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Standard

Fieldbus Standard for Use in Industrial Control Systems Part 3: Data Link Service Definition

ANSI/ISA-S50.05, Fieldbus Standard for Use in Industrial Control Systems, Part 3: Data Link Service Definition

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Introduction

Keywords

fieldbus, time-critical communications, time-scheduled communications, automation networks, control networks

General

This part of this International Standard is one of a set of International Standards produced to facilitate the interconnection of automation system components. It is related to other International Standards in the set as defined by the Fieldbus Reference Model, which is based in part on the Reference Model for Open Systems Interconnection. Both Reference Models subdivide the area of standardization for interconnection into a series of layers of specification, each of manageable size.

Purpose

The purpose of this part of this International Standard is to define the service provided

a) to the Fieldbus Application Layer at the boundary between the Application and Data Link Layers of the Fieldbus Reference Model, and

b) to the OSI Network Layer at the boundary between the Network and Data Link Layers of the OSI Basic Reference Model.

The Data Link Service is provided by the Data Link Protocol making use of the services available from the Physical Layer. This part of this International Standard also defines the Data Link Service characteristics that the immediately higher-level protocol may exploit. The relationship between the International Standards for Fieldbus Data Link Service, Fieldbus Data Link Protocol, Fieldbus Physical Service, and OSI Network or Fieldbus Application Protocol is illustrated in Figure 1.

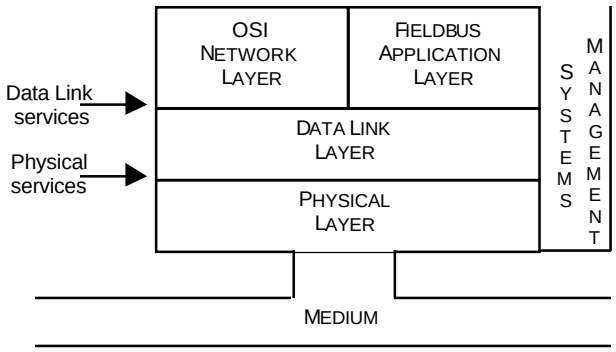

Figure 1 — Relationship of this part of this International Standard to other Fieldbus and OSI standards

Throughout the set of Fieldbus standards, the term “service” refers to the abstract capability provided by one layer of the OSI or Fieldbus Basic Reference Model to the layer immediately above. Thus, the Data Link Service defined in this document is a conceptual architectural service, independent of administrative divisions.

1 Scope

The Fieldbus Data Link service definition is a Data Link layer Standard designed to support time-critical messaging communications between devices in an automation environment. The term “time-critical” is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant, and possibly human life.

This part of this International Standard defines in an abstract way the externally visible service provided by the Fieldbus Data Link Layer in terms of:

a) the primitive actions and events of the service;

b) the parameters associated with each primitive action and event, and the form that they take; and

c) the interrelationship between, and the valid sequences of, these actions and events.

The services defined in this part of this International Standard are a superset of those provided by OSI Data Link Protocols as specified in ISO 8886. The services defined in this part of this International Standard may be used by any OSI Network Protocol or Fieldbus Application Protocol.

1.1 Specifications

The principal objective of this part of this International Standard is to specify the characteristics of a conceptual Data Link Service suitable for time-critical communications, and thus supplement the OSI Basic Reference Model in guiding the development of Data Link protocols for time-critical communications.

1.2 Conformance

This part of this International Standard does not specify individual implementations or products, nor does it constrain the implementations of Data Link entities within industrial automation systems. However, its annexes may recommend exposed programming language interfaces within such systems.

There is no conformance of equipment to this Data Link Service Definition standard. Instead, conformance is achieved through implementation of conforming Data Link protocols that fulfill the Data Link Service defined in this part of this International Standard. Conformance may also be achieved through implementation of exposed programming language interfaces as specified in annexes to this part of this International Standard.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7498-1:1984, *Information processing systems — Open systems interconnection — Basic reference model.*

ISO 7498/AD1:1987, *Information processing systems — Open systems interconnection — Connectionless data transmission.*

ISO 7498-3:1987, *Information processing systems — Open systems interconnection — Naming and addressing.*

ISO/IEC 8886:1992, *Information technology — Open systems interconnection — Telecommunications and information exchange between systems — Data link service definition.*

ISO/IEC 10039:1990, *Information technology — Telecommunication and information exchange between systems — Medium access control service definition.*

ISO/TR 8509:1987, *Information processing systems — Open systems interconnection — Service conventions.*

ISO/IEC 10731:1992, *Information technology — Open systems interconnection — Conventions for the definition of OSI services.*

[IEC CDV 1158-4][1], *Digital data communications for measurement and control — Fieldbus for use in industrial control systems — Part 4 : Data link protocol specification.*

[1] Editing NOTE — References enclosed in square brackets […] are to documents that have not yet reached final IS or TR status, but which should reach that status before or concurrently with this document. These references will be corrected to the final IS or TR reference during the pre-IS edit of this part of this International Standard.

3 Definitions

For the purposes of this part of this International Standard, the following definitions apply:

3.1 Reference model definitions

This part of this International Standard is based in part on the concepts developed in ISO 7498 parts 1 and 3, and in ISO 7498/AD1, and makes use of the following terms defined therein:

3.1.1	DL-address	[7498-3]
3.1.2	DL-address-mapping	[7498-1]
3.1.3	called-DL-address	[7498-3]
3.1.4	calling-DL-address	[7498-3]
3.1.5	centralized multi-end-point-connection	[7498-1]
3.1.6	DL-connection	[7498/AD1]
3.1.7	DL-connection-end-point	[7498-1]
3.1.8	DL-connection-end-point-identifier	[7498-3]
3.1.9	DL-connection-mode transmission	[7498/AD1]
3.1.10	DL-connectionless-mode transmission	[7498/AD1]
3.1.11	correspondent (N)-entities correspondent DL-entities correspondent Ph-entities	[7498-1]
3.1.12	DL-duplex-transmission	[7498-1]
3.1.13	DL-entity	[7498-1]
3.1.14	DL-facility	[7498-1]
3.1.15	flow control	[7498-1]
3.1.16	(N)-layer DL-layer Ph-layer	[7498-1]
3.1.17	layer-management	[7498-1]
3.1.18	DL-local-view	[7498-3]
3.1.19	DL-name	[7498-3]

3.1.20	naming-(addressing)-domain	[7498-3]
3.1.21	peer-entities	[7498-1]
3.1.22	primitive name	[7498-3]
3.1.23	DL-protocol	[7498-1]
3.1.24	DL-protocol-connection-identifier	[7498-1]
3.1.25	DL-protocol-data-unit	[7498-1]
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3.1.30	segmenting	[7498-1]
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3.1.32	DL-service-access-point	[7498-1]
3.1.33	DL-service-access-point-address	[7498-3]
3.1.34	DL-service-connection-identifier	[7498-1]
3.1.35	DL-service-data-unit	[7498-1]
3.1.36	DL-simplex-transmission	[7498-1]
3.1.37	DL-subsystem	[7498-1]
3.1.38	DL-user-data	[7498-1]

3.2 Service convention definitions

This part of this International Standard also makes use of the following terms defined in ISO/TR 8509 and ISO/IEC 10731 as they apply to the Data Link Layer:

3.2.1 accepter

3.2.2 asymmetrical service

3.2.3 confirm (primitive);
requester.deliver (primitive)

3.2.4 deliver (primitive)

3.2.5 DL-confirmed-facility

3.2.6 DL-facility

3.2.7 DL-mandatory-facility

3.2.8 DL-non-confirmed-facility

3.2.9 DL-provider-initiated-facility

3.2.10 DL-provider-optional-facility

3.2.11 DL-service-primitive; primitive

3.2.12 DL-service-provider

3.2.13 DL-service-user

3.2.14 DL-user-optional-facility

3.2.15 indication (primitive); accepter.deliver (primitive)

3.2.16 multi-peer

3.2.17 request (primitive); requester.submit (primitive)

3.2.18 requester

3.2.19 response (primitive); accepter.submit (primitive)

3.2.20 submit (primitive)

3.2.21 symmetrical service

3.3 Data Link Service definitions

For the purpose of this part of this International Standard, the following definitions also apply:

3.3.1 DL-segment, link, local link: A single DL-subnetwork in which any of the connected DLEs may communicate directly, without any intervening DL-relaying, whenever all of those DLEs that are participating in an instance of communication are simultaneously attentive to the DL-subnetwork during the period(s) of attempted communication.

3.3.2 extended link: A DL-subnetwork, consisting of the maximal set of links interconnected by DL-relays, sharing a single DL-name (DL-address) space, in which any of the connected DL-entities may communicate, one with another, either directly or with the assistance of one or more of those intervening DL-relay entities.

NOTE — An extended link may be composed of just a single link.

3.3.3 node: A single DL-entity as it appears on one local link.

3.3.4 bridge: A DL-relay entity which performs selective store-and-forward and routing functions to:

a) connect two or more separate DL-subnetworks (links) to form a unified DL-subnetwork (the extended link); and

b) provide a means by which two end systems can communicate, when at least one of the end systems is periodically inattentive to the interconnecting DL-subnetwork.

3.3.5 sending DLS-user: A DL-service user that acts as a source of DL-user-data.

3.3.6 receiving DLS-user: A DL-service user that acts as a recipient of DL-user-data.

NOTE — A DL-service user can be concurrently both a sending and receiving DLS-user.

3.3.7 peer DLC: A point-to-point DL-connection offering DL-duplex-transmission between two peer DLS-users where each can be a sending DLS-user, and each as a receiving DLS-user may be able to exert flow control on its sending peer. A peer DLC is negotiated to provide either symmetrical service or asymmetrical service. A peer DLC may also be negotiated to provide only DL-simplex service.

3.3.8 multi-peer DLC: A centralized multi-end-point DL-connection offering DL-duplex-transmission between a single distinguished DLS-user, known as the **publisher** or **publishing** DLS-user, and a set of peer but undistinguished DLS-users, known collectively as the **subscribers** or **subscribing** DLS-users, where the publishing DLS-user can send to the subscribing DLS-users as a group (but not individually), and the subscribing DLS-users can send to the publishing DLS-user (but not to each other). A multi-peer DLC always provides asymmetrical service. It may also be negotiated to provide only DL-simplex service, either from the publisher to the subscribers, or from the subscribers to the publisher.

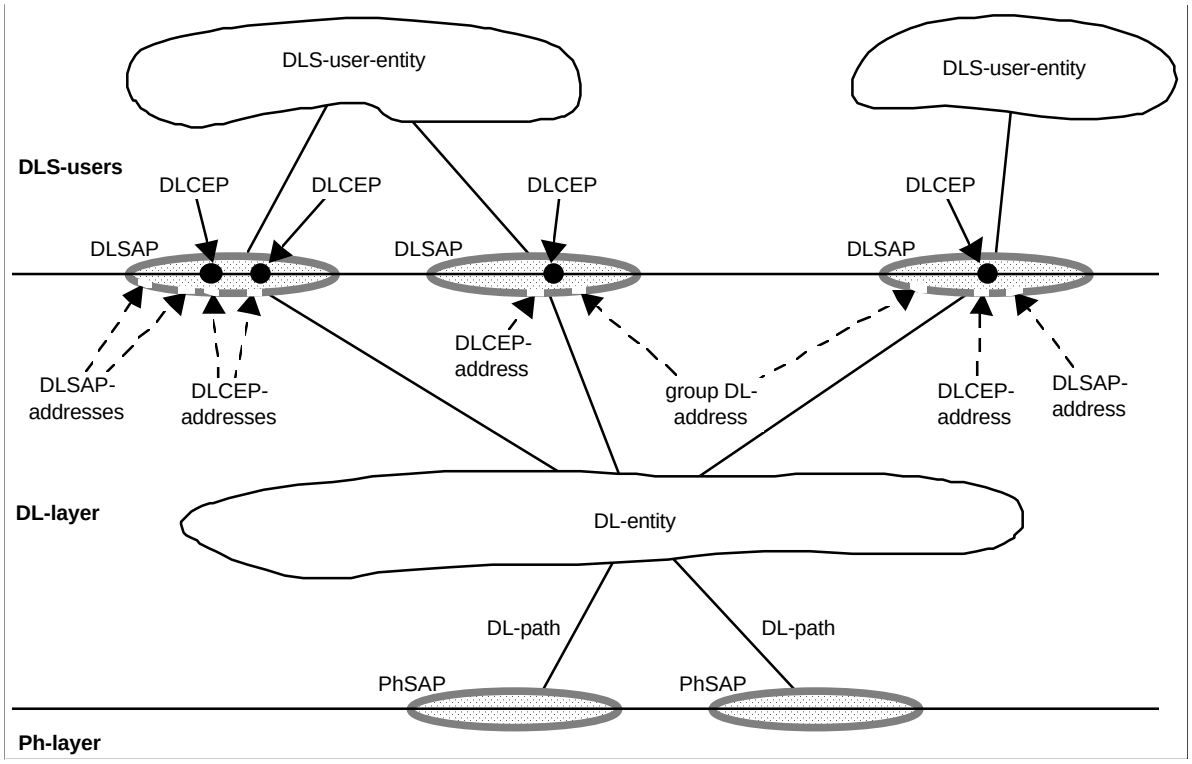
NOTES

1. In this last case, the characterizations as publisher and subscriber are misnomers.

2. The publishing DLS-user may need to employ control of its publishing rate, because a subscribing DLS-user cannot exert either flow or rate control on its publishing peer entity. Similar considerations apply to subscribing DLS-users with respect to their sending DLSDUs to the publishing DLS-user.

3.3.9 DLSAP: A distinctive point at which DL-services are provided by a single DL-entity to a single higher-layer entity.

NOTE — This definition, derived from ISO 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses. (See Figure 2.)



LEGEND:

1.DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers.

2.DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP. A DLCEP-address also designates a specific point of information flow (its DLCEP) within the DLSAP.

3.A single DL-entity may have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP.

4.This figure also shows the relationships of DL-paths and PhSAPs.

Figure 2 — Relationships of DLSAPs, DLCEPs, DLSAP-addresses, DLCEP-addresses, and group DL-addresses

3.3.10 (individual) DLSAP-address: A DL-address that designates only one DLSAP within the extended link. A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP.

3.3.11 group DL-address: A DL-address that potentially designates more than one DLSAP within the extended link. A single DL-entity may have multiple group DL-addresses associated with a single DLSAP. A single DL-entity also may have a single group DL-address associated with more than one DLSAP.

3.3.12 DL(SAP)-address: Either an individual DLSAP-address, designating a single DLSAP of a single DLS-user, or a group DL-address potentially designating multiple DLSAPs, each of a single DLS-user.

NOTE — This terminology is chosen because ISO 7498-3 does not permit the use of the term DLSAP-address to designate more than a single DLSAP at a single DLS-user.

3.3.13 DLCEP-address: A DL-address that designates either:

a) one peer DL-connection-end-point; or

b) one multi-peer publisher DL-connection-end-point and implicitly the corresponding set of subscriber DL-connection-end-points

where each DL-connection-end-point exists within a distinct DLSAP and is associated with a corresponding distinct DLSAP-address.

NOTE — A DLCEP-address is an extension of the use of DL-addresses beyond that specified in ISO 7498-3.

3.3.14 DLSEP-address: A DL-address that designates a DL-scheduling-end-point within a DLE.

NOTE — This is an extension of the use of DL-addresses beyond that specified in ISO 7498-3.

3.3.15 transaction: A single DLPDU, or a sequence of two immediately consecutive related DLPDUs, resulting from a single DLS-user request.

3.3.16 initiator: A DLE role in which a DLE sends a DLPDU to a peer responder DLE, which immediately sends a reply DLPDU back to the initiator DLE (and potentially to other DLEs) as part of the same transaction.

NOTE — Some prior national standards have referred to this role as a “master” role.

3.3.17 responder: A DLE role in which a DLE sends a DLPDU as an immediate reply to a DLPDU received from a peer initiator DLE, all as part of a single transaction.

NOTE — Some prior national standards have referred to this role as a “slave” role.

3.3.18 timeliness, DL-timeliness: Timeliness is an attribute of a datum that provides an assessment of the temporal currency of that datum. This attribute is of particular importance in sampled-data systems, which may need to make decisions based on the timeliness, or lack of timeliness, of current data samples.

As a general rule, timeliness is a user attribute that can be affected negatively by the various layers of the data transport system. That is, a datum that was timely when the requesting user presented it to a data communications subsystem for transmission may become untimely due to delays in the communications subsystem.

DL-timeliness is an attribute of a DLS-user datum relating the timing of a DLS-user/DLE interaction that writes or reads that datum to one or more other (earlier) DLS-user/DLE interactions.

NOTE — These concepts also support migration from previous national standards.

4 Symbols and abbreviations

DL- Data Link layer (as a prefix)

DLC DL-connection

DLCEP DL-connection-end-point

DLE DL-entity (the local active instance of the Data Link layer)

DLL DL-layer

DLPDU DL-protocol-data-unit

DLS DL-service

DLSAP DL-service-access-point

DLSDU DL-service-data-unit

DLSEP DL-schedule-end-point

FIFO First-in first-out (queuing method)

OSI Open systems interconnection

Ph- Physical layer (as a prefix)

PhE Ph-entity (the local active instance of the Physical layer)

PhL Ph-layer

QoS Quality of service

5 Conventions

5.1 General conventions

This part of this International Standard uses the descriptive conventions given in ISO TR/8509 and more recently in ISO/IEC 10731.

The service model, service primitives, and time-sequence diagrams used are entirely abstract descriptions; they do not represent a specification for implementation.

5.2 Parameters

Service primitives, used to represent service user/service provider interactions (ISO/TR 8509 and ISO/IEC 10731), convey parameters that indicate information available in the user/provider interaction.

This part of this International Standard uses a tabular format to describe the component parameters of the DL-service primitives. The parameters that apply to each group of DL-service-primitives are set out in tables in clauses 2 through 4, 6 through 8, 13 through 21, 23 through 25, and 27 through 31. Each table consists of up to six columns, containing the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the DLS:

—the request primitive's input parameters;

—the request primitive's output parameters;

—the indication primitive's output parameters;

—the response primitive's input parameters; and

—the confirm primitive's output parameters.

NOTE — The request, indication, response, and confirm primitives are also known as requester.submit, accepter.deliver, accepter.submit, and requester.deliver primitives, respectively [ISO/IEC 10731].

One parameter (or part of it) is listed in each row of each table. Under the appropriate service primitive columns, a code is used to specify the type of usage of the parameter on the primitive and parameter direction specified in the column:

"**M**"—parameter is mandatory for the primitive.

"**U**"—parameter is a User option and may or may not be provided depending on the dynamic usage of the DLS-user. When not provided, a default value for the parameter is assumed.

"**C**"—parameter is conditional upon other parameters or upon the environment of the DLS-user.

"**CU**"—parameter is a conditional User option and may or may not be permitted depending upon other parameters or upon the environment of the DLS-user. When permitted, it may or may not be provided depending on the dynamic usage of the DLS-user. When permitted and not provided, a default value for the parameter is assumed.

" " (blank)—parameter is never present.

Some entries are further qualified by items in brackets. These may be:

a) a parameter-specific constraint

"(=)" indicates that the parameter is semantically equivalent to the parameter in the service primitive to its immediate left in the table.

"(≤)" indicates that the set of parameter values has an implicit order and that the parameter's value is less than or equal to that of the parameter in the service primitive to its immediate left in the table (that is, left by one or two columns).

"(≥)" indicates that the set of parameter values has an implicit order and that the parameter's value is greater than or equal to that of the parameter in the service primitive to its immediate left in the table (that is, left by one or two columns).

b) an indication that some note applies to the entry

"(**n**)" indicates that the following note **n** contains additional information pertaining to the parameter and its use.

In any particular interface, not all parameters need be explicitly stated. Some may be implicitly associated with the DLSAP at which the primitive is issued.

In the diagrams that illustrate these interfaces, dashed lines indicate cause-and-effect or time-sequence relationships, and wavy lines indicate that events are roughly contemporaneous.

5.3 Identifiers

Most of the DLS primitives specify one or more identifier parameters that are drawn from either a local DL-identifier space or a local DLS-user-identifier space. The existence and use of such identifiers in an implementation of the services specified in this part of this International Standard is a purely local issue. Nevertheless, these identifiers are specified explicitly in these primitives to provide a descriptive means:

a) of relating a confirm primitive with its corresponding request primitive;

b) of relating a response primitive with its corresponding indication primitive;

c) of canceling (aborting) an outstanding request primitive before receiving its corresponding confirm primitive;

d) for referring within a request or response primitive to persistent DL-objects, such as buffers and queues, that were created as the result of a previous DLS primitive; and

e) for referring within an indication or confirm primitive to persistent DL-objects that were created as the result of a previous DLS primitive.

Adherence to the OSI principle of architectural layering necessitates the presumption of distinct non-intersecting identifier spaces for the DLS-provider and each separate DLS-user, because they may have non-overlapping local views. Consequently, DLS-user identifiers are required for (a) and (e); while DL-identifiers are required for (b), (c), and (d).

6 Overview of the Data Link Service

The DLS provides for the transparent and reliable transfer of data between DLS-users. It makes the way that supporting communications resources are utilized invisible to these DLS-users.

In particular, the DLS provides for the following:

a) Independence from the underlying Physical Layer. The DLS relieves DLS-users from all direct concerns regarding which configuration is available (for example, direct connection, or indirect through one or more bridges) and which physical facilities are used (for example, which of a set of diverse physical paths).

b) Transparency of transferred information. The DLS provides for the transparent transfer of DLS-user-data. It does not restrict the content, format, or coding of the information, nor does it ever need to interpret the structure or meaning of that information. It may, however, restrict the amount of information that can be transferred as an indivisible unit.

NOTE — A DLS-user may segment arbitrary-length data into limited-length DLSDUs before making DL-service requests, and may reassemble received DLSDUs into those larger data units.

c) Reliable transfer of data. The DLS relieves the DLS-user from concerns regarding insertion or corruption of data, or, if requested, loss, duplication, or misordering of data, which may occur. In some cases of unrecovered errors in the Data Link Layer, duplication or loss of DLSDUs may occur. In cases where protection against misordering of data is not employed, misordering can occur.

NOTE — Detection of duplicate, lost or misordered DLSDUs may be performed by DLS-users.

d) Quality of Service (QoS) selection. The DLS provides DLS-users with a means to request and to agree upon a quality of service for the transfer of data. QoS is specified by means of QoS parameters representing aspects such as mode of operation, transit delay, accuracy, and reliability.

e) Addressing. The DLS allows the DLS-user to identify itself and to specify the DLSAPs between which a DLC is to be established. DL-addresses have only regional significance within a specific DL-segment. Extended DL-addresses have only regional significance within a specific DL-subsystem over a set of bridged DL-segments. Therefore, it is not appropriate to define a global addressing structure.

NOTE — The DLS is required to differentiate between the individual systems that are physically or logically connected to a multipoint data link and to differentiate between connections. For commonality with other service definitions, this mechanism is referred to as addressing and the objects used to differentiate between systems are referred to as addresses. In a formal sense, this is an extension of the use of addresses beyond that specified in ISO 7498-3.

f) Scheduling. The DLS allows the set of DLS-users to provide some guidance on the internal scheduling of the distributed DLS-provider. This guidance supports the time-critical aspects of the DLS, by permitting the DLS-user some degree of management over when opportunities for communication will be granted to various DLEs for various DLSAP-addresses and DLCEPs.

g) Common time sense. The DLS can provide the DLS-user with a sense of time that is common to all DLS-users on the extended link.

h) Queues and buffers. The DLS can provide the sending or receiving DLS-user with either a FIFO queue or a retentive buffer or a non-retentive buffer (that is, one that becomes empty after being read), where each queue item or buffer can hold a single DLSDU.

6.1 Overview of DL-subnetwork structuring

A DL-subnetwork consists of a set of DL-segments (links) interconnected by DL-relay entities (bridges) that provide DL-layer-internal coordination and routing services to the set of interconnected DLEs.

A DL-segment consists of a set of DLEs, all of which are connected directly (that is, without intervening DL-relay entities) to a single shared logical communications channel, known as a **link**.

A link (logical communications channel) consists of one or more physically-independent logically-parallel cooperatively-scheduled real communications channels, which are known as **path**s.

A single shared PhL-provider enables communications among the DLEs on a given path. A link is made up of conceptually parallel paths. An example is shown in Figure 3.

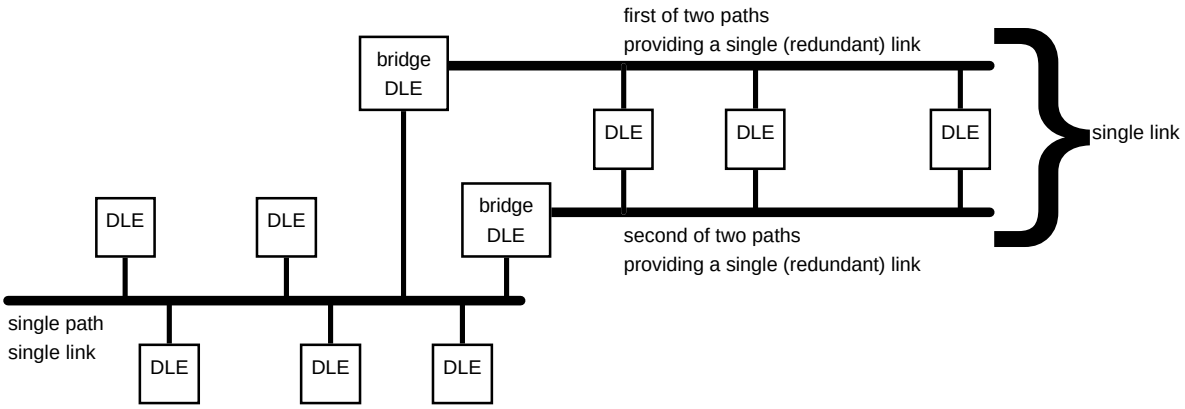


Figure 3 — Example of paths, links, bridges, and the extended link

NOTES

1. A link consisting of more than one path is an instance of DL-redundancy. This is distinct from Ph-redundancy, which is necessarily hidden from the DLL and all DLEs due to the principles of layering (ISO 7498-1).

2. In a logical sense, DLEs are connected to links and bridges interconnect links. Yet in a physical sense, DLEs are connected to paths and bridges interconnect paths. DL-communication-services are independent of the specific path employed, and the DLS-user has no cognizance of any path multiplicity.

6.2 Overview of DL-naming (addressing)

DL-names, known conventionally as DL-addresses, are identifiers from a defined identifier space — the DL-address-space — that serve to name objects within the scope of the data link layer. Examples of such objects are data-link-service-access-points (DLSAPs), data-link-connection-end-points (DLCEPs), and data-link-entities (DLEs).

The DL-address-space from which DL-addresses are drawn may be partitioned into sub-spaces of DL-addresses:

a) to cluster addresses of the same generic function, such as

   1) DLSAP-addresses naming specific DLSAPs;

   2) DL-addresses naming groups of DLSAPs;

3) DL-addresses designating one or more DLCEPs; and

4) DL-addresses designating DLEs;

b) to cluster addresses for administrative purposes, such as addresses that are

1) known to be local to, and allocable by, a single DLE;

2) known to be local to a single link (DL-segment) but not to have a known specific DLE-locality; or

3) known to have no implicit DL-locality;

c) to cluster addresses for routing purposes, such as addresses that are known to be local to a single DL-segment or a single DLE.

6.2.1 Functional partitioning of the DL-address-space

The space of DL-addresses may be partitioned functionally as follows:

a) DLE-specific DLSAP-addresses;

b) other DLSAP-addresses;

NOTE — These addresses can designate at most one DLSAP within a single DLE within the entire set of DL-interconnected DLEs.

c) group DL-addresses designating a group of DLSAPs;

NOTE — These addresses are sometimes (incorrectly) referred to as group-DLSAP-addresses (see 3.3.11).

d) DLE-specific DLCEP-addresses;

e) other DLCEP-addresses;

f) specific aspects of a specific DLE; or

g) specific aspects of a group of DLEs.

6.2.2 Administrative partitioning of the DL-address-space

The space of DL-addresses may be partitioned administratively as follows:

a) DLE-specific DL-addresses, which are known to refer to objects within the scope of a specific DLE, and which are allocable by that DLE;

b) DL-segment (link) specific but DLE-independent DL-addresses, which are known to refer to objects within the scope of a specific DL-segment, and which are allocable locally by the DL-address-space administrator for that DL-segment; or

c) DL-segment-independent DL-addresses, which are known to refer to objects within the DL-connected set of DL-segments, and which are allocable by the DL-address-space administrator for the connected set of DL-segments.

NOTE — A DL-address-space administrator can always allocate a set of addresses to a subordinate administrator for its sub-administration. For example, the DL-administrator for the entire set of DL-connected DL-segments can allocate a contiguous block of unassigned

DL-addresses to the DL-administrator for a specific DL-segment, or to the local administrator within a single DLE.

6.2.3 Routing-related partitioning of the DL-address-space

The space of DL-addresses may be partitioned to assist DL-routing activities as follows:

a) DLE-specific DL-addresses;

b) DL-segment (link) specific but DLE-independent DL-addresses; or

c) DL-segment-independent DL-addresses.

7 Types and classes of Data Link Service

There are four types of DLS:

a) a DL(SAP)-address, queue and buffer management service (defined in clauses 9 through 12);

b) a connection-mode data transfer service with four classes of service (defined in clauses 13 through 19);

c) a connectionless-mode data transfer service with three classes of service (defined in clauses 20 through 24); and

d) a time and transaction scheduling service (defined in clauses 25 through 29).

All four types of DLS are always provided; the DLS-user may choose those most appropriate for use. Within the DLS types, the DLS-user is limited to those classes of service supported by the selected DL-protocol implementation.

NOTE — Classes of service are defined in detail in the clauses that describe a specific type of DLS.

8 Quality of Service (QoS) attributes common to multiple types of Data Link Service

A DLS-user may select, directly or indirectly, many aspects of the various data link services. The term "Quality of Service" (QoS) refers to those aspects that are under the direct control of the DLS-provider. QoS can only be properly determined when DLS-user behavior does not constrain or impede the performance of the DLS.

Static QoS attributes are selected once for an entire type of DLS. **Dynamic** QoS attributes are selected independently at each DL-service invocation. **Semi-static** QoS attributes are static attributes for one type of DLS and serve as defaults for corresponding dynamic attributes in another type of DLS.

Most QoS attributes have default values that can be set by DL-management and then overridden on a per-DLSAP-address basis by the DLS-user.

NOTE — The existence of multiple levels of default QoS attribute values and of means of setting those default values can simplify use of the DL-services. Some implementations of this DL-service may provide additional levels of default QoS beyond those specified in this part of this International Standard.

Four QoS attributes of the DL-data transfer services apply conceptually to both connection-mode and connectionless operation. The DLS-user may specify values for these attributes when binding a DLSAP-address to the DLS-user's DLSAP; any unspecified attributes will assume the default values set by DL-management:

a) Two of these four attributes are considered dynamic; their DLSAP-address-related values serve merely as defaults for each appropriate DL-service-invocation and can be overridden on an instance by instance basis.

b) The third and fourth attributes are semi-static; they are static for connectionless DL-services, but dynamic for all DLCEP-establishment requests and responses, where its value serves merely as a default for each appropriate DL-service-invocation and can be overridden on an instance by instance basis.

A fifth attribute applies only to connection-mode operation and is dynamic for each DLCEP.

8.1 DLL priority (dynamic QoS attribute)

All DLCEP establishment requests and responses, all connectionless data transfer requests, and many DL-scheduling requests, specify an associated DLL priority used in scheduling DLL data transfer services. This DLL priority also determines the maximum amount of DLS-user-data that can be conveyed in a single DLPDU. This maximum is determined by the DL-protocol specification.

The DL-protocol shall support three DLL priority levels, each of which shall be capable of conveying a specified amount of DLS-user data per appropriate DLPDU. The three DLL priorities with their corresponding ranges of conveyable DLS-user-data (per DLPDU) are, from highest priority to lowest priority:

a) urgent — capability of conveying up to 64 DLS-user octets per DLPDU;

b) normal — capability of conveying up to 128 DLS-user octets per DLPDU; and

c) time-available — capability of conveying up to 256 DLS-user octets per DLPDU.

NOTES

1. URGENT and NORMAL are considered **time-critical** priority levels; TIME-AVAILABLE is considered a **non-time-critical** priority level.

2. DLCEP establishment may negotiate URGENT to NORMAL or TIME-AVAILABLE, or NORMAL to TIME-AVAILABLE.

The default QoS value can be set by DL-management; when not so set its value is TIME-AVAILABLE.

8.2 DLL maximum confirm delay (dynamic QoS attribute)

Each DLCEP establishment request, and each response, specifies upper bounds on the maximum time duration permitted for the completion of each related instance of a sequence of connection-oriented DLS primitives:

a) the common maximum time for completion of

   — a related sequence of DL-CONNECT primitives;

   — a related sequence of DL-RESET primitives;

   — a related sequence of DL-SUBSCRIBER-QUERY primitives; and

b) the maximum time for completion of a related sequence of DL-DATA primitives.

Each connectionless service request specifies an upper bound on the maximum time duration permitted for the completion of each related instance of a sequence of connectionless DLS primitives:

c) the maximum time for completion of a related sequence of locally-confirmed DL-UNITDATA primitives; and

d) the common maximum time for completion of

   — a related sequence of remotely-confirmed DL-UNITDATA primitives;

   — a related sequence of DL-LISTENER-QUERY primitives; or

   — an instance of the DL-UNITDATA-EXCHANGE service.

Each parameter either has the value **UNLIMITED** or specifies an upper bound, in units of 1 ms, from 1 ms to 60 s, inclusive. The value UNLIMITED provides compatibility with prior OSI protocols and provides a means for DL-CONNECT requests to remain in a “listening” or “half-open” state. The completion status of “timeout” cannot occur on a DLS-user request that specifies UNLIMITED.

The parameters for the DL-DATA and locally-confirmed DL-UNITDATA primitives specify intervals less than or equal to that for the DL-CONNECT, DL-RESET, DL-SUBSCRIBER-QUERY, remotely-confirmed DL-UNITDATA, and DL-LISTENER-QUERY primitives.

The intervals specified are the maximum permissible delays:

1) between the issuing of the specified request primitives and the issuing of the corresponding confirm primitives; and

2) between the initiation and completion of a single instance of the specified publishing or unitdata-exchange service.

NOTE — For DLEs that do not support a time resolution of 1 ms, the requested time interval may be rounded up to the next-greatest multi-

ple of that resolution that the DLE does support, or to approximately 60 s if the DLE has no sense of time.

The default QoS values can be set by DL-management; when not so set the value for each of these QoS parameters is UNLIMITED.

8.3 DLPDU authentication (semi-static QoS attribute)

Each DLCEP establishment negotiation, and each connectionless data transfer, uses this attribute to determine:

a) a lower bound on the amount of DL-addressing information used in the DLPDUs that provide the associated DLL data transfer services;

NOTE — This has a slight impact on the residual rate of DLPDU misdelivery; more addressing information reduces the potential for misdelivery.

b) whether the current state of a sending peer or publisher DLCEP should be sent at low-frequency to the DLC's peer or subscriber DLCEP(s) even when there are no unconfirmed DLS-user requests outstanding at the sending DLCEP; and

NOTE — This continuing background transmission is known as **residual activity**.

c) whether all related scheduling actions should be executed locally.

NOTE — These last two aspects are of particular importance in safety systems.

The three levels specifiable, with their amounts of DL-addressing information, are:

1) **ORDINARY** — each DLPDU shall include the minimum permitted amount of addressing information;

2) **SOURCE —** each DLPDU shall include a source DL-address where possible;

3) **MAXIMAL** — each DL-address shall include the maximal amount of addressing information possible. Also, all related scheduling actions should be executed locally; and each sending peer or publisher DLCEP of the DLC should maintain a low-frequency report of state information when there is no DLS-user activity.

