

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Industrial communication networks – Fieldbus specifications –  
Part 3-21: Data-link layer service definition – Type 21 elements**

**Réseaux de communication industriels – Spécifications des bus de terrain –  
Partie 3-21: Définition des services de couche liaison de données – Eléments  
de Type 21**

Withdrawn



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**INDUSTRIAL COMMUNICATION NETWORKS –  
FIELDBUS SPECIFICATIONS –****Part 3-21: Data-link layer service definition –  
Type 21 elements**

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International Standard IEC 61158-3-21:2010 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This standard cancels and replaces IEC/PAS 62573 published in 2008. This first edition constitutes a technical revision.

This bilingual version published in 2012-01 corresponds to the English version published in 2010-08.

The text of this standard is based on the following documents:

| FDIS         | Report on voting |
|--------------|------------------|
| 65C/604/FDIS | 65C/618/RVD      |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version has not been voted upon.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61158 series, published under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

NOTE 2 The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

Withdrawn

## INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the “three-layer” fieldbus reference model described in IEC/TR 61158-1.

Throughout the set of fieldbus standards, the term “service” refers to the abstract capability provided by one layer of the OSI Basic Reference Model to the layer immediately above. Thus, the data-link layer service defined in this standard is a conceptual architectural service, independent of administrative and implementation divisions.

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## INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

### Part 3-21: Data-link layer service definition – Type 21 elements

## 1 Scope

### 1.1 Overview

This part of IEC 61158 provides the common elements for basic time-critical messaging communications between devices in an automation environment. The term “time-critical” in this context means the prioritized full-duplex collision-free time-deterministic communication, of which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the required time risks the failure of the applications requesting the actions, with attendant risk to equipment, plant, and possibly human life.

This standard defines in an abstract way the externally visible service provided by the Type 21 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 interrelationships between these actions and events, and their valid sequences.

The purpose of this standard is to define the services provided to:

- The Type 21 application layer at the boundary between the application and DLLs of the fieldbus reference model;
- Systems management at the boundary between the DLL and the systems management of the fieldbus reference model.

### 1.2 Specifications

The principal objective of this standard is to specify the characteristics of conceptual DLL services suitable for time-critical communications, and to supplement the OSI Basic Reference Model in guiding the development of data link protocols for time-critical communications. A secondary objective is to provide migration paths from previously existing industrial communications protocols.

This standard may be used as the basis for formal data link programming interfaces. Nevertheless, it is not a formal programming interface, and any such interface will need to address implementation issues not covered by this standard, including:

- a) The sizes and octet ordering of various multi-octet service parameters;
- b) The correlation of paired primitives for request and confirm, or indication and response.

### 1.3 Conformance

This standard does not specify individual implementations or products, nor do they constrain the implementations of data-link entities within industrial automation systems.

There is no conformance of equipment to this data-link layer service definition standard. Instead, conformance is achieved through implementation of the corresponding data-link protocol that fulfils the Type 21 DLL services defined in this standard.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61158-2:2010<sup>1</sup>, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-4-21:2010<sup>1</sup>, *Industrial communication networks – Fieldbus specifications – Part 4-21: Data-link layer protocol specification – Type 21 elements*

ISO/IEC 7498-1, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 7498-3, *Information technology – Open Systems Interconnection – Basic Reference Model: Naming and addressing*

ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

ISO/IEC 10731:1994, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

## 3 Terms, definitions, symbols, abbreviations, and conventions

### 3.1 Reference model terms and definitions

This standard is based in part on the concepts developed in ISO/IEC 7498-1 and ISO/IEC 7498-3, and makes use of the following terms defined therein.

|                                                     |                  |
|-----------------------------------------------------|------------------|
| <b>3.1.1 DL-address</b>                             | [ISO/IEC 7498-3] |
| <b>3.1.2 DL-address-mapping</b>                     | [ISO/IEC 7498-1] |
| <b>3.1.3 called-DL-address</b>                      | [ISO/IEC 7498-3] |
| <b>3.1.4 calling-DL-address</b>                     | [ISO/IEC 7498-3] |
| <b>3.1.5 centralized multi-end-point-connection</b> | [ISO/IEC 7498-1] |
| <b>3.1.6 DL-connection</b>                          | [ISO/IEC 7498-1] |
| <b>3.1.7 DL-connection-end-point</b>                | [ISO/IEC 7498-1] |
| <b>3.1.8 DL-connection-end-point-identifier</b>     | [ISO/IEC 7498-1] |
| <b>3.1.9 DL-connection-mode transmission</b>        | [ISO/IEC 7498-1] |
| <b>3.1.10 DL-connectionless-mode transmission</b>   | [ISO/IEC 7498-1] |

<sup>1</sup> To be published.

