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SPECIFICATION**

**IEC
PAS 62406**

First edition
2005-08

**Real-time Ethernet TCnet
(Time-Critical Control Network)**

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



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Real-time Ethernet TCnet (Time-Critical Control Network)

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The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
65C/353/NP	65C/370/RVN

Following publication of this PAS, the technical committee or subcommittee concerned will transform it into an International Standard.

It is intended that the content of this PAS will be incorporated in the futures new editions of the various parts of IEC 61158 series according to the structure of this series.

This PAS shall remain valid for an initial maximum period of three years starting from 2005-08. The validity may be extended for a single three-year period, following which it shall be revised to become another type of normative document or shall be withdrawn.

Real-time Ethernet TCnet (Time-Critical Control Network)

1 Introduction

1.1 General

This PAS describes a set of the specifications essential for the ISO/IEC 8802-3 based “Time-critical Control Network (TCnet)”, which is one of the communication networks for Real- Time Ethernet (RTE) defined in IEC 61784-2 and is referred to as “RTE-TCnet” hereafter, and each specification in this PAS is to be classified into a separate part of IEC 61158 series.

This PAS meets the industrial automation market objective of providing predictable time deterministic and reliable time-critical data transfer and means, which allow co-existing with non time-critical data transfer over the ISO/IEC 8802-3 series communications medium, for support of cooperation and synchronization between automation processes on field devices in real time application system. 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.

This PAS specifies the part of the protocol set of the RTE-TCnet communication profile and/or of one or more communication profiles related to a common family of RTE-TCnet. The RTE-TCnet communication profile, shown in Figure 1 as one of the profile set, is based on the 7 layer OSI Basic Reference model. For regular ISO/IEC 8802-3 based applications the upper layers mapped over the Data Link layer is in the ordinary way, on the other hand for time-critical applications with Common Memory running in parallel the specific application layer for RTE-TCnet is specified. The Data Link layer for RTE-TCnet has the extension, but compliant to the ISO/IEC 8802-3 MAC protocol in order to provide both services for time-critical communications and common memory applications respectively.

	Regular ISO/IEC 8802-3 based applications	Time-critical applications with Common memory
Application layer	TELNET, FTP, HTTP OPC XML-DA etc	Common memory
Transport layer	RFC 768(UDP) RFC 793 (TCP)	null
Network layer	RFC 791 (IP)	
Data Link layer	ISO/IEC 8802-3 Specific scheduling extension	
Physical layer	ISO/IEC 8802-3 (Redundant)	

Figure 1 – RTE-TCnet communication profile

This PAS addresses the essential part of the RTE-TCnet profile, which are the extension part of ISO/IEC 8802-3 based Data Link layer and the Application layer exploiting the services of the Data Link layer immediately below.

This PAS describes the specifications essential for RTE-TCnet profile, specifically on the Data Link layer and the Application layer, in terms of the “three-layer” Fieldbus Reference Model which is based in part on the OSI Basic Reference Model. Other part of RTE-TCnet profile is not in the scope of this PAS.

1.2 Nomenclature for references within this PAS

Clauses, including annexes, can be referenced in their entirety, including any subordinate subclauses, as “Clause N” or “Annex N”, where N is the number of the clause or letter of the annex.

Subclauses can be referenced in their entirety, including any subordinate subclauses, as “N.M” or “N.M.P” and so forth, depending on the level of the subclause, where N is the number of the subclause or letter of the annex, and M, P and so forth represent the successive levels of subclause up to and including the subclause of interest.

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Stated differently, a reference ending with “.0” designates the text and figures between a clause or subclause header and its first subordinate subclause.

2 Scope

2.1 Field of applications

In industrial control systems, several kinds of field devices such as Drives, Sensors and Actuators, Programmable controllers, Distributed Control Systems and Human Machine Interface devices are required to be connected with control networks. The process control data and the state data is transferred among these field devices in the system and the communications between these field devices requires simplicity in application programming and to be executed with adequate response time. In most industrial automation systems such as food, water, sewage, paper and steel, including a rolling mill, the control network is required to provide time-critical response capability for their application, as required in ISO/TR 13283 for time critical communications architectures.