The default QoS value can be set by DL-management; when not so set its value is ORDINARY. DLCEP establishment may negotiate ORDINARY to source to maximal.

8.4 DL-scheduling-policy (semi-static QoS attribute)

This attribute is static for connectionless services, but is dynamic for connection-mode services.

For each DLSAP-address, and each DLCEP, the DLS-user can override the normal (implicitly-scheduled) DLL policy of providing the requested DL-service as soon as possible, and instead can defer any inter-DLS-user communication required by a DL-DATA or DL-UNITDATA request DLS-primitive until that deferral is canceled by an involved DLS-user. A DL-COMPEL-SERVICE request, specifying the affected DLSAP-address or DLCEP, permits the continued execution of just a single deferred in-process request or response DLS-primitive. Only DL-services that provide DLS-user intercommunication are affected by this attribute.

NOTE — DLC support services such as DL-CONNECT, DL-RESET, and DL-DISCONNECT, and intra-DL-provider services such as DL-SUB-

SCRIBER-QUERY and DL-LISTENER-QUERY, are not affected by this attribute.

The two choices are:

a) **IMPLICIT** — any required communications with peer DLS-user(s) from this DLSAP-address, or from this DLCEP, will occur as soon as possible;

NOTE — The choice IMPLICIT is incompatible with a DLCEP that is bound as sender to a buffer, because writing to a buffer does not trigger transmission. Thus the only usable choice for a sending buffer is EXPLICIT.

b) **EXPLICIT** — any required data or unitdata communications with peer DLS-user(s) from this DLSAP-address, or from this DLCEP, will occur only when the deferral is explicitly canceled by an involved DLS-user.

NOTE — Possible use of previously scheduled communications opportunities makes it possible for this deferral and subsequent release to result in earlier communications with the peer DLS-users than that provided by the IMPLICIT alternative.

The default QoS value cannot be set by DL-management; its value is always IMPLICIT.

8.5 DL-timeliness (dynamic DLCEP QoS attributes)

This attribute applies only to retentive DL-buffers, to DLCEPs at which DL-buffers are bound, and to those DLS-primitives that transfer DLS-user data to or from DL-buffers at such DLCEPs.

Each DLCEP establishment request, and each response, can specify DL-timeliness criteria that are to apply to information sent from, or received into, retentive buffers at that DLCEP. Four types of DL-timeliness can be supported: RESIDENCE timeliness, UPDATE timeliness, SYNCHRONIZED timeliness, and TRANSPARENT timeliness. All four types of timeliness, and the case where there is no timeliness, are shown in Figure 4:

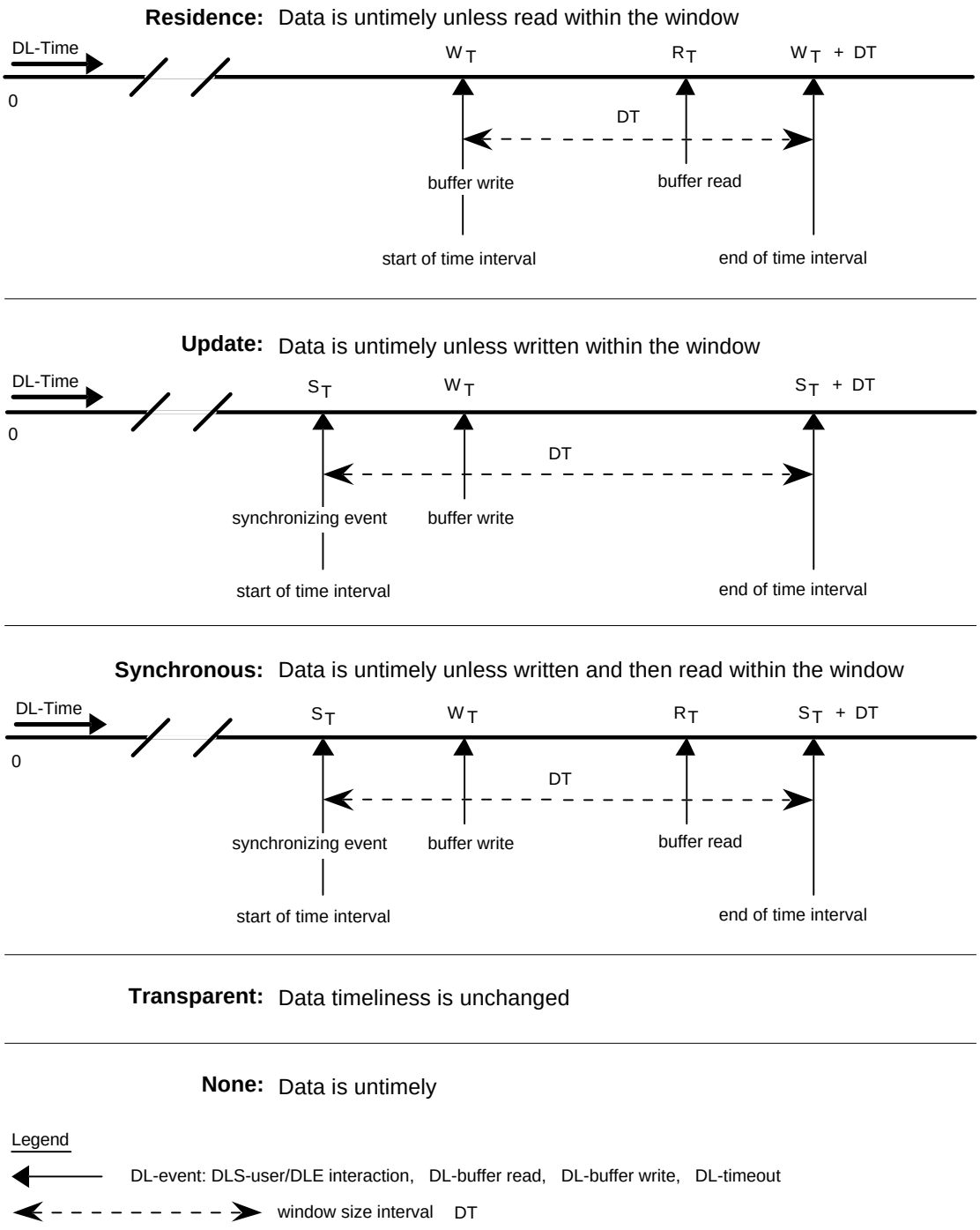


Figure 4 — Types of DL-timeliness

a) **RESIDENCE** timeliness is an assessment based upon the length of time that a DLS-user datum has been resident in a buffer, which is the time interval between

1) the moment when the buffer is written (by a DL-PUT request primitive or by reception into the buffer at a DLCEP); and

2) the moment when the buffer is read (by a DL-GET request primitive or by transmission from the buffer at a DLCEP);

$$\text{DL-timeliness} \equiv 0 \leq (RT - WT) < \Delta T \qquad \text{(Eq. 1)}$$

NOTE — This type of timeliness was called **Asynchronous** in prior national standards.

b) **UPDATE** timeliness is an assessment based upon the time interval between

1) the moment of occurrence of a multi-DLE synchronizing event (a DL-BUFFER-RECEIVED indication or DL-BUFFER-SENT indication); and

2) the moment when the buffer is written (by a DL-PUT request primitive or by reception into the buffer at a DLCEP);

$$\text{DL-timeliness} \equiv 0 \leq (WT - ST) < \Delta T \qquad \text{(Eq. 2)}$$

NOTE — A type of timeliness closely related to this one was called **Punctual** in prior national standards.

c) **SYNCHRONIZED** timeliness is an assessment based upon the time intervals and timing relationships between

1) the moment of occurrence of a multi-DLE synchronizing event (a DL-BUFFER-RECEIVED indication or DL-BUFFER-SENT indication);

2) the moment when the buffer is written (by a DL-PUT request primitive or by reception into the buffer at a DLCEP); and

3) the moment when the buffer is read (by a DL-GET request primitive or by transmission from the buffer at a DLCEP);

$$\text{DL-timeliness} \equiv 0 \leq (WT - ST) \leq (RT - ST) < \Delta T \qquad \text{(Eq. 3)}$$

NOTE — This type of timeliness was called **Synchronous** in prior national standards.

d) **TRANSPARENT** timeliness occurs when timeliness is selected on a DLCEP but none of the above assessments are performed. In such a case the DLC preserves any prior buffer timeliness, but does not itself invalidate that timeliness. When no prior buffer timeliness exists, the default timeliness value shall be TRUE.

e) **NO** timeliness occurs when timeliness is not selected on a DLCEP. In such a case the DL-timeliness attribute of DLS-user data always shall be FALSE.

The DL-time when the original buffer is written by a DL-PUT request primitive also can be conveyed to DLS-users that read a copy of the buffer. This DL-time is not available when the buffer timeliness is FALSE.

NOTE — DL-time is described in clauses 25 through 29.

9 Facilities of the DL(SAP)-address, queue and buffer management Data Link Service

The DLS provides the following facilities to the DLS-user:

a) A means for creating and deleting a retentive buffer, a non-retentive buffer, or a FIFO queue of specified depth, for use

   1) in communicating DLS-user-data between a DLS-user and the DLS-provider;

   2) in redistributing received DLS-user data without continuing DLS-user intervention; and

   3) in facilitating DLS-user supervision of the timing of DLSDU-conveyance to peer DLS-users;

b) A means for associating an individual DLSAP-address or group DL-address, referred to collectively as a DL(SAP)-address, with, and disassociating a DL(SAP)-address from, the DLSAP at which the request is made.

Default values for some Quality of Service (QoS) attributes for connection-mode and connectionless data transfer services using the specified DL(SAP)-address can be specified when the association is made.

Additionally, the DLS-user may specify that previously created buffers or FIFO queues be used for each potential direction and priority of connectionless data transfer at the specified DL(SAP)-address.

c) A means by which DLSDUs of limited size are written to or read from a buffer or read from a FIFO queue.

10 Model of the DL(SAP)-address, queue and buffer management Data Link Service

This part of this International Standard uses the abstract model for a layer service defined in clause 4 of ISO/TR 8509 and ISO/IEC 10731. The model defines interactions between the DLS-user and the DLS-provider that take place at a DLSAP. Information is passed between the DLS-user and the DLS-provider by DL-service-primitives that convey parameters.

The DL(SAP)-address, queue and buffer management primitives are used to provide a local service between a DLS-user and the local DLE. Remote DLEs and remote DLS-users are not directly involved, so there is no need for the other primitives (indication, response, confirm) of ISO/TR 8509. Therefore the DL(SAP)-address, queue and buffer management services are provided by request (requester.submit) primitives with input and output parameters.

11 Sequence of primitives at one DLSAP

11.1 Constraints on sequence of primitives

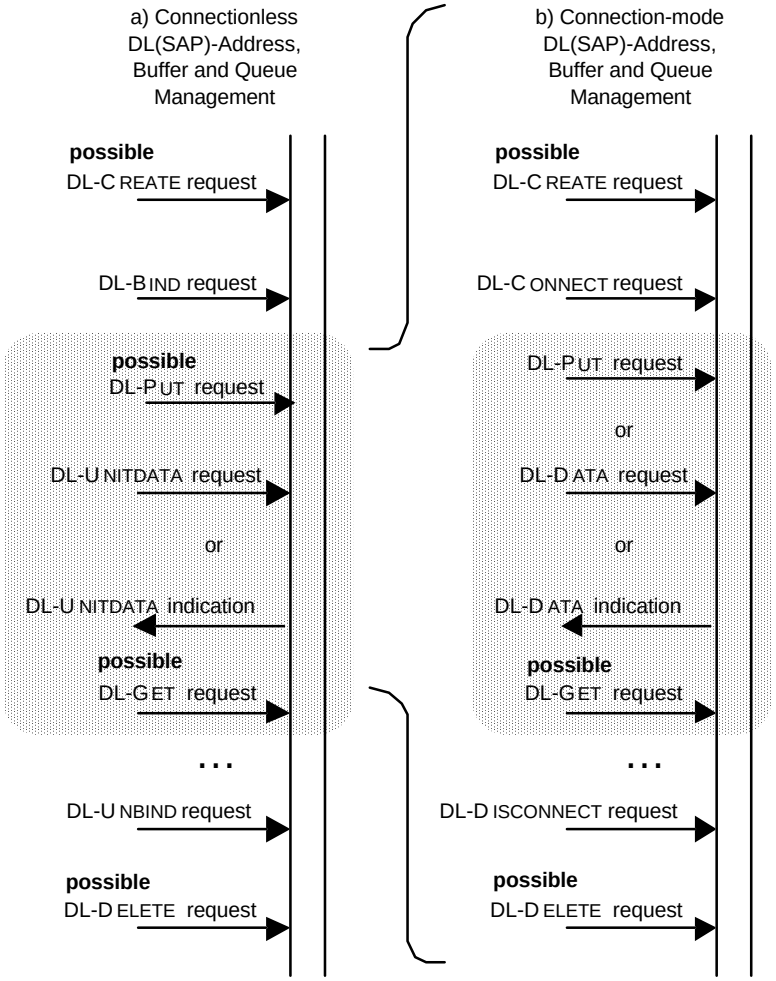
Table 1 — Summary of DL(SAP)-address, queue and buffer management primitives and parameters

Service	Primitive	Parameter
Buffer or Queue Creation	DL-CREATE request	(*in* Buffer-or-queue DLS-user-identifier, Queuing policy, Maximum DLSDU size, *out* Status, Buffer-or-queue DL-identifier)
Buffer or Queue Deletion	DL-DELETE request	(*in* Buffer-or-queue DL-identifier, *out* Status)
DL(SAP)-address Activation	DL-BIND request	(*in* DL(SAP)-address DLS-user-identifier, DL(SAP)-address, DL(SAP)-role, Receiving-buffer-or-queue-bindings, Sending-buffer-or-queue-bindings, Default-QoS-as-sender, *out* Status, DL(SAP)-address DL-identifier)
DL(SAP)-address Deactivation	DL-UNBIND request	(*in* DL(SAP)-address DL-identifier)
Update Buffer	DL-PUT request	(*in* Buffer DL-identifier, DLS-user-data, DLS-user-data-timeliness, *out* Status)
Copy Buffer or Dequeue	DL-GET request	(*in* Buffer-or-queue DL-identifier, *out* Status, Reported-service-identification-class, Reported-service-identification, DLS-user-data, DLS-user-data-timeliness)

NOTE — DL-identifiers in parameters are local and assigned by the DLS-provider and used by the DLS-user to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue to the DLS-provider at the DLS interface. DLS-user-identifiers in parameters are local and assigned by the DLS-user and used by the DLS-provider to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue to the DLS-user at the DLS interface.

This subclause defines the constraints on the sequence in which the primitives defined in clause 12 may occur. The constraints determine the order in which primitives occur, but do not fully specify when they may occur.

The DL(SAP)-address, queue and buffer management primitives and their parameters are summarized in Table 1. The major relationships among the primitives at a single DLE are shown in Figure 5.



LEGEND —

1.Primitives within the gray-background areas can be repeated many times between instances of the primitives in the clear-background areas.

2.The entire right-hand part of the figure is another alternative to the gray-background area of the left-hand part of the figure, and also can be repeated many times between instances of the primitives in the left-hand clear-background areas.

3.DL-PUT and DL-GET request primitives both can be used earlier and later than shown.

Figure 5 — Sequence of primitives for the DL(SAP)-address, queue and buffer management DL-services

12 DL(SAP)-address, queue and buffer management facilities

DL(SAP)-address management facilities bind a DL(SAP)-address to, and unbind a previously bound DL(SAP)-address from, the DLSAP at which the primitive is invoked. Such a binding is required while communicating using the specified DL(SAP)-address.

Queue and buffer management facilities permit, but do not require, a DLS-user to use retentive or non-retentive buffers or specified depth FIFO queues when employing the DLS-provider's data communications facilities. (See Figure 6.) Since these buffers and queues are managed by the DLS-provider, they sup-

port DLS-user interactions and data transfer and scheduling paradigms not available with DLS-user-based queuing.

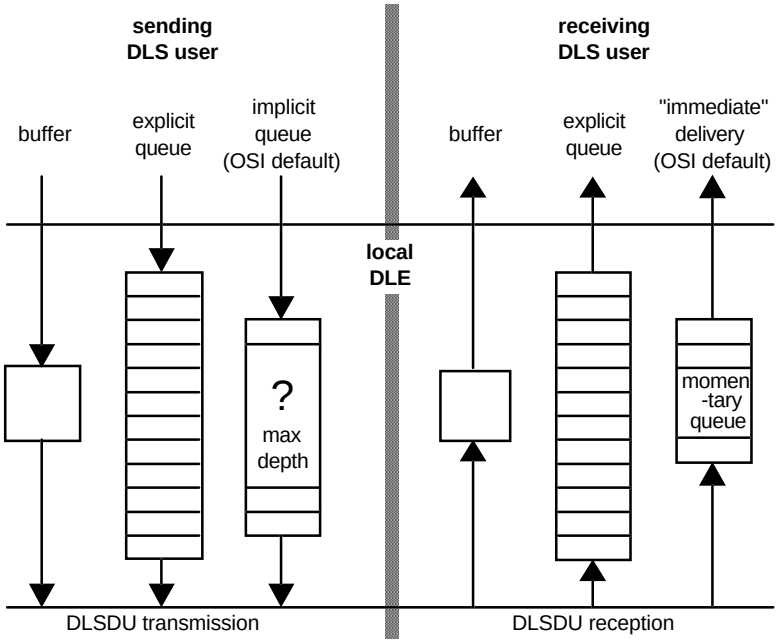


Figure 6 — Supported methods of data management for transmission and delivery

12.1 Create

12.1.1 Function

The create buffer or queue DL-service-primitive can be used to create a retentive buffer or non-retentive buffer or limited-depth FIFO queue for later constrained association with a DLSAP — either through a DL(SAP)-address or through a DLCEP. The resulting buffer or FIFO queue initially will be empty.

NOTE — This facility may also be provided by local DL-management actions, which are beyond the scope of this standard.

12.1.2 Types of parameters

Table 2 indicates the primitive and parameters needed for the create buffer or queue DL-service.

Table 2 — DL-buffer-and-queue-management Create primitive and parameters

DL-CREATE	**Request**	
Parameter Name	input	output
Buffer-or-queue DLS-user-identifier	M	
Queuing policy	M	
Maximum queue depth	C	
Maximum DLSDU size	M	
Status		M
Buffer-or-queue DL-identifier		C

12.1.2.1 Buffer-or-queue DLS-user-identifier

The buffer-or-queue DLS-user-identifier parameter specifies a means of referring to the buffer or queue in output parameters of other local DLS primitives that convey the name of the buffer or queue from the local DLE to the local DLS-user.

The naming-domain of the buffer-or-queue DLS-user-identifier is the DLS-user's local-view.

12.1.2.2 Queuing policy

The Queuing Policy parameter specifies whether to create either:

a) **BUFFER-R** — a retentive buffer, whose contents are not affected by being read, which can be overwritten (as a single atomic action) by either the DLS-provider or DLS-user, and which can be used only with the connectionless unitdata-exchange and connection-oriented data services; or

b) **BUFFER-NR** — a non-retentive buffer, which is set empty after being read, which can be overwritten (as a single atomic action) by either the DLS-provider or DLS-user, and which can be used only with the connectionless unitdata-exchange service; or

c) **QUEUE** — a FIFO queue of maximum depth *K* that contains between zero and *K* DLSDUs, which will reject attempts to remove DLSDUs when empty and to append DLSDUs when full, and which can be used with the connectionless unitdata-transfer and connection-oriented data services, and for DLSDU-receipt with the connectionless unitdata-exchange service.

The values of the Queuing Policy are BUFFER-R, BUFFER-NR, and QUEUE.

NOTES

1. Buffer and queue bindings result from DL-BIND request, DL-CONNECT request, and DL-CONNECT response primitives.

2. An explicit queue must have one output binding and at least one input binding to be useful. Multiple input bindings provide a means of coalescing inputs from many sources into a single queue. Multiple output bindings are not permitted, because a queue-not-empty condition typically causes transmission to be attempted at the DLCEP, or from the DLSAP-address, to which the queue is bound.

3. A retentive buffer (BUFFER-R) must have one input binding and at least one output binding to be useful. Multiple input bindings are not permitted, because they would permit any data source to overwrite the buffer at any time, with no indication to the buffer users of which source was involved. Multiple output bindings are useful, to share the contents of the buffer among multiple users or to support differing-rate redistribution of cached data within bridges.

4. A non-retentive buffer (BUFFER-NR) must have one input binding and one output binding to be useful. Multiple input bindings are not useful for the reason stated in 2. Multiple output bindings are not useful; their existence would lead to non-intuitive semantics for the buffer.

5. Buffers can be overwritten at any time, with complete loss of the prior contents except to those users that had begun to read the prior contents of the buffer (via DL-GET request primitives or sending DLCEPs) before the overwriting begins. Therefore buffers are well suited for caching of distributed data, where it is desired to retain the most recent value of received information, and are poorly suited for general messaging.

12.1.2.2.1 Maximum queue depth

The Maximum Queue Depth parameter is present when the Queuing Policy parameter has the value QUEUE. When present, this parameter specifies K, the maximum number of items in the associated queue. The supported values for this parameter shall include the values one (1), two (2), three (3), and four (4).

NOTE — Implementations of this DL-service may extend the range of this parameter to include:

a) values greater than four (4); and

b) the value zero (0), creating a null queue.

12.1.2.3 Maximum DLSDU size

The Maximum DLSDU Size parameter specifies an upper bound on the size (in octets) of DLSDUs that can be put into the buffer or queue. The maximum size permitted for such DLSDUs may be constrained by a companion DL-protocol specification and by DL-management

NOTE — This parameter does not preclude implementations from using a fixed, small set of record sizes when allocating buffers or entries in a queue.

12.1.2.4 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) "success"

b) "failure — insufficient resources"

c) "failure — parameter violates management constraint"

d) "failure — number of requests violates management constraint" or

e) "failure — reason unspecified"

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

If the status is "success," then the created buffer or queue is subject to the following constraints:

1) If a BUFFER-NR or BUFFER-R was created, then it can be written explicitly either

   — by one priority of a receiving DLSAP-address whose DL(SAP)-role is INITIATOR, CONSTRAINED RESPONDER, or UNCONSTRAINED RESPONDER;

   — by a receiving DLCEP; or

   — by a DLS-user through a DL-PUT request primitive, if no other binding exists to write the buffer.

   It is not permitted to bind such a buffer so that it is written from two distinct sources.

2) If a BUFFER-R or QUEUE was created, then it can be read explicitly either

   — by one priority of a sending DLSAP-address whose DL(SAP)-role is BASIC;

   — by a sending DLCEP; or

   — by a DLS-user through a DL-GET request primitive, if no other binding exists to read the buffer.

   It is not permitted to bind such a buffer or queue so that it is read by two distinct sinks.

12.1.2.5 Buffer-or-queue DL-identifier

The buffer-or-queue DL-identifier parameter is present when the Status parameter indicates that the DL-CREATE request primitive was successful. The buffer-or-queue DL-identifier parameter gives the local DLS-user a means of referring to the buffer or queue in input parameters of other local DLS primitives that convey the name of the buffer or queue from the local DLS-user to the local DLE.

The naming-domain of the buffer-or-queue DL-identifier is the DL-local-view.

12.1.3 Sequence of primitives

The sequence of primitives in creating, later using, and eventually deleting a buffer or queue is defined in the time sequence diagram of Figure 5.

12.2 Delete

12.2.1 Function

The delete buffer or queue DL-service-primitive can be used to delete a buffer or queue created by an earlier create buffer or queue DL-service-primitive.

NOTES

1. This primitive can only be used to delete a buffer or queue that was created by a prior DL-CREATE request primitive; it cannot be used to delete a buffer or queue that was created by prior local DL-management actions.

2. This facility may also be provided by local DL-management actions, which are beyond the scope of this standard.

12.2.2 Types of parameters

Table 3 indicates the primitive and parameters needed for the delete buffer or queue DL-service.

Table 3 — DL-buffer-and-queue-management Delete primitive and parameters

DL-DELETE	**Request**	
Parameter Name	input	output
Buffer-or-queue DL-identifier	M	
Status		M

12.2.2.1 Buffer-or-queue DL-identifier

The buffer-or-queue DL-identifier parameter specifies the local DL-identifier returned by a successful prior DL-CREATE request primitive whose buffer or queue has not yet been deleted. The DLS-provider will release the local DL-identifier and associated DLS-provider resources.

The DLS-user may not delete a buffer or queue that is still associated with a DLSAP.

NOTE — Such associations can occur only as a result of a DL-BIND request, or DL-CONNECT request or response, or of DL-management action.

12.2.2.2 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”

b) “failure — resource in use”

c) “failure — management-controlled resource” or

d) “failure — reason unspecified”

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

12.2.3 Sequence of primitives

The sequence of primitives in creating and later deleting a buffer or queue is defined in the time sequence diagram of Figure 5.

12.3 Bind

12.3.1 Function

The bind DL(SAP)-address DL-service-primitive is used:

a) to associate a DL(SAP)-address with the DLSAP at which the primitive is invoked;

b) to establish the DL(SAP)’s role, if any, when participating in the DL-Unitdata and DL-Unitdata-Exchange connectionless services at that DL(SAP)-address;

c) to associate up to six previously created retentive buffers or non-retentive buffers or limited-depth FIFO queues with the various priorities and directions of potential data transfer at the specified DL(SAP)-address; and

d) to specify default values for some Quality of Service (QoS) attributes for connection-mode and connectionless data transfer services using the specified DL(SAP)-address.

NOTE — This facility may also be provided by local DL-management actions, which are beyond the scope of this standard.

12.3.2 Types of parameters

Table 4 indicates the primitive and parameters needed for the bind DL(SAP)-address DL-service.

Table 4 — DL(SAP)-address-management Bind primitive and parameters

DL-BIND	Request	
Parameter Name	input	output
DL(SAP)-address DLS-user-identifier	M	
DL(SAP)-address	M	
DL(SAP)-role	M	
Indicate-null-UNITDATA-EXCHANGE-transactions	C	
Remote-DLSAP-address	C	
Receiving-buffer-or-queue-bindings		
URGENT-buffer-or-queue DL-identifier	U	
NORMAL-buffer-or-queue DL-identifier	U	
TIME-AVAILABLE-buffer-or-queue DL-identifier	U	
Sending-buffer-or-queue-bindings		
URGENT-buffer-or-queue DL-identifier	CU	
NORMAL-buffer-or-queue DL-identifier	CU	
TIME-AVAILABLE-buffer-or-queue DL-identifier	CU	
Default QoS as sender		
DLL priority	CU	
DLL maximum confirm delay		
on DL-CONNECT, DL-RESET, DL-SUBSCRIBER-QUERY	CU	
on DL-DATA	CU	
on locally-confirmed DL-UNITDATA	CU	
on remotely-confirmed DL-UNITDATA, DL-LISTENERQUERY, DL-UNITDATA-EXCHANGE	CU	
DLPDU authentication	CU	
DL-scheduling-policy	CU	
Status		M
DL(SAP)-address DL-identifier		C

12.3.2.1 DL(SAP)-address DLS-user-identifier

The DL(SAP)-address DLS-user-identifier parameter specifies a means of referring to the DL(SAP)-address in output parameters of other local DLS primitives that convey the name of the DL(SAP)-address from the local DLE to the local DLS-user.

The naming-domain of the DL(SAP)-address DLS-user-identifier is the DLS-user's local-view.

12.3.2.2 DL(SAP)-address

The DL(SAP)-address parameter specifies an individual local DLSAP-address or group DL-address to be associated with the invoking (necessarily local) DLSAP.

12.3.2.3 DL(SAP)-role

The DL(SAP)-role parameter constrains, as specified in Table 5, the DL-connectionless DL-UNITDATA and DL-UNITDATA-EXCHANGE service primitives that can be issued with this DL(SAP)-address at the local DLSAP (to which this DL(SAP)-address is being bound). It also constrains whether the DL(SAP)-address may have an associated DLCEP and the permitted types of bindings (implicit queue, explicit queue, or explicit buffer) to the DL(SAP)-address. Permitted values for this parameter are specified in Table 5.

Table 5 — DL(SAP)-role Constraints on DLSAPs, DLCEPs, and other DLS Primitives

DL(SAP)-role	sending DLSAP-address bindings	receiving DL(SAP)-address bindings	DLCEP permitted	DL-UNITDATA		UNITDATA-EXCHANGE Indication possible
				Request permitted	Indication possible	
BASIC	IQ, EQ	IQ, EQ	yes	yes	yes	no
GROUP	—	IQ, EQ	no	no	yes	no
INITIATOR	EB	EB, EQ	no	no	no	yes
CONSTRAINED RESPONDER	EB	EB, EQ	no	no	no	yes
UNCONSTRAINED RESPONDER	EB	EB, EQ	no	no	no	yes

LEGEND:
—: not applicable
EQ : explicit queue
IQ :implicit queue on transmit, immediate (as soon as possible) delivery on receipt
EB : explicit retentive or non-retentive buffer

The default value for this parameter is BASIC.

NOTE — The roles of INITIATOR, CONSTRAINED RESPONDER, and UNCONSTRAINED RESPONDER support migration from previous national standards.

12.3.2.3.1 Indicate-null-UNITDATA-EXCHANGE-transactions

The indicate-null-UNITDATA-EXCHANGE-transactions Boolean parameter is present when the DL(SAP)-role parameter has the value INITIATOR, CONSTRAINED RESPONDER, or UNCONSTRAINED RESPONDER. When present, the indicate-null-UNITDATA-EXCHANGE-transactions parameter specifies whether an instance of a UNITDATA-EXCHANGE transaction that occurs at this DLSAP-address should generate a DL-UNITDATA-EXCHANGE indication even when no DLS-user data transfer (in either direction) occurred.

NOTES

1. Such an indication would attest to the DLS-user that communication with the DLE of the addressed remote peer DLS-user was still possible. In other DL-protocols in which all DLS-users are on the same unbridged local link, this attestation is sometimes provided by a "live list."

2. UNITDATA-EXCHANGE and the use of the indicate-null-UNITDATA-EXCHANGE-transactions parameter are covered in clauses 20 through 24.

12.3.2.3.2 Remote-DLSAP-address

The remote-DL(SAP)-address parameter is present when the DL(SAP)-role parameter has the value CONSTRAINED RESPONDER. When present, this parameter specifies an individual DLSAP-address, specifying that the DL-UNITDATA-EXCHANGE service may be initiated only from the specified DLSAP-address.

12.3.2.4 Receiving buffer-or-queue bindings

When present, each buffer-or-queue DL-identifier parameter specifies the local DL-identifier returned by a successful prior DL-CREATE request primitive (or DL-management action) that created a buffer or queue, which has not yet been deleted.

When the DL(SAP)-role parameter has the value BASIC or GROUP, then:

a) explicit bindings to a buffer are not permitted;

b) explicit bindings to a queue are permitted; and

c) if no binding at a given DLL-priority exists, then the DLSAP-address is implicitly bound at that priority to the default OSI delivery service, which is immediate (as soon as possible) delivery.

When bound as in (b), the maximum-DLSDU-size for each specified receive queue shall accommodate the maximum amount of DLS-user data permitted within a single DLPDU of the priority corresponding to the binding, as specified in 8.1.

When the DL(SAP)-role parameter has the value INITIATOR, CONSTRAINED RESPONDER, or UNCONSTRAINED RESPONDER, then:

d) explicit bindings to a buffer are permitted;

e) explicit bindings to a queue are permitted; and

f) if no binding at a given DLL-priority exists, then it is not possible to receive a DLSDU of that priority at that DLSAP-address.

NOTE — If a queue is bound to the receiving (DLS-provider to DLS-user) direction of data transfer at a DL(SAP)-address at a specified priority, as in (b) or (e), then the DLS-user has specified the maximum number of queued received DLSDUs, and can choose when to process those DLSDUs.

12.3.2.4.1 URGENT buffer-or-queue DL-identifier

12.3.2.4.2 NORMAL buffer-or-queue DL-identifier

12.3.2.4.3 TIME-AVAILABLE buffer-or-queue DL-identifier

12.3.2.5 Sending buffer-or-queue bindings

When present, each buffer-or-queue DL-identifier parameter specifies the local DL-identifier returned by a successful prior DL-CREATE request primitive (or DL-management action) that created a buffer or queue that has not yet been deleted.

When the DL(SAP)-role parameter has the value BASIC, then:

a) explicit bindings to a buffer are not permitted;

b) explicit bindings to a queue are permitted; and

c) if no binding at a given DLL-priority exists, then the DLSAP-address is implicitly bound at that priority to a default OSI queue.

NOTE — If a queue is bound to the sending (DLS-user to DLS-provider) direction of data transfer at a DLSAP-address at a specified priority, as in (b) or (c), then transmission of the queued DLSDUs in FIFO order will be attempted, as appropriate, when the queue is non-empty.

When the DL(SAP)-role parameter has the value INITIATOR, CONSTRAINED RESPONDER, or UNCONSTRAINED RESPONDER, then:

d) explicit bindings to a buffer are permitted;

e) explicit or implicit bindings to a queue are not permitted; and

f) if no binding at a given DLL-priority exists, then it is not possible to source a DLSDU at that priority from that DLSAP-address.

When the DL(SAP)-role parameter has the value GROUP, then no bindings are permitted or implied; it is not possible to attribute a group DL-address as the source of a DLSDU.

12.3.2.5.1 URGENT buffer-or-queue DL-identifier

12.3.2.5.2 NORMAL buffer-or-queue DL-identifier

12.3.2.5.3 TIME-AVAILABLE buffer-or-queue DL-identifier

12.3.2.6 Default QoS as sender

The DLS-user may specify default values for some of the QoS parameters that apply to connection-mode and connectionless data transmission, as described in clause 8. These default values will be used whenever data or unitdata transmission services are initiated at this DLSAP-address, unless explicitly overridden during an actual service invocation.

When the DL(SAP)-role parameter has the value INITIATOR, CONSTRAINED RESPONDER, or UNCONSTRAINED RESPONDER, some of these QoS attributes as sender are irrelevant and shall be absent. When the DL(SAP)-role parameter has the value GROUP, all of these QoS attributes as sender are irrelevant and shall be absent.

12.3.2.6.1 DLL priority

This QoS attribute is not relevant when the DL(SAP)-role parameter has the value INITIATOR, CONSTRAINED RESPONDER, UNCONSTRAINED RESPONDER, or GROUP and thus shall be absent.

12.3.2.6.2 DLL maximum confirm delay

This QoS attribute is not relevant when the DL(SAP)-role parameter has the value CONSTRAINED RESPONDER, UNCONSTRAINED RESPONDER, or GROUP and thus shall be absent.

12.3.2.6.3 DLPDU authentication

This QoS attribute is not relevant when the DL(SAP)-role parameter has the value GROUP and thus shall be absent.

12.3.2.6.4 DL-scheduling-policy

This QoS attribute is not relevant when the DL(SAP)-role parameter has the value INITIATOR, CONSTRAINED RESPONDER, UNCONSTRAINED RESPONDER, or GROUP and thus shall be absent.

12.3.2.7 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully, or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — insufficient resources”;

c) “failure — DL(SAP)-address invalid or unavailable”;

d) “failure — DL(SAP)-role not supported”;

e) “failure — remote DL(SAP)-address invalid”;

f) “failure — invalid buffer or queue binding”;

g) “failure — parameter inconsistent with DL(SAP)-role”;

h) “failure — parameter violates management constraint”;

j) “failure — number of requests violates management constraint”; or

k) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

12.3.2.8 DL(SAP)-address DL-identifier

The DL(SAP)-address DL-identifier parameter is present when the status parameter indicates that the DL-BIND request primitive was successful. The DL(SAP)-address DL-identifier parameter gives the local DLS-user a means of referring to the DL(SAP)-address in input parameters of other local DLS primitives that convey the name of the DL(SAP)-address from the local DLS-user to the local DLE.