|               |                                                                                                                       |                  |
|---------------|-----------------------------------------------------------------------------------------------------------------------|------------------|
| <b>3.1.11</b> | <b>correspondent (N)-entities</b><br><b>correspondent DL-entities (N=2)</b><br><b>correspondent Ph-entities (N=1)</b> | [ISO/IEC 7498-1] |
| <b>3.1.12</b> | <b>DL-duplex-transmission</b>                                                                                         | [ISO/IEC 7498-1] |
| <b>3.1.13</b> | <b>(N)-entity</b><br><b>DL-entity (N=2)</b><br><b>Ph-entity (N=1)</b>                                                 | [ISO/IEC 7498-1] |
| <b>3.1.14</b> | <b>DL-facility</b>                                                                                                    | [ISO/IEC 7498-1] |
| <b>3.1.15</b> | <b>flow control</b>                                                                                                   | [ISO/IEC 7498-1] |
| <b>3.1.16</b> | <b>(N)-layer</b><br><b>DL-layer (N=2)</b><br><b>Ph-layer (N=1)</b>                                                    | [ISO/IEC 7498-1] |
| <b>3.1.17</b> | <b>layer-management</b>                                                                                               | [ISO/IEC 7498-1] |
| <b>3.1.18</b> | <b>DL-local-view</b>                                                                                                  | [ISO/IEC 7498-3] |
| <b>3.1.19</b> | <b>DL-name</b>                                                                                                        | [ISO/IEC 7498-3] |
| <b>3.1.20</b> | <b>naming-(addressing)-domain</b>                                                                                     | [ISO/IEC 7498-3] |
| <b>3.1.21</b> | <b>peer-entities</b>                                                                                                  | [ISO/IEC 7498-1] |
| <b>3.1.22</b> | <b>primitive name</b>                                                                                                 | [ISO/IEC 7498-3] |
| <b>3.1.23</b> | <b>DL-protocol</b>                                                                                                    | [ISO/IEC 7498-1] |
| <b>3.1.24</b> | <b>DL-protocol-connection-identifier</b>                                                                              | [ISO/IEC 7498-1] |
| <b>3.1.25</b> | <b>DL-protocol-data-unit</b>                                                                                          | [ISO/IEC 7498-1] |
| <b>3.1.26</b> | <b>DL-relay</b>                                                                                                       | [ISO/IEC 7498-1] |
| <b>3.1.27</b> | <b>Reset</b>                                                                                                          | [ISO/IEC 7498-1] |
| <b>3.1.28</b> | <b>responding-DL-address</b>                                                                                          | [ISO/IEC 7498-3] |
| <b>3.1.29</b> | <b>Routing</b>                                                                                                        | [ISO/IEC 7498-1] |
| <b>3.1.30</b> | <b>Segmenting</b>                                                                                                     | [ISO/IEC 7498-1] |
| <b>3.1.31</b> | <b>(N)-service</b><br><b>DL-service (N=2)</b><br><b>Ph-service (N=1)</b>                                              | [ISO/IEC 7498-1] |
| <b>3.1.32</b> | <b>(N)-service-access-point</b><br><b>DL-service-access-point (N=2)</b><br><b>Ph-service-access-point (N=1)</b>       | [ISO/IEC 7498-1] |
| <b>3.1.33</b> | <b>DL-service-access-point-address</b>                                                                                | [ISO/IEC 7498-3] |
| <b>3.1.34</b> | <b>DL-service-connection-identifier</b>                                                                               | [ISO/IEC 7498-1] |
| <b>3.1.35</b> | <b>DL-service-data-unit</b>                                                                                           | [ISO/IEC 7498-1] |
| <b>3.1.36</b> | <b>DL-simplex-transmission</b>                                                                                        | [ISO/IEC 7498-1] |
| <b>3.1.37</b> | <b>DL-subsystem</b>                                                                                                   | [ISO/IEC 7498-1] |
| <b>3.1.38</b> | <b>systems-management</b>                                                                                             | [ISO/IEC 7498-1] |
| <b>3.1.39</b> | <b>DLS-user-data</b>                                                                                                  | [ISO/IEC 7498-1] |

### 3.2 Service convention terms and definitions

This standard also makes use of the following terms defined in ISO/IEC 10731 as they apply to the data-link layer.

#### 3.2.1 acceptor

#### 3.2.2 asymmetrical service

#### 3.2.3 confirm (primitive); requestor.deliver (primitive)

#### 3.2.4 deliver (primitive)

#### 3.2.5 DL-confirmed-facility

#### 3.2.6 DL-facility

#### 3.2.7 DL-local-view

#### 3.2.8 DL-mandatory-facility

#### 3.2.9 DL-non-confirmed-facility

#### 3.2.10 DL-protocol-machine

#### 3.2.11 DL-provider-initiated-facility

#### 3.2.12 DL-provider-optional-facility

#### 3.2.13 DL-service-primitive; primitive

#### 3.2.14 DL-service-provider

#### 3.2.15 DL-service-user

#### 3.2.16 DLS-user-optional-facility

#### 3.2.17 indication (primitive); acceptor.deliver (primitive)

#### 3.2.18 multi-peer

#### 3.2.19 request (primitive); requestor.submit (primitive)

#### 3.2.20 requestor

#### 3.2.21 response (primitive); acceptor.submit (primitive)

#### 3.2.22 submit (primitive)

#### 3.2.23 symmetrical service

### 3.3 Data link service terms and definitions

#### 3.3.1

##### **DL-segment, link, local link**

single data link (DL) subnetwork in which any of the connected data link entities (DLEs) may communicate directly, without any intervening data link 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

##### **Data link service access point (DLSAP)**

distinctive point at which DL-services are provided by a single DLE to a single higher-layer entity

NOTE This definition, derived from ISO/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses.

**3.3.3****DLSAP address**

either an individual DLSAP address designating a single DLSAP of a single data link service (DLS) user (DLS-user), or a group DL-address potentially designating multiple DLSAPs, each of a single DLS-user

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

**3.3.4****(individual) DLSAP-address**

DL-address that designates only one DLSAP within the extended link

NOTE A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP.

**3.3.5****Data link connection endpoint address (DLCEP-address)**

DL-address that designates either:

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

**3.3.6****Frame check sequence (FCS) error**

error that occurs when the computed frame check sequence value after reception of all the octets in a data link protocol data unit (DLPDU) does not match the expected residual

**3.3.7****frame**

synonym for DLPDU

**3.3.8****network management**

management functions and services that perform network initialization, configuration, and error handling

**3.3.9****protocol**

convention on the data formats, time sequences, and error correction for data exchange in communication systems

**3.3.10****receiving DLS-user**

DL-service user that acts as a recipient of DLS-user data

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

**3.3.11****sending DLS-user**

DL-service user that acts as a source of DLS-user data

**3.3.12****device**

single DLE as it appears on one local link

### 3.3.13

#### **DL– entity identifier**

address that designates the (single) DLE associated with a single device on a specific local link

### 3.3.14

#### **device unique identification**

unique 8 octet identification to identify a Type 21 device in a network. This ID is a combination of a 6 octet ISO/IEC 8802-3:2000 MAC address and 2 octet DL-address

### 3.3.15

#### **ring**

active network where each node is connected in series to two other devices

NOTE A ring may also be referred to as a loop.