Plant production may be compromised due to errors, which could be introduced to the control system if the network does not provide a time-critical response. Therefore the following characteristics are required for a time-critical control network.

A deterministic response time between the control device nodes

Ability to share process data seamlessly across the control system

RTE-TCnet is applicable to such industrial automation environment, in which time-critical communications is primarily required. 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.

2.2 Scope and objectives

This PAS specifies the protocol set necessary for RTE-TCnet, specifically of the Data Link layer and the Application layer, which is mapped on top of the Data Link layer to exploit the services in terms of the “three-layer” Fieldbus Reference Model which is based in part on the OSI Basic Reference Model. Both Reference Models subdivide the area of standardization for interconnection into a series of layers of specification, each of manageable size. Throughout this PAS, the term “service” refers to the abstract capability provided by one layer of the OSI Basic Reference model to the layer immediately above.

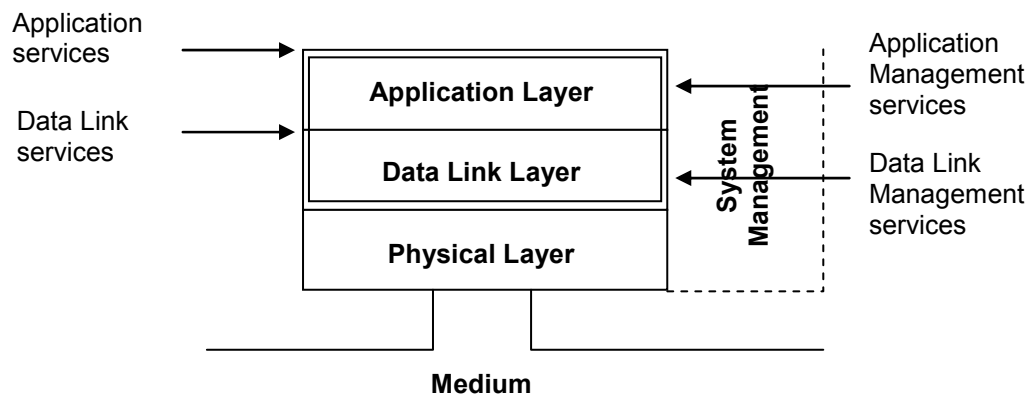


Figure 2 – Scope of this PAS

The relationship between the Data Link layer Services and Protocol, the Application Layer Services and Protocol, and the Systems management in this PAS is illustrated in Figure 2.

NOTE Systems management, as used in this PAS, is a local mechanism for managing the layer protocols.

This PAS consists of

- Data Link Layer Service definitions
- Data Link Layer Protocol specification
- Application Layer Service definitions
- Application Layer Protocol specification

The services both of the Data Link and the Application layer in this PAS is a conceptual architectural service, independent of administrative and implementation divisions.

The Data Link layer describes the extension for RTE-TCnet of ISO/IEC 8802-3 Data Link layer, and the Application layer describes the utilization of the global common memory, which is a conceptual virtual shared memory over the RTE-TCnet however is mapped onto the physical common memory provided in each node and is used for time-critical intercommunications among all participating application entities on each node over the RTE-TCnet in very simple fashion of output and input to/from regular memory configuration.

3 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 61158-3:2003, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems – Part 3: Data link service definition*

IEC 61158-4:2003 3, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems – Part 4: Data link protocol specification*

IEC 61158-5:2003, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems – Part 5: Application layer service definition*

IEC 61158-6:2003, *Digital data communications for measurement and control – Fieldbus for use in industrial control systems – Part 6: Application layer protocol specification*

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

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 8822:1994, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824-1:2002, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

ISO/IEC 8825-1:2002, *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*

ISO/IEC 8886:1996, *Information technology – Open Systems Interconnection – Data link service definition*

ISO/IEC 9545:1994, *Information technology – Open Systems Interconnection – Application Layer structure*

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

ISO/TR 13283:1998, *Industrial automation – Time critical communications architectures – User requirements and network management for time-critical communications systems*

4 Terms and definitions

Terms and definitions of this PAS are described separately in 6.4 for Data Link Layer Service definitions, in 7.4 for Data Link Layer Protocol specification, in 8.4 for Application Layer Service definition and in 9.4 for Application Layer Protocol specification.