The naming-domain of the DL(SAP)-address DL-identifier is the DL-local-view.

12.3.3 Sequence of primitives

The sequence of primitives in:

a) binding a DL(SAP)-address to the invoking DLSAP, and optionally binding one or more buffers or queues to the DL(SAP)-address; and

b) later unbinding the DL(SAP)-address and buffers or queues from the DLSAP

is defined in the time sequence diagram of Figure 5.

12.4 Unbind

12.4.1 Function

The unbind DL(SAP)-address DL-service-primitive is used to unbind a DL(SAP)-address from the invoking DLSAP. Any buffers or queues that were explicitly bound to the DL(SAP)-address are also unbound from that DL(SAP)-address at the same time.

NOTES

1. This primitive can only be used to unbind a DL(SAP)-address that was bound to the DLSAP by a prior DL-BIND request primitive. It cannot be used to unbind a DL(SAP)-address that was bound to the DLSAP by prior local DL-management actions.

2. This facility may also be provided by local DL-management actions, which are beyond the scope of this standard.

12.4.2 Types of parameters

Table 6 indicates the primitive and parameters needed for the unbind DL(SAP)-address DL-service.

Table 6 — DL(SAP)-address-management Unbind primitive and parameters

DL-UNBIND	Request
Parameter Name	input
DL(SAP)-address DL-identifier	M

12.4.2.1 DL(SAP)-address DL-identifier

The DL(SAP)-address DL-identifier parameter specifies the local DL-identifier returned by a successful prior DL-BIND request primitive. The DLS-provider shall unbind the local DL-identifier and its associated DL(SAP)-address, and any associated buffers or queues, from the invoking DLSAP, after first disconnecting all DLCEPs, unbinding all buffer and queues that were bound to those DLCEPs, and terminating all outstanding DL-UNITDATA requests associated with that DLSAP-address.

12.4.3 Sequence of primitives

The sequence of primitives in:

a) binding a DL(SAP)-address, and possibly buffers or queues, with the invoking DLSAP; and

b) later unbinding the DL(SAP)-address and those buffers or queues from the DLSAP

is defined in the time sequence diagram of Figure 5.

12.5 Put

12.5.1 Function

The put buffer DL-service-primitive is used to copy a DLSDU to a buffer. In some cases it may also be used to set the buffer empty.

12.5.2 Types of parameters

Table 7 indicates the primitive and parameters needed for the put buffer DL-service.

Table 7 — DL-buffer-management Put primitive and parameters

DL-PUT	Request	
Parameter Name	input	output
Buffer DL-identifier	M	
DLS-user-data	U	
DLS-user-data-timeliness	U	
Status		M

12.5.2.1 Buffer DL-identifier

The buffer DL-identifier parameter specifies the local DL-identifier returned by a successful prior DL-CREATE request primitive that created a buffer (or by DL-management).

12.5.2.2 DLS-user-data

When present, the DLS-user-data parameter specifies one or more octets of DLS-user-data, up to the maximum DLSDU size specified in the associated DL-CREATE request primitive, possibly further constrained

by DLC negotiation. The DLE may also note the current DL-time for later reporting as the time-of-production (see 12.6.2.6.1).

When DLS-user-data is not present, then:

a) If the buffer is bound to a DLCEP-address, then the DL-Put request fails and a status of “failure — invalid DLSDU size” is returned to the requesting DLS-user.

b) Otherwise, when (a) does not apply, then the DL-Put request primitive resets the buffer to its initial empty state.

12.5.2.3 DLS-user-data-timeliness

The DLS-user-data-timeliness parameter specifies whether the associated DLS-user-data meets the requesting DLS-user’s timeliness criteria, or not. Its value is either TRUE (one or more criteria exist, and all were met) or FALSE (either no criteria exist, or one or more of the criteria were not met).

If the data in this buffer is then sent to other DLS-users through a DLC, then this timeliness attribute will be logically ANDed with the assessment(s) of any DLCEP-evaluated timeliness criteria and the result associated with the receiving buffer, if any.

NOTE — Buffer timeliness is presented to the DLS-user(s) by the DL-GET primitive.

The default value for this parameter is FALSE.

12.5.2.4 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — invalid DLSDU size”; or

c) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

12.5.3 Sequence of primitives

The sequence of primitives in using a buffer is defined in the time sequence diagram of Figure 5.

12.6 Get

12.6.1 Function

The get buffer or queue DL-service-primitive is used to read a DLSDU from a buffer or attempt to remove a DLSDU from a FIFO queue.

When the DL-GET request primitive specifies a buffer (see 12.5.2.1, 15.2.9.1(a), and 24.2.2.3) and the buffer is empty, then the DL-GET request primitive returns an appropriate failure status. Otherwise, the DL-GET request primitive copies the DLSDU from the buffer and returns it.

When the DL-GET request primitive specifies an explicit queue and the queue is empty, then the DL-GET request primitive returns an appropriate failure status. Otherwise, the DL-GET request primitive dequeues

the DLSDU from the FIFO queue and returns it, together with associated DL(SAP)-addresses or an associated DLCEP DL-identifier, if appropriate.

12.6.2 Types of parameters

Table 8 indicates the primitive and parameters needed for the get buffer or queue DL-service.

Table 8 — DL-buffer-and-queue-management Get primitive and parameters

DL-GET	**Request**	
Parameter Name	input	output
Buffer-or-queue DL-identifier	M	
Status		M
Reported-service-identification-class		C
Reported-service-identification		
Receiving DLCEP DLS-user-identifier		C
Called DL(SAP)-address DLS-user-identifier		C
Calling DLSAP-address		C
DLL-priority		C
DLS-user-data		C
DLS-user-data-timeliness		
Local DLE timeliness		C
Sender and remote DLE timeliness		C
Time-of-production		C

12.6.2.1 Buffer-or-queue DL-identifier

The buffer-or-queue DL-identifier parameter specifies the local DL-identifier returned by a successful prior DL-CREATE request primitive (or by DL-management).

12.6.2.2 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. Attempting to copy a DLSDU from a buffer that is empty, or to remove a DLSDU from a FIFO queue that is empty, will result in failure. The value conveyed in this parameter will be as follows:

a) “success”;

b) “possible failure — empty buffer”;

c) “failure — empty queue”; or

d) “failure — reason unspecified”.

NOTES

1. An empty buffer can be considered to contain a null DLSDU when used with the unitdata exchange service and so may be treated as “success” by the DLS-user.

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a

DL-protocol standard that provides services as specified in this part of this International Standard.

12.6.2.3 Reported-service-identification-class

This parameter is present when the status parameter indicates that the DL-GET request was successful. When present, this parameter specifies the structure of the associated reported-service-identification parameter. The values of this parameter are:

a) none — implying that a buffer is being retrieved and that source information is not present;

b) DLCEP — the receiving DLCEP DL-identifier is present; or

c) DL(SAP)-address — the receiving DL(SAP)-address DL-identifier, the sending DLSAP-address, and the priority of the DLSDU are present.

12.6.2.4 Reported-service-identification

This compound parameter is present when the status parameter indicates that the DL-GET request was successful. When present, this parameter identifies the service endpoint(s) and priority of the reported DLSDU.

12.6.2.4.1 Receiving-DLCEP DLS-user-identifier

The receiving-DLCEP DLS-user-identifier parameter is present when the reported-service-identification-class parameter specifies DLCEP. When present, this parameter identifies the DLCEP at which the associated DLSDU was received.

12.6.2.4.2 Called-DL(SAP)-address DLS-user-identifier

The called-DL(SAP)-address DLS-user-identifier parameter is present when the reported-service-identification-class parameter specifies DL(SAP)-ADDRESS. When present, this parameter identifies the destination DL(SAP)-address at which the associated DLSDU was received.

12.6.2.4.3 Calling-DLSAP-address

The calling-DLSAP-address parameter is present when the reported-service-identification-class parameter specifies DL(SAP)-ADDRESS. When present, this parameter identifies the source DLSAP-address from which the associated DLSDU was sent.

NOTE — If the DLS-user has issued a DL-BIND request for the calling-DLSAP-address, then this parameter also can take the form of a DLSAP-address DLS-user-identifier.

12.6.2.4.4 DLL-priority

The DLL-priority parameter is present when the reported-service-identification-class parameter specifies DL(SAP)-ADDRESS. When present, this parameter identifies the sender’s DLL priority of the received DLSDU.

12.6.2.5 DLS-user-data

The DLS-user-data parameter is present when the status parameter indicates that the DL-GET request was successful. The DLS-user-data parameter returns a single DLSDU consisting of one or more octets of

DLS-user-data, up to the maximum DLSDU size specified in the associated DL-CREATE request primitive (or by DL-management).

12.6.2.6 DLS-user-data-timeliness

The DLS-user-data-timeliness parameter is present when the status parameter indicates that the DL-GET request was successful and the buffer-or-queue DL-identifier parameter specifies a buffer. When present, this parameter specifies up to three aspects of DLS-user-data timeliness.

12.6.2.6.1 Local-DLE-timeliness

The local-DLE-timeliness parameter specifies whether the associated DLS-user-data met the receiving DLCEP's timeliness criteria, or not. Its value is either TRUE (timeliness criteria exist, and all were met) or FALSE (either no timeliness criteria exist, or one or more of the criteria were not met). When the buffer is not bound as a sink to a DLCEP, but is instead written by a local DL-PUT request, then the value of this parameter is always TRUE. When the buffer is bound as a sink to a DLSAP-address whose DL(SAP)-role is INITIATOR, CONSTRAINED RESPONDER, or UNCONSTRAINED RESPONDER, then the value of this parameter is always FALSE.

12.6.2.6.2 Sender-and-remote-DLE-timeliness

The sender-and-remote-DLE-timeliness parameter specifies whether the associated DLS-user-data met both the sending DLS-user's timeliness criteria and any sending and intermediary receiving DLCEPs' timeliness criteria, or not. Its value is either TRUE (so specified by the sending DLS-user, and timeliness criteria exist for each of the transporting DLCEPs, and all were met) or FALSE (either so specified by the sending DLS-user, or timeliness was not selected for one or more of the transporting DLCEP(s), or one or more of the timeliness criteria were not met).

NOTE — DL-timeliness is partitioned into separate receiver timeliness and sender timeliness:

a) to distinguish between those aspects of timeliness whose criteria are specified by the receiving DLS-user and those that are not;

b) to provide assistance in DLS-user diagnosis of the source of non-timeliness — either the DLS-user-data source and remote portions of the distributed DLS-provider or the local DLE and the receiving DLS-user; and

c) to facilitate migration of existing national standards.

12.6.2.6.3 Time-of-production

The time-of-production parameter is present only when:

a) the sending DLCEP specified true for its time-of-production QoS parameter (see 15.2.10.1.4); and

b) the value of the sender-and-remote-DLE-timeliness parameter (see 12.6.2.6.2) returned by this DL-GET primitive is TRUE.

The time-of-production parameter specifies the DL-time at which a DLS-user transferred the associated DLS-user-data to the (distributed) DLS-provider.

NOTES

1. For a buffer bound as a source at a DLCEP, this is the DL-time at which the sending DLS-user issued the DL-PUT request that placed the associated DLS-user-data in the sending DL-buffer.

2. If a DL-relay entity (a bridge) acts as a distributor by connecting a receiving DLCEP to a second explicitly-scheduled sending DLCEP through a shared intermediate buffer, then at the final receiver the time-of-production is still the time at which the sending DLS-user

(at the first DLCEP) issued the DL-PUT request that placed the associated DLS-user-data in the original sending DL-buffer.

12.6.3 Sequence of primitives

The sequence of primitives in using a buffer or queue is defined in the time sequence diagram of Figure 5.

13 Facilities of the connection-mode Data Link Service

The DLS provides the following facilities to the DLS-user:

a) A means to establish (see Figure 7) either

1) a peer DLC between two DLS-users for exchanging DLSDUs between the two DLS-users,

NOTE — It is also possible for a peer DLC to be negotiated to provide just DL-simplex transmission from one of the DLS-users to the other.

2) a multi-peer DLC between a single publishing DLS-user and a set of subscribing DLS-users for sending DLSDUs

i) from the publishing DLS-user to the set of subscribing DLS-users, and

ii) optionally, from any of the subscribing DLS-users to the publishing DLS-user.

NOTE — It is also possible for a multi-peer DLC to be negotiated to provide just DL-simplex transmission from the publishing DLS-user to the set of subscribing DLS-users or from the set of subscribing DLS-users to the publishing DLS-user.

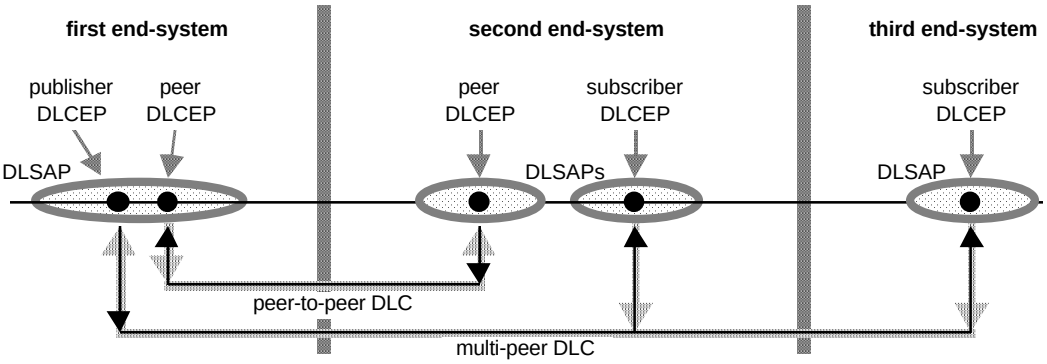


Figure 7 — Peer-to-peer and multi-peer DLCs and their DLCEPs

b) A means of establishing an agreement for a certain Quality of Service (QoS) associated with a DLC, between the initiating DLS-user, the responding DLS-user(s), and the distributed DLS-provider.

c) A means of transferring DLSDUs of limited length on a DLC. The transfer of DLSDUs is transparent, in that the boundaries of DLSDUs and the contents of DLSDUs are preserved unchanged

by the DLS, and there are no constraints on the DLSDU content (other than limited length) imposed by the DLS.

NOTE — The length of a DLSDU is limited because of internal mechanisms employed by the DL-protocol (see 7.6.3.2 of ISO 7498-1).

d) A means of conveying timeliness information about those DLSDUs and their conveyance by the (distributed) DLS-provider in certain modes of DLC operation.

e) A means by which the receiving DLS-user at a peer DLCEP may flow control the rate at which the sending DLS-user may send DLSDUs, if supported by the DLC's QoS.

NOTE — A subscribing DLS-user of a multi-peer DLC may not flow control the rate at which the publishing DLS-user sends DLSDUs because this flow control would affect all the DLC's other DLS-users. Instead, the publishing DLS-user should employ some form of self-administered control of its publishing rate to minimize the probability of DLSDU loss due to congestion at receiving DLS-users. A sending DLS-user at a peer DLCEP whose QoS does not support flow control should adopt a similar policy of rate control.

f) A means by which a DLCEP, and possibly a DLC, can be returned to a defined state and the activities of the DLS-users resynchronized by use of a Reset DL-facility.

NOTE — Reset of a multi-peer DLCEP by a subscribing DLS-user or its local DLE does not cause the DLC to be reset at any of its other DLCEPs.

g) A means by which the publishing DLS-user of a multi-peer DLC can query whether there are any subscribing DLS-users of the DLC.

h) A means for the unconditional, and therefore possibly destructive, release of a DLCEP and possibly a DLC, by one of the DLC's DLS-users or by the DLS-provider.

NOTE — Release of a multi-peer DLCEP by a subscribing DLS-user or its local DLE does not cause the release of the DLC at any of its other DLCEPs.

There are four classes of connection-mode DLS: classes A (most comprehensive) to D (minimal). They differ in only a single QoS attribute — the available set of data delivery features (see 15.2.2). Classes A and B are capable of emulating OSI connection-mode and OSI connectionless services. Classes C and D are capable of emulating OSI connectionless services. All offer features that provide a basis for data distribution and distributed database cache-coherency protocols.

NOTE — True connectionless services also are available, independent of these four classes (see clauses 20 through 24).

14 Model of the connection-mode Data Link Service

This part of this International Standard uses the abstract model for a layer service defined in clause 4 of ISO/TR 8509 and ISO/IEC 10731. The model defines interactions between the DLS-user and the DLS-provider that take place at the DLC's DLSAPs. Information is passed between the DLS-user and the DLS-provider by DL-service-primitives that convey parameters.

14.1 DLCEP-identification

A DLS-user may need to distinguish among several DLCEPs at the same DLSAP; thus a local DLCEP-identification mechanism is provided. All primitives issued at such a DLSAP within the context of a DLC use this mechanism to identify the local DLCEP. Other uses exist, such as the timeliness QoS parameters of 15.2.10 and the scheduling primitives of 29.2 and 29.3. Thus this DLCEP-identification is explicitly

included within the primitives that reference a local DLCEP. The naming-domain of this DLCEP-identification is the DL-local-view (see also 5.3).

14.2 Model of a peer DLC

Between the two end-points of a peer DLC there may exist a QoS-dependent flow control function that relates the behavior of the DLS-user receiving data to the ability of the other DLS-user to send data. As a means of specifying this flow control feature and its relationship with other capabilities provided by the connection-mode DLS, the OSI abstract queue model of a peer DLC, which is described in the following paragraphs, is used.

NOTE 1 — The abstract queues referred to in this model are used solely for describing the interactions at the DLCEPs between the DLS-users, as mediated by the DLS-provider. They have no intended relationship to the actual queues managed by the primitives of clauses 9 through 12.

This abstract queue model of a peer DLC is discussed only to aid in the understanding of the end-to-end DL-service features perceived by DLS-users. It is not intended to serve as a substitute for a precise, formal description of the DLS, nor as a complete specification of all allowable sequences of DLS-primitives. (Allowable primitive sequences are specified in clause 16. See also the note below.) In addition, this model does not attempt to describe all the functions or operations of DLEs that are used to provide the DLS. No attempt to specify or constrain DLE implementation is implied.

NOTE 2 — The internal mechanisms that support the operation of the DLS are not visible to the DLS-user. Along with the interactions between service primitives described by this model (for example, the issue of a DL-RESET request at a DLSAP may prevent the receipt of a DL-DATA indication, corresponding to a previously issued DL-DATA request, by the peer DLS-user) there may also be:

a) constraints applied locally on the ability to invoke DLS-primitives; and

b) service procedures defining particular sequencing constraints on some DLS-primitives.

14.2.1 OSI abstract queue model concepts

The OSI abstract queue model represents the operation of a peer DLC in the abstract by a pair of abstract queues linking the two DLCEPs. There is one abstract queue for each direction of information flow (see Figure 8).

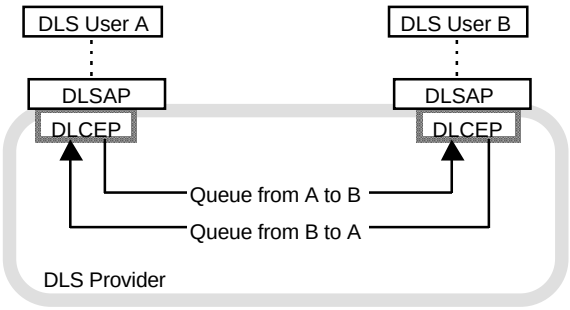


Figure 8 — OSI abstract queue model of a peer DLC between a pair of DLS-users

Each OSI abstract queue represents a flow control function in one direction of transfer. The ability of a DLS-user to add objects to an abstract queue will be determined by the behavior of the other DLS abstract queue. Objects are entered or removed from the abstract queue as a result of interactions at the two DLSAPs. Each peer DLC is considered to have one pair of abstract queues.

The following objects may be placed in an abstract queue by a DLS-user (see clauses 17 through 19):

a) a connect object, representing a DL-Connect primitive and its parameters;

b) a data object, representing a DL-Data primitive and its parameters;

c) a reset object, representing a DL-Reset primitive and its parameters; and

d) a disconnect object, representing a DL-Disconnect primitive and its parameters.

The following objects may be placed in an abstract queue by the DLS-provider (see clauses 17 through 19):

1) a reset object, representing a DL-Reset primitive and its parameters;

2) a synchronization mark object (see 14.2.4); and

3) a disconnect object, representing a DL-Disconnect primitive and its parameters.

The abstract queues are defined to have the following general properties:

i) An abstract queue is empty before a connect object has been entered and can be returned to this state, with loss of its contents, by the DLS-provider.

ii) Objects are entered into an abstract queue by the sending DLS-user, subject to control by the DLS-provider. Objects may also be entered by the DLS-provider.

iii) Objects are removed from the abstract queue under the control of the receiving DLS-user.

iv) Objects are normally removed in the same order that they were entered (however, see 14.2.3).

v) An abstract queue has a limited capacity, but this capacity is not necessarily either fixed or determinable.

vi) Depending on the peer DLC's QoS, the abstract queue may occasionally duplicate or lose data objects.

14.2.2 Peer DLC / DLCEP establishment

When the DLS-provider receives a DL-CONNECT request primitive at one of the DLSAPs it associates a pair of abstract queues and an abstract peer DLC between the two DLSAPs, and enters either a connect object or a disconnect object into the appropriate abstract queue. From the standpoint of the DLS-users of the peer DLC, the abstract queues remain associated with the peer DLC until a disconnect object representing a DL-DISCONNECT primitive is either entered into or removed from the abstract queue.

DLS-user A, who initiates a peer DLC establishment by entering a connect object representing a DL-CONNECT request primitive into the abstract queue from DLS-user A to DLS-user B, is not allowed to enter any other object, other than a disconnect object, into the abstract queue until after the connect object representing the DL-CONNECT confirm primitive has been removed from the DLS-user B to DLS-user A abstract queue.

In the abstract queue from DLS-user B to DLS-user A, objects other than a disconnect object can be entered only after DLS-user B has entered a connect object representing a DL-CONNECT response primitive, and has received a subsequent DL-CONNECTION-ESTABLISHED indication primitive. A disconnect object can be entered at any time.

While a peer DLC exists, the properties exhibited by the abstract queues represent the agreements concerning QoS reached among the DLS-users and the DLS-provider during this DLC establishment procedure.

14.2.3 Data transfer

Flow control on the peer DLC is represented in this queue model by the management of the queue capacity, allowing objects to be added to the queues. The addition of an object may prevent the addition of a further object.

Once objects are in the queue, the DLS-provider may manipulate pairs of adjacent objects, resulting in deletion. An object may be deleted if, and only if, the object that follows it is defined to be destructive with respect to the object. If necessary, the last object on the queue will be deleted to allow a destructive object to be entered — they may therefore always be added to the queue. Disconnect objects are defined to be destructive with respect to all other objects. Reset objects are defined to be destructive with respect to all other objects except connect and disconnect objects.

The relationships between objects that may be manipulated in the above fashion are summarized in Table 9.

Table 9 — Relationships between abstract queue model objects

The following (column) object is defined with respect to the preceding (row) object	**Connect**	**Data**	**Reset**	**Synchronization Mark**	**Disconnect**
CONNECT	N/A	—	—	N/A	DES
DATA	N/A	—	DES	N/A	DES
RESET	N/A	—	DES	—	DES
SYNCHRONIZATION MARK	N/A	—	DES	N/A	DES
DISCONNECT	N/A	N/A	N/A	N/A	DES

LEGEND:

N/A : X will not precede Y in a valid state of a queue
—: not to be destructive nor to be able to advance ahead
DES : to be destructive to the preceding object

Whether the DLS-provider performs actions resulting in deletion or not will depend upon the behavior of the peer DLC users and the agreed QoS for the peer DLC. With few exceptions, if a DLS-user does not remove objects from an abstract queue, the DLS-provider shall, after some unspecified time, perform all the permitted deletions.

14.2.4 Peer DLC / DLCEP reset

To model the reset service accurately, a synchronization mark object is required. The synchronization mark object exhibits the following characteristics:

a) It cannot be removed from an abstract queue by a DLS-user.

b) An abstract queue appears empty to a DLS-user when a synchronization mark object is the next object in the queue.

c) A synchronization mark can be destroyed by a disconnect object (see Table 9).

d) When a reset object is immediately preceded by a synchronization mark object, both the reset object and the synchronization mark object are deleted from the abstract queue.

The initiation of a reset procedure is represented in the two abstract queues as follows:

1) Initiation of a reset procedure by the DLS-provider is represented by the introduction into each abstract queue of a reset object followed by a synchronization mark object.

2) A reset procedure initiated by the DLS-user is represented by the addition, by the DLS-provider, of objects into both abstract queues:

   i) from the reset requester to the peer DLS-user of a reset object; and

   ii) from the peer DLS-user to the reset requester of a reset object followed by a synchronization mark object.

NOTE 1 — The DLS-provider is always able to add a synchronization mark object following a reset object.

Unless destroyed by a disconnect object, a synchronization mark object remains in the abstract queue until the next object following it in the abstract queue is a reset object. Then the DLS-provider deletes both the synchronization mark object and the following reset object.

NOTE 2 — Restrictions on the issuance of certain other types of DL-primitives are associated with the initiation of a reset procedure. These restrictions result in constraints on the entry of certain object types into the abstract queue until the reset procedure is completed (see 19.3.3).

14.2.5 Peer DLC / DLCEP release

The insertion into an abstract queue of a disconnect object, which may occur at any time, represents the initiation of a peer DLC release procedure. The release procedure may be destructive with respect to other objects in the two queues. The release procedure eventually results in the emptying of the queues and the disassociation of the queues from the peer DLC.

The insertion of a disconnect object may also represent the rejection of a peer DLC establishment attempt or the failure to complete peer DLC establishment. In such cases, if a connect object representing a DL-CONNECT request primitive is deleted by a disconnect object, then the disconnect object is also deleted. The disconnect object is not deleted when it deletes any other object, including the case where it deletes a connect object representing a DL-CONNECT response.

14.3 Model of a multi-peer DLC

Between the publishing and subscribing end-points of a multi-peer DLC, during the process of DLC establishment, there exists a relationship between the behavior of the responding DLS-user(s) and that of the initiating DLS-user. After DLC establishment, there exists a relationship between the publishing DLS-user and the subscribing DLS-user(s). As a means of specifying these relationships, the OSI abstract queue model of a multi-peer DLC, which is described in the following paragraphs, is used.

NOTE 1 — The abstract queues referred to in this model are used solely for describing the interactions at the DLCEPs between the DLC users and the DLC provider. They have no relationship to actual queues managed by the primitives of clauses 9 through 12.

This abstract queue model of a multi-peer DLC is discussed only to aid in the understanding of the end-to-end DL-service features perceived by DLS-users. It is not intended to serve as a substitute for a precise, formal description of the DLS, nor as a complete specification of all allowable sequences of DLS primitives. (Allowable primitive sequences are specified in clause 16. See also the note below.) In addition, this model does not attempt to describe all the functions or operations of DLEs that are used to provide the DLS. No attempt to specify or constrain DLE implementation is implied.

NOTE 2 — The internal mechanisms that support the operation of the DLS are not visible to the DLS-user. In addition to the interactions between service primitives described by this model (for example, the issue of a DL-DISCONNECT request at a receiving DLSAP will prevent

the receipt of a DL-DATA indication, corresponding to a previously issued DL-DATA request, by the sending DLS-user) there may also be:

a) constraints applied locally on the ability to invoke DLS-primitives; and

b) service procedures defining particular sequencing constraints on some DLS-primitives.

14.3.1 OSI abstract queue model concepts

The OSI abstract queue model represents the operation of a multi-peer DLC in the abstract by a set of abstract queues linking the publishing DLCEP with the subscribing DLCEPs — one queue per receiving DLCEP (see Figure 9).

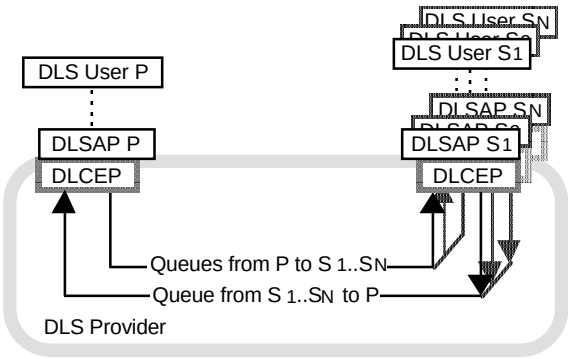


Figure 9 — OSI abstract queue model of a multi-peer DLC between a publishing DLS-user and a set of subscribing DLS-users

Each OSI abstract queue represents one direction of transfer. The ability of a subscribing DLS-user to remove objects from an abstract queue will be determined by the behavior of the publishing DLS-user. The ability of a publishing DLS-user to remove objects from an abstract queue will be determined by the aggregate behavior of the set of the publishing DLS-user and the subscribing DLS-users.

The following objects may be placed in an abstract queue by any sending DLS-user (see clauses 17 through 19):

a) a connect object, representing a DL-CONNECT primitive and its parameters; and

b) a data object, representing a DL-DATA primitive and its parameters.

The following objects may be placed in an abstract queue by the publishing DLS-user (see clauses 17 through 19):

c) a reset object, representing a DL-RESET primitive and its parameters; and

d) a disconnect object, representing a DL-DISCONNECT primitive and its parameters.

The publishing DLS-user may place a connect object in either a single abstract queue or simultaneously in the entire set of publisher-to-subscriber abstract queues. The publisher places all other objects simultaneously in the entire set of publisher-to-subscriber abstract queues. Each subscriber places all objects in the single subscribers-to-publisher abstract queue.

The following objects may be placed in an abstract queue by the DLS-provider (see clauses 17 through 19):

1) a reset object, representing a DL-RESET primitive and its parameters; and

2) a disconnect object, representing a DL-DISCONNECT primitive and its parameters.

The abstract queues are defined to have the following general properties:

i) An abstract queue is empty before a connect object has been entered and can be returned to this state, with loss of its contents, by the DLS-provider.

ii) Objects are entered into an abstract by the sending DLS-user, subject to control by the DLS-provider. Objects may also be entered by the DLS-provider.

iii) Objects are removed from the abstract queue under the control of the receiving DLS-user.

iv) Objects are normally removed in the same order that they were entered (however, see 14.3.3).

v) An abstract queue has a limited capacity, but this capacity is not necessarily either fixed or determinable. When the sending DLS-user places a new object in an abstract queue that has reached its capacity, the oldest object in the abstract queue is lost.

vi) Depending on the multi-peer DLC's QoS, the abstract queue may occasionally duplicate or lose data objects.

14.3.2 Multi-peer DLC / DLCEP establishment

When the DLS-provider receives a DL-CONNECT request primitive at one of the DLSAPs, it associates a pair of abstract queues and an abstract multi-peer DLC between the two DLSAPs and enters either a connect object or a disconnect object into the appropriate abstract queue. From the standpoint of the DLS-users of the multi-peer DLC, the abstract queues remain associated with the multi-peer DLC until a disconnect object representing a DL-DISCONNECT primitive is either entered into or removed from the abstract queue.

The publishing DLS-user, who initiates a multi-peer DLC establishment by entering a connect object representing a DL-CONNECT request primitive into each of the separate publisher-to-subscriber abstract queues, is not allowed to enter any other object, other than a disconnect object, into the abstract queues until after the connect object representing the DL-CONNECT confirm primitive has been removed from the merged subscribers-to-publisher abstract queue. A disconnect object can be entered at any time.

A subscribing DLS-user, who initiates a multi-peer DLCEP establishment by entering a connect object representing a DL-CONNECT request primitive into the subscribers-to-publisher abstract queue, is not allowed to enter any other object, other than a disconnect object, into the abstract queue until after the connect object representing the DL-CONNECT confirm primitive has been removed from its publisher-to-subscriber abstract queue. In the subscriber-specific abstract queue from the publisher to that subscriber, objects other than a disconnect object can be entered only after the publishing DLS-user has entered a connect object representing a DL-CONNECT response primitive. A disconnect object can be entered at any time.

While the multi-peer DLC exists between the publisher and a specific subscriber, the properties exhibited by the two abstract queues between them represent the agreements concerning QoS reached between the publishing DLS-user, that subscribing DLS-user, and the DLS-provider during the DLCEP establishment procedure.

14.3.3 Data transfer

Flow control on the multi-peer DLC is represented in this abstract queue model by the management of the abstract queue capacity, allowing objects to be added to the abstract queues. The addition of an object may prevent the addition of a further object or may cause the loss of the first data object in the abstract queue.

The addition of a disconnect object to the abstract queue may cause the loss of all prior objects still in the abstract queue. The ordering of objects in the abstract queue is identical to that implied by Table 9.

Whether the DLS-provider performs actions resulting in deletion or not will depend upon the behavior of the multi-peer DLC's users. With few exceptions, if a subscribing DLS-user does not remove objects from an abstract queue at the same long-term rate as the publishing DLS-user places them in the abstract queue, then some objects will be lost.

14.3.4 Multi-peer DLC/DLCEP reset

The initiation of a reset procedure is represented in the abstract queues as follows:

a) Initiation of a reset procedure by the DLS-provider is represented by the introduction of a reset object into one or more abstract queues.

b) A reset procedure initiated by the publishing DLS-user is represented by the addition, by the DLS-provider, of a reset object into each publisher-to-subscriber abstract queue.

c) A reset procedure initiated by a subscribing DLS-user is represented by the addition, by the DLS-provider, of a reset object into the subscribers-to-publisher abstract queue at that subscriber.

NOTE — Restrictions on the issuance of certain other types of DL-primitives are associated with the initiation of a reset procedure. These restrictions will result in constraints on the entry of certain object types into the abstract queue until the reset procedure is completed (see 19.3.3).

14.3.5 Multi-peer DLC subscriber query

At any time during the existence of a multi-peer DLC, its publishing DLS-user can query whether there are any subscribing DLS-users.

NOTE — This query does not result in the identification of any of these receiving DLS-users.

This query occurs within the scope of the multi-peer DLC, and thus cannot precede DLC establishment, nor can either the query or its confirmation follow DLC release. In all other respects, this query is asynchronous to the other activities of the multi-peer DLC.

14.3.6 Multi-peer DLC/DLCEP release

The insertion into an abstract queue of a disconnect object, which may occur at any time, represents the initiation of a DLCEP, and possibly a DLC, release procedure. The release procedure may be destructive with respect to other objects in the queues. The release procedure eventually results in the emptying of the abstract queues and the disassociation of the abstract queues from the multi-peer DLC. For a release initiated by a subscribing DLS-user, only the publisher-to-subscriber abstract queue associated with that subscribing DLS-user is emptied and dissociated from the multi-peer DLC; the abstract queues associated with other DLS-users are unaffected.

The insertion of a disconnect object may also represent the rejection of a multi-peer DLC/DLCEP establishment attempt or the failure to complete multi-peer DLC/DLCEP establishment.

15 Quality of connection-mode service

The term “Quality of Service” (QoS) refers to certain characteristics of a DLC as observed between the connection end-points. QoS describes aspects of a DLC that are attributable solely to the DLS-provider. QoS can only be properly determined when DLS-user behavior does not constrain or impede the performance of the DLS.

Once a DLC is established, the DLS-users at the DLCEPs have the same knowledge and understanding of the actual QoS of the DLC.

15.1 Determination of QoS for connection-mode service

QoS is described in terms of QoS parameters. These parameters give DLS-users a method of specifying their needs and give the DLS-provider a basis for protocol selection. In this part of this International Standard, all QoS parameters are selected on a per-connection basis during the establishment phase of a DLCEP, or of a DLC and DLCEP.

Some of the DLC’s QoS parameters are defined in clause 8; others are defined in 15.2. The selection procedures for these parameters are described in detail in 17.2.3. Once the DLC is established, throughout the lifetime of the DLC, the agreed QoS values are not reselected at any point in time.