### 3.3.16

#### **linear topology**

topology where the devices are connected in series, with two devices each connected to only one other device, and all others each connected to two other devices, for example, connected in a line

### 3.3.17

#### **R-port**

port in a communication device that is part of a ring structure

### 3.3.18

#### **real-time**

ability of a system to provide a required result in a bounded time

### 3.3.19

#### **real-time communication**

transfer of data in real-time

### 3.3.20

#### **Real-time Ethernet (RTE)**

ISO/IEC 8802-3:2000 based network that includes real-time communication

NOTE 1 Other communications can be supported, providing that the real-time communication is not compromised.

NOTE 2 This definition is based on, but not limited to, ISO/IEC 8802-3:2000. It could be applicable to other IEEE802 specifications, e.g., IEEE802.11.

### 3.3.21

#### **RTE end device**

device with at least one active RTE port

### 3.3.22

#### **RTE port**

media access control (MAC) sublayer point where an RTE is attached to a local area network (LAN)

NOTE This definition is derived from that of bridge port in ISO/IEC 10038: 1993, as applied to local MAC bridges.

### 3.3.23

#### **switched network**

network also containing switches

NOTE Switched network means that the network is based on IEEE802.1D and IEEE802.1Q with MAC bridges and priority operations.

**3.3.24****link**

transmission path between two adjacent nodes [derived from ISO/IEC 11801]

**3.4 Symbols and abbreviations****3.4.1 Common symbols and abbreviations**

|       |                                                                |
|-------|----------------------------------------------------------------|
| DL    | data link (used as a prefix or adjective)                      |
| DLC   | data link connection                                           |
| DLCEP | data link connection endpoint                                  |
| DLE   | data link entity (the local active instance of the DLL)        |
| DLL   | data link layer                                                |
| DLPDU | data link protocol data unit                                   |
| DLPM  | data link protocol machine                                     |
| DLM   | data link management                                           |
| DLME  | data link management entity (the local active instance of DLM) |
| DLMS  | data link management service                                   |
| DLS   | data link service                                              |
| DLSAP | data link service-access-point                                 |
| DLSDU | data link service-data-unit                                    |
| FIFO  | first-in, first-out (queuing method)                           |
| NMT   | network management                                             |
| OSI   | Open Systems Interconnection                                   |
| Ph-   | physical layer (as a prefix)                                   |
| PHY   | physical interface transceiver                                 |
| PhL   | physical layer                                                 |
| RTE   | Real-time Ethernet                                             |
| IEC   | International Electrotechnical Commission                      |
| IP    | Internet Protocol (see RFC 791)                                |
| ISO   | International Organization for Standardization                 |
| MAC   | media access control                                           |
| NRT   | non-real-time                                                  |
| PDU   | protocol data unit                                             |
| SAP   | service access point                                           |
| RT    | real-time                                                      |
| TCP   | Transmission Control Protocol (see RFC 793)                    |
| UDP   | User Datagram Protocol (see RFC 768)                           |

**3.4.2 Type 21: Additional symbols and abbreviations**

|     |                         |
|-----|-------------------------|
| EFR | extremely fast recovery |
| GD  | general device          |
| LNM | line network manager    |
| PO  | power on                |

|              |                                             |
|--------------|---------------------------------------------|
| PnP          | plug and play                               |
| RNM          | ring network manager                        |
| RNMP         | primary ring network manager                |
| RNMS         | secondary ring network manager              |
| RNAC         | ring network auto configuration             |
| UID          | device unique identification                |
| Type 21 NMIB | Type 21 network management information base |

### 3.5 Conventions

#### 3.5.1 Common conventions

This standard uses the descriptive conventions given 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.

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

This standard uses a tabular format to describe the component parameters of the DLS primitives. The parameters that apply to each group of DLS primitives are set out in tables throughout the remainder of this standard. Each table consists of up to six columns, containing the name of the service parameter, and a column for each of those primitives and parameter-transfer directions used by the DLS, including

the request primitive's input parameters;  
the request primitive's output parameters;  
the indication primitive's output parameters;  
the response primitive's input parameters;  
the confirmation primitive's output parameters.

NOTE The request, indication, response and confirmation primitives are also known as requestor.submit, acceptor.deliver, acceptor.submit, and requestor.deliver primitives, respectively (see ISO/IEC 10731).

One parameter, or a portion of it, is listed in each row of each table. Under the appropriate service primitive columns, a code is used to specify how the parameter is used, and its direction:

- M** parameter: mandatory for the primitive;
- U** parameter: a user option that may or may not be provided depending on the dynamic use 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;
- (Blank) parameter is never present.

Some entries are further qualified by items in parentheses. These may be one of:

- a) (=) A parameter-specific constraint indicating that the parameter is semantically equivalent to the parameter in the service primitive to its immediate left in the table;

- b) (n) An indication that following note n contains additional information pertaining to the parameter and its use.

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

In the diagrams illustrating these interfaces, dashed lines indicate cause and effect or time sequence relationships, and wavy lines indicate that events occur at approximately the same time.

### 3.5.2 Additional conventions

In the diagrams illustrating the DLS and DLM interfaces, dashed lines indicate cause and effect or time sequence relationships between actions at different stations, while solid lines with arrows indicate cause and effect time sequence relationships that occur within the DLE provider at a single station.

The following notation, a shortened form of the primitive classes defined in 3.5.1, is used in the figures and tables.

**req:** request primitive

**ind:** indication primitive

**cnf:** confirmation primitive (confirmation)

**rsp:** response primitive

## 4 Data-link layer services and concepts

### 4.1 General

#### 4.1.1 Overview

This standard specifies the Type 21 data link services for an ISO/IEC 8802-3:2000 based time-deterministic control network, which is one of the communication networks for RTE. The communication services support timing demands typical of high-performance automation applications. They do not change the basic principles of ISO/IEC 8802-3:2000, but extend it toward RTE. Thus, it is possible to continue to use standard Ethernet hardware, infrastructure components, or test and measurement equipment, such as network analyzers.