5 Symbols and abbreviations

Symbols and abbreviations of this PAS are described separately in 6.5 for Data Link Layer Service definitions, in 7.5 for Data Link Layer Protocol specification, in 8.4.8 for Application Layer Service definition and in 9.4.3 for Application Layer Protocol specification.

6 Data Link Layer Service definitions

6.1 Introduction

The Data Link layer service of RTE-TCnet is defined in this section. This section of the Data Link layer service definitions is to be one of type of IEC 61158-3 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, which is based in part on the Basic 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.

The Data Link Service is provided by the Data Link Protocol making use of the services available from the Physical Layer. This section 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 Application Service, Fieldbus Application Protocol and Systems Management is illustrated in Figure 3.

NOTE Systems Management, as used in this PAS, is a local mechanism for managing the layer protocols.

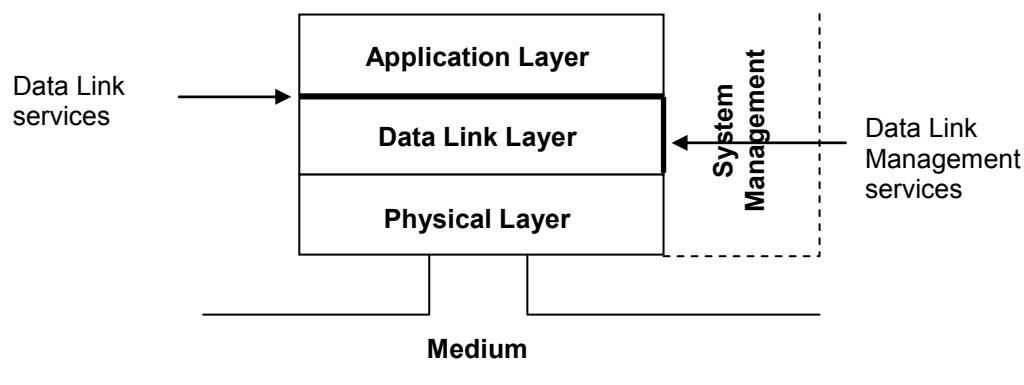


Figure 3 – Relationship of the RTE-TCnet Data link layer to other RTE layers and to users of RTE Data link service

6.2 Scope

6.2.1 Overview

The Data Link service of RTE-TCnet provides 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 section defines in an abstract way the externally visible services provided by the 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 section is to define the services provided to

- 1) The Application layer at the boundary between the Application and Data Link layers of the Fieldbus Reference Model, and
- 2) Systems Management at the boundary between the Data Link layer and Systems Management of the Fieldbus Reference Model

Seven distinct types of services are defined in IEC 61158-3; each has a corresponding protocol in IEC 61158-4. This RTE-TCnet Data Link service is to be included as an additional type into IEC 61158-3 as well as the corresponding RTE-TCnet Data Link protocol, defined in section 7 as an additional type into IEC 61158-4.

As additional type of IEC 61158 the RTE-TCnet Data Link service provides a superset of those services expected of OSI Data Link Protocol as specified in ISO/IEC 8886. Thus the RTE-TCnet Data Link service is able to support:

- a) The OSI Network Layer at the boundary between the Network and Data Link Layers of the OSI Basic Reference Model
- b) The IETF (IP) Network Layer

The RTE-TCnet Data Link Service and the different Types of Data Link services defined in IEC 61158-3 are each presumed self-consistent, but in general are unrelated to the other Types of service.

6.2.2 Specifications

The principal objective of this section is to specify the characteristics of conceptual Data Link 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.

This PAS 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 PAS, 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.

6.2.3 Conformance

This PAS does not specify individual implementations or products, nor does it constrain the implementations of Data Link entities within industrial automation systems.