15.2 Definition of QoS parameters

QoS attributes are as follows:

15.2.1 DLCEP class

Each DLC/DLCEP establishment request specifies the class of the DLCEP. The three choices for DLCEP class are:

a) **PEER** — the DLS-user can exchange DLSDUs with one other peer DLS-user;

b) **PUBLISHER** — the DLS-user can send DLSDUs to a set of zero or more associated subscribing DLS-users and may be able to receive DLSDUs from any of those subscribing DLS-users; or

c) **SUBSCRIBER** — the DLS-user can receive, and request, DLSDUs from the associated publishing DLS-user and may be able to send DLSDUs to that publishing DLS-user.

The default QoS value for the DLCEP class is PEER.

15.2.2 DLCEP data delivery features

Both members of a peer DLC, or the publishing DLS-user of a multi-peer DLC, specify the data delivery features of the DLC’s DLCEP(s). The available choices of DLCEP data delivery features depends on the class of DLS provided (see Table 10). The five choices for DLCEP data delivery features, and their effects, are:

a) **CLASSICAL** — the DLS-user can send data that will be delivered without loss, duplication or misordering to the receiving DLS-user(s). All relevant DLS-users will be notified of any loss of synchronization on the DLC.

b) **DISORDERED** — the DLS-user can send data that will be delivered immediately upon receipt to the receiving DLS-user(s), without duplication but potentially in a different order than the order in

which it was originally sent. All relevant DLS-users will be notified of any unrecoverable loss of DLS-user-data or loss of synchronization on the DLC.

c) **ORDERED** — the DLS-user can send data that will be delivered immediately upon receipt to the receiving DLS-user(s), without duplication or misordering, but with potential loss of some DLS-user-data. Loss of DLS-user-data will not be reported, and recovery of DLS-user data lost prior to the last-reported DLS-user data will not be attempted.

NOTE — Recovery of lost DLS-user data subsequent to that last reported is permitted but is not required.

d) **UNORDERED** — the DLS-user can send data that will be delivered immediately upon receipt to the receiving DLS-user(s). Loss, duplication, and misordering of DLS-user-data will not be detected or reported. No attempt will be made by the DLS-provider to recover from such events.

e) **NONE** — the DLS-user cannot send data in this direction of data transfer.

There are four classes of connection-mode DLS:

A CLASSICAL, ORDERED, and UNORDERED peer and multi-peer DLCs are all supported; DISORDERED peer and multi-peer DLCs may be supported;

B only ORDERED and UNORDERED peer and multi-peer DLCs, and CLASSICAL peer DLCs, are supported; CLASSICAL and DISORDERED multi-peer DLCs are not supported; DISORDERED peer DLCs may be supported;

C only ORDERED and UNORDERED peer and multi-peer DLCs are supported; CLASSICAL and DISORDERED peer and multi-peer DLCs are not supported; and

D only UNORDERED peer and multi-peer DLCs are supported; ORDERED, CLASSICAL, and DISORDERED peer and multi-peer DLCs are not supported.

Table 10 — Attributes and class requirements of DLCEP data delivery features

DLCEP data delivery features	action on lost DLSDUs	action on duplicate DLSDUs	action on mis-ordered DLSDUs	permitted forms of buffer and queue use	support on a peer-to-peer DLC (note 4)	support on a publisher -to-subscribers DLC (note 4)	support on a subscribers -to-publisher DLC (note 4)
NONE	none	none	none	none	Mandatory in all classes	Mandatory in all classes	Mandatory in all classes
UNORDERED (DEFAULT)	not detected	not detected	not detected (note 2)	buffer ⇒ buffer buffer ⇒ queue queue ⇒ queue (3)	Mandatory in all classes	Mandatory in all classes	Optional in all classes
ORDERED	detected	discarded	discarded	buffer ⇒ buffer buffer ⇒ queue queue ⇒ queue (3)	Mandatory in classes A,B,C	Mandatory in classes A,B,C	not possible
CLASSICAL	recovered (note 1)	discarded	recovered: delivered in order	queue ⇒ queue	Mandatory in classes A,B	Mandatory in class A	not possible
DISORDERED	recovered (note 1)	discarded	delivered as received	queue ⇒ queue	Optional in classes A,B	Optional in class A	not possible

NOTES

1. An unrecoverable data loss causes the DLE to initiate a reset procedure.

2. DL-communication topologies in which misordering is possible cause UNORDERED DLCs to be upgraded to ORDERED during DLC negotiation.

3. Queue-to-queue use provides a QoS similar to connectionless service.

4. The DLE shall support all DLCEP data-delivery features required of its DLS class. (The DLE classes are introduced in clause 13.) If the DLE does not support DISORDERED but does support CLASSICAL, then the DLE shall upgrade the DLCEP data delivery features from DISORDERED to CLASSICAL. In all other cases, if the DLE does not support a requested DLCEP data delivery feature that is optional for its DLS class, then the DLE shall reject the DLC/DLCEP establishment request.

On a peer DLC, the QoS value for the DLCEP data delivery features may be chosen independently for each direction of data transfer. The default QoS value in each direction for the DLCEP data delivery features is UNORDERED.

On a multi-peer DLC, the QoS value for the DLCEP data delivery features for the subscribers-to-publisher direction of data transfer is restricted to UNORDERED and NONE. The default QoS value for the DLCEP data delivery features in the publisher-to-subscribers direction is UNORDERED. The default QoS value for the DLCEP data delivery features in the subscribers-to-publisher direction is NONE.

Selection of any of the following QoS attribute values may cause the DLS-provider to upgrade DLCEP data delivery features from UNORDERED to ORDERED:

1) specification of a maximum DLSDU size (see 15.2.8) greater than the maximum number of DLS-user octets that can be conveyed by a DLPDU of the specified DLL priority (see 15.2.3); or

2) specification of DL-timeliness criteria (see 15.2.10) other than none for transmissions from a peer or publisher DLCEP; or

3) selection of a DLCEP data delivery feature other than unordered or none for the other (reverse) direction of a peer DLCEP.

This upgrade may also occur when multiple active paths can exist between the DLC's participating DLS-providers.

The DLS provider may also upgrade from DISORDERED to CLASSICAL during this negotiation process.

No other negotiation of either of the DLCEP's data delivery features is permitted.

Table 10 summarizes these DLCEP data delivery features, their attributes, and the DLS classes in which they are available.

15.2.3 DLL priority

This parameter is defined and its default value specified in 8.1 and 12.3.2.6.1.

NOTE — DLC initiation and DLC termination DLPDUs are sent at TIME-AVAILABLE priority on the link but are restricted to convey no more DLS-user-data than is permitted for NORMAL priority DLPDUs.

15.2.4 DLL maximum confirm delay

This parameter is defined and its default values specified in 8.2 and 12.3.2.6.2. Failure to complete a DL-CONNECT or DL-RESET request within the specified interval shall result in a DLS-provider initiated release of the DLCEP, and possibly of the DLC.

NOTE — For DLEs that do not support a time resolution of 1 ms, the requested time interval may be rounded up to the next-greatest multiple of the resolution that the DLE does support.

This parameter provides user-specifiable bounds on the extent of DLC error recovery effort.

15.2.5 DLPDU authentication

This parameter is defined and its default value is specified in 8.3 and 12.3.2.6.3. The DLS-user may override that default value when establishing a DLCEP.

15.2.6 Residual activity

Each DLC/DLCEP establishment request, and each response, specifies whether the current state of a sending peer or publisher DLCEP should be sent at low-frequency to the DLC's peer or subscriber DLCEP(s) even when there are no unconfirmed DLS-user requests outstanding at the sending DLCEP.

NOTE — This background transmission is known as DLC **residual activity**.

The default value for this parameter is FALSE, unless overridden by DL-management or by a DLPDU-authentication attribute of MAXIMAL.

15.2.7 DL-scheduling-policy

This parameter is defined and its default value is specified in 8.4 and 12.3.2.6.4. The DLS-user may override that default value when establishing a DLCEP. When the DLCEP is bound as sender to a buffer, then the DLS-user shall ensure that this parameter has the value EXPLICIT.

15.2.8 Maximum DLSDU sizes

Each DLC/DLCEP establishment request, and each response, specifies an upper bound on the size (in octets) of DLSDUs that will be offered for transmission, and an upper bound on the size of DLSDUs that are acceptable for reception. For peer DLCs, the maximum DLSDU size permitted will be the smaller of that offered by the sender, that permitted by the receiver, and that permitted by DLL management. For multi-peer DLCs, the maximum DLSDU size permitted will be the smaller of that offered by the publisher and that permitted by the publisher's DLL management. For subscribers of multi-peer DLCs, the DLC will be refused by the DLS-provider if the maximum DLSDU size established by the publisher is larger than:

a) that permitted by the subscriber; or

b) that permitted by the subscriber's DLL management.

The default value for both the sender's and receiver's maximum DLSDU size is the maximum number of DLS-user octets that can be carried by a single DLPDU of the specified DLL Priority (see 8.1). The DLS-provider shall always support that DLSDU size.

NOTE — These negotiation rules do not preclude either derivative protocol specifications or real implementations from using a fixed, small set of sizes when allocating buffers or entries in a queue.

15.2.9 DLCEP buffer-or-queue bindings

Each DLCEP establishment request, and each response, can bind one or two local retentive buffers or specified-depth FIFO queues, created by DL-CREATE buffer and queue management primitives (or by DL-management), to the DLCEP.

NOTE — When these bindings are made for a DLS-user of a peer DLC, or a publishing DLS-user of a multi-peer DLC, they determine the maximum transmit window (that is, number of transmitted but unacknowledged DLSDUs) for that direction of DLC data transfer. Since the size of the transmit window can also be limited by DL-management, or by an implementation, the queue depth only imposes an upper limit on the window size:

a) One queue or retentive buffer can be bound to a DLCEP to convey DLSDUs from the DLS-user to the DLS-provider.

b) One queue or retentive buffer can be bound to a DLCEP to convey DLSDUs from the DLS-provider to the DLS-user.

c) It is also possible to bind a queue or retentive buffer to be written at one DLCEP and to source data at another DLCEP. Such an intermediate buffer or queue can serve to cross scheduling boundaries or redistribute received DLS-user data to a second set of DLS-users.

Such a binding is made by specifying, for the appropriate parameter, a buffer-or-queue DL-identifier that resulted from a prior DL-CREATE request (or by DL-management) and that has not yet been deleted.

When the DLCEP's sending data delivery features specify UNORDERED or ORDERED, both the sender and receiver(s) may specify a queuing policy of BUFFER-R or QUEUE. When the DLCEP's sending data delivery features specify DISORDERED or CLASSICAL, both the sender and receiver(s) may specify a queuing policy of QUEUE; a queuing policy of BUFFER-R is not permitted. A queuing policy of BUFFER-NR is never permitted.

15.2.9.1 Binding to a retentive buffer

When a sending retentive buffer is bound to a DLCEP by a DLS-user:

a) A DL-PUT request primitive overwrites the buffer with a DLSDU.

NOTE — After creation, the buffer is empty. After it has first been written, a buffer bound to a DLCEP can never again be empty.

b) A DL-BUFFER-SENT indication primitive notifies the DLS-user of the specific DLCEP on which the buffer was transmitted, and to which the buffer is bound, that the buffer was just transmitted.

c) A DL-COMPEL request primitive causes the transmission, at the first opportunity, of the contents of the buffer at the moment of transmission; the primitive does not itself specify a DLSDU. As a consequence, the only meaningful scheduling policy for buffers is EXPLICIT.

When a receiving retentive buffer is bound to a DLCEP by a DLS-user:

d) A DL-BUFFER-RECEIVED indication primitive notifies the DLS-user of the overwriting of the buffer by a newly-received DLSDU; the primitive does not itself specify a DLSDU.

e) A DL-GET request primitive copies the DLSDU from the buffer.

15.2.9.2 Binding to a FIFO queue

When a sending FIFO queue of maximum depth *K* is bound to a DLCEP by a DLS-user:

a) A DL-PUT request primitive is not permitted.

b) A DL-DATA request primitive attempts to append a DLSDU to the queue, but fails if the queue already contains *K* DLSDUs. If the append operation was successful, then the DLSDU will be transmitted at the first opportunity, after all preceding DLSDUs in the queue.

When a receiving FIFO queue of maximum depth *K* is bound to a DLCEP by a DLS-user

c) A DL-GET request primitive attempts to remove a DLSDU from the queue, but fails if the queue is empty.

d) A DL-DATA indication primitive notifies the receiving DLS-user of the result of appending a newly-received DLSDU to the receive queue; the primitive does not itself specify a DLSDU.

15.2.9.3 Default bindings

When these binding options are not specified, the conventional implicitly-queued sending and direct receiving interfaces between DLS-user and DLS-provider are employed, and each associated DL-DATA primitive contains a DLSDU:

a) DL-Put and DL-Get request primitives are not permitted.

b) A DL-Data request primitive by the sending DLS-user attempts to append a DLSDU to the implicit queue, but fails if the queue is full. If the append operation was successful, then the DLSDU will be transmitted at the first opportunity, after all preceding DLSDUs in the queue.

c) A DL-Data indication primitive notifies a receiving DLS-user of a newly-received DLSDU and conveys that DLSDU to the DLS-user. No apparent queuing is provided within the DLL.

15.2.10 DLCEP timeliness

Each DLCEP establishment request, and each response, can specify DL-timeliness QoS criteria that are to apply to information sent or received at that DLCEP (see 8.5).

15.2.10.1 Sender timeliness

This set of sub-parameters applies only when the buffer-and-queue-bindings-as-sender specify a retentive buffer.

15.2.10.1.1 DL-timeliness class

The DLS-user shall specify one of the four types of DL-timeliness specified in 8.5 — RESIDENCE, UPDATE, SYNCHRONIZED, or TRANSPARENT — or shall specify NONE, indicating that DL-timeliness shall not be provided.

The default value for this parameter is NONE.

15.2.10.1.2 Time window size (ΔT)

When the value for the DL-timeliness-class parameter is RESIDENCE, UPDATE, or SYNCHRONIZED, then the DLS-user shall specify the applicable time window size (ΔT), with a permitted maximum of 60 s.

15.2.10.1.3 Synchronizing DLCEP

When the value for the DL-timeliness-class parameter is UPDATE or SYNCHRONIZED, then the DLS-user shall specify the DL-identifier (see 17.2.1.2) of the DLCEP whose activity (DL-BUFFER-SENT indication or DL-BUFFER-RECEIVED indication (see 19.2) is to be used as the synchronizing activity for the timeliness

computation. If the synchronizing DLCEP disconnects before the referencing DLCEP, then after that disconnection the resulting sender timeliness shall be FALSE.

15.2.10.1.4 Time of production

When the value for the DL-timeliness-class parameter is RESIDENCE, UPDATE, SYNCHRONIZED, or TRANSPARENT, then the DLS-user may specify that the DL-time of DLS-user-data production should be distributed to the consuming peer DLS-users to facilitate their assessment of DLS-user-timeliness. Permitted values for this parameter are TRUE and FALSE.

The default value for this parameter is FALSE.

15.2.10.2 Receiver timeliness

This set of sub-parameters applies only when the buffer-and-queue-bindings-as-receiver specify a retentive buffer.

15.2.10.2.1 DL-timeliness class

The DLS-user shall specify one of the four types of DL-timeliness specified in 8.5 — RESIDENCE, UPDATE, SYNCHRONIZED, or TRANSPARENT — or shall specify NONE, indicating that DL-timeliness shall not be provided.

The default value for this parameter is NONE.

15.2.10.2.2 Time window size (ΔT)

When the value for the DL-timeliness-class parameter is RESIDENCE, UPDATE, or SYNCHRONIZED, then the DLS-user shall specify the applicable time window size (ΔT), with a permitted maximum of 60 s.

15.2.10.2.3 Synchronizing DLCEP

When the value for the DL-timeliness-class parameter is UPDATE or SYNCHRONIZED, then the DLS-user shall specify the DL-identifier (see 17.2.1.2) of the DLCEP whose activity (DL-BUFFER-SENT indication or DL-BUFFER-RECEIVED indication (see 19.2) is to be used as the synchronizing activity for the timeliness computation. If the synchronizing DLCEP disconnects before the referencing DLCEP, then after that disconnection the resulting receiver timeliness shall be FALSE.

16 Sequence of primitives

16.1 Concepts used to define the connection-mode DL-service

The service definition uses the following concepts:

a) A DLC can be dynamically established (or terminated) between the DLS-users for the purpose of exchanging data. It is also possible statically to pre-establish an unordered or ordered DLC.

b) Associated with each DLC, certain measures of QoS are agreed between the DLS-provider and the DLS-users when the DLC is established.

c) The DLC allows transmission of DLS-user-data and preserves the data's division into DLSDUs:

— The transmission of this data may be subject to flow control, depending on the DLCEP class and data delivery features.

— The transmission and reception of this data may also be subject to timeliness assessments, which are combined with any previously-determined data timeliness to determine the overall timeliness of the DLS-user-data.

d) The DLC can be returned to a defined state, and the activities of either or both of the two DLS-users synchronized, by use of a Reset Service.

e) Failure to provide the requested service may be signaled to the DLS-user. There are three classes of failure:

1) failures involving termination of the DLC;

2) failures involving duplication, loss, or disordering of user data, as permitted by the DLC's QoS, but without loss of the DLC; and

NOTE — This includes resetting of the DLC.

3) failures to provide the requested QoS, but without loss of user data or loss of the DLC.

16.2 Constraints on sequence of primitives

This subclause defines the constraints on the sequence in which the primitives defined in clauses 17 through 19 may occur. The constraints determine the order in which primitives occur, but do not fully specify when they may occur. Other constraints, such as flow control of data, will affect the ability of a DLS-user or a DLS-provider to issue a primitive at any particular time.

The connection-mode primitives and their parameters are summarized in Tables 11 and 12.

Table 11 — Summary of DL-connection-mode primitives and parameters (part 1)

Phase	Service	Primitive	Parameter
DLC / DLCEP ESTABLISHMENT	DLC / DLCEP Establishment	DL-CONNECT request	(*in* DLCEP DLS-user-identifier, Called DL(SAP)-address (2) or Called DLCEP-address or UNKNOWN, Calling DLSAP-address DL-identifier or Calling DLCEP DL-identifier, optional Calling DLCEP-address, QoS parameter set, limited DLS-user-data, *out* DLCEP DL-identifier)
		DL-CONNECT indication	(*out* DLCEP DL-identifier, Called DL(SAP)-address DLS-user-identifier, Calling DLSAP-address, (2) QoS parameter set, limited DLS-user-data)
		DL-CONNECT response	(*in* DLCEP DLS-user-identifier, DLCEP DL-identifier, Responding DL(SAP)-address DL-identifier or Responding DLCEP DL-identifier, optional Responding DLCEP-address, (2) QoS parameter set, limited DLS-user-data)
		DL-CONNECT confirm	(*out* DLCEP DLS-user-identifier, Responding DL(SAP)-address (2) or UNKNOWN, QoS parameter set, limited DLS-user-data)
		DL-CONNECTION-ESTABLISHED indication	(*out* DLCEP DLS-user-identifier)
DLC / DLCEP RELEASE	DLC / DLCEP Release	DL-DISCONNECT request	(*in* DLCEP DL-identifier, Reason, limited DLS-user-data)
		DL-DISCONNECT indication	(*out* DLCEP-identifier-type, DLCEP DLS-user-identifier, DLCEP DL-identifier, Originator, Reason, limited DLS-user-data)

NOTES

1. DL-identifiers in parameters are local and assigned by the DLS-provider and used by the DLS-user to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue to the DLS-provider at the DLS interface. DLS-user-identifiers in parameters are local and assigned by the DLS-user and used by the DLS-provider to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue to the DLS-user at the DLS interface.
2. If the DLS-user has issued a DL-BIND request for a DL(SAP)-address, then a parameter referencing that DL(SAP)-address can also take the form of a DL(SAP)-address DL-identifier.

Table 12 — Summary of DL-connection-mode primitives and parameters (part 2)

Phase (cont.)	**Service**	**Primitive**	**Parameter**
DATA TRANSFER	Normal Data Transfer	DL-DATA request	(*in* Request DLS-user-identifier, DLCEP DL-identifier, DLS-user-data)
		DL-DATA indication	(*out* DLCEP DLS-user-identifier, Queue DLS-user-identifier, DLS-user-data)
		DL-DATA confirm	(*out* Request DLS-user-identifier, Status)
		DL-BUFFER-SENT indication	(*out* DLCEP DLS-user-identifier, Buffer DLS-user-identifier)
		DL-BUFFER-RECEIVED indication	(*out* DLCEP DLS-user-identifier, Buffer DLS-user-identifier, Duplicated DLSDU)
	DLC / DLCEP Reset / Resynchronize	DL-RESET request	(*in* DLCEP DL-identifier, Reason, limited DLS-user-data)
		DL-RESET indication	(*out* DLCEP DLS-user-identifier, Originator, Reason, limited DLS-user-data)
		DL-RESET response	(*in* DLCEP DL-identifier, limited DLS-user-data)
		DL-RESET confirm	(*out* DLCEP DLS-user-identifier, limited DLS-user-data, Status)
		DL-RESET-COMPLETED indication	(*out* DLCEP DLS-user-identifier)
	Subscriber Query	DL-SUBSCRIBER-QUERY request	(*in* DLCEP DL-identifier)
		DL-SUBSCRIBER-QUERY confirm	(*out* DLCEP DLS-user-identifier, Status)

NOTE — DL-identifiers in parameters are local and assigned by the DLS-provider and used by the DLS-user to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue to the DLS-provider at the DLS interface. DLS-user-identifiers in parameters are local and assigned by the DLS-user and used by the DLS-provider to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue to the DLS-user at the DLS interface.

16.2.1 Relation of primitives at the two DLC end-points

With few exceptions, a primitive issued at one DLCEP will have consequences at another DLCEP. The relations of primitives at one DLCEP to primitives at another DLCEP of the same DLC are defined in the appropriate subclause in clauses 17 through 19 and are summarized in the diagrams of Figures 10 through 15.

However, a DL-DISCONNECT request or indication primitive may terminate any of the other sequences before completion. A DL-RESET request or indication primitive may terminate a data transfer sequence before completion.

16.2.2 Sequence of primitives at one DLC end-point

The possible overall sequences of primitives at a DLCEP are defined in the state transition diagram, Figure 16. In the diagram:

a) DL-Disconnect stands for either the request or the indication form of the primitive in all cases.

b) The labeling of the states “local DLS-user initiated reset pending” (6) and “other reset pending” (7) indicate the party that started the local interaction and does not necessarily reflect the value of the originator parameter.

c) The “idle state” (1) reflects the absence of a DLCEP. It is the initial and final state of any sequence, and once it has been re-entered the DLCEP is released.

d) The use of a state transition diagram to describe the allowable sequences of service primitives does not impose any requirements or constraints on the internal organization of any implementation of the service.

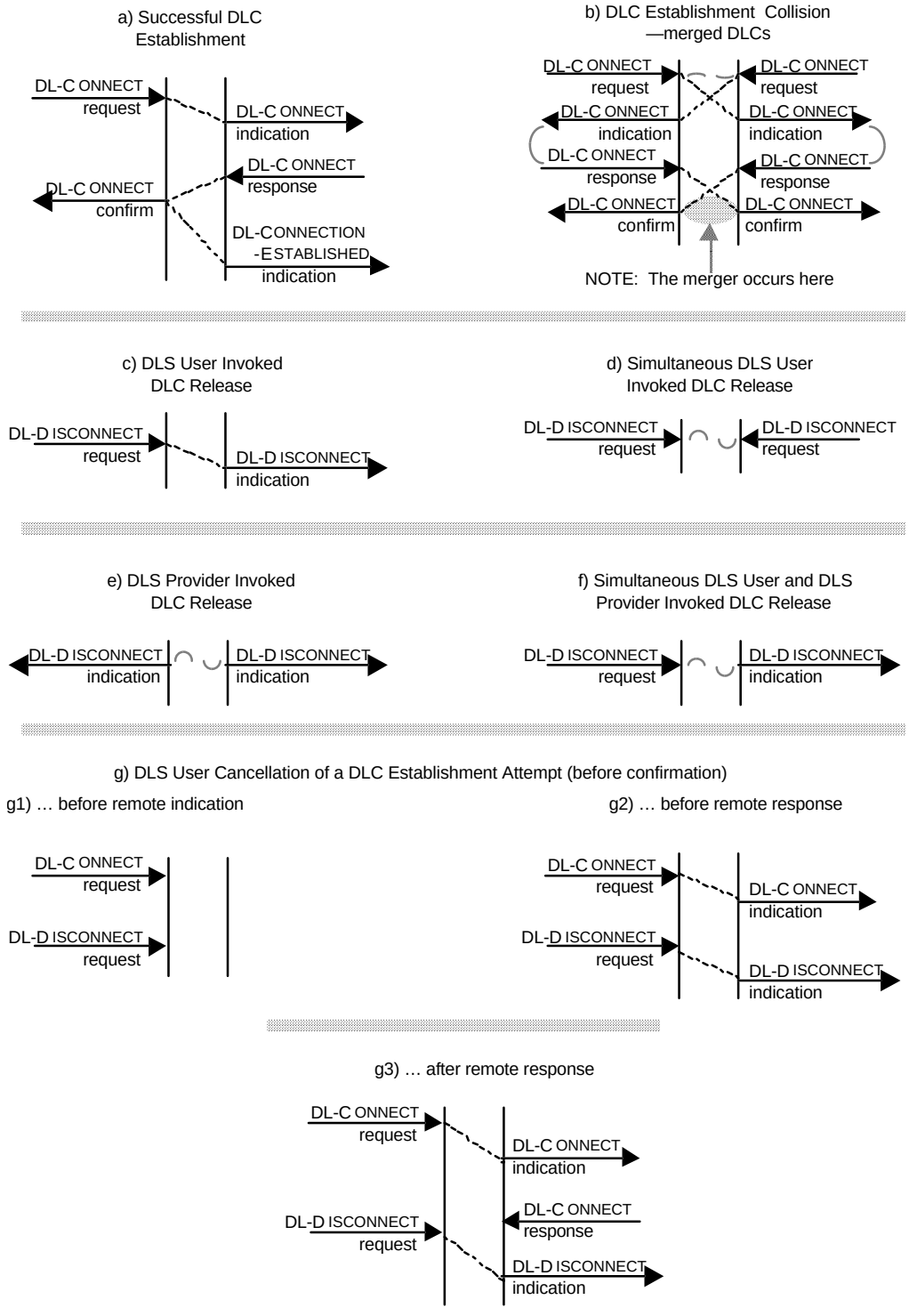


Figure 10 — Summary of DL-connection-mode service primitive time-sequence diagrams for Peer DLCs (part 1)

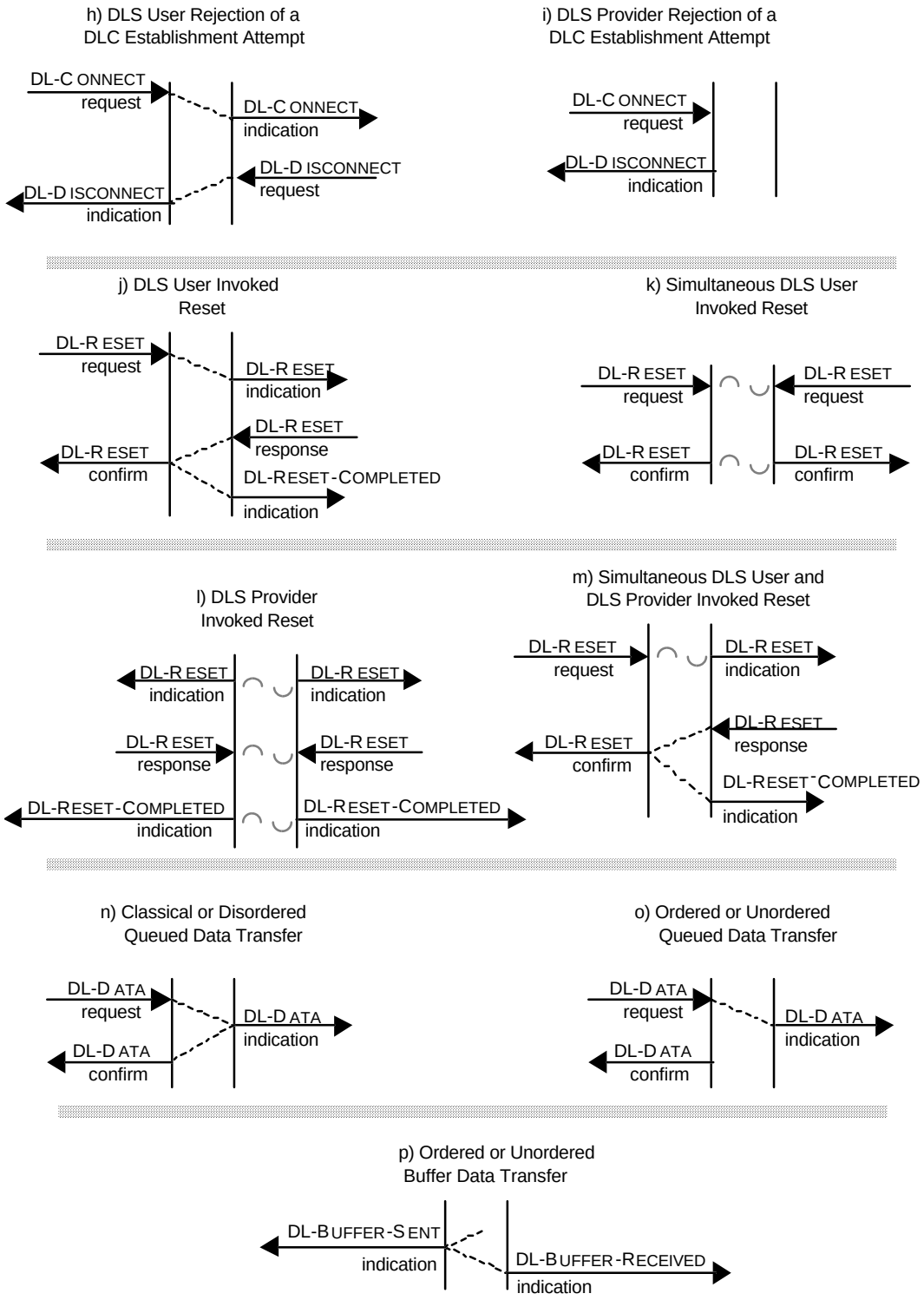


Figure 11 — Summary of DL-connection-mode service primitive time-sequence diagrams for Peer DLCs (part 2)

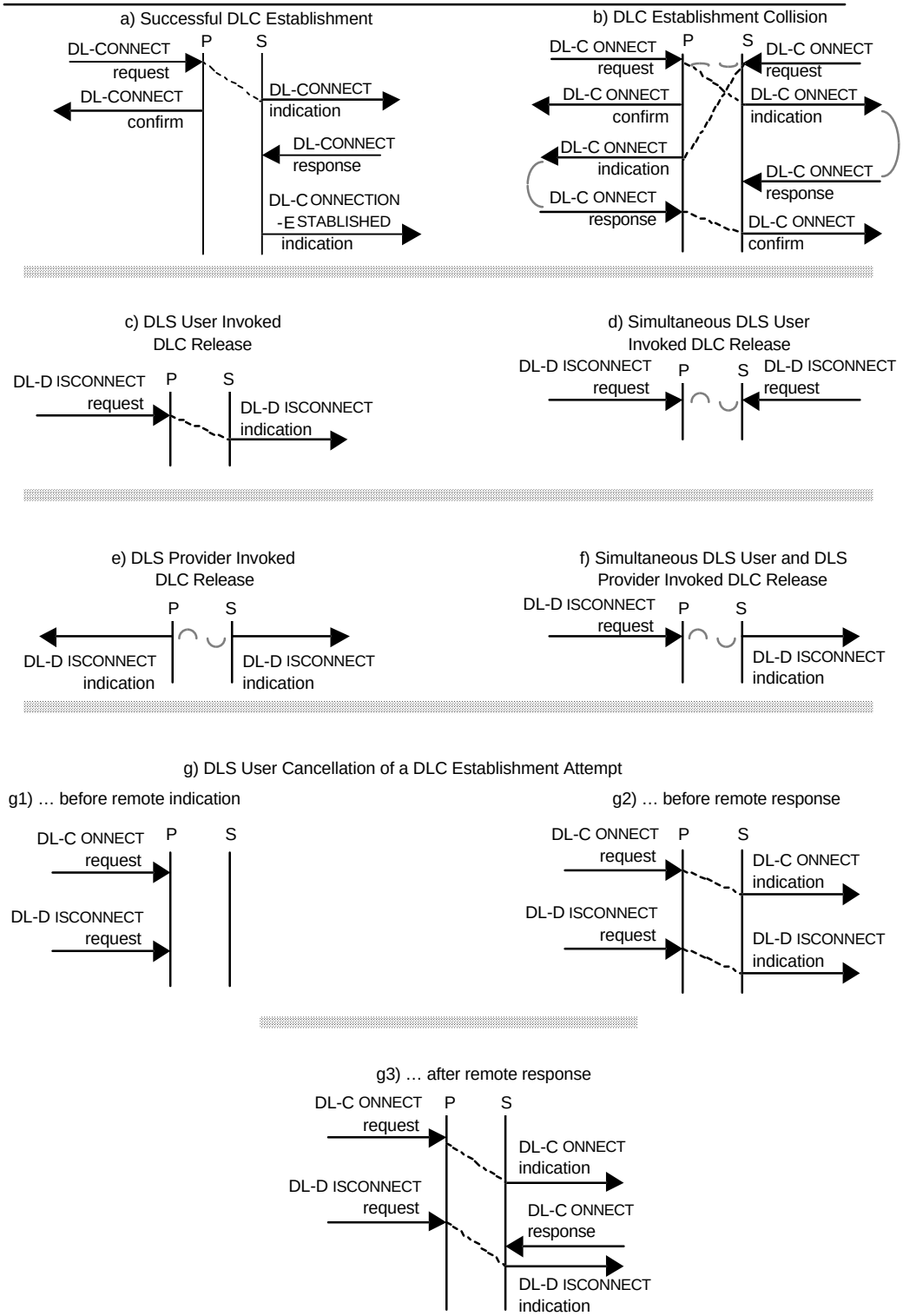


Figure 12 — Summary of DL-connection-mode service primitive time-sequence diagrams for publishers of a multi-peer DLC (part 1)