The Type 21 DLL provides reliable and transparent data communication between two Type 21 end devices. The Type 21 DLL also guarantees abstract transparent data transfer between DL-users so that DLL provides flexible and convenient network connectivity to network users.

#### 4.1.2 Overview of full duplex flow control

A Type 21 device is based on an integrated switch with two ports (ring ports) connected to the ring. Therefore, a Type 21 network system is made up of full-duplex, collision-free switching devices configured as a ring or a line network. Figure 1 shows the full-duplex flow control procedure in a Type 21 network system. Type 21 guarantees collision-free data transmission between two devices linked by a full-duplex Ethernet connection so that the Type 21 DLL provides reliable, transparent, and collision-free data transmission to the DLS-users.

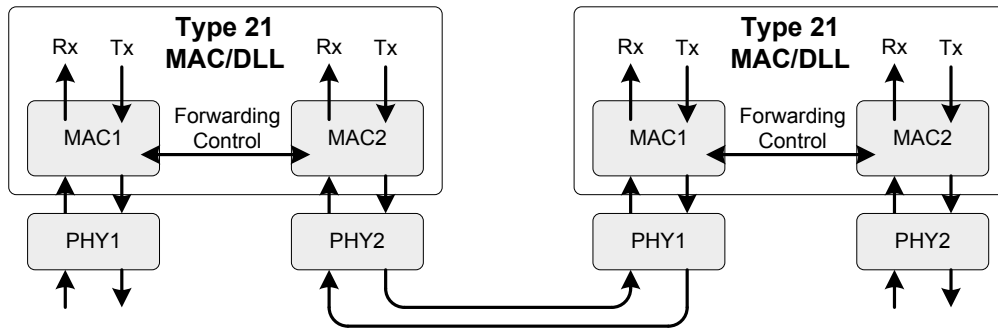


Figure 1 – Full-duplex flow control

### 4.1.3 Types and classes of DL-layer service

#### 4.1.3.1 Overview

The DLS provides transparent and reliable data transmission between DLS-users over Type 21. The DLS is based on services provided by the physical layer of ISO/IEC 8802-3:2000 to the conceptual interface between the physical and data link layers.

Three types of data transmission services are provided.

#### Data service (DL-DATA)

Data service is used to transmit a Type 21 frame to a destination device or devices using the priority option. DL-DATA service is a queued service using the RT-queue.

#### Sporadic data service (DL-SPDATA)

Sporadic data service is used to transmit a common protocol frame, such as TCP/IP or UDP. Type 21 data link layer transmits without modification any received DLSDUs generated by a DLS-user. In this case, DLSDU is assumed to include DLPDU. DL-SPDATA is a queued service using the NRT-queue.

#### Network control message

Network-control-message service is used by the DL-management entity to share network-related information with the other devices in a Type 21 network segment.

#### 4.1.3.2 Primitives of the data service

The sequence of primitives for the data service is shown in Figure 2.

DL-DATA request and DL-DATA indication correspond to the MA-DATA request and MA-DATA indication defined by ISO/IEC 8802-3:2000, respectively.

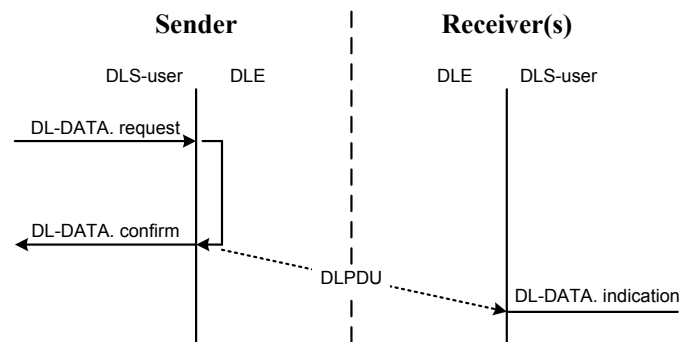


Figure 2 – Sequence diagram of DL-DATA service

The sender DLS-user prepares a DLSDU for a single receiver-side DLS-user, or for multiple DLS-users. The DLSDU is passed to the local DLE *via* the DLS interface by means of a DL-DATA request primitive. The DLE queues the service request, and the queued service request is transmitted by the DLPM to the receiver DLE or to multiple DLEs.

The receiving DLE(s) attempt to deliver the received DLSDU to the specified DLS-user(s).

There is no confirmation of correct receipt at the remote DLEs or of delivery to the intended DLS-user(s); acknowledgements do not occur. When the DLSDU is transmitted, it reaches all receiver-side DLEs at about the same time, ignoring signal propagation delays. Each DLE addressed by the DLSDU that has received the data error-free, passes the DLSDU and associated addressing information to the local DLS-user by means of a DL-DATA indication primitive.

#### 4.1.3.3 Primitives of the sporadic data service

The sequence of primitives for the sporadic data service is shown in Figure 3. DL-SPDATA request and DL-SPDATA indication correspond to the MA-DATA request and MA-DATA indication defined by ISO/IEC 8802-3:2000, respectively.

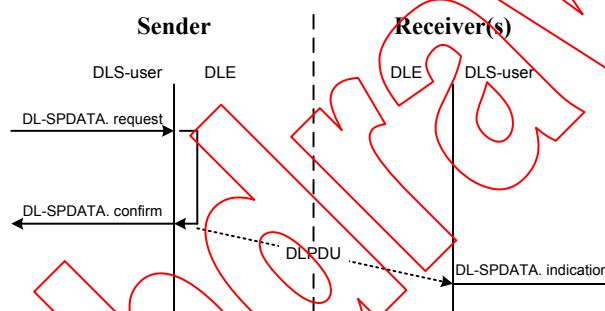


Figure 3 – Sequence diagram of DL-SPDATA service

DL-SPDATA service is used to transmit other protocol frames, such as TCP/IP or UDP. DL-SPDATA service is transmitted through both R-ports using the non-real-time (NRT) queue without referring to the path table and without modification of the received DLSDU.