There is no conformance of equipment to this Data Link Service definition specification. Instead, conformance is achieved through implementation of conforming Data Link protocols that fulfill any given Type of Data Link Services as defined in this PAS.

6.3 Void

6.4 Terms and definitions

6.4.1 node

Single DL-entity as it appears on one local link

6.4.2 node-id

Two-octet primary identifier for the DLE on the local link, whose values are constrained. A permissible value is from 1 to 255. A value 0 is specifically used for SYN node, which emits SYN frame.

6.4.3 DLSAP

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

6.4.4 DLCEP-address

DL-address which 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

6.4.5 multi-peer DLC

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. 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).

6.4.6 multipoint connection

Connection from one node to many nodes. Multipoint connection allows data transfer from a single publisher to many subscriber nodes.

6.5 Symbols and abbreviations

6.5.1 Common symbols and abbreviations

6.5.1.1 CSMA/CD Carrier sense multiple access with collision detection

6.5.1.2 DA Destination address

6.5.1.3 DL- Data Link Layer (as a prefix)

6.5.2 DLC DL-connection

6.5.2.1 DLCEP DL-connection-end-point

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

6.5.2.3 DLL DL-layer

6.5.2.4 DLPDU DL-protocol-data-unit

6.5.2.5 DLM DL-management

6.5.2.6 DLME DL-management Entity (the local active instance of DL-management)

6.5.2.7 DLMS DL-management Service

6.5.2.8 DLS DI-service

6.5.2.9 DLSAP DL-service-access-point

6.5.2.10 DLSDU DL-service-data-unit

6.5.2.11 MSDU MAC service data unit

6.5.2.12 OSI Open systems interconnection

6.5.2.13 Ph- Physical layer (as a prefix)

6.5.2.14 PhL Ph-layer

6.5.2.15 PhS Ph-service

6.5.2.16 PhSAP Ph-service-access-point

6.5.2.17 QoS Quality of service

6.5.2.18 SA Source address

6.5.3 RTE-TCnet: Additional symbols and abbreviations

6.5.3.1 CM Common memory

6.5.3.2 GCM Global common memory

6.5.3.3 RTE Real Time Ethernet

6.6 Conventions

6.6.1 General conventions

This PAS 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.

6.6.1.1 Parameters

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 PAS 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 specification. 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.

6.6.1.2 Identifiers

Many 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 PAS is a purely local issue. Nevertheless, these identifiers are specified explicitly in these primitives to provide a descriptive means

- a) of canceling (aborting) an outstanding request primitive before receiving its corresponding confirm primitive;
- b) for referring within a request or response primitive to persistent DL-objects, such as buffers and queues, which were created as the result of a previous DLS primitive; and
- c) for referring within an indication or confirm primitive to persistent DL-objects which 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 b); while DL-identifiers are required for c).

6.6.2 Additional convention

In the diagrams which illustrate 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 which occur within the DLE-provider at a single station.

6.7 Data link service and concept

6.7.1 General description of services

6.7.1.1 General

The DLS provides for transparent and reliable transfer of data between DLS-users over RTE-TCnet. The DLS is based on services provided by the physical layer of ISO/IEC 8802-3 to the conceptual interface between the Physical and Data Link layers.

Two types of data transmission services are provided:

- a) **Time-critical Cyclic data service:** The connection-oriented buffer transfers between pre-established point-to-multipoint DLCEPs on the same local link.
- b) **Sporadic message data service:** The unacknowledged connectionless message transfers between single DLSAPs, or unacknowledged connectionless message transfer from a single DLSAP to a group of DLSAPs on the extended link.

NOTE For the purpose of clarity, the expressions "buffer transfer" and "message transfer" are used to distinguish between the two types of communications services, connection-oriented and connectionless, respectively, that are offered by this DLS.

The buffer transfer service or the Time-critical Cyclic data service is based on cyclic data transfers of three kinds of transmission period. The transmission periods and the total volumes of each level of the buffer transfer by the multiple distributed DLS-providers on the same local link are defined when the system is configured, and are based on application needs. Cyclic data transfers are automatically triggered by the communications system without the user requesting them.