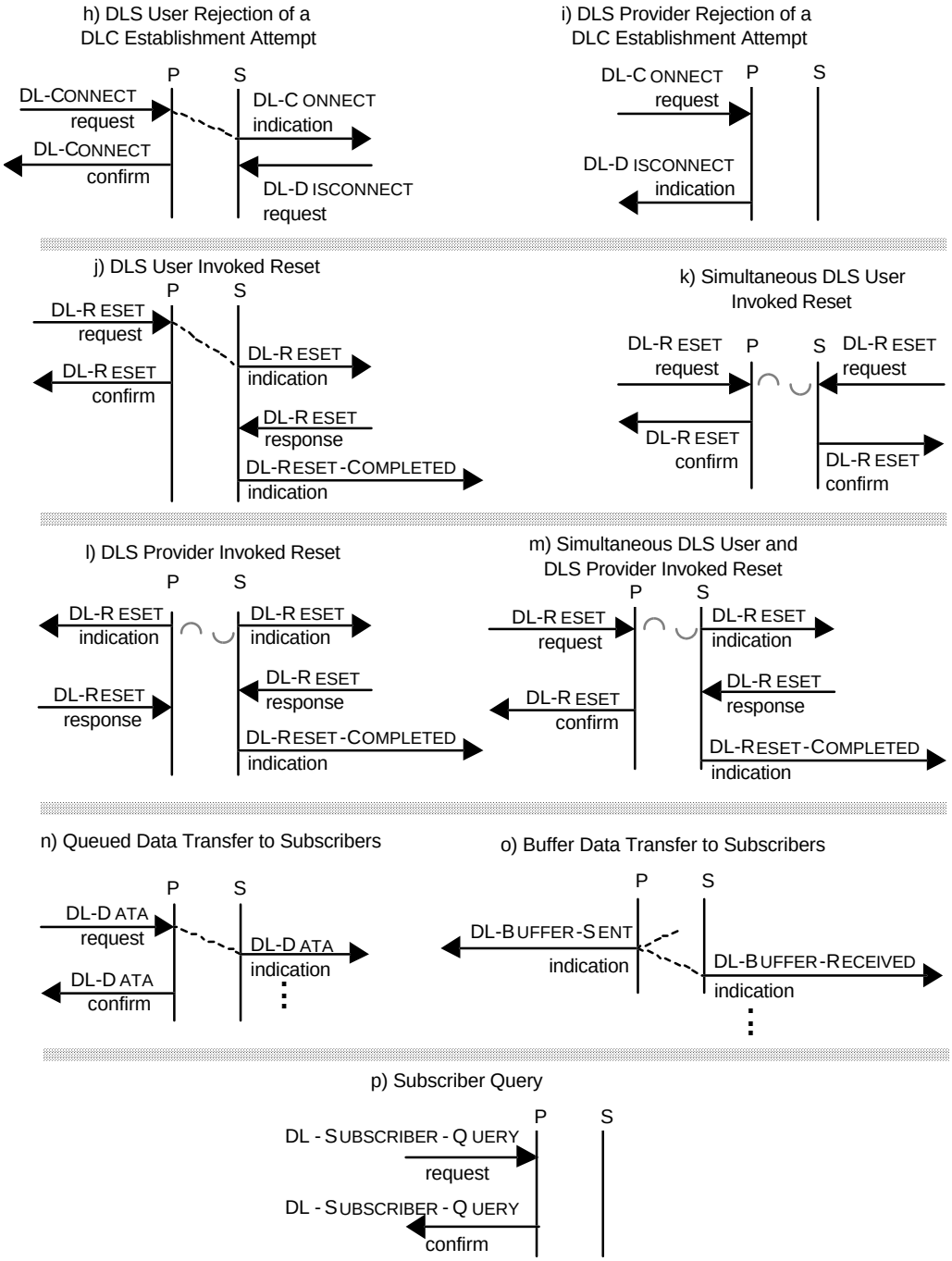


Figure 13 — Summary of DL-connection-mode service primitive time-sequence diagrams for publishers of a multi-peer DLC (part 2)

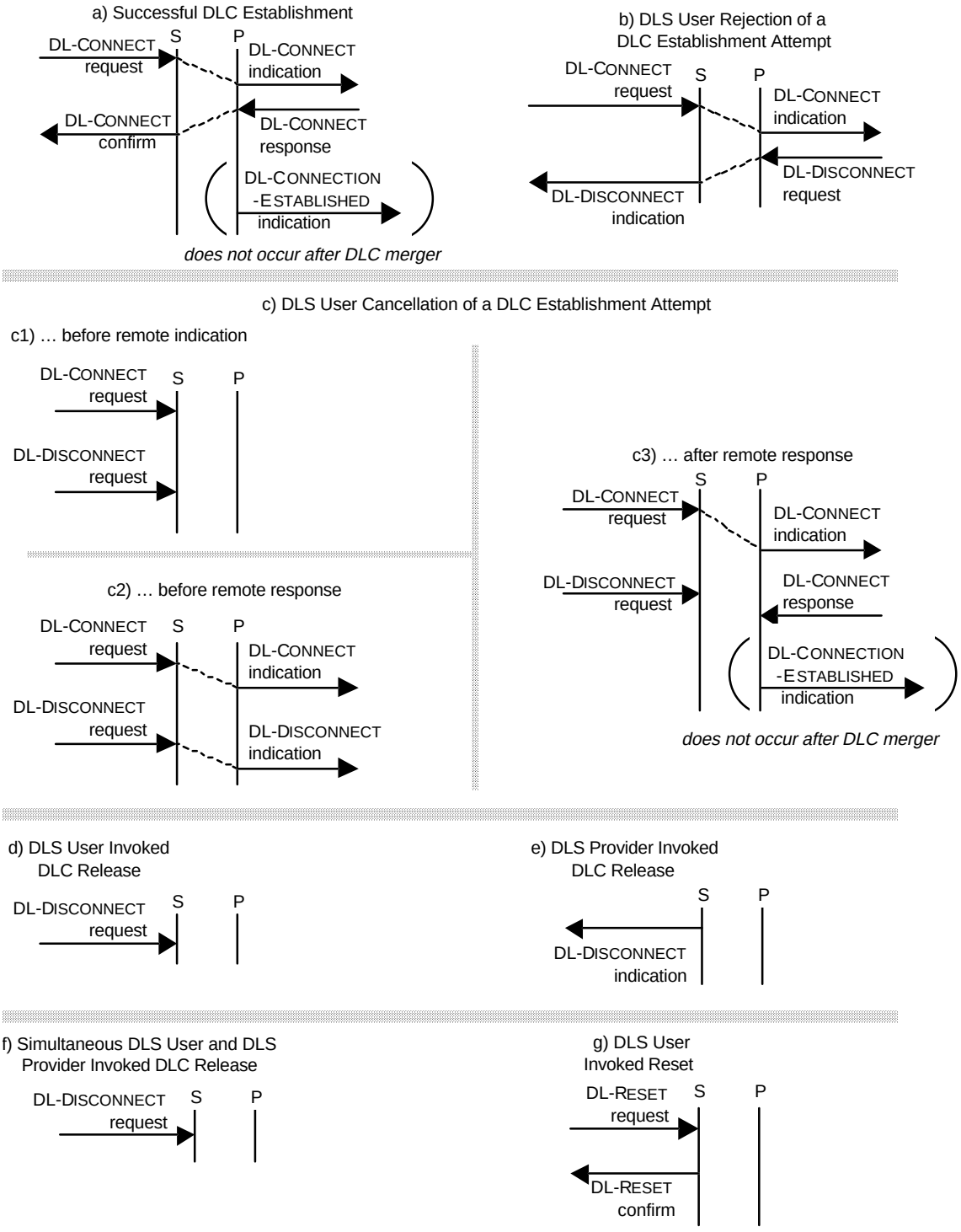


Figure 14 — Summary of additional DL-connection-mode service primitive time-sequence diagrams for a multi-peer DLC subscriber where the diagrams differ from the corresponding ones for a publisher (part 1)

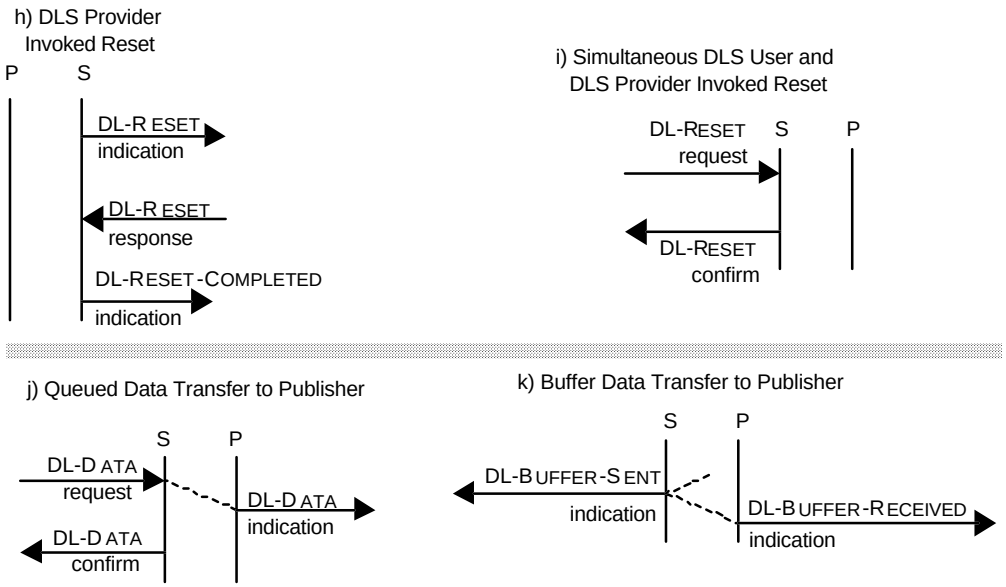


Figure 15 — Summary of additional DL-connection-mode service primitive time-sequence diagrams for a multi-peer DLC subscriber where the diagrams differ from the corresponding ones for a publisher (part 2)

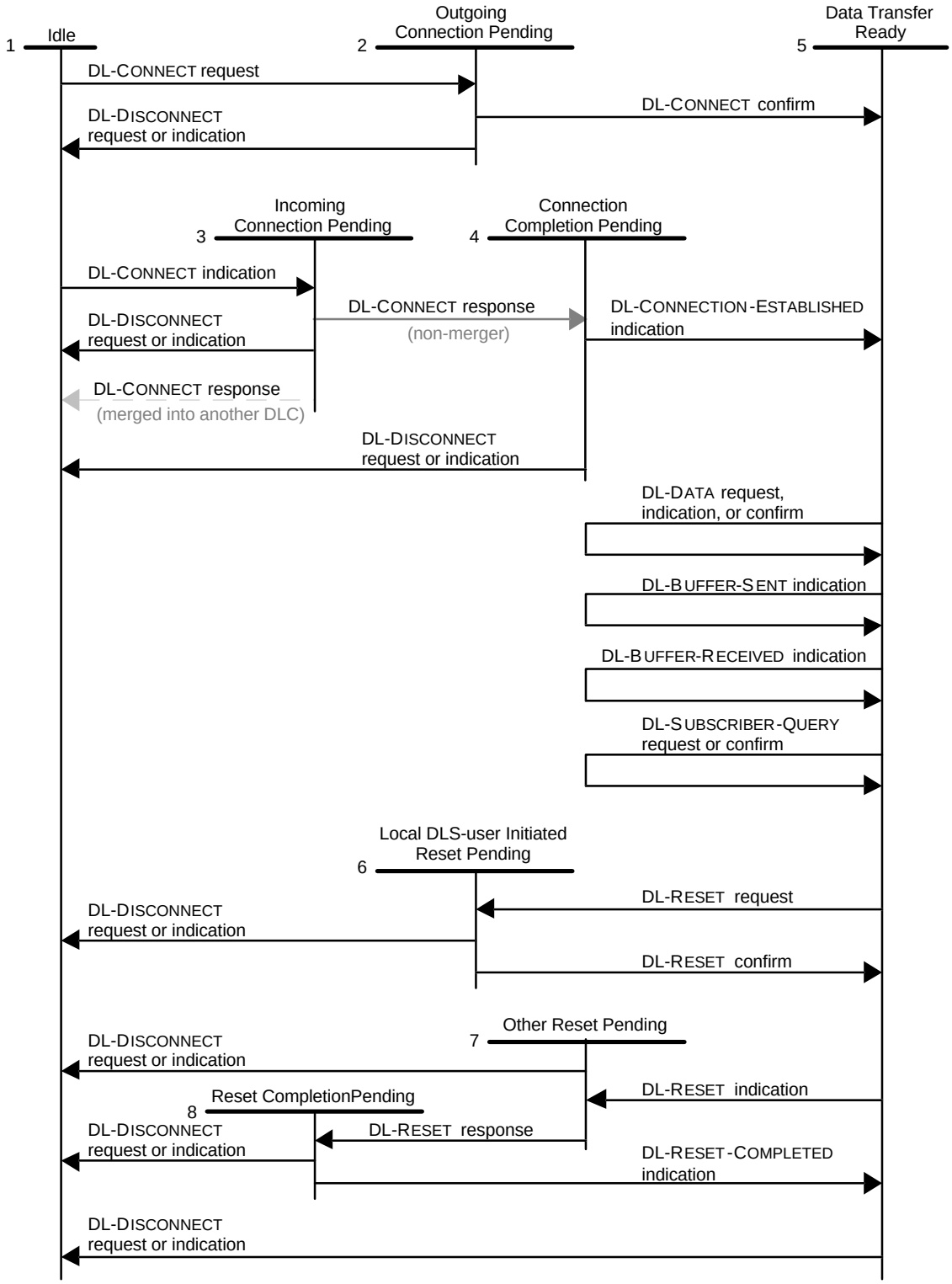


Figure 16 — State transition diagram for sequences of DL-connection-mode service primitives at a DLCEP

17 Connection establishment phase

17.1 Function

The DLC / DLCEP establishment service primitives can be used to establish a DLCEP, and possibly a DLC.

NOTE — This function may also be provided by local DL-management actions, which are beyond the scope of this standard.

Simultaneous DL-CONNECT request primitives at the two DLSAPs may be merged into one DLC by the concurrently requesting-and-responding DLS-users as indicated in Figures 22 and 23.

17.2 Types of primitives and parameters

Tables 13 and 14 indicate the types of primitives and the parameters needed for DLC/DLCEP establishment.

17.2.1 Local-view identifiers

17.2.1.1 DLCEP DLS-user-identifier

The DLCEP DLS-user-identifier parameter specifies a means of referring to the DLCEP in output parameters of other local DLS primitives that convey the name of the DLCEP from the local DLE to the local DLS-user. It is specified by the DLS-user on DL-CONNECT request and response primitives and is used by the DLE to refer to the DLC-end-point in DLS output parameters of other DLC primitives.

The naming-domain of the DLCEP DLS-user-identifier is the DLS-user's local-view.

17.2.1.2 DLCEP DL-identifier

The DLCEP DL-identifier parameter, which is returned by the DLS-user on DL-CONNECT response primitives, and which is returned by the DLS-provider on DL-CONNECT request and indication primitives, provides a local means of identifying a specific DLC-end-point in input parameters of other local DLS primitives that convey the name of the DLC-end-point from the local DLS-user to the local DLE.

The naming-domain of the DLCEP DL-identifier is the DL-local-view.

17.2.2 Addresses

The parameters that take addresses as values refer to either DL(SAP)-addresses or DLCEP-addresses. A DLCEP-address, which is used within a DL-protocol to identify a DLCEP, is structurally similar to a DLSAP-address and is drawn from the same overall address space.

Table 13 — DLC / DLCEP establishment primitives and parameters (part 1)

DL-CONNECT	**Request**		**Indication**	**Response**	**Confirm**
Parameter Name	input	output	output	input	output
DLCEP DLS-user-identifier	M			M	M (1)
DLCEP DL-identifier		M	M	M (=)	
Called address	M		M (=)		
Calling address	M		M (=)		
Responding address				M	M (=)
Calling DLCEP-address	U			U	
QoS parameter set					
DLCEP class	U		M (=)	U (2)	M (=)
DLCEP data delivery features					
from requester to responder(s)	U		M (=, 3)	U (=, 3)	M (=)
from responder(s) to requester	U		M (=, 3)	U (=, 3)	M (=)
DLL priority	U		M (=)	U (≤)	M (=)
Maximum confirm delay					
on DL-CONNECT, DL-RESET, and DL-SUBSCRIBER-QUERY	U		M (=)	U	M (=)
on DL-DATA	U		M (=)	U	M (=)
DLPDU-authentication	U		M (≥)	U	M (≥)
Residual activity					
as sender	U		M (=)	U (≤)	M (=)
as receiver	U		M (=)	U (≤)	M (=)
DL-scheduling-policy	U			U	
Maximum DLSDU sizes					
from requester	CU		M (≤)	CU (≤)	M (=)
from responder	CU		M (≤)	CU (≤)	M (=)
Buffer-and-queue bindings					
as sender	CU			CU	
as receiver	CU			CU	
Sender timeliness					
DL-timeliness-class	CU		M (=)	CU	M (=)
Time window size (ΔT)	CU			CU	
Synchronizing DLCEP	CU			CU	
Time-of-production	CU		C(=)	CU	C (=)
Receiver timeliness					
DL-timeliness-class	CU		M (=)	CU	M (=)
Time window size (ΔT)	CU			CU	
Synchronizing DLCEP	CU			CU	
DLS-user-data	U		M (=)	U	M (=)

NOTES

1.The DLCEP DLS-user-identifier on the confirm primitive shall equal the DLS-user-identifier specified in the corresponding DL-CONNECT request primitive.

2.The DLCEP classes shall match Peer with Peer and Publisher with Subscriber.

3.The DLCEP data delivery feature UNORDERED may be upgraded to ORDERED, and DISORDERED may be upgraded to CLASSICAL.

Table 14 — DLC / DLCEP establishment primitives and parameters (part 2)

DL-CONNECTION-ESTABLISHED	Indication
Parameter Name	output
DLCEP DLS-user-identifier	M (1)
NOTE — The DLCEP DLS-user-identifier shall equal the DLS-user-identifier specified in the corresponding DL-CONNECT response primitive.	

17.2.2.1 Called address

The called address parameter conveys an address identifying the remote DLSAP(s) at which the DLC is to be established. It shall be either:

a) a DLSAP-address;

b) a group DL-address;

NOTE — If the called address for a peer or subscriber DLC is a group DL-address, then the DLC will be established with the DLSAP whose response is first received, and the others will be disconnected when and if they respond.

c) a DLCEP-address; or

NOTE — Direct knowledge of a DLCEP-address can be obtained only through extra-protocol means. The ability to specify such an address supports migration from previous national standards and facilitates the use of simple pre-configured devices within open systems.

d) the value unknown.

For (a) through (c), where the called address is known, it takes the form of:

1) a DL-address in the request primitive; and

NOTES

1. If the Called Address is a DL(SAP)-address and the requesting DLS-user has issued a DL-BIND request for the Called Address, then this parameter also can take the form of a DL-identifier in the request primitive.

2. In some cases such a DL-CONNECT request may not result in corresponding DL-CONNECT indication(s) and response(s).

2) a local DLS-user-identifier for a DL(SAP)-address in the indication primitive.

For (d), when the requesting DLS-user is attempting to establish:

i) a peer DLCEP, and the DLS-user has learned the calling-DLCEP-address assigned to the requested DLCEP by extra-protocol means, and the remote peer DLS-user is specifying a DLCEP-address as the called address in its attempts to establish a DLC; or

ii) a publishing DLCEP, and both the publishing and subscribing DLS-users have learned the DLCEP-address assigned to the DLC by extra-protocol means;

then the requesting DLS-user may specify in this parameter the value UNKNOWN, rather than a DL(SAP)-address. In such a case, when the calling address is not itself a DLCEP DL-identifier, then it shall also specify the calling DLCEP-address as described in 17.2.2.4.

17.2.2.2 Calling address

a) The calling address parameter conveys an address of the local DLSAP from which the DLC has been requested. This parameter is a DLSAP-address in the indication primitive; except as in (b), it takes the form of a local DLSAP-address DL-identifier in the request primitive.

NOTE — If the receiving DLS-user has issued a DL-BIND request for the Calling Address, then this parameter also can take the form of a DLSAP-address DLS-user-identifier in the indication primitive.

b) When the requesting DLS-user is the publisher of an existing multi-peer DLC and wishes to use the request to solicit or add new subscribers to that DLC, then the requesting DLS-user shall specify in this parameter the DLCEP DL-identifier returned by the earlier DL-CONNECT request or indication primitive that was used to establish that multi-peer DLC, rather than a DLSAP-address DL-identifier.

NOTE — The QoS parameters of the new DL-CONNECT request primitive should be compatible with those of the already-existing multi-peer DLC.

17.2.2.3 Responding address

The responding address parameter normally conveys a DLSAP-address of the DLSAP with which the DLC has been established. In the response primitive, this parameter takes the form of a local DLSAP-address DL-identifier; in the confirm primitive, this parameter is either a DLSAP-address or the value **UNKNOWN**.

NOTES

1. The value UNKNOWN occurs when establishing a multi-peer PUBLISHER DLC.

2. If the receiving DLS-user has issued a DL-BIND request for the Responding Address, then this parameter also can take the form of a DLSAP-address DLS-user-identifier in the confirm primitive.

When:

a) the responding DLS-user is the publisher of an existing multi-peer DLC and wishes to join the requesting DLS-user to that DLC as a new subscriber; or

b) the responding DLS-user detects a DL-Connect request collision and wishes to merge requested and indicated DLCs,

then the responding DLS-user shall specify in this parameter the DLCEP DL-identifier returned by the earlier DL-CONNECT request or indication primitive used to establish that DLC, rather than a DLSAP-address DL-identifier. The DLS-provider interprets this response as an attempt to merge the newly-indicated DLC into the existing DLC, after which the newly-indicated DLCEP no longer exists.

NOTES

3. The QoS parameters of the new DL-CONNECT response primitive should be compatible with those of the already-existing DLC.

4. The DLCEP-identifier for the newly-indicated DLCEP is no longer valid.

5. No other primitives can or will be issued at that DLCEP.

17.2.2.4 Calling DLCEP-address

The optional Calling DLCEP-address parameter conveys a specific DLCEP-address (structurally similar to a DLSAP-address and drawn from the same overall address space) for use as the local DLCEP-address for the DLC. This parameter is absent when the specified calling address in the request primitive, or the responding address in the response primitive, is a DLCEP DL-identifier.

When this parameter is both permitted and absent, and when the DLCEP requires a local DLCEP-address, then the DLE chooses a DLCEP-address from those available to it and assigns the DLCEP-address to the DLC.

17.2.3 Quality of Service parameter set

The QoS parameter consists of a list of sub-parameters. For all parameters common to request and indication primitives, or to response and confirm primitives, the values on the primitives are related so that:

a) on the request primitive, any defined value is allowed, provided that the specified value is consistent with the values of the other parameters of the same invocation of the request primitive;

b) on the response primitive, any defined value is allowed, subject to the constraints specified in the following paragraphs; and

c) on the indication (or confirm) primitive, the quality of service indicated may differ from the value specified for the corresponding request (or response) primitive as indicated in Table 13.

In general the negotiation rules result in choosing the lesser of two offered levels of functionality. DLS-users that find the resulting QoS to be unacceptable should respond by issuing a DL-DISCONNECT request and specifying as a reason the unacceptability of the negotiated QoS.

17.2.3.1 DLCEP class

If the value specified in the DL-CONNECT indication is PEER, the response shall be PEER. If the value specified in the DL-CONNECT indication is PUBLISHER, then the response shall be SUBSCRIBER. If the value specified in the DL-CONNECT indication is SUBSCRIBER, then the response shall be PUBLISHER.

17.2.3.2 DLCEP data delivery features

The specified values (from-requester-to-responder(s) and from-responder(s)-to-requester) shall be returned in the DL-CONNECT response, except that the value UNORDERED may be upgraded to ORDERED and the value DISORDERED may be upgraded to CLASSICAL.

17.2.3.3 DLL priority

Any defined priority lower than or equal to that specified in the corresponding indication is allowed for the response. Thus the value URGENT may be downgraded to NORMAL or TIME-AVAILABLE, and NORMAL may be downgraded to TIME-AVAILABLE.

17.2.3.4 DLL maximum confirm delay

17.2.3.5 DLPDU-authentication

17.2.3.6 Residual activity

17.2.3.7 DL-scheduling-policy

17.2.3.8 Maximum DLSDU sizes

Any defined value less than or equal to that specified in the corresponding indication is allowed for the response. The DLS-provider may reduce the sizes specified by the requesting DLS-user to meet DLSDU size limits set by local DLS management.

17.2.3.9 DLCEP buffer and queue bindings

The DLS-provider shall reject any attempt to establish a DLC between a sending queue and a receiving buffer. All other possible combinations are permitted.

17.2.3.10 Timeliness

17.2.4 DLS-user-data

The user-data parameter allows the transmission of DLS-user-data between DLS-users, without modification by the DLS-provider. The DLS-user may transmit any integral number of octets up to the limit for DLPDUs of NORMAL priority.

NOTE — The number of octets of DLS-user-data permitted is limited to that available for DLPDUs of NORMAL priority, even though DLC initiation DLPDUs are conveyed at TIME-AVAILABLE priority, to ensure that the maximum size of such DLPDUs, including all DLC parameters needed for negotiation, is not larger than the largest DLPDU used in the data transfer service.

17.3 Sequence of primitives

The sequence of primitives in a successful DLC/DLCEP establishment is defined by the time-sequence diagram in Figures 17 through 23. These DLC/DLCEP establishment procedures may fail either:

a) due to the inability of the DLS-provider to establish a DLCEP and possibly a DLC; or

b) due to the unwillingness of the called DLS-user to accept a DL-Connect indication primitive.

NOTE — For these cases, see the DLC/DLCEP release service (see 18.4).

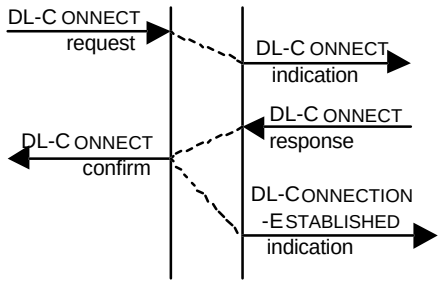


Figure 17 — Peer DLC/DLCEP establishment initiated by a single DLS-user

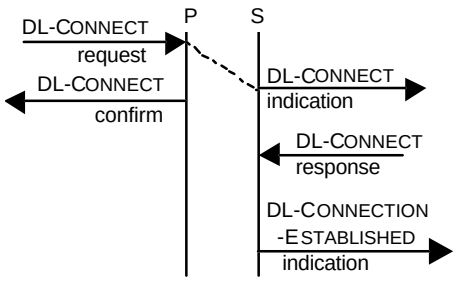


Figure 18 — Multi-peer DLC/DLCEP establishment initiated by the Publishing DLS-user

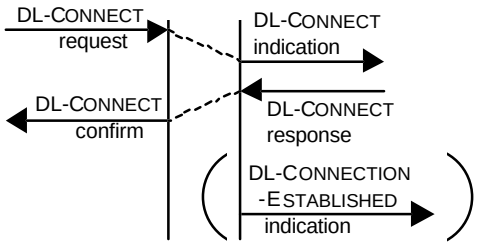


Figure 19 — Multi-peer DLC/DLCEP establishment initiated by a Subscribing DLS-user

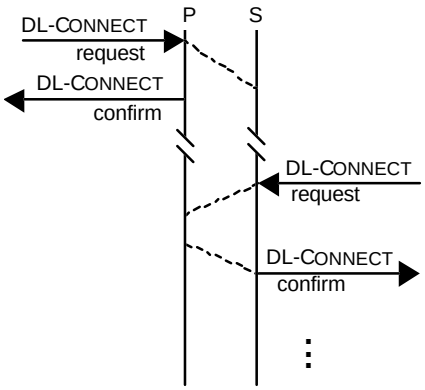


Figure 20 — Multi-peer DLC/DLCEP establishment using known DLCEP addresses initiated first by the Publishing DLS-user

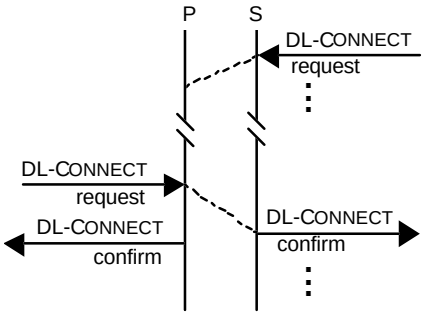


Figure 21 — Multi-peer DLC/DLCEP establishment using known DLCEP addresses initiated first by one or more Subscribing DLS-users

17.3.1 DLC establishment collision

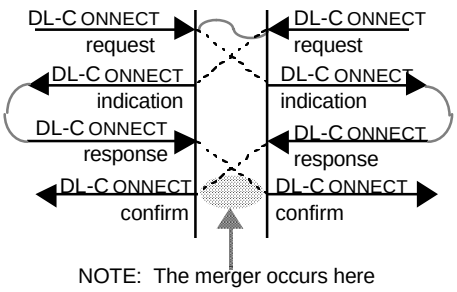


Figure 22 — Peer DLC/DLCEP establishment initiated simultaneously by both Peer DLS-users, resulting in a merged DLC

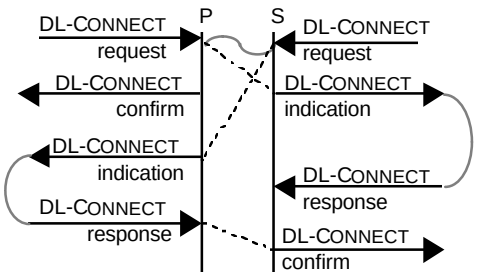


Figure 23 — Multi-peer DLC/DLCEP establishment initiated simultaneously by both Publishing and Subscribing DLS-users, resulting in a merged DLC

18 Connection release phase

18.1 Function

The DLC / DLCEP release service primitives are used to release a DLCEP and possibly a DLC. The release may be initiated by any of the following:

a) either or both of the DLS-users, to release an established DLCEP;

b) the DLS-provider, to release an established DLCEP (all failures to maintain a DLC at a DLCEP are indicated in this way);

c) the DLS-user, to reject a DL-Connect indication;

d) the DLS-provider, to indicate its inability to establish a requested DLC / DLCEP; or

e) the DLS-user that issued the DL-Connect request, to abandon the DLC / DLCEP establishment attempt before the DLCEP has been made available for use by receipt of a DL-CONNECT confirm primitive.

Initiation of the release service element is permitted at any time regardless of the current phase of the DLCEP. Once a release service has been initiated, the DLCEP will be disconnected and any associated buffers or queues shall be unbound from the DLCEP.

A DL-DISCONNECT request cannot be rejected. The DLS does not guarantee delivery of any DLSDU associated with the DLC once the release phase is entered. Nevertheless, the release service may convey a limited amount of user data from a releasing peer (or publisher) to a peer (or subscriber), provided that neither that peer (or subscriber) nor the DLS-provider has concurrently invoked the release service.

NOTES

1. These primitives can only be used to release a DLCEP that was established by a prior DL-CONNECT primitive; they cannot be used to release a DLCEP that was established by prior local DL-management actions.

2. This function may also be provided by local DL-management actions, which are beyond the scope of this standard.

18.2 Types of primitives and parameters

Table 15 indicates the types of primitives and the parameters needed for DLC/DLCEP release.

18.2.1 DLCEP-identifier-type

The DLCEP-identifier-type parameter indicates whether the associated DLCEP identifier is:

a) a DLS-user-identifier that was provided by the DLS-user as a parameter of the associated prior DL-Connect request or response primitive; or

b) a DL-identifier that was provided to the DLS-user as a parameter of the immediately-prior DL-Connect indication primitive.

The latter case (b) shall occur only when the DLS-provider must disconnect the DLCEP after issuing a DL-CONNECT indication primitive and before receiving a corresponding DL-CONNECT response or DL-DISCONNECT request primitive from the local DLS-user.

Table 15 — DLC / DLCEP release primitives and parameters

DL-DISCONNECT	**Request**	**Indication**
Parameter Name	input	output
DLCEP-identifier-type		M
DLCEP DLS-user-identifier		C
DLCEP DL-identifier	M	C
Originator		M
Reason	U	M (=)
DLS-user-data	U	M (=)

18.2.2 DLCEP DLS-user-identifier

The DLCEP DLS-user-identifier parameter has the same value as the DLCEP DLS-user-identifier parameter provided with the DL-CONNECT request or response primitive that occurred during DLCEP initiation. It is present on the DL-DISCONNECT indication primitive except when disconnection occurs after issuing a DL-CONNECT indication primitive and before receiving a corresponding DL-CONNECT response or DL-DISCONNECT request primitive.

18.2.3 DLCEP DL-identifier

The DLCEP DL-identifier parameter has the same value as the DLCEP DL-identifier parameter returned by the DL-CONNECT request or indication primitive that initiated the DLCEP. It is always present on the DL-DISCONNECT request primitive and is present on the DL-DISCONNECT indication primitive only when disconnection occurs after issuing a DL-CONNECT indication primitive and before receiving a corresponding DL-CONNECT response or DL-DISCONNECT request primitive.

18.2.4 Originator

The originator parameter identifies the source of the release. Its value indicates either the remote DLS-user, the remote DLS-provider, the local DLS-provider, or that the originator is unknown.

18.2.5 Reason

The reason parameter gives information about the cause of the release. The value conveyed in this parameter will be as follows:

a) When the originator parameter indicates a DLS-provider-generated release, the value is one of:

1) “disconnection — permanent condition”;

2) “disconnection — transient condition”;

3) “disconnection after timeout”;

4) “connection rejection — calling DLSAP DL-identifier is invalid”;

5) “connection rejection — DL(SAP)-address unknown”;

6) “connection rejection — DLSAP unreachable, permanent condition”;

7) “connection rejection — DLSAP unreachable, transient condition”;

8) “connection rejection — QoS not available, permanent condition”;

9) “connection rejection — QoS not available, transient condition”;

10) “connection rejection — QoS not available, transient condition”;

11) “connection rejection after timeout”; or

12) “reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

b) When the originator parameter indicates a DLS-user-initiated release, the value is one of:

1) “disconnection — normal condition”;

2) “disconnection — abnormal condition”;

3) “disconnection — terminated by unbind of source DLSAP-address”;

4) “connection rejection — unacceptable QoS, permanent condition”;

5) “connection rejection — non-QoS reason, permanent condition”;

6) “connection rejection — transient condition”; or

7) “reason unspecified”.

c) When the originator parameter indicates an unknown originator, the value of the Reason parameter is “reason unspecified”. This allows parameters to be implied when they cannot be explicitly conveyed in a DL-protocol.

18.2.6 DLS-user-data

The user-data parameter allows the transmission of DLS-user-data between DLS-users, without modification by the DLS-provider. The DLS-user may transmit any integral number of octets up to the limit for DLPDUs of NORMAL priority. Delivery of this data to the remote DLS-user(s) is not assured.

NOTES

1. The number of octets of DLS-user-data permitted is limited to that available for DLPDUs of NORMAL priority, even though DLC termination DLPDUs are conveyed at TIME-AVAILABLE priority, to provide uniformity with the DLS-user-data permitted in the DL-CONNECT service.

2. The delivery of this data is assured only for the case specified in 18.3(a).

18.3 Sequence of primitives when releasing an established DLC/DLCEP

The sequence of primitives depends on the origins of the release action. The sequence may be:

a) initiated by one DLS-user, with a request from that DLS-user leading to an indication to the other;

b) initiated by both DLS-users, with a request from each of the DLS-users;

c) initiated by the DLS-provider, with an indication to each of the DLS-users; or

d) initiated independently by one DLS-user and the DLS-provider, with a request from the originating DLS-user and an indication to the other DLS-user.

In cases (b) and (d), any DLS-user data associated with a DLS-user-initiated request may not be delivered to the remote DLS-user(s).

The sequences of primitives in these four cases are defined by the time-sequence diagrams in Figures 24 through 33.

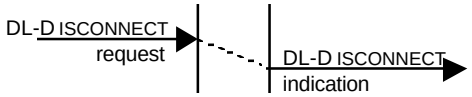


Figure 24 — Peer DLS-user invocation

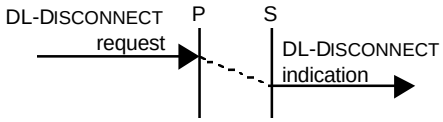


Figure 25 — Publishing DLS-user invocation

Figure 26 — Subscribing DLS-user invocation

Figure 27 — Simultaneous invocation by both DLS-users

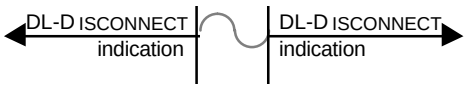


Figure 28 — Peer DLS-provider invocation

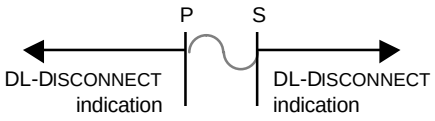


Figure 29 — Publishing DLS-provider invocation

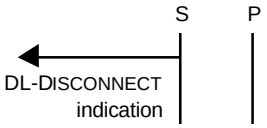


Figure 30 — Subscribing DLS-provider invocation

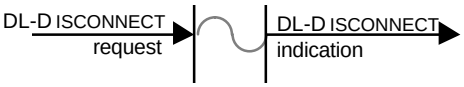


Figure 31 — Simultaneous Peer DLS-user and DLS-provider invocations

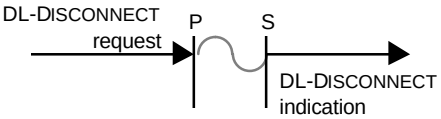


Figure 32 — Simultaneous Publishing DLS-user and DLS-provider invocations

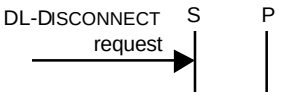


Figure 33 — Simultaneous Subscribing DLS-user and DLS-provider invocations

18.4 Sequence of primitives in a DLS-user rejection of a DLC / DLCEP establishment attempt

A DLS-user may reject a DLC/DLCEP establishment attempt by using a DL-DISCONNECT request. The originator parameter in the DL-DISCONNECT primitives will indicate DLS-user-initiated release. The sequence of events is defined in the time-sequence diagram in Figures 34 through 36.