#### 4.1.3.4 Primitives of the network control message service

The sequence of primitives for the network control message service is shown in Figure 4. DL-NCM\_SND request and DL-NCM\_SND indication correspond to the MA-DATA request and MA-DATA indication defined by ISO/IEC8802-3:2000, respectively.

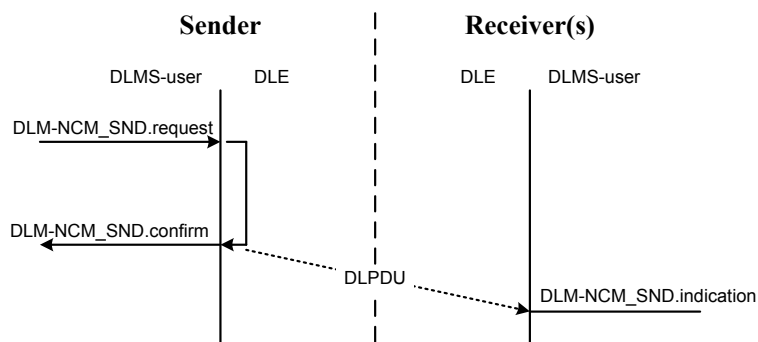
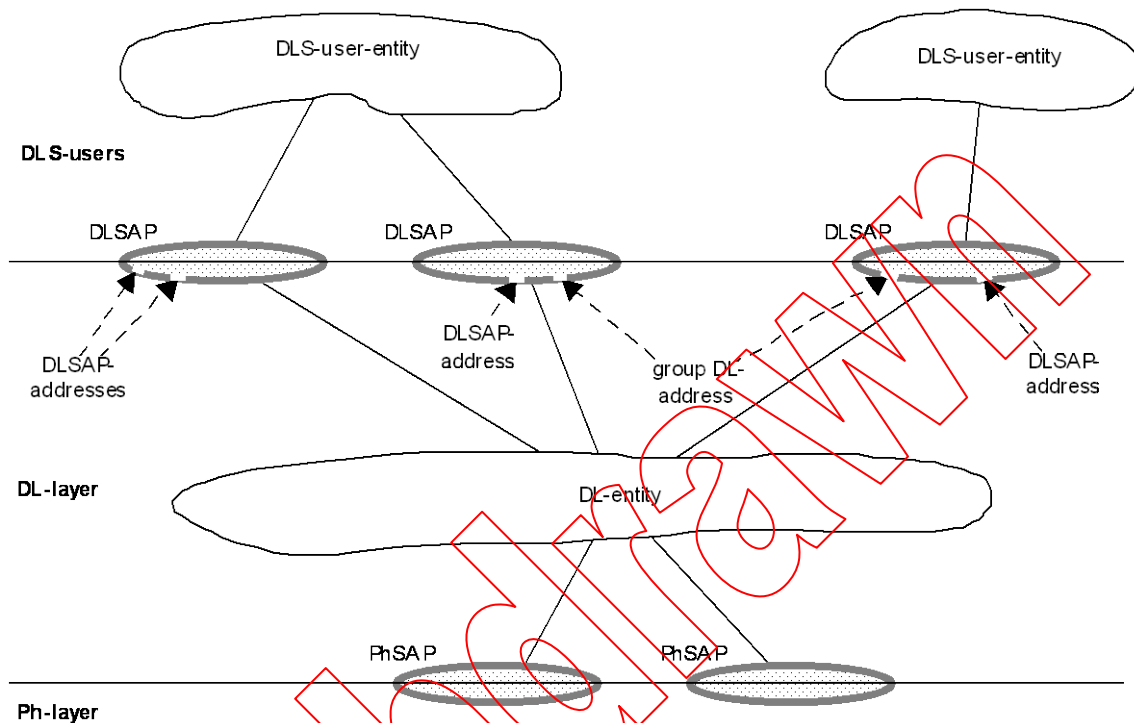


Figure 4 – Sequence diagram of NCM service primitive

The DL-NCM\_SND service is used to transmit a network control message. The DL-NCM\_SND service is transmitted to one or both R-ports through the real-time (RT) queue.

#### 4.1.3.5 Addressing

Figure 5 shows the Relationships of DLSAPs, DLSAP-addresses, and group DL-addresses.



NOTE 1 DLSAPs and physical layer service access points (PhSAPs) are depicted as ovals spanning the boundary between two adjacent layers.

NOTE 2 DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP.

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

**Figure 5 – Relationships of DLSAPs, DLSAP-addresses, and group DL-addresses**

Each DLE on the link is designated by a DL-address. The range of individual DL-addresses is limited, from 0 to a maximum of 255. Table 1 shows the DL-address assignment (see IEC 61158-4-21:2010, 5.3.3.2).

The DL-address 0xFFFF is used for broadcast message. This DL-address is either configured by the application process or is set on the device (for example, using address switches).

**Table 1 – Destination DL-address**

| Field Name             | Position   | Value/Description                                                                                                                                                                                                                    |
|------------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Destination DL-address | Bit 0 – 15 | 0xFFFF: broadcast address<br>0xFFFFE: network control address (C_NCM_ADDR)<br>0xFFFFD – 0xFFDE: user-defined multicast address<br>0xFFDD: invalid address<br>0x0100 to 0xFFDC: reserved<br>0x0000 to 0x00FF: regular Type 21 address |

#### 4.1.3.6 Broadcast address

If the destination DL-address is 0xFFFF, the destination MAC address field contains the ISO/IEC 8802-3:2000 broadcast MAC address (see IEC 61158-4-21:2010, 5.3.3.2.2).

#### 4.1.3.7 Network control address

If the destination DL-address is C\_NCM\_ADDR, the destination MAC address field contains C\_NCM\_MAC\_ADDR. However, NCM\_LINK\_ACTV and NCM\_ADV\_THIS messages are transmitted using C\_NCM\_ADDR as destination address (see IEC 61158-4-21:2010, 5.3.3.2.3).