There are also three types of Time-critical Cyclic data service according to the transmission period:

- a) **High-speed Cyclic data transmission**
- b) **Medium-speed Cyclic data transmission**
- c) **Low-speed Cyclic data transmission**

The message transfer service or the Sporadic message data service is based on aperiodic data transfer, sporadically occurred upon DLS-user requesting one or more message to transfer. The priority level and the target token rotation time, corresponding to the target time to obtain the transmission right to send out the message data on the medium, is defined when the system is configured, and are based on application needs. The transmit delay is depending on the priority level and the target token rotation time. Regular ISO/IEC 8802-3 Ethernet message frame is transferred by means of this message transfer service.

The DLS provides DLS-users with a means to set up a quality of service for the transfer of data. QoS is specified by means of QoS parameters representing aspects such as data transmit delay, priority level, DLCEP data length, and so on. A DL-management Service (DLMS) is defined in 6.8.

6.7.1.2 Overview of the Data frames flow on the medium

Overview of the data frames flow on the medium is shown in

Figure 4 and Figure 5.

The DLL provides the opportunity of transferring data to each node in a sequential order and within a predetermined time period. At the start time of every High-speed-Transmission-period (Tsyn), the SYN frame is broadcasted to all RTE-TCnet nodes. Received the SYN frame, the node with sequential number 1 (Node 1) starts sending its data frames, and after the completion of its data frames transmission Node 2 can send out its data frames. The Nth node (Node N) can obtain the transmission right after the (N-1) th node completes its data frames transmission. The sequential number is assigned to each node at the time approval to join the RTE-TCnet is granted, and is up to 255.

Each node can hold the transmission right for a preset time and must transfer the transmission right to the next node within the preset time. The data to be sent and the data to be held over are determined by priority.

Data transmission includes cyclic data and sporadic message transmission. Cyclic data transmission is divided into High, Medium and Low-speed Cyclic data transmission. Each node sends the High-speed Cyclic data frames on each occasion when it obtains the transmission right. The data of lower priorities, that is the Medium-speed Cyclic data, the sporadic message data and the Low-speed Cyclic data respectively, is sent or not sent depending on the circumstances.

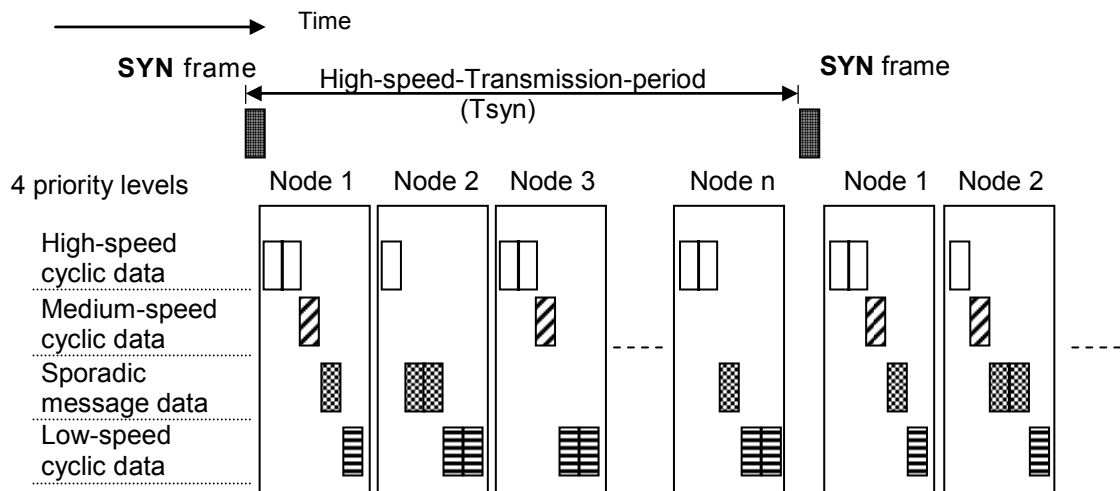


Figure 4 – Overall flow of Data frames during 1 Minimum Cycle period (High-speed Transmission-period)