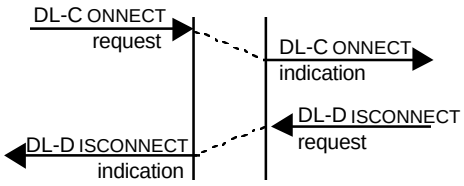


Figure 34 — Sequence of primitives in a Peer DLS-user rejection of a DLC/DLCEP establishment attempt

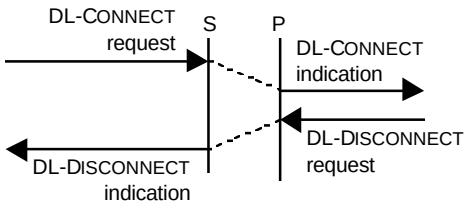


Figure 35 — Sequence of primitives in a Publishing DLS-user rejection of a DLC/DLCEP establishment attempt

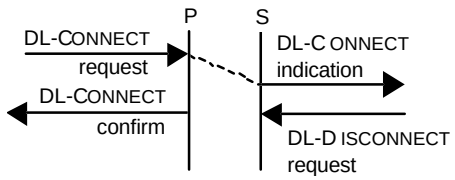


Figure 36 — Sequence of primitives in a Subscribing DLS-user rejection of a DLC/DLCEP establishment attempt

If the DLS-provider is unable to establish a DLC/DLCEP, it indicates this to the requester by a DL-DISCONNECT indication. The originator parameter in this primitive indicates a DLS-provider-originated release. The sequence of events is defined in the time-sequence diagram in Figure 37.

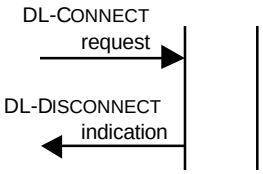


Figure 37 — Sequence of primitives in a DLS-provider rejection of a DLC/DLCEP establishment attempt

If the DLS-user, having previously sent a DL-CONNECT request and not having received a DL-CONNECT confirm or DL-DISCONNECT indication, wishes to abort the DLC/DLCEP establishment attempt, the DLS-user shall issue a DL-DISCONNECT request. The resulting sequence of primitives is dependent upon the relative timing of the primitives involved and the transit delay of the DLS-provider as defined by the time-sequence diagram in Figures 38 through 42. No information can be implied by detecting which of these alternatives occur.

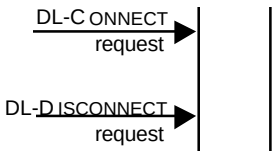


Figure 38 — Sequence of primitives in a DLS-user cancellation of a DLC/DLCEP establishment attempt: both primitives are destroyed in the queue

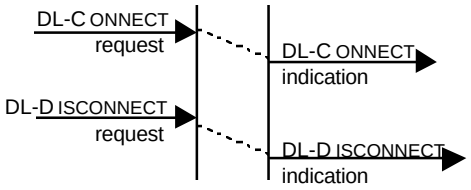


Figure 39 — Sequence of primitives in a DLS-user cancellation of a DLC/DLCEP establishment attempt: DL-DISCONNECT indication arrives before DL-CONNECT response is sent

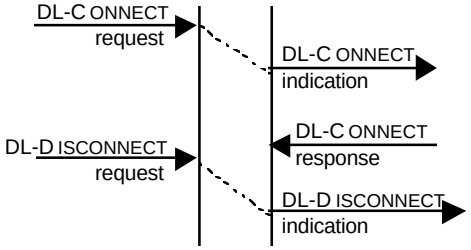


Figure 40 — Sequence of primitives in a DLS-user cancellation of a DLC/DLCEP establishment attempt: Peer DL-DISCONNECT indication arrives after DL-CONNECT response is sent

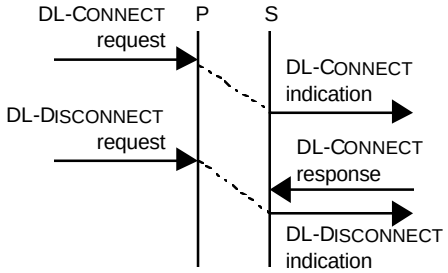


Figure 41 — Sequence of primitives in a DLS-user cancellation of a DLC/DLCEP establishment attempt: Publisher's DL-DISCONNECT indication arrives after DL-CONNECT response is sent

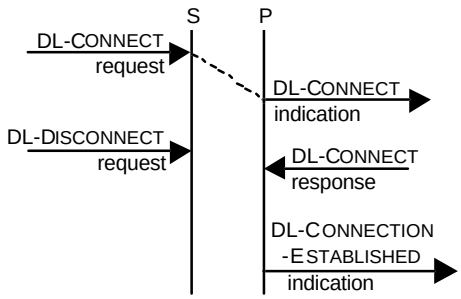


Figure 42 — Sequence of primitives in a DLS-user cancellation of a DLC/DLCEP establishment attempt: Subscriber's DL-DISCONNECT request arrives after DL-CONNECT request has been communicated to the Publisher

19 Data transfer phase

19.1 Queue data transfer

19.1.1 Function

The queue data transfer service primitives provide for conveyance of user data (DLSDUs) in either direction, or in both directions simultaneously, on a DLC. The DLS preserves the boundaries of the DLSDUs.

19.1.2 Types of primitives and parameters

Table 16 indicates the types of primitives and the parameters needed for queue data transfer.

Table 16 — Queue data transfer primitive and parameters

DL-DATA	**Request**	**Indication**	**Confirm**
Parameter Name	input	output	output
Request DLS-user-identifier	M		M (=)
DLCEP DL-identifier	M		
DLCEP DLS-user-identifier		M	
Queue DLS-user-identifier		C	
DLS-user-data	M	C (=)	
Status			M

19.1.2.1 Request DLS-user-identifier

The Request DLS-user-identifier parameter, specified by the DLS-user on DL-DATA request primitives, provides a local means of pairing the resulting DL-DATA confirm primitive with the causative DL-DATA request primitive.

19.1.2.2 DLCEP DL-identifier

The DLCEP DL-identifier parameter, specified in the DL-DATA request primitive, has the same value as the DLCEP DL-identifier parameter returned by the DL-CONNECT request or indication primitive that initiated the DLCEP.

19.1.2.3 DLCEP DLS-user-identifier

The DLCEP DLS-user-identifier parameter has the same value as the DLCEP DLS-user-identifier parameter returned by the DL-CONNECT confirm or DL-CONNECTION-ESTABLISHED indication primitive that occurred during initiation of the DLCEP at which the DLS-user-data was received.

19.1.2.4 Queue DLS-user-identifier

The queue DLS-user-identifier parameter has the same value as a queue DLS-user-identifier parameter from a prior DL-CREATE primitive (or as created by DL-management) and indicates the same queue as the one specified in the appropriate-direction buffer-or-queue-binding parameter (see 17.2.3.9) of the DL-CONNECT request or response primitive that initiated the DLCEP.

19.1.2.5 DLS-user-data

This parameter allows the transmission of data between DLS-users without alteration by the DLS-provider. The initiating DLS-user may transmit any integral number of octets greater than zero, up to the limit negotiated for the implied direction of data transfer.

19.1.2.5.1 Request primitive

If the initiating DLS-user has bound a buffer to the DLCEP as a source, then this primitive is invalid and the DLC shall be terminated by the DLS-provider with a DL-DISCONNECT indication issued to the appropriate DLS-user(s).

If the initiating DLS-user has bound a FIFO queue of maximum depth *K* to the DLCEP as a source, then a DL-DATA request primitive attempts to append a DLSDU to the queue, but fails if the queue already contains *K* DLSDUs. If the append operation is successful, then the DLSDU will be transmitted at the first opportunity after all preceding DLSDUs in the queue. A DL-PUT request primitive is not permitted. Instead, the queue serves to limit the number of DLS-user requests that can be outstanding (that is, not yet confirmed to the DLS-user).

If the initiating DLS-user has not bound a buffer or FIFO queue to the DLCEP as a source, then a DL-DATA request primitive attempts to append a DLSDU to an implicit queue of indeterminate capacity, but fails if the queue is full. If the append operation was successful, then the DLSDU will be transmitted at the first opportunity after all preceding DLSDUs in the queue.

At the moment of the request, if the explicit or implicit FIFO queue is full, then the request will be rejected with an appropriate failure status on the DL-DATA request primitive.

19.1.2.5.2 Indication primitive

If the receiving DLS-user has bound a FIFO queue to the DLCEP as a sink and that queue is not full, then:

a) the newly-received DLSDU is appended to that queue and the DLS-user-data parameter is omitted from the associated DL-Data indication primitive. The DLSDU must be read using a DL-Get request primitive.

If the receiving DLS-user has no binding to the DLCEP as a sink, then:

b) an implicit queue of indeterminate capacity is used as a temporary receive queue, after which the DLSDU is delivered as the DLS-user-data parameter of the associated DL-DATA indication primitive.

NOTE — When a buffer is bound to the DLCEP as a sink, a DL-DATA-Indication primitive cannot occur.

If it is not possible to append the received DLSDU to the implicit or explicit receive queue, then:

c) if the DLCEP's data delivery features are unordered or ordered, then the DLSDU shall be discarded and a DL-Data indication primitive shall not be issued to the DLS-user; or

d) if the DLCEP's data delivery features are classical or disordered, then the DLSDU shall be retained by either the sending or receiving DLE (or both) until such delivery is possible, or until the DLCEP is reset or disconnected, or until the DLSDU is no longer available at the sending DLCEP (which will in turn cause a reset at the receiving DLCEP).

A DL-DATA-Indication primitive reporting the DLSDU's receipt occurs at the receiving DLS-user's DLSAP.

19.1.2.6 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “temporary failure — queue full”;

c) “failure — incorrect amount of requesting DLS-user data specified”;

d) “failure — incompatible DLC state”;

e) “failure — reset or disconnection”;

f) “failure — timeout”; or

g) “failure — reason unspecified”.

NOTES

1. The only compatible DLC state is Data Transfer Ready (see Figure 16).

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

19.1.3 Sequence of primitives

The operation of the DLS in transferring DLSDUs can be modeled as a queue of unknown size within the DLS-provider (see clause 14). The ability of a DLS-user to issue a DL-DATA request or of a DLS-provider to issue a DL-DATA indication depends on the behavior of the receiving DLS-user and the resulting state of the queue.

The sequence of primitives in a successful queue-to-queue data transfer is defined in the time-sequence diagrams in Figures 43 through 45. The sequence of primitives in a failed queue-to-queue data transfer is defined in the time-sequence diagram in Figure 46.

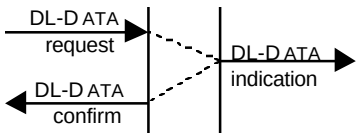


Figure 43 — Sequence of primitives for a Classical or Disordered peer-to-peer queue-to-queue data transfer

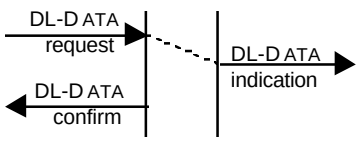


Figure 44 — Sequence of primitives for an Ordered or Unordered peer-to-peer, or an Unordered subscriber-to-publisher queue-to-queue data transfer

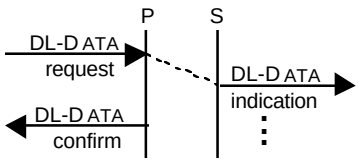


Figure 45 — Sequence of primitives for a publisher-to-subscribers queue to queue data transfer

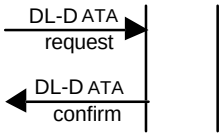


Figure 46 — Sequence of primitives for a failed queue-to-queue data transfer

If a DL-RESET or a DL-DISCONNECT primitive occurs, then the above sequences of causality may be overridden. In such a case, if a DL-DATA request primitive is outstanding, then a corresponding DL-DATA confirm primitive shall be issued before the reset or disconnection is signaled to the DLS-user.

19.2 Buffer data transfer

19.2.1 Function

The buffer data transfer primitives provide a means of notifying the DLS-user responsible for a buffer that the buffer was just transmitted, or that a DLSDU was just received into the buffer.

NOTE — A DL-BUFFER-SENT indication will never be coincident with a DL-DATA confirm and may or may not be related to a DL-DATA indication at one or more remote DLS-users. A DL-BUFFER-RECEIVED indication will never be coincident with a DL-DATA indication and cannot be related to a DL-DATA request at a remote DLS-user.

19.2.2 Types of primitives and parameters

Tables 17 and 18 indicate the types of primitives and the parameters needed for buffer data transfer.

Table 17 — Buffer sent primitive and parameter

DL-BUFFER-SENT	**Indication**
Parameter Name	output
DLCEP DLS-user-identifier	M
Buffer DLS-user-identifier	M

Table 18 — Buffer received primitive and parameter

DL-BUFFER-RECEIVED	**Indication**
Parameter Name	output
DLCEP DLS-user-identifier	M
Buffer DLS-user-identifier	M
Duplicated DLSDU	M

19.2.2.1 DLCEP DLS-user-identifier

The DLCEP DLS-user-identifier parameter has the same value as the DLCEP DLS-user-identifier parameter returned by the DL-CONNECT confirm or DL-CONNECTION-ESTABLISHED indication primitive that occurred during initiation of the DLCEP at which the DLS-user-data was received.

19.2.2.2 Buffer DLS-user-identifier

The buffer DLS-user-identifier parameter has the same value as a buffer DLS-user-identifier parameter from a prior DL-CREATE primitive (or as created by DL-management), designating the same retentive buffer as the one specified in the appropriate-direction buffer-or-queue-binding parameter (see 17.2.3.9) of the DL-CONNECT request or response primitive that initiated the DLCEP.

19.2.2.3 Duplicated DLSDU

The duplicated-DLSDU parameter allows the DLS-user to determine whether the DLSDU is known by the DLL to be a duplicate of a previously-received DLSDU or not. When the indication is of the re-receipt of a known duplicated DLSDU, this parameter shall have the value "TRUE"; in all other cases it shall have the value "FALSE". Since UNORDERED DLCs do not provide duplicate-DLSDU-detection, this parameter always has the value FALSE when the DLSDU was received at a DLCEP whose data delivery features are UNORDERED.

NOTE — The DLS-user may be able to use this information to distinguish between problems within the remote peer DLS-user-entity and problems within the distributed DLS-provider.

19.2.3 Sequence of primitives

The sequence of primitives in a successful buffer to buffer, or buffer to queue, data transfer is defined in the time-sequence diagrams in Figures 47 through 50.

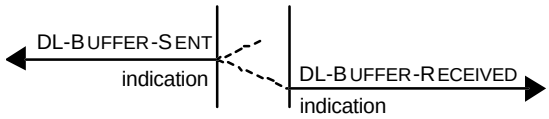


Figure 47 — Sequence of primitives for an Ordered or Unordered peer-to-peer, or an Unordered subscriber-to-publisher, buffer to buffer data transfer

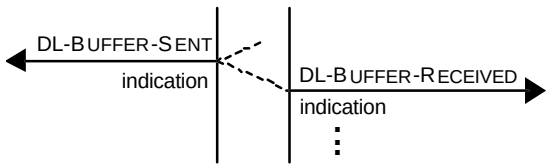


Figure 48 — Sequence of primitives for a publisher-to-subscribers buffer to buffer data transfer

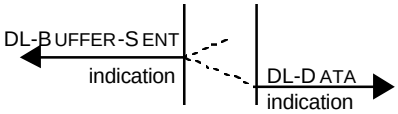


Figure 49 — Sequence of primitives for an Ordered or Unordered peer-to-peer, or an Unordered subscriber-to-publisher, buffer to queue data transfer

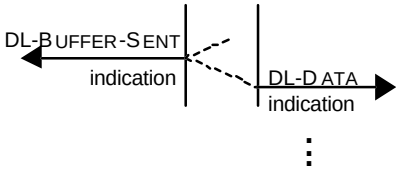


Figure 50 — Sequence of primitives for a publisher-to-subscribers buffer to queue data transfer

The above sequences of primitives may remain incomplete if a DL-RESET or a DL-DISCONNECT primitive occurs.

19.3 Reset

19.3.1 Function

The Reset service may be used:

a) by the DLS-user of a peer or publisher DLCEP, to resynchronize the use of the DLC and optionally to exchange a limited amount of user data with the DLC's other DLS-user(s); or

b) by the DLS-provider, to report detected loss of data unrecoverable within the DLS. All loss of data that does not involve loss of the DLC is reported in this way.

If the DLC is congested, invocation of the Reset service will unblock the flow of DLSDUs by causing the DLS-provider:

1) to discard DLSDUs; and

2) to notify the appropriate DLS-user(s) that did not invoke Reset that a Reset has occurred.

The service will be completed in a finite time, whether previously-queued DLSDUs are accepted by the DLS-user or not. Any DLSDUs not delivered to the DLS-users before completion of the service will be discarded by the DLS-provider.

NOTES

1. A Reset may require a recovery procedure to be performed by the DLS-users.

2. These primitives cannot result in the disconnection of DLCEPs that were established by prior local DL-management actions.

19.3.2 Types of primitives and parameters

Tables 19 and 20 indicate the types of primitives and the parameters needed for the reset service.

19.3.2.1 DLCEP DL-identifier

The DLCEP DL-identifier parameter has the same value as the DLCEP DL-identifier parameter returned by the DL-CONNECT request or indication primitive that initiated the DLCEP.

19.3.2.2 DLCEP DLS-user-identifier

The DLCEP DLS-user-identifier parameter has the same value as the DLCEP DLS-user-identifier parameter returned by the DL-CONNECT confirm or DL-CONNECTION-ESTABLISHED indication primitive that occurred during initiation of the DLCEP at which the DL-RESET or DL-RESET-COMPLETED indication primitive was received.

19.3.2.3 Originator

The originator parameter indicates the source of the Reset; the set of values is identical to that specified in 18.2.2. The parameter's value indicates either the remote DLS-user, the remote DLS-provider, the local DLS-provider, or that the originator is unknown.

Table 19 — DLC/DLCEP reset primitives and parameters (part 1)

DL-RESET	**Request**	**Indication**	**Response**	**Confirm**
Parameter Name	input	output	input	output
DLCEP DL-identifier	M(1)		M (2)	
DLCEP DLS-user-identifier		M(2)		M (1)
Originator		M		
Reason	U	M (=)		
DLS-user-data	U	M (=)	U	M (=)
Status				M

NOTES

1. The DLCEP DLS-user-identifier on the confirm primitive shall be for the same DLCEP as that specified in the request primitive.
2. The DLCEP DL-identifier on the response primitive shall be for the same DLCEP as that specified in the indication primitive.

Table 20 — DLC/DLCEP reset primitives and parameters (part 2)

DL-RESET-COMPLETED	**Indication**
Parameter Name	output
DLCEP DLS-user-identifier	M

19.3.2.4 Reason

The reason parameter gives information about the cause of the reset. The value conveyed in this parameter will be as follows:

a) When the originator parameter indicates a DLS-provider-generated reset, the value is one of:

1) "resynchronization after activation of a DL-management-established DLCEP";

2) "resynchronization after timeout";

3) "resynchronization after maximum number of retransmission requests or attempts";

4) "resynchronization after detected sequence number error";

5) "resynchronization after other detected DLCEP state inconsistencies";

6) "resynchronization caused by an attempt to transmit a DLSDU whose size is invalid for the DLCEP"; or

7) "reason unspecified".

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

b) When the originator parameter indicates a DLS-user-initiated reset, the value is one of:

1) “resynchronization after DLS-user timeout”;

2) “resynchronization after DLS-user-detected DLS-user-state inconsistencies”;

3) “reason unspecified”; or

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

c) When the originator parameter indicates an unknown originator, the value of the Reason parameter is “reason unspecified”. This allows parameters to be implied when they cannot be explicitly conveyed in the DL-protocol.

19.3.2.5 DLS-user-data

The user-data parameter allows the transmission of DLS-user-data between DLS-users, without modification by the DLS-provider. The DLS-user may transmit any integral number of octets up to the limit for DLPDUs of the DLC’s priority.

NOTE — The delivery of this data is assured only for the case where the reset service is invoked by only one peer or publishing DLS-user and not simultaneously by another DLS-user or the DLS-provider, and where the reset service completes before the initiation of a subsequent reset or disconnect.

19.3.2.6 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — incompatible DLC state”;

c) “failure — disconnection”; or

d) “failure — reason unspecified”.

NOTES

1. The only compatible DLC state is Data Transfer Ready (see Figure 16).

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

19.3.3 Sequence of primitives

The interaction between each DLS-user and the DLS-provider shall be one of the following exchanges of primitives:

a) a DL-Reset request from the DLS-user, followed by a DL-Reset confirm from the DLS-provider; or

b) a DL-Reset indication from the DLS-provider, followed by a DL-Reset response from the DLS-user, followed by a DL-RESET-COMPLETED indication from the DLS-provider.

The DL-RESET request acts as a synchronization mark in the stream of DLSDUs that are sent by the issuing DLS-user. The DL-RESET indication acts as a synchronization mark in the stream of DLSDUs that are received by the peer DLS-user. The DL-RESET response acts as a synchronization mark in the stream of

DLSDUs that are sent by the responding DLS-user. The DL-RESET confirm acts as a synchronization mark in the stream of DLSDUs that are received by the DLS-user that originally issued the reset.

When the requesting DLS-user is the publisher of a multi-peer DLC, then this behavior is modified to account for the fact that synchronization marks corresponding to DL-RESET response primitives are not actually sent to the publishing DLCEP, but rather a DL-RESET confirm primitive is locally generated at the publishing DLCEP after sending the DL-RESET request synchronization mark to the subscribing DLCEPs.

In general, the resynchronization properties of the Reset service are that:

1) No DLSDU sent by the DLS-user before the DL-Reset request or response in that sent stream shall be delivered to the peer DLS-user after the corresponding DL-Reset indication or confirm in that received stream.

   The DLS-provider shall discard all DLSDUs submitted before the issuing of the DL-Reset request that have not been delivered to the peer DLS-user when the DLS-provider issues the DL-Reset indication.

   Also, the DLS-provider shall discard all DLSDUs submitted before the issuing of the DL-Reset response that have not been delivered to the requester of the DL-Reset when the DLS-provider issues the DL-Reset confirm.

2) No DLSDU sent by the DLS-user after the synchronization mark in that sent stream shall be delivered to another DLS-user before the synchronization mark in that received stream.

However, this partitioning of DLSDUs into pre-reset and post-reset epochs is only approximate when the DLCEP data delivery features are UNORDERED, because the lack of complete ordering includes a lack of complete ordering of the entries in the abstract queues.

The complete sequence of primitives depends upon the origin of the Reset action and the occurrence or otherwise of conflicting origins. Thus the Reset service may be:

i) invoked by one DLS-user of a peer DLC and possibly simultaneously by the DLS-provider, leading to interaction (a) with that DLS-user and interaction (b) with the peer DLS-user;

ii) invoked by both DLS-users of a peer DLC, leading to interaction (a) with both DLS-users;

iii) invoked by the DLS-provider of a peer DLC, leading to interaction (b) with both DLS-users;

iv) invoked by the subscribing user of a multi-peer DLC or by that part of the DLS-provider associated with the subscribing DLS-user, leading to interaction (a) with that DLS-user and no interaction with the DLC's other DLS-user(s);

v) invoked by that part of the DLS-provider associated with the publishing DLS-user, leading to interaction (b) with the DLC's DLS-users; or

vi) invoked by the publishing user of a multi-peer DLC and possibly simultaneously by one or more subscribing users, leading to interaction (a) with the invoking DLS-user(s) and interaction (b) with all the DLC's other DLS-users.

The sequences of primitives for these six alternatives are defined in the time-sequence diagrams in Figures 51 through 61.

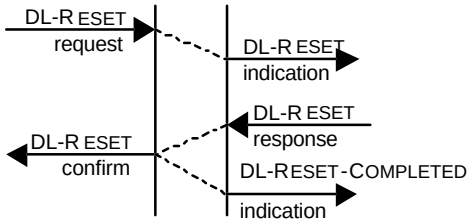


Figure 51 — Sequence of primitives in a Peer DLS-user initiated Reset

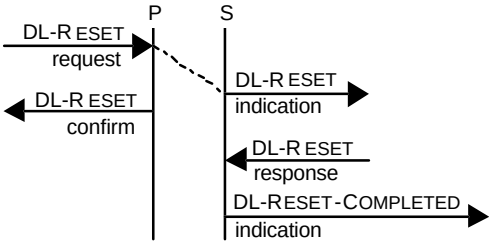


Figure 52 — Sequence of primitives in a Publishing DLS-user initiated Reset

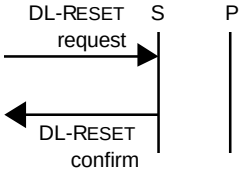


Figure 53 — Sequence of primitives in a Subscribing DLS-user initiated Reset

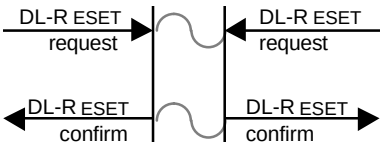


Figure 54 — Sequence of primitives in a simultaneous Peer DLS-users initiated Reset

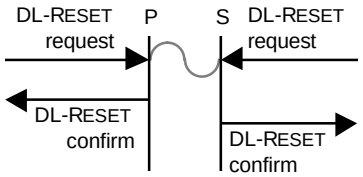


Figure 55 — Sequence of primitives in a simultaneous Multi-peer DLS-users initiated Reset

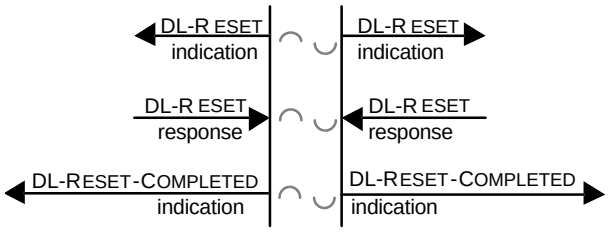


Figure 56 — Sequence of primitives in a Peer DLS-provider initiated Reset

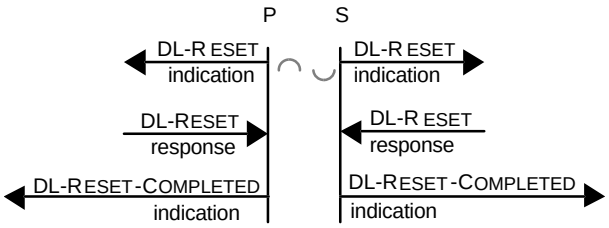


Figure 57 — Sequence of primitives in a Publishing DLS-provider initiated Reset

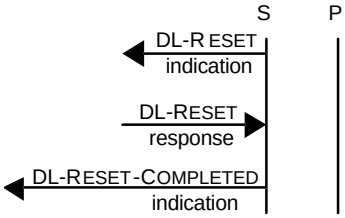


Figure 58 — Sequence of primitives in a Subscribing DLS-provider initiated Reset

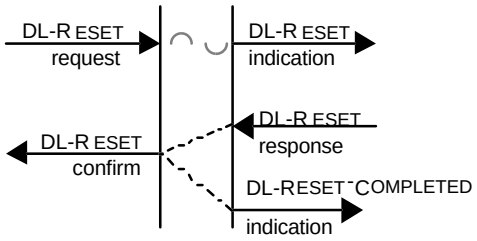


Figure 59 — Sequence of primitives in a simultaneous Peer DLS-user and DLS-provider initiated Reset

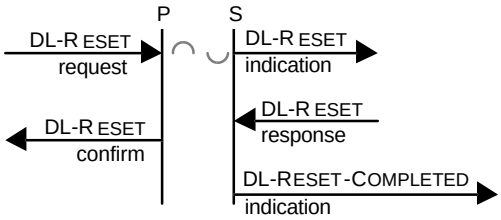


Figure 60 — Sequence of primitives in a simultaneous Publishing DLS-user and DLS-provider initiated Reset

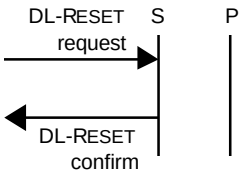


Figure 61 — Sequence of primitives in a simultaneous Subscribing DLS-user and DLS-provider initiated Reset

The above sequences of primitives may remain incomplete if a DL-DISCONNECT primitive occurs. In such a case, if a DL-RESET request primitive is outstanding, then a corresponding DL-RESET confirm primitive shall be issued before the disconnection is signaled to the DLS-user.

19.4 Subscriber query

19.4.1 Function

The subscriber query service primitives provide for the publishing DLS-user to query the existence of any subscribers on a multi-peer DLC. The information returned specifies whether the set of subscribing DLS-users of the multi-peer DLC appears to be empty.

19.4.2 Types of primitives and parameters

Table 21 indicates the types of primitives and the parameters needed for subscriber query.

Table 21 — Subscriber query primitives and parameters

DL-SUBSCRIBER-QUERY	Request	Confirm
Parameter Name	input	output
DLCEP DL-identifier	M	
DLCEP DLS-user-identifier		M
Status		M

19.4.2.1 DLCEP DL-identifier

The DLCEP DL-identifier parameter has the same value as the DLCEP DL-identifier parameter returned by the DL-CONNECT request or indication primitive that initiated the DLCEP.

19.4.2.2 DLCEP DLS-user-identifier

The DLCEP DLS-user-identifier parameter has the same value as the DLCEP DLS-user-identifier parameter returned by the DL-CONNECT confirm or DL-CONNECTION-ESTABLISHED indication primitive that occurred during initiation of the DLCEP at which the DL-SUBSCRIBER-QUERY request was received.

19.4.2.3 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was initiated successfully or failed for the reason specified, and whether any receiving DLS-users appear to exist or not. The value conveyed in this parameter will be as follows:

a) “success — a subscriber exists”;

b) “indeterminate — timeout”;

c) “failure — incompatible DLC state”;

d) “failure — disconnection”; or

e) “failure — reason unspecified”.

NOTES

1. The status “failure — timeout” may be interpreted with an unknown degree of confidence as “success — no subscribers.”

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard which provides services as specified in this part of this International Standard.

19.4.3 Sequence of primitives

The sequence of primitives in a successful subscriber is defined in the time-sequence diagram in Figure 62. The scheduling of DL-SUBSCRIBER-QUERY is always IMPLICIT.

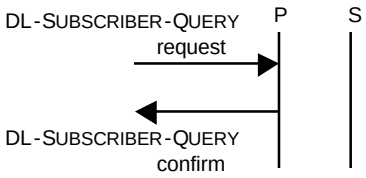


Figure 62 — Sequence of primitives for Subscriber Query

The above sequence of primitives may remain incomplete if a DL-DISCONNECT primitive occurs.

20 Facilities of the connectionless-mode Data Link Service

NOTE — These facilities may not be adequate of themselves to provide the ordered-delivery enhancement to the basic connectionless OSI data link services of ISO 8886 that ISO/IEC 10039 promises to users of local area network medium access control protocols. In such a case, it may be necessary to use an ordered DLC and a convergence sub-protocol to emulate the enhanced connectionless services of ISO/IEC 10039, with a PEER DLC used to support point-to-point (unicast) services and a MULTI-PEER DLC used to support multicast services.

The DLS provides the following facilities to the DLS-user:

a) A means of transferring DLSDUs of limited length from one source DLSAP to a destination DLSAP or group of DLSAPs, without establishing or later releasing a DLC. The transfer of DLS-DUs is transparent, in that the boundaries of DLSDUs and the contents of DLSDUs are preserved unchanged by the DLS, and there are no constraints on the DLSDU content (other than limited length) imposed by the DLS. QoS for this transmission can be selected by the sending DLS-user.

NOTE — The length of a DLSDU is limited because of internal mechanisms employed by the DL-protocol (see 7.6.3.2 of ISO 7498-1).

b) A means by which the status of delivery to that destination DLSAP can be returned to the source DLSAP.

c) A means by which previously submitted DLSDUs of limited length can be exchanged between two DLSAPs and status about the exchange can be provided to the DLS-users, without establishing or later releasing a DLC. The transfer of the DLSDUs is transparent, in that the boundaries of the DLSDUs and the contents of the DLSDUs are preserved unchanged by the DLS, and there are no constraints on the DLSDU content (other than limited length) imposed by the DLS.

NOTES

1. The length of a DLSDU is limited because of internal mechanisms employed by the DL-protocol (see 7.6.3.2 of ISO 7498-1).

2. Because this is a unitdata service, it is inherently asymmetric the status available to the two DLS-users reflects that asymmetry. Each DLS-user receives status that the exchange occurred, but only the one with the DL(SAP)-address role of INITIATOR can receive status that its DLSDU was successfully delivered to the other DLS-user.

3. The ability to constrain a DLSAP-address bound in a RESPONDER role to unitdata-exchange only with a specified DLSAP-address bound in an INITIATOR role can be viewed as a form of asymmetric light-weight peer-to-peer unordered DLC.

d) A means by which a DLS-user can be notified that such an exchange was attempted, but that no DLSDUs were available for the exchange.

e) A means by which a DLS-user can query if there are any DLS-users that can receive DLSDUs sent to a specified (usually group) DL(SAP)-address.

21 Model of the connectionless-mode Data Link Service

This part of this International Standard uses the abstract model for a layer service defined in clause 4 of ISO/TR 8509 and ISO/IEC 10731. The model defines interactions between the DLS-user and the DLS-provider that take place at a DLSAP. Information is passed between the DLS-user and the DLS-provider by DL-service-primitives that convey parameters.

21.1 Model of DL-connectionless-mode unitdata transmission

A defining characteristic of data-link connectionless-mode unitdata transmission is the independent nature of each invocation of the DL-service.

As a descriptive aid, the data-link connectionless-mode unitdata transmission service, as provided between any two DLSAPs, can be modeled in the abstract as an association between the two DLSAPs. This association is permanent, but its activation requires autonomous actions, in the form of appropriate DL-BIND requests, at the two DLSAPs.

Only one type of object, the unitdata object, can be handed over to the DLS-provider, via a DLSAP, for transmission. In Figure 63, DLS-user A represents the DLS-user that passes objects to the DLS-provider. DLS-user B represents the DLS-user that accepts objects from the DLS-provider.

The operations that are performed by the DLS-provider for a particular DLL association depend on the QoS specified by the requesting DLS-user. Awareness of the characteristics of the DLS provider is part of the DLS-user's à priori knowledge of the OSI environment.

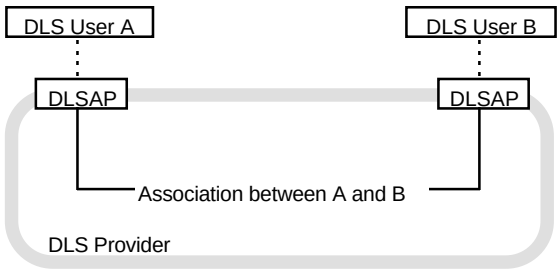


Figure 63 — Model for a data-link connectionless-mode unitdata transmission or unitdata exchange

21.2 Model of DL-connectionless-mode unitdata exchange

A defining characteristic of data-link connectionless-mode unitdata exchange is the independent nature of each invocation of the DL-service.

As a descriptive aid, the data-link connectionless-mode unitdata exchange service, as provided between any two DLSAPs, can be modeled in the abstract as an association between the two DLSAPs. This association is permanent, but its activation requires autonomous actions, in the form of appropriate DL-BIND requests, at the two DLSAPs.