NOTE C\_NCM\_ADDR cannot be accessed by the DLS-user.

#### 4.1.3.8 User-defined multicast address

A user-defined multicast address may be used to indicate multiple recipients. This standard does not restrict the use of the user-defined multicast address and it is not a mandatory feature in Type 21 (see IEC 61158-4-21:2010, 5.3.3.2.4).

### 4.2 Detailed description of the data service

#### 4.2.1 General

DL-DATA request and DL-DATA indication correspond to the MA-DATA request and MA-DATA indication defined by ISO/IEC 8802-3:2000, respectively.

DL-DATA service provides 1:1 or 1:N data transmission in a Type 21 segment. DL-DATA service is used by the DLS-user to send a DLSDU to a single peer end device or multiple peer end devices. The DL-DATA service is processed by the priority option indicated in the DL-DATA request primitive. Figure 6 shows the DL-DATA service procedure.

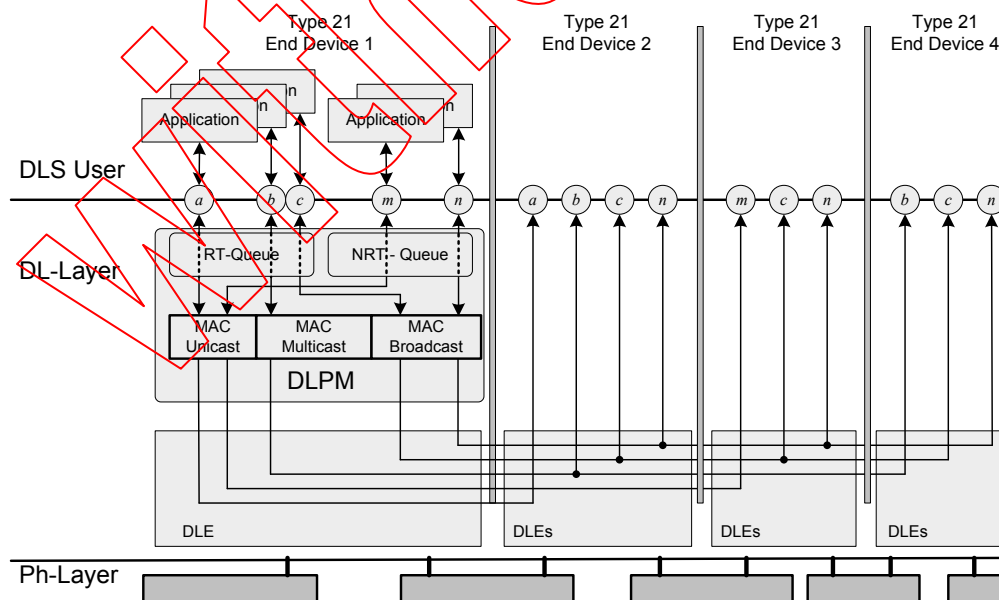


Figure 6 – DL-DATA service

#### 4.2.2 Sequence of primitives

The data service primitives and their associated parameters are summarized in Table 2, and the primitive sequence is shown in Figure 2.

**Table 2 – Primitives and parameters used in DL-DATA service**

| Function                                   | Location    | Primitive          | Direction | Parameters                                                                                       |
|--------------------------------------------|-------------|--------------------|-----------|--------------------------------------------------------------------------------------------------|
| Send data                                  | Sender      | DL-DATA request    | To DLE    | DST_addr<br>Priority<br>DSAP<br>SSAP<br>Group mask<br>Group mask length<br>DLSDU<br>DLSDU length |
| Send data confirmation to calling DLS-user | Sender      | DL-DATA confirm    | From DLE  | Status                                                                                           |
| Receive data                               | Receiver(s) | DL-DATA indication | From DLE  | DST_addr<br>SRC_addr<br>SSAP<br>DLSDU<br>DLSDU length                                            |

### 4.2.3 Transmit/receive data

#### 4.2.3.1 Function

DL-DATA service primitives allow the DLS-user to transfer message data to a single peer DLS-user or multiple peer DLS-users at remote devices.

#### 4.2.3.2 Types of primitives and the parameters

##### 4.2.3.2.1 General

Table 3 indicates the parameters of DL-DATA service.

**Table 3 – DL-DATA Primitives and Parameters**

| DL-DATA           | Request | Indication | Confirm |
|-------------------|---------|------------|---------|
| Parameter         | Input   | Output     | Output  |
| DST_addr          | M       | M(=)       | —       |
| SRC_addr          | —       | M          | —       |
| Priority          | M       | M(=)       | —       |
| DSAP              | M       | —          | —       |
| SSAP              | U       | U(=)       | —       |
| Group mask        | U       | —          | —       |
| Group mask length | U       | —          | —       |
| DLSDU             | M       | M(=)       | —       |
| DLSDU length      | M       | M(=)       | —       |
| Status            | —       | —          | M       |

#### 4.2.3.2.2 DST\_addr

This parameter indicates the destination DL-address of the DLE(s) for which the DLPDU is intended. It may be an individual or multicast (including broadcast) DL-address. Note that this is the DL-address, not the MAC address (see Table 1).

#### 4.2.3.2.3 SRC\_addr

This parameter indicates the source DL-address of an individual DLE, which sends the DLPDU.

#### 4.2.3.2.4 Destination service access point (DSAP)

This parameter indicates the destination service access point of the DLE for which the DLPDU is intended. The DSAP address is not reserved for any particular application.

#### 4.2.3.2.5 Priority

This parameter indicates the message priority of the DL-DATA service request and the priority of the frame in the RT-queue. A DLS-user can indicate the message priority of a DL-DATA service request according to the application.

#### 4.2.3.2.6 Source service access point (SSAP)

This parameter indicates the source service access point of the DLE from which the DLPDU is being sent. The source SAP address is not reserved for any particular application.

#### 4.2.3.2.7 Data link service data unit (DLSDU)

This parameter specifies the information that is transferred from local DLS-user to the remote DLS-user.

#### 4.2.3.2.8 DLSDU length

This parameter indicates the length of DLSDU in octets.

