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Industrial communication networks – Fieldbus specifications – Part 3-14: Data-link layer service definition – Type 14 elements

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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International Standard IEC 61158-3-14 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition and its companion parts of the IEC 61158-3 subseries cancel and replace IEC 61158-3:2003. This edition of this part constitutes a technical addition. This part and its Type 14 companion parts also replace IEC/PAS 62409, published in 2005.

This edition includes the following significant changes with respect to the previous edition:

a) deletion of the former Type 6 fieldbus, and the placeholder for a Type 5 fieldbus data-link layer, for lack of market relevance;

b) addition of new types of fieldbuses;

c) division of this part into multiple parts numbered 3-1, 3-2, …, 3-19.

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

FDIS	Report on voting
65C/473/FDIS	65C/484/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.

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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- withdrawn;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 The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

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

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.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 3-14: Data-link layer service definition – Type 14 elements

1 Scope

1.1 Overview

This part of IEC 61158 provides common elements for basic 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 standard defines in an abstract way the externally visible service provided by the Type 14 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 which they take; and

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

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

- the Type 14 fieldbus application layer at the boundary between the application and data-link layers of the fieldbus reference model, and
- systems management at the boundary between the data-link layer and systems management of the fieldbus reference model.

1.2 Specifications

The principal objective of this standard is to specify the characteristics of conceptual data-link layer services 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. A secondary objective is to provide migration paths from previously-existing industrial communications protocols.

This specification may be used as the basis for formal DL-Programming-Interfaces. Nevertheless, it is not a formal programming interface, and any such interface will need to address implementation issues not covered by this specification, including

a) the sizes and octet ordering of various multi-octet service parameters, and

b) the correlation of paired request and confirm, or indication and response, primitives.

1.3 Conformance

This standard do 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 fulfills the Type 14 data-link layer services defined in this standard.

2 Normative references

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

IEC 61588:2004, *Precision clock synchronization protocol for networked measurement and control system*

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

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

ISO/IEC 8802-3, *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 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

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

RFC 768, *User Datagram Protocol*

RFC 791, *Internet protocol*

RFC 793, *Transmission Control Protocol*

3 Terms, definitions, symbols, abbreviations and conventions

The following terms, definitions, symbols, abbreviations and conventions apply.

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:

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 [7498-1]

3.1.7 DL-connection-end-point [7498-1]

3.1.8 DL-connection-end-point-identifier [7498-1]

3.1.9 DL-connection-mode transmission [7498-1]

3.1.10 DL-connectionless-mode transmission [7498-1]

3.1.11 correspondent (N)-entities [7498-1]
correspondent DL-entities (N=2)
correspondent Ph-entities (N=1)

3.1.12 DL-duplex-transmission [7498-1]

3.1.13 (N)-entity [7498-1]
DL-entity (N=2)
Ph-entity (N=1)

3.1.14 DL-facility [7498-1]

3.1.15 flow control [7498-1]

3.1.16 (N)-layer [7498-1]
DL-layer (N=2)
Ph-layer (N=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]

3.1.26 DL-relay [7498-1]

3.1.27 reset [7498-1]

3.1.28 responding-DL-address [7498-3]

3.1.29 routing [7498-1]

3.1.30 segmenting [7498-1]

3.1.31 (N)-service [7498-1]
DL-service (N=2)
Ph-service (N=1)

3.1.32 (N)-service-access-point [7498-1]
DL-service-access-point (N=2)
Ph-service-access-point (N=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 systems-management [7498-1]

3.1.39 DLS-user-data [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-provider-initiated-facility

3.2.11 DL-provider-optional-facility

3.2.12 DL-service-primitive; primitive

3.2.13 DL-service-provider

3.2.14 DL-service-user

3.2.15 DLS-user-optional-facility

3.2.16 indication (primitive); acceptor.deliver (primitive)

3.2.17 multi-peer

3.2.18 request (primitive); requestor.submit (primitive)

3.2.19 requestor

3.2.20 response (primitive); acceptor.submit (primitive)

3.2.21 submit (primitive)

3.2.22 symmetrical service

3.3 Data-link service terms and definitions

3.3.1
communication macrocycle
set of basic cycles needed for a configured communication activity in a macro network segment

3.3.2
communication phase
elapsed fraction of a cycle, measured from some fixed origin

3.3.3
communication scheduling
algorithms and operation for data transfers occurring in a deterministic and repeatable manner