Only one type of object, the unitdata object, can be handed over to the DLS-provider, via a DLSAP, for transmission. In Figure 63, DLS-user A represents the DLS-user which has configured its relevant

DLSAP-address in the role of INITIATOR. DLS-user B represents the DLS-user that has configured its relevant DLSAP-address in the role of CONSTRAINED RESPONDER or UNCONSTRAINED RESPONDER.

For each DLSAP-address, the configuring DL-BIND service specifies up to three buffers that can provide DLSDUs for transmission and up to three buffers or queues that can hold received DLSDUs.

Each invocation of the unitdata-exchange DL-service specifies a service priority and causes each DLE to select, from those sending buffers that are bound at the specified or higher priority, the highest-priority DLSDU that is available for transmission.

The unitdata-exchange DL-service consists of two phases. During the first phase, DLS-user A's DLE selects the DLSDU for transmission, if any, and sends it to DLS-user B's DLE, where the DLSDU is received and placed in the receive buffer or queue, if any, associated with the DLSDU's priority.

During the second phase, if a DLSDU was sent but was unable to be delivered in the first phase, then an error report is returned to DLS-user A's DLE. Otherwise, if either no DLSDU was sent or the sent DLSDU was successfully placed in the appropriate receive buffer or queue, then DLS-user B's DLE selects the DLSDU for transmission, if any, and sends it to DLS-user A's DLE, where the DLSDU is received and placed in the receive buffer or queue, if any, associated with the DLSDU's priority.

For each of the two DLSAPs involved in the transaction, if a DLSDU was either sent or received at the DLSAP, or if the DLSAP-address binding specified that unitdata-exchange indications are always required, then the DLE shall issue a DL-UNITDATA-EXCHANGE indication primitive at that DLSAP.

22 Quality of connectionless-mode service

The term "Quality of Service" (QoS) refers to certain characteristics of a connectionless-mode data transmission as observed between the DLSAPs. QoS describes aspects of a connectionless-mode data transmission that are attributable solely to the DLS-provider. QoS can only be properly determined when DLS-user behavior does not constrain or impede the performance of the DLS.

Whether the QoS during each instance of connectionless-mode data transmission appears the same to each DLS-user associated with the service depends:

a)on the nature of their association; and

b)on the type of information, concerning the nature of the service, made available to the DLS-user(s) by the DLS-provider prior to the invocation of the service.

22.1 Determination of QoS for connectionless-mode service

A basic characteristic of a connectionless-mode service is that no long-term dynamic association is set up between the parties involved. Thus, associated with each DL-connectionless-mode data transmission, certain measures of QoS are requested by the sending or initiating DLS-user when the primitive action is initiated.

NOTE — The ability to constrain a DLSAP-address bound in a CONSTRAINED-RESPONDER role to unitdata-exchange only with a specified DLSAP-address bound in an INITIATOR role can be viewed as a form of asymmetric association by configuration, but without any DL-related communication between the correspondent DLS-users.

22.2 Definition of QoS parameters

The QoS attributes for connectionless service are:

22.2.1 DLL priority

Connectionless data transfer and data exchange primitives specify the priority of the transferred DLSDU(s). This parameter is defined and its default value specified in 8.1 and 12.3.2.6.1.

22.2.2 DLL maximum confirm delay

This parameter is defined and its default value specified in 8.2 and 12.3.2.6.2.

NOTE — For DLEs that do not support a time resolution of 1 ms, the requested time interval may be rounded up to the next-greatest multiple of the resolution that the DLE does support.

22.2.3 Remote-DLE-confirmed

This Boolean parameter specifies whether the DLS-user requests confirmation of receipt of the associated DLSDU by the (implicitly identified) remote DLE. Its permissible values are **TRUE** and **FALSE**, and its default value is FALSE.

NOTE — When providing a unitdata service, selection of the value TRUE inevitably uses more link capacity than does selection of the value FALSE.

23 Sequence of primitives

23.1 Constraints on sequence of primitives

This subclause defines the constraints on the sequence in which the primitives defined in clause 24 may occur. The constraints determine the order in which primitives occur, but do not fully specify when they may occur. Other constraints, such as flow control of data, will affect the ability of a DLS-user or a DLS-provider to issue a primitive at any particular time.

The connectionless-mode primitives and their parameters are summarized in Table 22.

Table 22 — Summary of DL-connectionless-mode primitives and parameters

Service	Service sub-type	Primitive	Parameter
DATA TRANSFER	UNITDATA	DL-UNITDATA request	(*in* Request DLS-user-identifier, Called DL(SAP)-address, Calling DLSAP-address DL-identifier, QoS parameter set, limited DLS-user-data)
		DL-UNITDATA indication	(*out* Called DL(SAP)-address DLS-user-identifier, Calling DLSAP-address, QoS parameter set, Queue DLS-user-identifier, limited DLS-user-data)
		DL-UNITDATA confirm	(*out* Request DLS-user-identifier, Status)
	UNITDATA EXCHANGE	DL-UNITDATA-EXCHANGE indication (2)	(*out* Local DLSAP-address DLS-user-identifier, Remote DLSAP-address, QoS parameter set, Buffer-or-queue DLS-user-identifier, Status)
LISTENER QUERY	LISTENER QUERY	DL-LISTENER-QUERY request	(*in* Request DLS-user-identifier, DL(SAP)-address, QoS parameter)
		DL-LISTENER-QUERY con-firm	(*out* Request DLS-user-identifier, Status)

NOTES

1. DL-identifiers in parameters are local and assigned by the DLS-provider and used by the DLS-user to designate a specific DL(SAP)-address, schedule, buffer-or-queue to the DLS-provider at the DLS interface. DLS-user-identifiers in parameters are local and assigned by the DLS-user and used by the DLS-provider to designate a specific DL(SAP)-address, schedule, buffer-or-queue to the DLS-user at the DLS interface.
2. DL-UNITDATA-EXCHANGE indication occurs in isolation, without either request or confirm primitives, at both DLSAPs involved in an instance of the explicitly scheduled UNITDATA-EXCHANGE service. The DL-COMPEL-SERVICE and DL-SCHEDULE-SEQUENCE services (see 29.2, 29.3) provide the means for the explicit scheduling of the UNITDATA-EXCHANGE service.

23.2 Relation of primitives at the end-points of connectionless service

With few exceptions, a primitive issued at one DLSAP will have consequences at one or more other DLSAPs. The relations of primitives of each type at one DLSAP to primitives at the other DLSAPs are defined in the appropriate subclause in clause 24; all these relations are summarized in the diagrams of Figure 64.

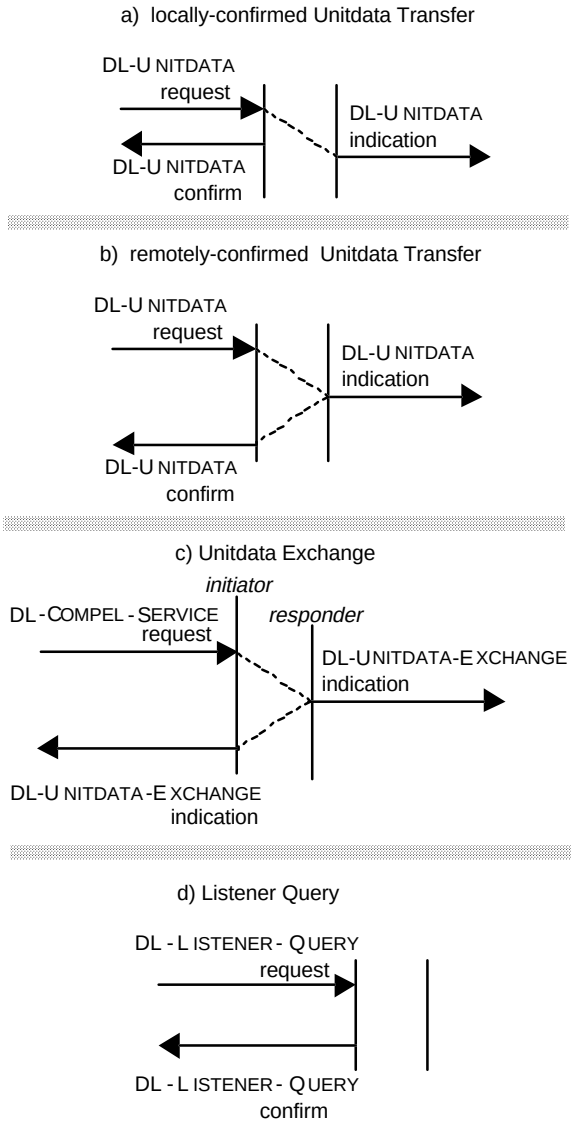


Figure 64 — Summary of DL-connectionless-mode service primitive time-sequence diagrams

23.3 Sequence of primitives at one DLSAP

The possible overall sequences of primitives at a DLSAP are defined in the state transition diagram, Figure 65. In the diagram, the use of a state transition diagram to describe the allowable sequences of service primitives does not impose any requirements or constraints on the internal organization of any implementation of the service.

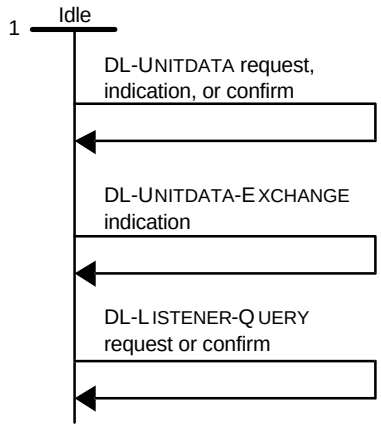


Figure 65 — State transition diagram for sequences of connectionless-mode primitives at one DLSAP

24 Connectionless-mode functions

DL-connectionless-mode unitdata transmission and unitdata exchange service primitives can be used to transmit independent DLSDUs from one DLSAP to another DLSAP. Each DLSDU is transmitted in a single DLPDU. The DLSDU is independent in the sense that it bears no relationship to any other DLSDU transmitted through an invocation of the DL-service. The DLSDU is self-contained in that all the information required to deliver the DLSDU is presented to the DLS-provider, together with the user data to be transmitted, in a single service access.

A DLSDU transmitted using DL-connectionless-mode unitdata transmission or unitdata exchange services is not considered by the DLS-provider to be related in any way to any other DLSDU. Although the DLS maintains the integrity of individual DLSDUs, it does not necessarily deliver them to the receiving DLS-user in the order in which they are presented by the sending DLS-user.

NOTE — Although the DL-UNITDATA-EXCHANGE service provides status about the delivery or transmission of one DLSDU when it reports the reception of a second DLSDU, there is no constraining relationship between the DLSDUs themselves.

No means are provided by which the receiving DLS-user may control the rate at which the sending DLS-user may send DLSDUs (peer-to-peer flow control). The DLS-provider will not maintain any state information about the flow of information between DLSAPs. Flow control exerted by the DLS-provider upon a sending DLS-user can only be described for a specific interface.

24.1 Data transfer

24.1.1 Function

This service provides the facilities of 20(a) and 20(b). It can be used to transmit an independent, self-contained DLSDU from one DLSAP to another DLSAP in a single service access and to return the status of that delivery to the originating DLSAP.

This service can also be used to transmit an independent, self-contained DLSDU from one DLSAP to a group of DLSAPs, all in a single service access. In this case, delivery status is not available to the originating DLSAP.

A DLSDU transmitted using DL-connectionless-mode data transfer is not considered by the DLS-provider to be related in any way to any other DLSDU. Although the DLS maintains the integrity of individual

DLSDUs, it does not necessarily deliver them to the receiving DLS-user in the order in which they are presented by the sending DLS-user.

NOTE — The possibility, probability, and reasons for such misordering are protocol-specific.

24.1.2 Types of primitives and parameters

Table 23 indicates the types of primitives and the parameters needed for the DL-connectionless-mode unitdata transmission service. This service may be initiated from any DLSAP-address whose binding DL(SAP)-role is BASIC. This service may be addressed to any DL(SAP)-address whose binding DL(SAP)-role is BASIC or GROUP.

Table 23 — DL-connectionless-mode unitdata transfer primitives and parameters

DL-UNITDATA	**Request**	**Indication**	**Confirm**
Parameter Name	input	output	output
Request DLS-user-identifier	M		M (=)
Called address	M	M (=)	
Calling address	M	M (=)	
QoS parameter set			
DLL priority	U	M (=)	
DLL maximum confirm delay	U		
remote-DLE-confirmed	U		
Queue DLS-user-identifier		C	
DLS-user-data	M	C (=)	
Status			M

24.1.2.1 Request DLS-user-identifier

The request DLS-user-identifier parameter, which is specified by the DLS-user on DL-UNITDATA request primitives, provides a local means of pairing the resulting DL-UNITDATA confirm primitive with the causative DL-UNITDATA request primitive. The naming-domain of this request identifier is the DLS-user-local-view.

24.1.2.2 Addresses

The parameters that take addresses as values (see 24.1.2.2.1 and 24.1.2.2.2) both refer to DL(SAP)-addresses.

24.1.2.2.1 Called address

The called address parameter conveys an address identifying the remote DLSAP(s) with which the DLS is to be provided. It is a DL(SAP)-address in the request primitive, but takes the form of a local DL(SAP)-address DLS-user-identifier in the indication primitive(s). It may be a DLSAP-address or a group DL-address.

NOTE — If the requesting DLS-user has issued a DL-BIND request for the Called Address, then this parameter also can take the form of a DL(SAP)-address DL-identifier in the request primitive.

24.1.2.2.2 Calling address

The calling address parameter conveys an address of the local DLSAP from which the DLS has been requested. It is a DLSAP-address in the indication primitive, but takes the form of a local DLSAP-address DL-identifier in the request primitive.

NOTE — If the receiving DLS-user has issued a DL-BIND request for the Calling Address, then this parameter also can take the form of a DLSAP-address DLS-user-identifier in the indication primitive.

24.1.2.3 Quality of Service

The value of the QoS parameter is a list of sub-parameters. For each parameter, the values on the primitives are related so that:

a) on the request primitive, any defined value is allowed, consistent with the other parameters; and

b) on the indication primitive, the quality of service indicated is equal to the value specified for the corresponding request primitive.

24.1.2.3.1 DLL priority

24.1.2.3.2 DLL maximum confirm delay

This QoS attribute is not reported on the indication primitive.

24.1.2.3.3 Remote-DLE-confirmed

When the called address is a group DL-address the specified value for this QoS attribute shall be FALSE. This QoS attribute is not reported on the indication primitive.

24.1.2.4 Queue DLS-user-identifier

The Queue DLS-user-identifier parameter has the same value as a Queue DLS-user-identifier parameter from a prior DL-CREATE primitive (or as created by DL-management). It is present when an explicit queue was specified for reception at the indicated priority by the DL-BIND request primitive that established the DL(SAP)-address indicated in the same primitive.

24.1.2.5 DLS-user data

This parameter allows the transmission of data between DLS-users without alteration by the DLS-provider. The initiating DLS-user may transmit any integral number of octets greater than zero, up to the limit determined by the DLL priority QoS parameter specified in the service request.

24.1.2.5.1 Request primitive

If the initiating DLS-user has bound a FIFO queue of maximum depth *K* to the DLSAP-address at the specified priority as a source, then a DL-UNITDATA request primitive attempts to append a DLSDU to the queue, but fails if the queue already contains *K* DLSDUs. If the append operation is successful, then the DLSDU will be transmitted at the first opportunity, after all preceding DLSDUs in the queue. A DL-PUT request primitive is not permitted. Instead, the queue serves to limit the number of DLS-user requests that can be outstanding (that is, not yet confirmed to the DLS-user).

If the initiating DLS-user has not bound a FIFO queue to the DLSAP-address at the specified priority as a source, then a DL-UNITDATA request primitive attempts to append a DLSDU to an implicit queue (for this DLSAP-address and priority) of indeterminate capacity but fails if the queue is full. If the append operation was successful, then the DLSDU will be transmitted at the first opportunity after all preceding DLSDUs in the queue.

At the moment of the request, if the explicit or implicit FIFO queue is full, then the request is terminated and a DL-UNITDATA confirm primitive is issued immediately with an appropriate negative status.

24.1.2.5.2 Indication primitive

If the receiving DLS-user has bound a FIFO queue to the DL(SAP)-address at the received DLSDU's priority as a sink, and that queue is not full, then:

a) the newly-received DLSDU is appended to that queue, and the DLS-user-data parameter is omitted from the associated DL-Unitdata indication primitive. The DLSDU must be read using a DL-Get request primitive.

If no such binding exists, then:

b) an implicit queue of indeterminate capacity is used as the receive queue, and the DLSDU is delivered as the DLS-user-data parameter of the associated DL-UNITDATA indication primitive.

If it is not possible to append the received DLSDU to the implicit or explicit receive queue, then:

c) the DLSDU shall be discarded and a DL-Unitdata indication primitive shall not be issued to the DLS-user.

A DL-UNITDATA-indication primitive reporting the DLSDU's receipt occurs at the receiving DLS-user's DLSAP.

24.1.2.6 Status

The status parameter allows the DLS-user to determine whether the requested service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) "success";

b) "failure — sending queue full";

c) "failure — no requesting DLS-user data specified";

d) "failure — requested QoS unavailable";

e) "failure — calling DLSAP DL-identifier is invalid";

f) "failure — incompatible DL(SAP)-role for calling address";

g) "failure — incompatible DL(SAP)-role for called address";

h) "failure — terminated by unbind of source DLSAP-address";

j) "failure — resource limitation in responder";

k) "failure — fault in responder";

m) "failure — timeout before transmission";

n) "failure — timeout after transmission, before acknowledgment"; or

p) "failure — reason unspecified".

NOTES

1. Failure (g) can result from specifying a group DL-address as the called address and requiring remote DLE confirmation.

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

24.1.3 Sequence of primitives

The sequence of primitives in a successful unitdata transfer is defined in the time-sequence diagrams in Figures 66, 67, and 68.

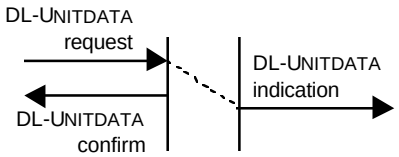


Figure 66 — Sequence of primitives for a successful locally-acknowledged connectionless-mode unitdata transfer

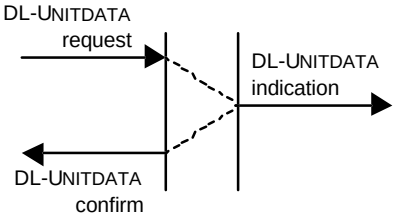


Figure 67 — Sequence of primitives for a successful remotely-acknowledged connectionless-mode unitdata transfer

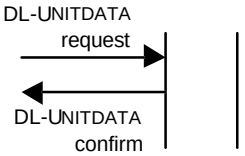


Figure 68 — Sequence of primitives for an unsuccessful connectionless-mode unitdata transfer

24.2 Data exchange

NOTE — DL-connectionless-mode data exchange services are an extension of the Unitdata services specified in ISO 7498/AD1.

24.2.1 Function

The DL-connectionless-mode unitdata exchange service is invoked through use of the DL-COMPEL-SERVICE service (see 29.2). The DL-connectionless-mode unitdata exchange service can be used:

a) to send a self-contained DLSDU from one local DLSAP, the initiator, to another DLSAP, the responder;

b) to cause a second independent self-contained DLSDU, which is ready for transmission at that responder DLSAP, to be returned to the initiator DLSAP; and

c) when neither DLSAP has a DLSDU ready to transmit, to notify the associated DLS-users that such an exchange was attempted.

The DLSDUs are independent in the sense that they bear no relationship to any other DLSDUs transmitted through other invocations of the DL-service. The DLSDUs are self-contained in that all the information required to deliver each DLSDU is presented to the DLS-provider, together with the user data to be trans-

mitted, in a single DL-PUT (see 12.5) service access. Thus no initial establishment or subsequent release of a DLC is required.

A DLSDU transmitted using DL-connectionless-mode data exchange is not considered by the DLS-provider to be related in any way to any other DLSDU. Although the DLS maintains the integrity of individual DLSDUs, it does not necessarily deliver them to the receiving (responding or initiating) DLS-user in the order in which they are presented by the sending (initiating or responding, respectively) DLS-user.

NOTE — The possibility, probability, and reasons for such misordering are protocol-specific.

Limited means are provided by which the receiving DLS-user may control the rate at which the sending DLS-user may send DLSDUs (peer-to-peer flow control).

1) The initiating DLS-user limits the rate at which both it and the responding DLS-user can send DLSDUs by controlling the frequency of the DL-Unitdata-Exchange service.

2) The responding DLS-user can limit the rate at which it can receive DLSDUs of a specified priority by explicitly binding a queue at that priority as a sink and keeping the queue full. The initiating DLS-user will be informed that the responding DLE discarded the received DLSDU (due to resource limitations) and may use this information as a form of back-pressure flow control.

The DLS-provider will not maintain any state information about the flow of information between DLSAPs. Flow control exerted by the DLS-provider upon a sending DLS-user can only be described for a specific interface.

24.2.2 Types of primitives and parameters

Table 24 indicates the primitive and the parameters used by the DL-connectionless-mode unitdata exchange service. This service may occur between any DLSAP-address (the initiator), whose binding DL(SAP)-role is INITIATOR, and any DLSAP-address (the responder):

a) whose binding DL(SAP)-role is unconstrained responder; or

b) whose binding DL(SAP)-role is constrained responder and whose associated remote-DL(SAP)-address as specified in the relevant DL-BIND request primitive (see 12.3.2.3.2) is equal to the initiator-DLSAP-address.

Table 24 — DL-connectionless-mode unitdata exchange primitive and parameters

DL-UNITDATA-EXCHANGE	Indication at INITIATOR	Indication at RESPONDER
Parameter Name	output	output
Local address	M (1)	M (2)
Remote address	M (2)	M (1)
QoS parameter set		
DLL priority of sent DLS-user data	C (3)	C (4)
DLL priority of received DLS-user data	C (4)	C (3)
Buffer-or-queue DLS-user-identifier	C	C
Status	M	M

NOTES

1. These two parameters designate the same DLSAP-address.
2. These two parameters designate the same DLSAP-address.
3. These two DLL priorities are equal.
4. These two DLL priorities are equal.

24.2.2.1 Local address

The local address parameter conveys an address identifying the local DLSAP at which the DLS occurred. It takes the form of a DLSAP-address DLS-user-identifier in the indication primitive.

24.2.2.2 Remote address

The remote address parameter conveys an address identifying the peer DLSAP at which the DLS occurred. It takes the form of a DLSAP-address in the indication primitive.

NOTE — If the DLS-user has issued a DL-BIND request for the Remote Address, then this parameter also can take the form of a DLSAP-address DLS-user-identifier in the indication primitive.

24.2.3 Quality of Service

The value of the QoS parameter is a list of sub-parameters. The first two sub-parameters are determined during the execution of this instance of the unitdata-exchange service and are reported as part of the service indication primitives.

Two other sub-parameters affect the execution of the service instance but are not explicitly reported. They are derived from the QoS parameters of the relevant DL-BIND request and DL-COMPEL-SERVICE request primitives and are summarized here.

24.2.3.1 DLL priority of sent DLS-user data

This is the priority of the actual DLSDU, if any, which is sent to the remote peer DLS-user, and is greater than or equal to the transaction priority specified in the DL-COMPEL-SERVICE request primitive that initiates the DL-UNITDATA-EXCHANGE service.

24.2.3.2 DLL priority of received DLS-user data

This is the priority of the actual DLSDU, if any, which is received from the remote peer DLS-user, and is greater than or equal to the transaction priority specified in the DL-COMPEL-SERVICE request primitive that initiates the DL-UNITDATA-EXCHANGE service.

24.2.3.3 DLL priority of transaction

This QoS attribute is implicit and is the priority specified in the DL-COMPEL-SERVICE request primitive (see 29.2) that initiated this instance of the DL-UNITDATA-EXCHANGE service.

24.2.3.4 DLL maximum confirm delay

This QoS attribute is implicit and is derived from the corresponding attribute of the DL-BIND request primitive (see 12.3) for the initiating DLSAP-address.

24.2.3.5 Indicate-null-UNITDATA-EXCHANGE-transactions

This QoS attribute is implicit and is derived from the corresponding attribute of the DL-BIND request primitive (see 12.3) for the local DLSAP-address.

24.2.4 Buffer-or-queue DLS-user-identifier

The buffer-or-queue DLS-user-identifier parameter has the same value as a buffer-or-queue DLS-user-identifier parameter from a prior DL-CREATE primitive (or as created by DL-management). It is always present because an explicit buffer or queue necessarily was specified for reception at the indicated priority by the DL-BIND request primitive that established the DL(SAP)-address indicated in the same primitive.

24.2.5 DLS-user data

The DL-connectionless-mode unitdata exchange service allows the exchange of data between DLS-users without alteration by the DLS-provider. The initiating and replying DLS-users may each transmit any integral number of octets greater than zero, up to the limits determined by the transaction priority specified in the DL-COMPEL-SERVICE request primitive (see 29.2) that initiates the DL-UNITDATA-EXCHANGE service, and further constrained by the actual DLL priority of the selected DLSDU.

The service name DL-UNITDATA-EXCHANGE reflects the potentiality for two-way exchange of unitdata, but the actual service also supports unidirectional data transport in either direction. The service also succeeds when neither party has a DLSDU to exchange.

24.2.5.1 Indication primitive at the initiator

a) If the initiating DLS-user

1) has bound a buffer to the initiating DLSAP-address,

i) as a sending buffer; and

ii) at the transaction priority specified in the DL-COMPEL-SERVICE request primitive (see 29.2) that initiates the DL-UNITDATA-EXCHANGE service, or at a higher priority, and

2) if that buffer is not empty,

then:

A) the DLSDU from the highest-priority non-empty buffer shall be sent to the responding DLS-user of the DL-UNITDATA-EXCHANGE service, together with a request for the highest priority available DLSDU whose priority is at least the transaction's priority; and

B) if the selected buffer is non-retentive, then the buffer is emptied upon successful completion of the DL-UNITDATA-EXCHANGE service.

b) Otherwise, if (a) does not apply, then a null DLSDU is sent to the responding DLS-user of the DL-UNITDATA-EXCHANGE service, together with a request for the highest priority available DLSDU whose priority is at least the transaction's priority.

NOTES

1. The initiator and responder addresses and QoS are provided as part of the UNITDATA-EXCHANGE invocation and not from information associated with the buffered DLSDU.

2. DLSDUs can be put in a sending buffer either:

A) by use of the DL-PUT request primitive (see 12.5); or

B) as a result of a DL-BUFFER-RECEIVED or DL-UNITDATA-EXCHANGE indication primitive that uses the same buffer for DLSDU receipt.

c) If a reply DLPDU is received and the reply DLPDU conveys a DLSDU, then

1) if the initiating DLS-user bound a buffer or FIFO queue of maximum depth *K* to the initiator DLSAP-address, as a receiving buffer or queue, at the priority of the response DLSDU, then

i) the newly-received DLSDU is put in the receive buffer or an attempt is made to append the DLSDU to the FIFO receive queue; or

ii) a DL-UNITDATA-EXCHANGE indication primitive notifies the initiating DLS-user of the result of putting the newly-received DLSDU in the receive buffer or of attempting to append it to the FIFO receive queue. When not reporting an error, the DL-UNITDATA-EXCHANGE indication primitive notifies the initiating DLS-user of the priority of the received reply DLSDU.

NOTE — The DL-UNITDATA-EXCHANGE indication primitive does not convey the received DLSDU; the DLSDU must be read using a DL-GET request primitive.

2) otherwise, when (1) does not apply, then the received DLSDU is discarded and a DL-UNITDATA-EXCHANGE indication primitive notifies the initiating DLS-user of the data loss.

d) If a reply DLPDU is received but the reply DLPDU does not convey a DLSDU, then a DL-UNITDATA-EXCHANGE indication primitive notifies the initiating DLS-user of the completion of the unitdata exchange service, unless:

1) no DLSDU has been transferred in either direction; and

2) the Indicate-null-UNITDATA-EXCHANGE-transactions (see 12.3.2.3.1) parameter that was specified as part of the DL-BIND request associated with the initiating DLSAP-address specified that such indications were not to occur.

e) If no reply DLPDU is received and a timeout occurs, then a DL-UNITDATA-EXCHANGE indication primitive notifies the initiating DLS-user of the error.

24.2.5.2 Indication primitive at the responder

If a DLPDU is received as part of the DL-UNITDATA-EXCHANGE service, then:

a) If the DL(SAP)-role of the DLS-user at the responding DLSAP-address:

1) is basic, initiator or group; or

2) is constrained responder and the DLSAP-address of the initiator is not equal to the Remote-DLSAP-address that necessarily was specified as part of the DL-Bind request associated with the responding DLSAP-address,

then a reply DLPDU shall be sent to inform the initiator of the error and no DL-UNITDATA-EXCHANGE indication primitive shall occur at the responder.

b) Otherwise, when (a) does not apply, then if a DLSDU was sent by the initiator as part of the DL-UNITDATA-EXCHANGE service, then:

1) if the receiving DLS-user has bound a buffer or FIFO queue of maximum depth *K* to the called DLSAP-address, as a receiving buffer or queue, at the priority of the response DLSDU, then the newly-received DLSDU is copied into the receive buffer or is appended to the FIFO receive queue if possible.

NOTE — The DL-UNITDATA-EXCHANGE indication primitive does not itself specify the received DLSDU; the DLSDU must be read using a DL-GET request primitive.

2) otherwise, when (1) does not apply, the newly-received DLSDU is discarded.

c) Otherwise, when neither (a) nor (b) apply, then if no DLSDU was sent as part of the DL-UNITDATA-EXCHANGE service, then a consequent local DL-UNITDATA-EXCHANGE indication primitive shall notify the responding DLS-user of the lack of a received DLSDU.

d) When (b) or (c) apply, then:

1) if the responding DLS-user has bound a buffer to the responding DLSAP-address as a sending buffer, at the received transaction's priority or at a higher priority, and if that buffer is not empty, then:

i) the DLSDU from the highest-priority non-empty buffer shall be sent as a reply to the initiating DLS-user of the DL-UNITDATA-EXCHANGE service; and

ii) if the selected buffer is non-retentive, then the buffer shall be set empty after completion of this instance of the DL-UNITDATA-EXCHANGE service.

NOTE — DLSDUs can be put in a sending buffer either:

A) by use of the DL-PUT request primitive (see 12.5); or

B) as a result of a DL-BUFFER-RECEIVED indication or DL-UNITDATA-EXCHANGE indication primitive that uses the same buffer for DLSDU receipt.

2) Otherwise, when (1) does not apply, then the absence of such data shall be reported to the initiating DLS-user of the DL-UNITDATA-EXCHANGE service.

When no error has occurred and no DLSDU has been transferred in either direction, then the indicate-null-UNITDATA-EXCHANGE-transactions (see 12.3.2.3.1) parameter which necessarily was specified as part of the DL-BIND request associated with the responding DLSAP-address determines whether the DL-UNITDATA-EXCHANGE indication occurs or not. In all other cases the primitive shall be issued to the responding DLS-user.

If a DL-UNITDATA-EXCHANGE indication primitive is issued to the responding DLS-user, then the primitive shall notify that DLS-user of:

A) the applicable error condition, if any; or

B) the receipt and priority, or lack of receipt, of a DLSDU from the requesting DLS-user and the priority of the selected reply DLSDU, if any.

24.2.6 Status

The status parameter allows the DLS-user to determine whether an instance of the DL-UNITDATA-EXCHANGE service was provided successfully or failed for the reason specified. The value conveyed in this parameter to the initiator will be as follows:

a) "success";

b) "failure — resource limitation in initiator";

c) "failure — resource limitation in responder";

d) "failure — resource limitation in DLS-provider";

e) "failure — fault in responder";

f) "failure — fault in DLS-provider";

g) “failure — responder address paired with different initiator address”;

h) “failure — incompatible DL(SAP)-role for responder address”;

j) “failure — incompatible DL(SAP)-role for initiator address”;

k) “failure — terminated by unbind of source DLSAP-address”;

m) “failure — no responding DLS-user data specified”;

n) “failure — timeout before transmission”;

p) “failure — timeout after transmission, before reply”; or

q) “failure — reason unspecified”.

The value conveyed in this parameter to the responder will be as follows:

1) “success”;

2) “failure — resource limitation in responder”;

3) “failure — fault in responder”;

4) “failure — no responding DLS-user data specified”; or

5) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, these lists of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

24.2.7 Sequence of primitives

The sequence of primitives in a successful data exchange is defined in the time-sequence diagram in Figure 69.

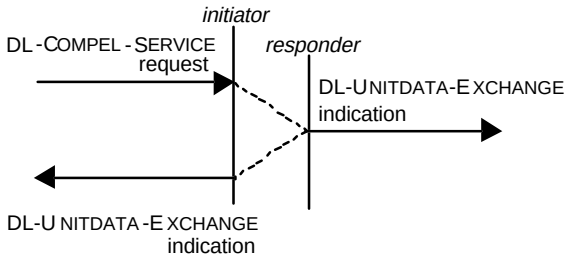


Figure 69 — Sequence of primitives for connectionless-mode unitdata exchange

24.3 Listener query

24.3.1 Function

The listener query service primitives provide for a DLS-user to query the existence of any listeners for a DLSAP-address or a group DL-address. The only information returned is whether the set of listeners appears to be empty.

24.3.2 Types of primitives and parameters

Table 25 indicates the types of primitives and the parameters needed for listener query.

Table 25 — Listener query primitives and parameters

DL-LISTENER-QUERY	Request	Confirm
Parameter Name	input	
Request DLS-user-identifier	M	M (=)
Called address	M	
QoS Parameters		
Maximum confirm delay	U	
Status		M

24.3.2.1 Request DLS-user-identifier

The request DLS-user-identifier parameter, which is specified by the requesting DLS-user on DL-LISTENER-QUERY request primitives, provides a local means of pairing the resulting DL-LISTENER-QUERY confirm primitive with the causative DL-LISTENER-QUERY request primitive.

24.3.2.2 Called address

The called address parameter identifies the DLSAP-address or group DL-address about which the DLS-user is querying.

24.3.2.3 QoS parameters

24.3.2.3.1 Maximum confirm delay

The maximum confirm delay parameter allows the DLS-user to specify the maximum time duration permitted for the completion of the primitive. This parameter is defined and its default value is specified in 8.2 and 12.3.2.6.2.

The interval specified is the maximum permissible delay between the issuing of the DL-LISTENER-QUERY request primitive and the issuing of the corresponding DL-LISTENER-QUERY confirm primitive.

24.3.2.4 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was initiated successfully or failed for the reason specified, and whether any listening DLS-users appear to exist or not. The value conveyed in this parameter will be as follows:

a) “success — a listener exists”;

b) “failure — timeout”; or

c) “failure — reason unspecified”.

NOTES

1. The status “failure — timeout” may be interpreted with an unknown degree of confidence as “success — no listeners”

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard which provides services as specified in this part of this International Standard.

24.3.3 Sequence of primitives

The sequence of primitives in a successful listener query is defined in the time-sequence diagram in

Figure 70. The scheduling of DL-LISTENER-QUERY is always IMPLICIT.