#### 4.2.3.2.9 Status

This parameter allows the DLS-user to determine whether the requested service was provided successfully. If it failed, the reason is specified. The value of this parameter can be one of:

- a) "Success – successfully completed";
- b) "Failure – invalid requested parameter";
- c) "Failure – RT-queue is full";
- d) "Failure – unavailable destination".

### 4.3 Detailed description of the sporadic data service

#### 4.3.1 General

This DLS provides unacknowledged data transmission between single DLSAPs or unacknowledged data transmission from a single DLSAP to a group of DLSAPs on the extended link. DL-SPDATA request and DL-SPDATA indication correspond to the MA-DATA request and MA-DATA indication defined by ISO/IEC8802-3:2000, respectively. The DL-SPDATA service allows the DLS-user to transfer non-Type 21 message data to a single peer DLS-user or multiple peer DLS-users at remote devices. The DL-SPDATA service is processed through the NRT-queue. A DLSDU from a DLS-user is not modified, and is transmitted to both R-ports without referring to the path table.

### 4.3.2 Sequence of Primitive

The sporadic message data service primitives and the parameters are summarized in Table 4, and the primitive sequence is shown in Figure 3.

**Table 4 – Primitives and parameters used in DL-SPDATA service**

| Function                         | Location    | Primitive            | Direction | Parameters            |
|----------------------------------|-------------|----------------------|-----------|-----------------------|
| Send Sporadic Data               | Sender      | DL-SPDATA request    | To DLE    | DLSDU<br>DLSDU length |
| confirmation to calling DLS-user | Sender      | DL-SPDATA confirm    | From DLE  | Status                |
| Receive Sporadic Data            | Receiver(s) | DL-SPDATA indication | From DLE  | DLSDU<br>DLSDU length |

### 4.3.3 Transmit/receive sporadic data

#### 4.3.3.1 Function

DL-SPDATA service primitives allow the DLS-user to transfer message data to a single peer DLS-user or multiple peer DLS-users at remote nodes through the two R-ports.

#### 4.3.3.2 Type of primitives and the parameters

##### 4.3.3.2.1 General

Table 5 indicates the parameters of sporadic data service.

**Table 5 – DL-SPDATA Primitives and Parameters**

| DL-SPDATA    | Request | Indication | Confirm |
|--------------|---------|------------|---------|
| Parameter    | input   | output     | output  |
| DLSDU        | M       | M(=)       | —       |
| DLSDU length | M       | M(=)       | —       |
| Status       | —       |            | M       |

##### 4.3.3.2.2 Data link service data unit (DLSDU)

This parameter indicates the DLSDU generated by the DLS-user.

##### 4.3.3.2.3 DLSDU length

This parameter indicates the length of the DLSDU.

##### 4.3.3.2.4 Status

This parameter allows the DLS-user to determine whether or not the requested service was provided successfully. If it failed, the reason is specified. The value of this parameter can be one of:

- “Success – successfully completed”;
- “Failure – invalid requested parameter”;
- “Failure – the NRT-queue is full”.

## 4.4 Detailed description of network control message service

### 4.4.1 General

The network control message service is used by the DLM to share network-related information with the other devices in a Type 21 network segment. The network control message service is a local device information transfer service initiated by the DLM.

### 4.4.2 Sequence of Primitives

The network control message data service primitives and the parameters are summarized in Table 6, and the primitive sequence is shown in Figure 4.

**Table 6 – Primitives and parameters used on DL-NCM\_SND service**

| Function                        | Location | Primitive             | Direction | Parameters                                                      |
|---------------------------------|----------|-----------------------|-----------|-----------------------------------------------------------------|
| Send Network Control Message    | DLM      | DL-NCM_SND request    | To DLPM   | DST_addr<br>NCMT<br>DLMDU<br>DLMDU length<br>R-port             |
| Confirmation to calling DLM     | DLPM     | DL-NCM_SND confirm    | To DLM    | Status                                                          |
| Receive Network Control Message | DLPM     | DL-NCM_SND indication | To DLM    | DST_addr<br>SRC_addr<br>NCMT<br>DLMDU<br>DLMDU length<br>R-port |

### 4.4.3 Transmit/receive network control message

#### 4.4.3.1 Function

DL-NCM\_SND service primitives allow the DLS-user to transfer network control messages to a single peer DLS-user or multiple peer DLS-users at remote nodes through the R-port.

#### 4.4.3.2 Type of primitives and the parameters

##### 4.4.3.2.1 General

Table 7 indicates the parameters of the network control message service.

**Table 7 – DL-NCM\_SND Primitives and Parameters**

| DL-NCM_SND   | Request | Indication | Confirm |
|--------------|---------|------------|---------|
| Parameter    | input   | output     | output  |
| DST_addr     | M       | M(=)       | —       |
| SRC_addr     | M       | M          | —       |
| NCMT         | M       | M(=)       | —       |
| DLMDU        | M       | M(=)       | —       |
| DLMDU length | M       | M(=)       | —       |
| R-port       | M       | M          | —       |
| Status       | —       | —          | M       |

#### 4.4.3.2.2 DST\_addr

This parameter indicates the destination DL-address of the DLE(s) for which the DLPDU is intended. When the network control message (NCM) type is NCM\_LINK\_ACTV or NCM\_ADV\_THIS, the destination DL-address is set to C\_NCM\_ADDR (see IEC 61158-4-21:2010, 5.3.3.2.3). When the network control message type is NCM\_LINE\_START or NCM\_RING\_START, the destination DL-address is set to the broadcast address (see IEC 61158-4-21:2010, 5.3.3.2.2).

#### 4.4.3.2.3 SRC\_addr

This parameter indicates the source DL-address of an individual DLE from which the data link management data unit (DLMDU) is being sent.

#### 4.4.3.2.4 Network control message type (NCMT)

This parameter indicates the type of network control message. Table 8 describes the NCMT.