3.3.4
cyclic
repetitive in a regular manner

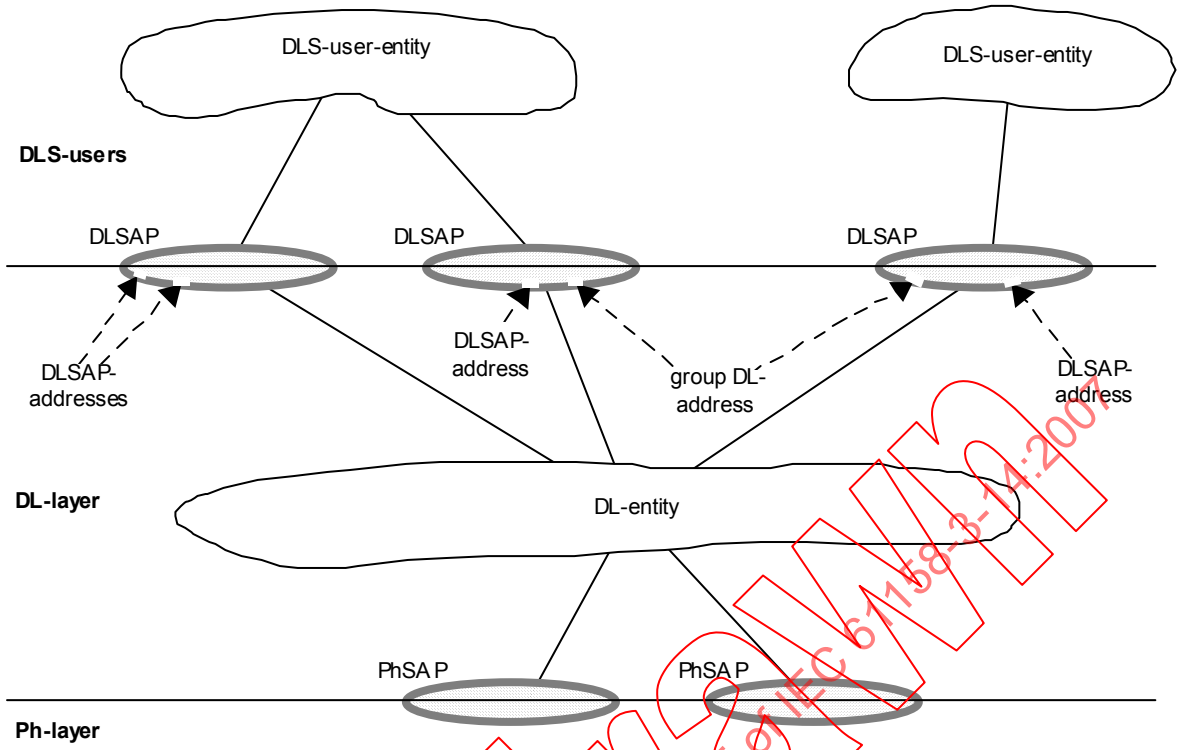
3.3.5
data DLPDU
DLPDU that carries a DLSDU from a local DLS-user to a remote DLS-user

3.3.6
destination FB Instance
FB instance that receives the specified parameters

3.3.7
DL-segment, link, local link
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

3.3.8
DLSAP
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/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses.



NOTE 1 DLSAPs and 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 DL-entity may have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP.

Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses

3.3.9
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/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.

3.3.10
(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.

3.3.11
extended link
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.

3.3.12
FCS error
error that occurs when the computed frame check sequence value after reception of all the octets in a DLPDU does not match the expected residual

3.3.13
frame
denigrated synonym for DLPDU

3.3.14
group DL-address
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

3.3.15
micro segment
part of a network where special scheduling is implemented

3.3.16
multipoint connection
connection from one node to many nodes

NOTE Multipoint connections allows data transfer from a single publisher to be received by many subscriber nodes.

3.3.17
node
single DL-entity as it appears on one local link

3.3.18
offset
number of octets from a specially designated position

3.3.19
real-time
ability of a system to provide a required result in a bounded time

3.3.20
real-time communication
transfer of data in real-time

3.3.21
real-time Ethernet (RTE)
ISO/IEC 8802-3-based network that includes real-time communication

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

NOTE 2 This definition is dedicated, but not limited, to ISO/IEC 8802-3. It could be applicable to other IEEE 802 specifications, for example IEEE 802.11.