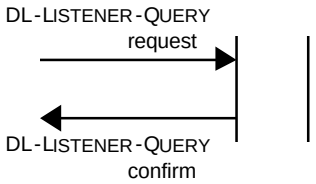


Figure 70 — Sequence of primitives for connectionless-mode listener query

25 Facilities and classes of the time and scheduling guidance Data Link Service

The DLS provides the following facilities to the DLS-user:

a) A means by which a DLS-user can request the current value of DL-time from the DLS-provider. This internal DL-time can have a resolution of a fraction of a microsecond and has a period of over 50 years. DLEs on the extended link which support a common sense of DL-time can usually synchronize that common time sense to within 1 ms and in some cases to within 10 μs. Thus this DL-service provides a means for DLS-users to indirectly synchronize and schedule their activities via this shared sense of DL-time.

b) A means by which a DLS-user can compel the DLS-provider to complete one already-issued DLS-request primitive whose execution has been deferred at the issuing DLS-user's request, and which was issued by the DLS-user itself with a local DLSAP-address or from a local DLCEP.

c) A means by which a local DLS-user can compel the DLS-provider to complete one already-issued DLS-request primitive whose execution has been deferred at the remote DLS-user's request, and which was issued by that remote DLS-user who is the peer or publisher connected to the local DLS-user's peer or subscriber DLCEP.

d) A means by which a publishing or subscribing DLS-user to an UNORDERED or ORDERED multi-peer DLC can compel the DLS-provider to distribute the current value of the buffer associated with the publishing DLCEP to the subscribing DLS-users at their subscribing DLCEPs.

e) A means by which a DLS-user can compel the DLS-provider to initiate the DL-UNITDATA-EXCHANGE service at a specified priority between a specified local DLSAP-address whose DL(SAP)-role binding is INITIATOR and another specified DLSAP-address whose DL(SAP)-role binding is UNCONSTRAINED RESPONDER or CONSTRAINED RESPONDER.

f) A means by which a DLS-user can group one or more requests of the types enumerated in (b), (c), (d), or (e) into a sequence and schedule that sequence for either one-time or periodic or repetitive DL-service.

g) A means by which a DLS-user can cancel a scheduled sequence of the type specified in (f).

h) A means by which a DLS-user can dynamically select a subset of a previously-scheduled sequence of the type specified in (f).

There are eight defined classes of time-related DLS:

1) **1 μs**, which offers a time-sense granularity of 1 μs or less and a maximal time differential from the network's time sense of 1 μs or less;

2) **10 μs**, which offers a time-sense granularity of 10 μs or less and a maximal time differential from the network's time sense of 10 μs or less;

3) **100 μs**, which offers a time-sense granularity of 100 μs or less and a maximal time differential from the network's time sense of 100 μs or less;

4) **1 ms**, which offers a time-sense granularity of 1 ms or less and a maximal time differential from the network's time sense of 1 ms or less;

5) **10 ms**, which offers a time-sense granularity of 10 ms or less and a maximal time differential from the network's time sense of 10 ms or less;

6) **100 ms**, which offers a time-sense granularity of 100 ms or less and a maximal time differential from the network's time sense of 100 ms or less;

7) **1 s**, which offers a time-sense granularity of 1 s or less and a maximal time differential from the network's time sense of 1 s or less; and

8) **unknown**, which offers a time-sense based on observing the most recent time-synchronization broadcast on the network, with a granularity and maximal time differential from the network's time sense based on that system-dependent frequency of broadcast.

NOTE — These classes provide an aggregate measure of local and reference DLE clock resolution and drift rate and of the frequency of time distribution on the local link.

26 Model of the time and scheduling guidance Data Link Service

This part of this International Standard uses the abstract model for a layer service defined in clause 4 of ISO/TR 8509 and ISO/IEC 10731. The model defines interactions between the DLS-user and the DLS-provider that take place at a DLSAP. Information is passed between the DLS-user and the DLS-provider by DL-service-primitives that convey parameters.

27 Quality of scheduling guidance service

The term "Quality of Service" (QoS) refers to certain characteristics of scheduling guidance for data transmission as observed between the DLSAPs and DLCEPs. QoS describes aspects of scheduling guidance that are attributable solely to the DLS-provider. QoS can only be properly determined when DLS-user behavior does not constrain or impede the performance of the DLS.

28 Sequence of primitives at one DLE

28.1 Constraints on sequence of primitives

This subclause defines the constraints on the sequence in which the primitives defined in clause 29 may occur. The constraints determine the order in which primitives occur but may not fully specify when they may occur. Other constraints may affect the ability of a DLS-user or a DLS-provider to issue a primitive at any particular time.

The scheduling guidance primitives and their parameters are summarized in Table 26. The relationships among the primitives at a single DLE are shown in Figure 71.

Table 26 — Summary of DL-scheduling-guidance primitives and parameters

Service	Primitive	Parameter
TIME QUERY	DL-TIME request	(*out* DL-time-quality, DL-time)
COMPEL SERVICE	DL-COMPEL-SERVICE request	(*in* Action class, optional Schedule DL-identifier, *out* Status)
SCHEDULE SEQUENCE	DL-SCHEDULE-SEQUENCE request	(*in* Schedule DLS-user-identifier. Sequence definition, optional Sequence priority, optional Schedule type, Starting conditions, Cycle specifications, optional DLSEP-address, *out* Schedule DL-identifier)
	DL-SCHEDULE-SEQUENCE confirm	(*out* Status, Schedule DLS-user-identifier, Scheduled starting time)
CANCEL SCHEDULE	DL-CANCEL-SCHEDULE request	(*in* Schedule DL-identifier)
	DL-CANCEL-SCHEDULE confirm	(*out* Schedule DLS-user-identifier)
	DL-CANCEL-SCHEDULE indication	(*out* Schedule DLS-user-identifier, Reason)
SUBSET SCHEDULE	DL-SUBSET-SEQUENCE request	(*in* Request DLS-user-identifier, Schedule DL-identifier, Subset mask)
	DL-SUBSET-SEQUENCE confirm	(*out* Request DLS-user-identifier, Status)

NOTE — DL-identifiers in parameters are local and assigned by the DLS-provider. DLS-user-identifiers in parameters are local and assigned by the DLS-user. Both types of identifiers are used by both the DLS-user and DLS-provider, as appropriate, to designate a specific DL(SAP)-address, DLCEP, schedule, buffer-or-queue at the DLS interface.

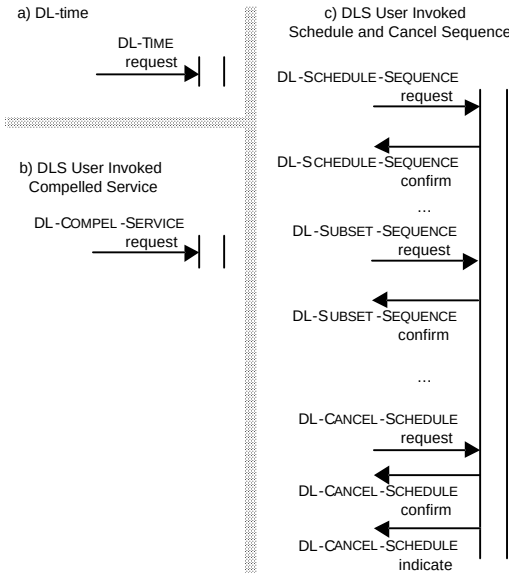


Figure 71 — Summary of time and scheduling-guidance service primitive time sequence diagrams

29 Scheduling guidance functions

Scheduling guidance functions permit a DLS-user to influence the timing or manner in which DL-services are provided. The use of many of these functions may occur more in a DL-management context than in an operational context. However, the functions are defined in this part of this International Standard so that they may be used in an operational context.

NOTE — It is anticipated that the operational use of these functions will prove increasingly important as experience is gained in the standardized use of time-critical communications.

29.1 DL-time

29.1.1 Function

The DL-scheduling-guidance DL-Time service primitive provides for a DLS-user to request the current sense of DL-time from the DLS-provider.

The base unit of this DL-time shall be 1 ms, with a potential resolution finer than 1 µs. The representation of DL-time shall be unique within a period of 50 years.

This time sense shall be synchronizable among DLEs on the extended link to within 1 µs, 10 µs, 100 µs, 1 ms, 10 ms, 100 ms, or 1 s, as determined by the time-synchronism classes of the devices in the synchronization path and any limitations imposed by the data rates of their interconnecting Physical Layer subsystems.

NOTES

1. Synchronization to within 10 µs may not be possible in systems where one of the PhEs has a signaling rate of less than 1 M bit/s, or where the asymmetry in PhL propagation delays between transmit (A → B) and receive (B → A) on any one local link exceeds 2 µs. Synchronization to within 1 ms may not be possible in systems where one of the PhEs has a signaling rate of less than 4 k bit/s, or where the asymmetry in PhL propagation delays between transmit (A → B) and receive (B → A) on any one local link exceeds 250 µs. Similar consid-

erations apply for the other time-synchronism classes.

2. Higher layer entities may correlate the DL-time with external time such as UTC or local human time or may cause the DL-time to be based on such external time.

3. Implementations are permitted to maintain an arbitrary granularity consistent with their time-synchronism class, provided that they do so in a manner that is interoperable at both the DLS-interface and within the DL-protocol.

29.1.2 Types of primitives and parameters

Table 27 indicates the primitive and parameters needed for DL-time.

Table 27 — DL-time primitive and parameters

DL-TIME	**Request**
Parameter Name	output
DL-time-quality	M
DL-time	M

29.1.2.1 DL-time-quality

The DL-time-quality parameter conveys both:

NOTE — A formal DL-programming-interface specification would include the detailed encoding of this multi-component parameter.

a) the reference source, if any, of DL-time:

   1) universal coordinated time (UTC) electronically synchronized with a reference source;

      NOTE — This may be obtained from an appropriate source such as a specialized radio receiver or a local atomic clock.

   2) universal coordinated time (UTC), whether obtained from a human or by electronic means, which can drift relative to the reference source;

   3) human-entered social time (that is, local date and time in some time zone); or

   4) DLS-provider-originated time (that is, not synchronized to any external time sense)

      NOTE — This time sense will be measured relative to the activation of the DLS-provider and will not be correlated with any sense of external time.

b) the time-synchronism maintained by the DLS-provider when propagating that time from the DL-time source to the local DLE and within all of the DLEs involved in that time propagation path. That time-synchronism includes

   1) the granularity of the synchronization between the DL-time source and the local DLE; and

   2) the number of intervening links on the DL-time propagation path from the DL-time source DLE to the local DLE, where a value of zero indicates that the DL-time originated within the local DLE itself.

The time-synchronism may also convey additional DL-protocol-specific information.

29.1.2.2 DL-time

The DL-time parameter conveys the current DLL synchronized sense of time to the DLS-user. DLS-users can use this DL-time to achieve close time synchronization throughout a single extended link. To facilitate

synchronization with other DLS-users on the local link, without any interference due to synchronization over the extended link, the DL-time may be represented as a sum of more than one component.

29.1.3 Sequence of primitives

The sequence of primitives for obtaining the DL-time is defined in the time-sequence diagram in Figure 72.

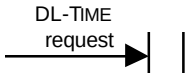


Figure 72 — Sequence of primitives for DL-time

29.2 Compel service

29.2.1 Function

The DL-scheduling-guidance Compel-Service service-primitive provides a means by which:

a) a DLS-user can compel the DLL to complete one already-issued DLS-request primitive whose execution has been deferred (awaiting explicit scheduling) at the issuing DLS-user's request, and which was issued by the DLS-user itself with a local DLSAP-address or from a local DLCEP;

b) a local DLS-user can compel the DLL to complete one already-issued DLS-request primitive whose execution has been deferred (awaiting explicit scheduling) at the remote DLS-user's request, and which was issued by that remote DLS-user who is the peer or publisher connected to the local DLS-user's peer or subscriber DLCEP;

c) a DLS-user to an UNORDERED or ORDERED DLC can compel the DLL to distribute the current value of a buffer associated with the local DLCEP to the remote DLS-user(s) of that DLC;

d) a DLS-user of an UNORDERED or ORDERED peer DLC can compel the DLL to distribute the current value of a buffer associated with the remote peer DLCEP to the requesting DLS-user;

e) a publishing or subscribing DLS-user to an UNORDERED or ORDERED multi-peer DLC can compel the DLL to distribute the current value of a buffer associated with the publishing DLCEP to the subscribing DLS-users at their subscribing DLCEPs; and

f) a DLS-user can compel the DLL to initiate the DL-UNITDATA-EXCHANGE service (see 24.2) at a specified priority between a specified local (that is, bound to the DLS-user's DLSAP) DLSAP-address whose DL(SAP)-role binding is INITIATOR and another specified DLSAP-address whose DL(SAP)-role binding is CONSTRAINED RESPONDER or UNCONSTRAINED RESPONDER.

29.2.2 Types of primitives and parameters

Table 28 indicates the primitive and parameters needed for the Compel Service service.

Table 28 — DL-scheduling-guidance Compel Service primitive and parameters

DL-COMPEL-SERVICE	**Request**	
Parameter Name	input	output
Action class	M	
DLCEP DL-identifier	C	
local-DLSAP-address DL-identifier	C	
remote-DLSAP-address	C	
DLL-priority	C	
optional Schedule DL-identifier	U	
Status		M

29.2.2.1 Action class

The Action class parameter specifies whether the scheduling action is either:

a) to compel execution of a deferred DLS-primitive or to compel publishing, at a specified local DLCEP;

b) to compel execution of a deferred DLS-primitive or to compel publishing, at the remote peer or publishing DLCEP associated with a specified local DLCEP,

c) to compel execution of a deferred DLS-primitive from a specified local DLSAP-address; or

d) to compel exchanging unitdata between specified local initiator and remote responder DLSAP-addresses at a specified or higher priority.

The values of the Action class parameter are **LOCAL-DLCEP**, **REMOTE-DLCEP**, **LOCAL-DLSAP-ADDRESS**, and **UNITDATA-EXCHANGE**.

29.2.2.1.1 DLCEP DL-identifier

The DLCEP DL-identifier parameter is present when the action class parameter has the value LOCAL-DLCEP or REMOTE-DLCEP. The DLCEP DL-identifier parameter identifies the specific DLC at the local DL-service interface on which a deferred DLS-primitive is being compelled to execute, or on which a publisher is being compelled to publish.

If the action class parameter has the value LOCAL-DLCEP, then the compelled execution of the deferred DLS-primitive, or the compelled publishing, occurs at that local DLCEP. If the action class parameter has the value REMOTE-DLCEP, then the compelled execution of the deferred DLS-primitive, or the compelled publishing, occurs at the remote DLCEP that is the peer or publisher of the local DLCEP's DLC.

29.2.2.1.2 Local-DLSAP-address DL-identifier

The local-DLSAP-address DL-identifier parameter is present when the action class parameter has the value LOCAL-DLSAP-ADDRESS or UNITDATA-EXCHANGE.

If the action class parameter has the value LOCAL-DLSAP-ADDRESS, then this parameter specifies the DLSAP-address at the local DL-service interface at which a deferred DL-UNITDATA request primitive is being compelled to execute.

If the action class parameter has the value UNITDATA-EXCHANGE, then this parameter specifies the DLSAP-address at the local DL-service interface at which a compelled implicit DL-UNITDATA-EXCHANGE service (see 24.2) is initiated. The DLSAP must be bound to this DLSAP-address with a DL(SAP)-role of INITIATOR.

29.2.2.1.3 Remote-DLSAP-address

The remote-DLSAP-address parameter is present when the action class parameter has the value UNITDATA-EXCHANGE. This parameter specifies the responder DLSAP-address for the compelled implicit DL-UNITDATA-EXCHANGE service. The peer DLS-user, through its DLSAP, must be bound to this DLSAP-address with a DL(SAP)-role of UNCONSTRAINED RESPONDER or CONSTRAINED RESPONDER.

NOTE — If the DLS-user has issued a DL-BIND request for the remote-DLSAP-address, then this parameter also can take the form of a DLSAP-address DL-identifier in the indication primitive.

29.2.2.1.4 DLL-priority

The DLL-priority parameter is present when the action class parameter has the value LOCAL-DLSAP-ADDRESS or UNITDATA-EXCHANGE. This parameter specifies the minimum priority permitted for any DLSDU conveyed during the compelled DL-UNITDATA service or the compelled implicit DL-UNITDATA-EXCHANGE service.

29.2.2.2 Schedule DL-identifier

The optional Schedule DL-identifier parameter specifies the schedule DL-identifier returned by a successful prior DL-SCHEDULE-SEQUENCE confirm primitive whose schedule has not yet been canceled, and whose associated sequence definition permits dynamic sequence construction.

When this parameter is absent, the DLE schedules the compelled DLS-user request for service on the same IMPLICIT basis as implicitly-scheduled requests (see 8.4). When this parameter is present, the DLE dynamically appends the compelled request to the specified sequence for one-time execution when that sequence is next executed by the DLE.

29.2.2.3 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — inappropriate request”; or

c) “failure — reason unspecified”.

NOTES

1. Successful completion of a compel-service request does not imply successful completion of the compelled DLS-primitive or compelled publishing or unitdata-exchange, but only that the DLE has been able to commit to the requested activity.

2. Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard which provides services as specified in this part of this International Standard.

29.2.3 Sequence of primitives

The sequence of primitives in the Compel Service service is defined in the time-sequence diagram of Figure 73.

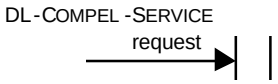


Figure 73 — Sequence of primitives for the Compel Service service

29.3 Schedule sequence

29.3.1 Function

The DL-scheduling-guidance schedule sequence service primitives provide for a DLS-user to schedule a predefined or dynamically-defined sequence of DL-COMPEL-SERVICE requests for subsequent execution, either:

a) one time only, or periodically (that is, cyclically with a specified period) until canceled, starting at a specified time or within a specified time interval; or

b) repetitively but not intentionally periodically, as frequently as possible, but no more than once per major DLL scheduling cycle of the local link.

NOTE — Periodic repetition supports a paradigm commonly used in sampled-data control systems that use mathematical algorithms based on the arithmetic of finite differences. A periodic repetition supports a paradigm commonly used by programmable logic controllers, where the basic cycle of the (distributed) machine is repeated as frequently as possible without concern for a fixed repetition period. These scheduling primitives permit the two to coexist on a single local link.

29.3.2 Types of primitives and parameters

Table 29 indicates the types of primitives and the parameters needed for the Schedule Sequence service.

29.3.2.1 Local-view DL-identifiers

29.3.2.1.1 Schedule DLS-user-identifier

The schedule DLS-user-identifier parameter specifies a means of referring to the schedule in output parameters of other local DLS primitives that convey the name of the schedule from the local DLE to the local DLS-user.

The naming-domain of the schedule DLS-user-identifier is the DLS-user's local-view.

29.3.2.1.2 Schedule DL-identifier

The schedule DL-identifier parameter, which is returned by the DLS-provider on successful DL-SCHEDULE-SEQUENCE request primitives, provides a local means of identifying a specific scheduling request in input parameters of other local DLS primitives that convey the name of the schedule from the local DLS-user to the local DLE.

The naming-domain of the schedule DL-identifier is the DL-local-view.

Table 29 — DL-scheduling-guidance Schedule Sequence primitives and parameters

DL-SCHEDULE-SEQUENCE	**Request**		**Confirm**
Parameter Name	input	output	output
Schedule DLS-user-identifier	M		M (=)
Schedule DL-identifier		M	
Sequence definition	M		
Sequence priority	U		
Schedule type	U		
Starting conditions			
Desired starting time	CU		
Earliest starting time	CU		
Latest ending time	CU		
Cycle specifications			
Cycle period	C		
Maximum permissible jitter	CU		
DLSEP-address	U		
Status			M
Scheduled starting time			C

29.3.2.2 Sequence definition

The sequence definition parameter specifies a sequence of encoded[1] DL-COMPEL-SERVICE requests, including constraints among the sequence elements on the execution order and contiguous execution

requirements of the sequence, and on whether the Subset Sequence service (see 29.5) can be used to subset the defined sequence dynamically.

The sequence definition may also specify that additional DL-COMPEL-SERVICE requests may be dynamically appended to the schedule for one-time execution, up to some DLS-user-specified limit on required additional link-capacity, through use of the optional schedule DL-identifier parameter of the DL-COMPEL-SERVICE request primitive. Subsetting does not apply to these dynamically-appended requests.

The DLS-provider will attempt to schedule the sequence according to its internal constraints and the other parameters in the current request.

NOTES

1. Scheduling request that do not require contiguous execution are more readily satisfied than ones which do, since the former permit the newly-requested transactions to be interleaved with currently-scheduled transactions while meeting the other scheduling constraints.

2. A formal DL-programming-interface specification would include the details of the sequence definition's encoding.

29.3.2.3 Sequence priority

This parameter specifies an optional DLS-provider priority (see 8.1) for scheduling of the sequence relative to other such sequences. Its default value is TIME-AVAILABLE.

29.3.2.4 Schedule type

The schedule type parameter specifies whether the sequence is to be scheduled for one-time or periodic execution or repetitive but not intentionally periodic execution. Its values are **ONE-TIME**, **PERIODIC,** and **REPETITIVE**. Its default value is ONE-TIME.

NOTE — REPETITIVE scheduling is a mode of scheduling in which execution of the specified sequence occurs as frequently as possible but in an equitable fashion that gives access opportunities to all DLEs on the local link. It is provided to support migration of prior national standards.

29.3.2.5 Starting conditions

This compound parameter specifies the conditions that determine when the scheduled sequence will be executed. These parameters are present when the schedule type parameter has the value PERIODIC or ONE-TIME.

29.3.2.5.1 Desired starting time

The Desired Starting Time parameter specifies the internal DL-time (see 29.1) at which execution of the specified sequence of DLS requests should start. The value of this parameter shall be either **IMMEDIATE** (meaning as-soon-as-possible) or a future DL-time within the interval from the current moment to the current moment plus 26 hours. The default value for this parameter is IMMEDIATE. The granularity of any specified DL-time shall be as described in 29.1.1.

NOTE — The interval of 26 hours provides the ability to schedule events one full day in advance, even when that day has 25 hours to account for changes in external social (human) time.

29.3.2.5.2 Earliest starting time

The Earliest Starting Time parameter specifies the earliest internal DL-time at which execution of the specified sequence of DLS requests may start. The value of this parameter shall be either IMMEDIATE or a future

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1 See NOTE 2

DL-time within the interval from the current moment to the moment specified by the Desired Starting Time parameter. The default value for this parameter is IMMEDIATE. The granularity of any specified DL-time shall be as described in 29.1.1.

29.3.2.5.3 Latest ending time

The Latest Ending Time parameter specifies the latest internal DL-time by which execution of the first instance of the specified sequence of DLS requests must complete. The value of this parameter shall be a future DL-time within the interval from the moment specified by the Desired Starting Time parameter to the current moment plus 26 hours. The default value for this parameter is the current moment plus 26 hours — the maximum specifiable. The granularity of this parameter shall be as described in 29.1.1.

29.3.2.6 Cycle specifications

This compound parameter specifies the conditions that determine the repetition interval when the scheduled sequence is to be executed repeatedly with a fixed periodicity. These parameters are present when the schedule type parameter has the value PERIODIC.

NOTE — No such conditions are needed when the sequence is to be executed repetitively.

29.3.2.6.1 Cycle period

The Cycle Period parameter specifies the increment in DL-time between successive starting times for the scheduled sequence. Its value shall be less than 26 hours. The granularity of this parameter shall be as described in 29.1.1.

NOTE — The DLS-provider will impose a lower limit on this parameter based upon link characteristics and configuration, and possibly on existing schedule commitments,

29.3.2.6.2 Maximum permissible jitter

The Maximum Permissible Jitter parameter specifies a single upper bound on the deviation in the starting time of any single period from the nominal starting time for that period, where that nominal starting time is the Scheduled Starting Time returned by the DL-SCHEDULE-SEQUENCE confirm primitive plus a multiple of the specified Cycle Period parameter. The value of this parameter shall be less than the value of the Cycle Period parameter. The default value for this parameter is zero. The granularity of this parameter shall be as described in 29.1.1.

NOTE — Specifying a non-zero value for this parameter permits improved link utilization and may permit requests to be added to an existing schedule that would otherwise have to be rejected due to conflicting timing requirements.

29.3.2.7 DLSEP-address

The optional DLSEP-address parameter conveys a specific DLSEP-address (structurally similar to a DLCEP-address and drawn from the same address space) for use as the local DLSEP-address for scheduled sequence execution. When this parameter is absent, the DLE chooses a DLSEP-address from those available to it and associates the DLSEP-address with the scheduled sequence.

29.3.2.8 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — invalid sequence definition”;

c) “failure — insufficient resources”;

d) “failure — cannot commit to requested start window”;

e) “failure — cannot commit to requested periodicity”;

f) “failure — parameter violates management constraint”;

g) “failure — number of requests violates management constraint”; or

h) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

29.3.2.9 Scheduled starting time

The Scheduled Starting Time parameter is present when the Schedule Type parameter specifies ONE-TIME or PERIODIC and the Status parameter indicates that the sequence was scheduled successfully. The Scheduled Starting Time parameter specifies the internal DL-time at which execution of the specified sequence of DLS requests started or is scheduled to start. The value of this parameter is a DL-time within the interval from the moment of the corresponding request to that moment plus 26 hours. The granularity of this parameter shall be as described in 29.1.1.

29.3.3 Sequence of primitives

The sequence of primitives in successfully scheduling a defined sequence, and later possibly canceling the scheduled sequence, is defined in the time-sequence diagram of Figure 74.

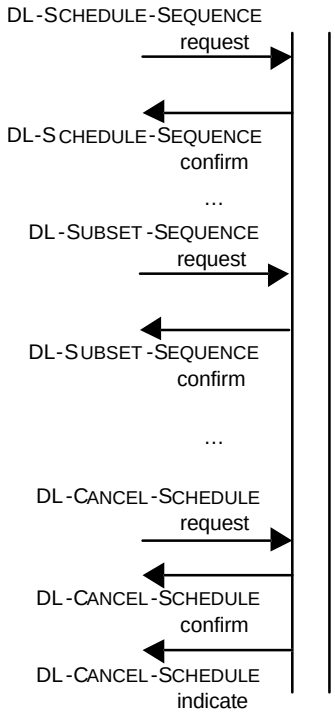

Figure 74 — Sequence of primitives for the sequence scheduling services

29.4 Cancel schedule

29.4.1 Function

The DL-scheduling-guidance cancel schedule service primitives provide for a DLS-user to cancel a previously scheduled sequence and release the schedule DL-identifier and DLS-provider resources associated with that schedule.

NOTE — This cancellation and release may not be instantaneous.

In some cases the DLS-provider may find it necessary to cancel a previously-committed schedule. Such an event is indicated to the scheduling DLS-user by the DL-SCHEDULE-SEQUENCE indication primitive.

29.4.2 Types of primitives and parameters

Table 30 indicates the types of primitives and the parameters needed for the cancel schedule service.

Table 30 — DL-scheduling-guidance Cancel Schedule primitives and parameters

DL-CANCEL-SCHEDULE	Request	Confirm	Indication
Parameter Name	input	output	output
Schedule DL-identifier	M		
Schedule DLS-user-identifier		M	M
Reason			M

29.4.2.1 Schedule DL-identifier

The Schedule DL-identifier parameter specifies the schedule DL-identifier returned by a successful prior DL-SCHEDULE-SEQUENCE confirm primitive whose schedule has not yet been canceled. The DLS-provider will cancel the schedule associated with the DL-identifier and release the schedule DL-identifier and associated DLS-provider resources.

29.4.2.2 Schedule DLS-user-identifier

The schedule DLS-user-identifier parameter has the same value as the schedule DLS-user-identifier or DL-identifier parameter from the corresponding earlier DL-SCHEDULE-SEQUENCE request or confirm primitive.

29.4.2.3 Reason

The reason parameter gives information about the cause of the sequence cancellation. The value conveyed in this parameter will be as follows:

a) “schedule preemption”;

b) “loss-of-schedule — rescheduling required”; or

c) “reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

29.4.3 Sequence of primitives

The sequence of primitives in canceling a scheduled sequence is defined in the time-sequence diagram in Figure 74. Unrequested cancellation by the DLS-provider is also shown.

29.5 Subset sequence

29.5.1 Function

The DL-scheduling-guidance subset sequence service primitives provide for a DLS-user to select dynamically a subset of a previously-scheduled subsettable sequence.

NOTE — This subsetting action may not be instantaneous.

29.5.2 Types of primitives and parameters

Table 31 indicates the types of primitives and the parameters needed for the subset sequence service.

Table 31 — DL-scheduling-guidance Subset Sequence primitives and parameters

DL-SUBSET-SEQUENCE	Request	Confirm
Parameter Name	input	output
Request DLS-user-identifier	M	M (=)
Schedule DL-identifier	M	
Subset mask	M	
Status		M

29.5.2.1 Request DLS-user-identifier

The Request DLS-user-identifier parameter, specified by the DLS-user on DL-SUBSET-SEQUENCE request primitives, provides a local means of pairing the resulting DL-SUBSET-SEQUENCE confirm primitive with the causative DL-SUBSET-SEQUENCE request primitive.

29.5.2.2 Schedule DL-identifier

The Schedule DL-identifier parameter specifies the schedule DL-identifier returned by a successful prior DL-SCHEDULE-SEQUENCE confirm primitive whose schedule has not yet been canceled. The DLS-provider will subset the schedule associated with the identifier.

29.5.2.3 Subset mask

The subset mask specifies the subset of the defined sequence that is to be excluded from the operational schedule.

NOTES

1. A formal DL-programming-interface specification would include the details of the subset mask's encoding.

2. The name and definition of this parameter are not intended to constrain the form of a conforming implementation. In particular, the subset mask need not be represented as a Boolean vector.

29.5.2.4 Status

The status parameter allows the DLS-user to determine whether the requested DL-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) "success";

b) "failure — sequence is not defined";

c) "failure — sequence is not subsettable"; or

d) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

29.5.3 Sequence of primitives

The sequence of primitives in subsetting a scheduled sequence is defined in the time-sequence diagram in Figure 74.

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Annex A — (normative) DL-Management service definition

(This annex forms an integral part of this standard.)

A.1 Scope and inheritance

This annex to Part 3 of this International Standard defines the form of DL-management services for protocols that implement the DL-services specified in the body of this part of this International Standard. Except for the difference in the intended class of users, clauses 1 through 5 of the body of this Part of this International Standard apply to this annex.

A.2 Facilities of the DL-management service

DL-management facilities provide a means for:

a) writing DLE configuration parameters;

b) reading DLE configuration parameters, operational parameters and statistics;

c) commanding major DLE actions; and

d) receiving notification of significant DLE events.

Together these facilities constitute the DL-management-service (DLMS).

A.3 Model of the DL-management service

This annex to this part of this International Standard uses the abstract model for a layer service defined in clause 4 of ISO/TR 8509 and ISO/IEC 10731. The model defines local interactions between the DLMS-user and the DLMS-provider. Information is passed between the DLMS-user and the DLMS-provider by DLM-service-primitives that convey parameters.

A.4 Constraints on sequence of primitives

This subclause defines the constraints on the sequence in which the primitives defined in A.5 through A.8 may occur. The constraints determine the order in which primitives occur, but do not fully specify when they may occur.

The DL-management primitives and their parameters are summarized in Table A.1. The only primitives with a relationship are shown in Figure A.1.

Table A.1 — Summary of DL-management primitives and parameters

Service	Primitive	Parameter
writing managed objects	DLM-SET request	(*in* DLM-object-identifier, Desired-value, *out* Status)
reading managed objects	DLM-GET request	(*in* DLM-object-identifier, *out* Status, Current-value)
commanding actions	DLM-ACTION request	(*in* Request DLMS-user-identifier, Desired-action, *out* Status)
	DLM-ACTION confirm	(*out* Request DLMS-user-identifier, Status)
notification of events	DLM-EVENT indication	(*out* DLM-event-identifier)
NOTE— DLMS-user-identifiers in parameters are local and assigned by the DLMS-user to designate a specific request at the DLMS interface.		

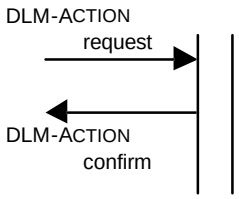

Figure A.1 — Sequence of primitives for the DLM action service

A.5 Set

A.5.1 Function

The set DLM-service-primitive can be used to set (write) the value of a DLE configuration parameter.

A.5.2 Types of parameters

Table A.2 indicates the primitive and parameters needed for the set DLM-service.

Table A.2 — DLM-Set primitive and parameters

DLM-SET	Request	
Parameter Name	input	output
DLM-object-identifier	M	
Desired-value	M	
Status		M

A.5.2.1 DLM-object-identifier

The DLM-object-identifier parameter specifies the primitive or composite object within the DLE whose value is to be altered. The naming-domain of the DLM-object-identifier is the DLM-local-view.

A.5.2.2 Desired-value

The desired-value parameter specifies the desired value for the DLM-object specified by the associated DLM-object-identifier. Its type is identical to that of the specified DLM-object.

A.5.2.3 Status

The status parameter allows the DLMS-user to determine whether the requested DLM-service was provided successfully, or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — DLM-object-identifier is unknown”;

c) “failure — desired-value is not permitted”; or

d) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

A.6 Get

A.6.1 Function

The get DLM-service-primitive can be used to get (read) the value of a DLE configuration parameter, operational parameter, or statistic.

A.6.2 Types of parameters

Table A.3 indicates the primitive and parameters needed for the get DLM-service.

Table A.3 — DLM-Get primitive and parameters

DLM-GET	**Request**	
Parameter Name	input	output
DLM-object-identifier	M	
Status		M
Current-value		C

A.6.2.1 DLM-object-identifier

The DLM-object-identifier parameter specifies the primitive or composite object within the DLE whose value is being requested. The naming-domain of the DLM-object-identifier is the DLM-local-view.

A.6.2.2 Status

The status parameter allows the DLMS-user to determine whether the requested DLM-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — DLM-object-identifier is unknown”; or

c) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

A.6.2.3 Current-value

The current-value parameter is present when the status parameter indicates that the requested service was performed successfully. The current-value parameter specifies the current value for the DLM-object specified by the associated DLM-object-identifier. Its type is identical to that of the specified DLM-object.

A.7 Action

A.7.1 Function

The action DLM-service-primitive can be used to command a specified action of the DLE.

A.7.2 Types of parameters

Table A.4 indicates the primitives and parameters needed for the action DLM-service.

Table A.4 — DLM-Action primitive and parameters

DLM-ACTION	**Request**	**Confirm**
Parameter Name	input	output
Request DLMS-user-identifier	M	M (=)
Desired-action	M	
Action-qualifiers	C	
Status		M
Additional-information		C

A.7.2.1 Request DLMS-user-identifier

The Request DLMS-user-identifier parameter, which is specified by the DLMS-user on DLM-ACTION request primitives, provides a local means of pairing the resulting DLM-ACTION confirm primitive with the causative DLM-ACTION request primitive. The naming-domain of this request identifier is the DLMS-user-local-view.

A.7.2.2 Desired-action

The Desired-action parameter specifies the desired action which the DLE should take.

A.7.2.2.1 Action-qualifiers

The optional action-qualifiers parameter specifies additional action-specific parameters that serve to qualify the commanded action.

A.7.2.3 Status

The status parameter allows the DLMS-user to determine whether the requested DLM-service was provided successfully or failed for the reason specified. The value conveyed in this parameter will be as follows:

a) “success”;

b) “failure — action is unknown”;

c) “failure — action is not permitted in current DLE state”;

d) “failure — action did not complete”; or

e) “failure — reason unspecified”.

NOTE — Addition to, or refinement of, this list of values to convey more specific diagnostic and management information is permitted in a DL-protocol standard that provides services as specified in this part of this International Standard.

A.7.2.3.1 Additional-information

The optional additional-information parameter provides action-specific additional information that augments the returned status.

A.7.3 Sequence of primitives

The sequence of primitives in a successful DLM-commanded action is defined in the time-sequence diagrams in Figure A.1.

A.8 Event

A.8.1 Function

The event DLM-service-primitive is used to report the occurrence of a DL-event that could be of significance to DL-management.

A.8.2 Types of parameters

Table A.5 indicates the primitive and parameters needed for the event DLM-service.

Table A.5 — DLM-Event primitive and parameters

DLM-EVENT	**Indication**
Parameter Name	output
DLM-event-identifier	M
Additional-information	C

A.8.2.1 DLM-event-identifier

The DLM-event-identifier parameter specifies the primitive or composite event within the DLE whose occurrence is being announced. The naming-domain of the DLM-event-identifier is the DLM-local-view.

A.8.2.1.1 Additional-information

The optional additional-information parameter provides event-specific additional information.

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