**Table 8 – Summary of Network Control Message Type**

| Network Control Message Type | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NCM_FAMILY_REQ               | This message type indicates that a new Type 21 link has been established through an R-port. This network control message is transmitted through the newly activated R-port.<br><br>DLM detects the status of each R-port using the Ph-LINK_STATUS_CHANGE and Ph-GET_LINK_STATUS services. When an R-port's status is changed from link inactive to link active, local device information is transmitted through the newly activated R-port. This message shall not be forwarded to the other port. |
| NCM_FAMILY_RES               | This message is used to confirm whether the recipient is a Type 21 device when the recipient receives the NCM_FAMILY_REQ message from the newly linked device. This message is transmitted through the R-port used to receive the NCM_FAMILY_REQ message. This message shall not be forwarded to the other port.                                                                                                                                                                                   |
| NCM_MEDIA_LINKED             | This message is used to indicate that a new Type 21 link has been established through the R-port. This message is transmitted through the newly activated R-port. When the recipient receives this message, the recipient increments the hop count in the frame and forwards the frame through the other R-port. This message is discarded by the LNM or the device that generated the message.                                                                                                    |
| NCM_ADV_THIS                 | NCM_ADV_THIS message is used to transmit the recipient's local device information when the recipient receives the NCM_MEDIA_LINKED message from the newly linked device. This message is transmitted through the R-port, which is used to receive the NCM_MEDIA_LINKED message.                                                                                                                                                                                                                    |
| NCM_LINE_START               | This message is used to broadcast that the network topology has been automatically configured as a line network. This message is initiated by the DLM whose state has changed to LNM when the existing line network is divided into two line networks or when a link failure is detected in a ring network, and the network is reconfigured as a line network.                                                                                                                                     |
| NCM_RING_START               | This message is used to broadcast that the network topology has been automatically configured as a ring network. This message is initiated and transmitted through both R-ports by the DLM whose state has changed to RNMP.                                                                                                                                                                                                                                                                        |
| NCM_ACK_RNMS                 | This message is used by the RNMS device to advise that the RNMS has been successfully selected. NCM_ACK_RNMS message is unicast from the RNMS to the RNMP.                                                                                                                                                                                                                                                                                                                                         |
| NCM_RETRY_RNMS               | This message is used to request a retransmission of the NCM_ACK_RNMS message from the RNMS device in the case where the RNMP device did not initially receive it. The NCM_RETRY_RNMS message is transmitted from the RNMP to the RNMS.                                                                                                                                                                                                                                                             |

**4.4.3.2.5 R-port**

This parameter indicates the Type 21 MAC port to send or receive a frame.

**4.4.3.2.6 Data link Management Data Unit (DLMDU)**

This parameter indicates the DLMDU. Local device information is used as the DLMDU in network control messages.

**4.4.3.2.7 DLMDU length**

This parameter indicates the length of the DLMDU in octets.

**4.4.3.2.8 Status**

This parameter allows the DLMS-user to determine whether the requested service was provided successfully. If it failed, the reason is specified. The value of this parameter can be one of:

- a) “OK – success – Network control message is successfully completed”;
- b) “Failure – invalid parameters in the request”.

## 5 Data-link management services

### 5.1 General

Clause 5 describes the interface between a DLE and a data link management system user (DLMS-user). The services of this interface are required for the protocol that implements the DLS specified in Clause 4

### 5.2 Data link management service (DLMS) facilities

The DLMS provides the facilities for the initialization, configuration, event and error handling between the DLMS-user and the logical functions in the DLE. The following functions are provided to the DLMS-user:

- a) Reset the local DLE;
- b) Request for and modification of the actual operating parameters and of the counters of the local DLE;
- c) Notification of unexpected events, errors, and status changes, both local and remote;
- d) Request for identification of the local DLE, and its DL SAP configuration.

### 5.3 Data link management service (DLMS)

#### 5.3.1 Overview

The DLMS provides the following services to the DLMS-user:

- a) Reset;
- b) Set-value;
- c) Get-value;
- d) SAP-allocation;
- e) SAP-deallocation;
- f) Get-SAP-information;
- g) Get-diagnostic-information;
- h) Event;
- i) Get-path.

The services Reset, Set-value, Get-value, SAP-allocation, SAP-deallocation, Get-diagnostic-information, Event, and Get-path are considered mandatory. The others are optional.

#### 5.3.2 Reset

The DLMS-user uses this service to cause the DLM to reset the DLE. Reset is equivalent to power on. The DLMS-user receives a confirmation of the reset.

#### 5.3.3 Set-value

The DLMS-user uses this service to assign new values to the DLE variables. The DLMS-user receives a confirmation of whether or not the specified variables have been set to the new values.

#### **5.3.4 Get-value**

This service enables the DLM to read DLE variables. The response includes the actual value of the specified variables.

#### **5.3.5 SAP-allocation**

The SAP-allocation service is used by the DLMS-user to obtain a SAP assignment from the DLM. To receive a service request from the peer device and deliver the received DLSDU to the corresponding DLS-user, the destination DLS-user should obtain a SAP assignment before the service transaction. However, the SSAP does not have to be assigned beforehand because the default SSAP value of 0 is used for normal DL services. A SSAP might be assigned for special application functions.

#### **5.3.6 SAP-deallocation**

The SAP-deallocation service is used by the DLMS-user to release and return the allocated SAP to DLM. The deallocated SAP can be used again using the SAP-allocation service.

#### **5.3.7 Get-SAP information**

The Get-SAP information service is used by the DLMS-user to obtain information from the DLM about the allocated SAP.

#### **5.3.8 Get-diagnostic-information**

The Get-diagnostic information service is used by the DLMS-user to obtain current diagnostic information about the local device, remote devices, and the network.

#### **5.3.9 Event**

DLM employs this service to inform the DLMS-user about certain events or errors in the DLL.

#### **5.3.10 Get-path**

The Get-path service is used by the DLS-user to obtain path information from the DLM to determine which is the preferred R-port.

### **5.4 Overview of interactions**

The DLMS and their primitives are summarized in Table 9.