3.3.22
receiving DLS-user
DL-service user that acts as a recipient of DLS-user-data

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

3.3.23
schedule
temporal arrangement of a number of related operations

3.3.24
scheduling macrocycle
time interval to implement a specific schedule

3.3.25
sending DLS-user
DL-service user that acts as a source of DLS-user-data

3.3.26
time offset
time difference from a specially designated time

3.4 Symbols and abbreviations

3.4.1 .cnf	Confirm primitive
3.4.2 .ind	Indication primitive
3.4.3 .req	Request primitive
3.4.4 .rsp	Response primitive
3.4.5 ARP	Address resolution protocol
3.4.6 Cnf	Confirmation
3.4.7 CSMA/CD	Carrier sense multiple access protocol with collision detection
3.4.8 DHCP	Dynamic host configuration protocol
3.4.9 DL-	Data-link layer (as a prefix)
3.4.10 DLC	DL-connection
3.4.11 DLCEP	DL-connection-end-point
3.4.12 DLE	DL-entity (the local active instance of the data-link layer)
3.4.13 DLL	DL-layer
3.4.14 DLPCI	DL-protocol-control-information
3.4.15 DLPDU	DL-protocol-data-unit
3.4.16 DLM	DL-management
3.4.17 DLME	DL-management entity (the local active instance of DL-management)
3.4.18 DLMS	DL-management Service
3.4.19 DLS	DL-service
3.4.20 DLSAP	DL-service-access-point
3.4.21 DLSDU	DL-service-data-unit
3.4.22 ECSME	Type 14 communication scheduling management entity
3.4.23 EM_	(as a prefix) Type 14 management
3.4.24 FIFO	First-in first-out (queuing method)
3.4.25 Ind	Indication
3.4.26 IP	Internet protocol
3.4.27 LLC	Logical link control

3.4.28 LMP Link management protocol

3.4.29 MAC Medium access control

3.4.30 MAU Medium attachment unit

3.4.31 OSI Open Systems Interconnection

3.4.32 PAD Pad (bits)

3.4.33 PDU Protocol data unit

3.4.34 Ph- Physical layer (as a prefix)

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

3.4.36 PhL Ph-layer

3.4.37 QoS Quality of service

3.4.38 Req Request

3.4.39 Rsp Response

3.4.40 RTE Real-time Ethernet

3.4.41 RT-Ethernet Real-time Ethernet

3.4.42 SAP Service access point

3.4.43 SDU Service data unit

3.4.44 SME System management entity

3.4.45 SNTP Simple network time protocol

3.4.46 TCP Transmission control protocol

3.4.47 UDP User datagram protocol

3.5 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/service 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 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 requestor.submit, acceptor.deliver, acceptor.submit, and requestor.deliver primitives, respectively (see 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.

(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;

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

4 DL service and concept

4.1 General

4.1.1 DLL architecture

The type 14 DLL is modeled in Figure 2 as an integrated data-link layer with UDP(TCP), IP, MAC and LLC sublayers defined in ISO/IEC 8802-3 and an extension protocol defined in the Type 14 parts of the IEC 61158 series, where

a) the Transfer Control Protocol (TCP) defined in RFC 793 is applied;

b) the User Datagram Protocol (UDP) defined in RFC 768 is applied;

c) the Internet Propocol (IP) defined in RFC 791 is applied;

d) the Logic Link Control (LLC) protocol defined in ISO/IEC 8802-3 is applied;

e) the Medium Access Control (MAC) layer protocol defined in ISO/IEC 8802-3 is applied.

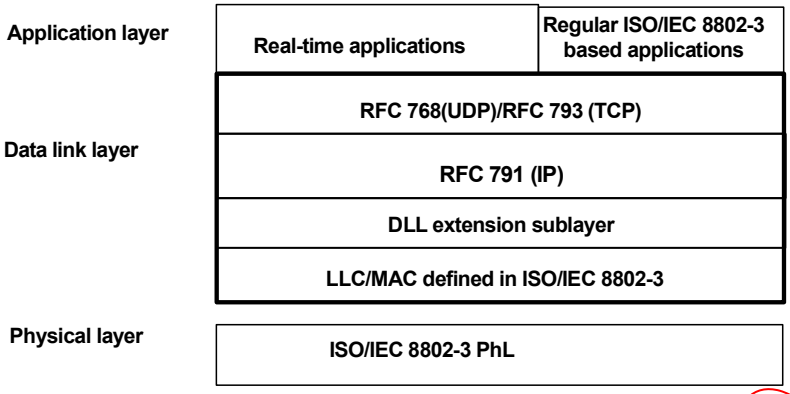


Figure 2 – Communication model

Additionally, a DLL extension sublayer is defined as the Type 14 Communication Scheduling Management Entity (ECSME) on ISO/IEC 8802-3 data-link protocol to manage the deterministic communication and regular communication.

