_address parameter of an MA-UNITDATA request primitive, the indication primitive will also be invoked by the MAC sublayer entity to the local LLC sublayer entity. This full duplex characteristic of the MAC sublayer may be due to unique functionality within the MAC sublayer or full duplex characteristics of the lower layers (e.g., all frames transmitted to the broadcast address will invoke MA-UNITDATA indication primitives at all stations in the network including the station that generated the request).

2.2.2.3 MA-UNITDATA-STATUS indication

2.2.2.3.1 Function. This primitive has local significance and shall provide the LLC sublayer with status information for a previous associated MA-UNITDATA request primitive.

2.2.2.3.2 Semantics of the Service Primitive. The semantics of this primitive are as follows:

```
MA-UNITDATA-STATUS indication(  
    source_address,  
    destination_address,  
    transmission_status,  
    provided_priority,  
    provided_service_class  
)
```

The source_address parameter must be an individual MAC sublayer entity address as specified in the associated MA-UNITDATA request primitive. The destination_address parameter shall be either an individual or a group MAC sublayer entity address as specified in the associated MA-UNITDATA request primitive. The transmission_status parameter is used to pass status information back to the local requesting LLC sublayer entity. The types of status that can be associated with this primitive are dependent on the particular implementation as well as the type of MAC sublayer that is used (e.g., "excessive collisions" may be a status returned by a CSMA/CD MAC sublayer entity).

The `provided_priority` parameter specifies the priority that was used for the associated data unit transfer. The `provided_service_class` parameter specifies the class of service provided for the data unit transfer.

2.2.2.3.3 When Generated. The MA-UNITDATA-STATUS indication primitive is passed from the MAC sublayer entity to the LLC sublayer to indicate the status of the service provided for a previous associated MA-UNITDATA request primitive.

2.2.2.3.4 Effect of Receipt. The effect of receipt of this primitive by the LLC sublayer is dependent upon the type of operation employed by the LLC sublayer entity.

2.2.2.3.5 Additional Comments. It is assumed that sufficient information is available to the LLC sublayer entity to associate the status with the appropriate request.

2.3 LLC Sublayer/LLC Sublayer Management Function Interface Service Specification. (This matter is the subject of further ongoing study and resolution.)