The holding time of the transmission right of each node is determined by the settings of the High-speed Cyclic, the Medium-speed Cyclic, the sporadic message and the Low-speed Cyclic data transmission periods and by the volume of transmission data for each node. After sending all the High-speed Cyclic data, the node sends the Medium-speed Cyclic data. If the holding time of the transmission right ends during sending the Medium-speed Cyclic data, the transmission of the Medium-speed Cyclic data is interrupted. The Node N obtains the transmission right again during the next High-speed transmission period, during which time all the High-speed Cyclic data and the remainder of the previous Medium-speed Cyclic data is sent. As to the Low-speed Cyclic data is sent out in this fashion.

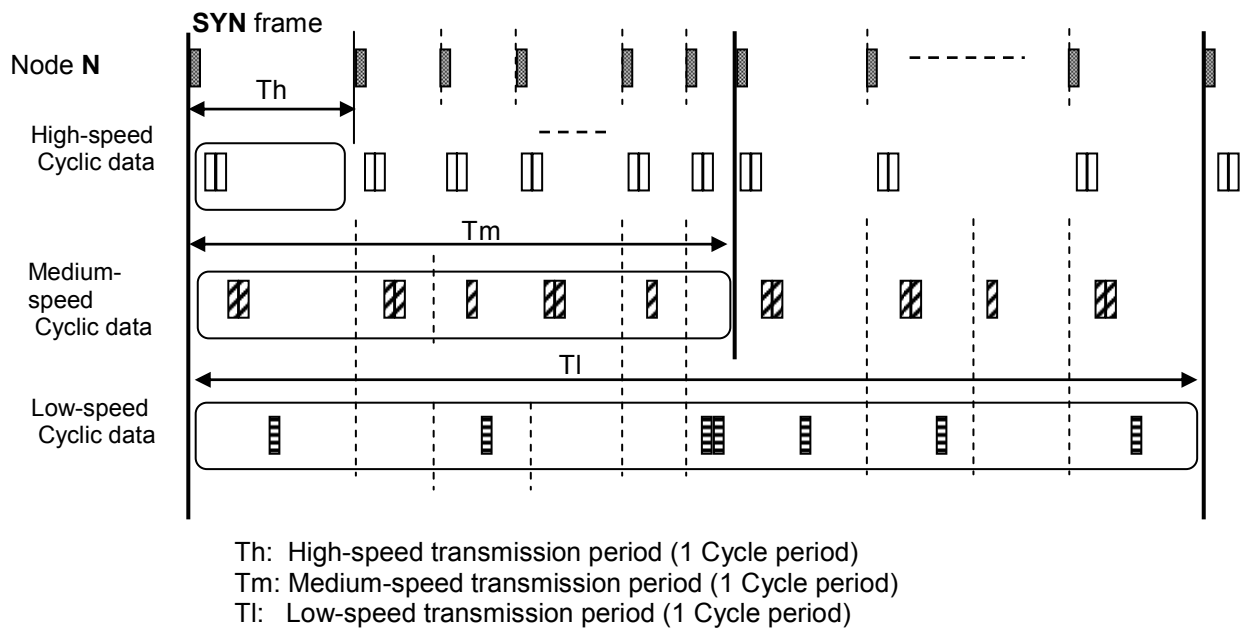


Figure 5 – Overall flow of Cyclic Data frames over 1 Maximum cycle period (Low-speed-Transmission-period)

6.7.1.3 Sequence of primitives

A request primitive is used by a DLS-user to request a service. A confirm primitive is returned to the DLS-user upon completion of the service. Moreover, an indication primitive is used to report to the DLS-user the receipt of new DLS-User Data or the receipt of a new message.

6.7.1.3.1 Primitives on Time-critical Cyclic Data service

The sequence of primitives on Time-critical Cyclic Data service is shown in Figure 6.