This ECSME provides the following functions:

f) transparent data transferring between DLE and DLS_User specified in ISO/IEC 8802-3 without modifying the data;

g) receiving DLS_User DATA from DLS_User and buffering them;

h) transferring DLS_User DATA to DLE in configured order and priority. The DLE will send it to Ethernet network using the protocols defined in ISO/IEC8802-3;

i) transferring decoded DLPDU from DLE to DLS_User.

ECSME supports two ways of communication scheduling:

j) free competitive communication scheduling based on the CSMA/CD;

k) deterministic communication based on the time-sharing scheduling policy defined later.

When the former scheduling is used, ECSME shall directly transfer the data between DLE and DLS_User without any buffering or handling.

When the latter k) is used, the ECSME in each Type 14 device shall transfer DLS_User DATA to DLE according to the pre-configured timing order and priority, the DLE shall process the data and send it to PhL, so that the collision is avoided.

ECSME is the extension based on LLC defined in ISO/IEC 8802-3. It transfers data between DLS_User and LLC without any changing.

ECSME does not alter the services provided by DLL to DLS_User defined in ISO/IEC 8802-3 as well as the interface between PhL and MAC. It only provides the transmission management of the DLS_User data.

4.1.2 Transaction between DLL and PhL

The transactions between DLL and PhL defined in ISO/IEC 8802-3 are applied without any changes.

4.2 Services provided by the DLL

The DLL provides connectionless data transfer services and connection-mode data transfer services defined in ISO/IEC 8802-3, RFC 768, RFC 791 and RFC 793 protocols.

For time synchronization, the services defined in IEC 61588:2004 apply.

For deterministic communication, additional services for scheduling management are defined based on ISO/IEC 8802-3.

5 DL-management services

5.1 Overview

This subclause defines the constraints on the sequence in which the primitives defined in this clause may occur. The constraints determine the order in which primitives occur, but do not fully specify when they may occur. Other aspects of actual system operation, such as PhL problems affecting messages in transit, will affect the ability of a DLS-user or a DLS provider to issue a primitive at any particular time.

5.2 Non-periodic data annunciation

5.2.1 General

This service is defined for a Type 14 device to broadcast all other devices if it has non-periodic data to be sent at the non-periodic data transferring phase.

When a Type 14 device has non-periodic data (such as alert, alarm, domain download/upload) to be sent, it shall broadcast the request primitive to all other nodes in the local micro-segment.

The sequence of primitive of this service is shown in Figure 3.

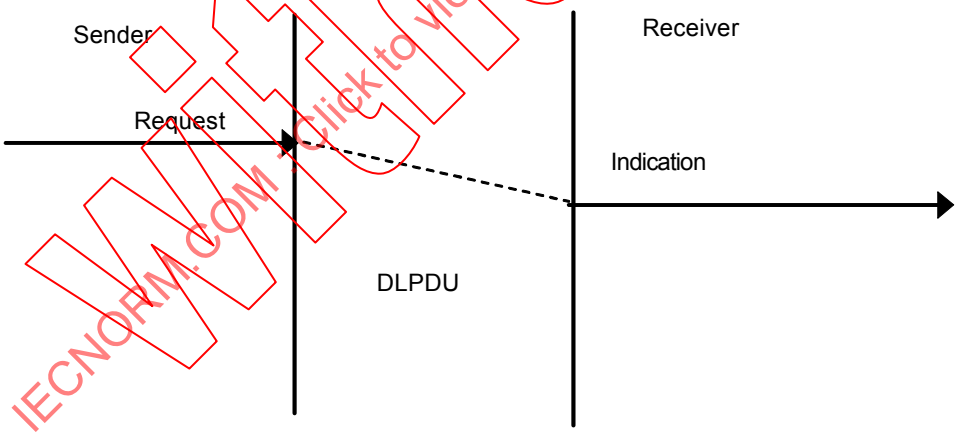


Figure 3 – Sequence of non-periodic data annunciation service and end of non-periodic data annunciation service