DL_DATA_REQ indication primitive informs the DLS-user initiates the data transfer using DL_PUT service from the corresponding DLS-user buffer associated with a specified DLCEP to the send buffer of local DLE for publishing the data.

DL_Put request primitive which responds to DL_DATA_REQ indication primitive allows the DLS-user to transfer data of the corresponding DLS-user buffer associated with a specified DLCEP by the DL_DATA_REQ indication primitive to the Send_buffer of the local DLE where the DLE is the publisher.

DL_Buffer_Received indication primitive informs the DLS-user that a subscribed data if a DLCEP has just correctly received. The data in the Receive_buffer of the local DLE is updated and is available, and is read by the DLS-user using the DL_Get request primitive.

DL_Get request primitive which responds to DL_Buffer_Received indication primitive allows the DLS-user to get the data in the Receive_buffer of the local DLE and to transfer the data from the Receive_buffer to the corresponding DLS-user buffer associated with the specified DLCEP by DL_Buffer_Received indication primitive by the DLE where the DLE is the subscriber.

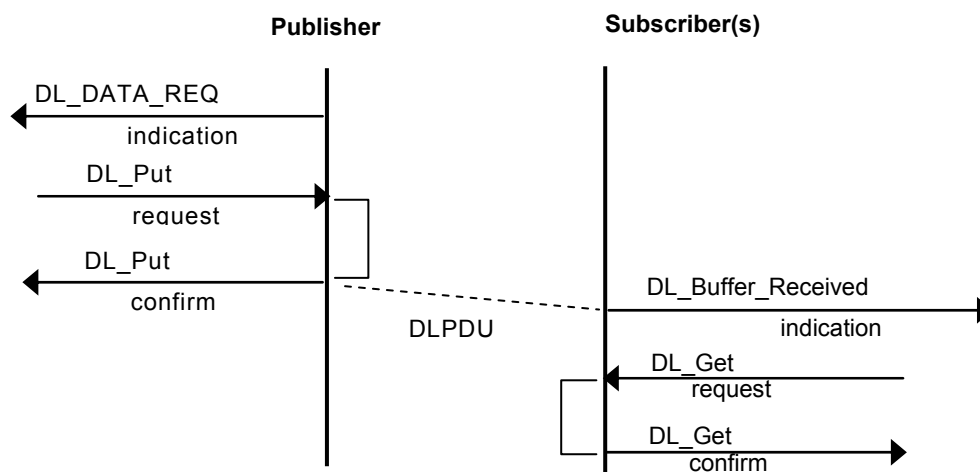


Figure 6 – Sequence Diagram of Time-critical Cyclic Data service

6.7.1.3.2 Sporadic Message Data service

The sequence of primitives on Sporadic Message Data service is shown in Figure 7.

DL_SPDATA request and DL_SPDATA indication correspond to the MA_DATA request and MA_DATA indication defined by ISO/IEC 8802-3 respectively.

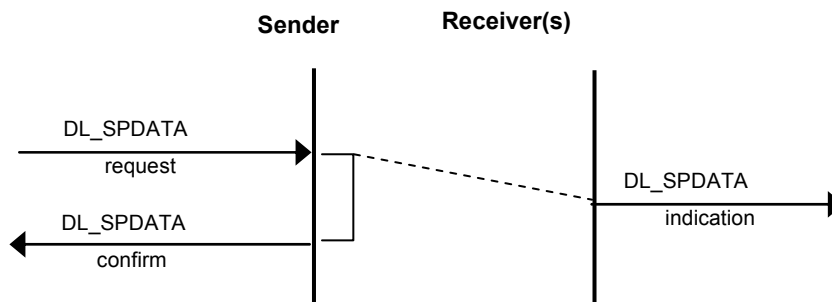


Figure 7 – Sequence diagram of Sporadic Message service

6.7.1.4 Addressing

Two different types of addressing are for the DL-addressing: one for Time-critical Cyclic Data service and the other for Sporadic Message Data service.

For buffer transfers of Time-critical Cyclic Data service: Each variable in the system is associated with a DLCEP-identifier that characterizes it within the system in a unique manner. Entities participating in a buffer transfer are not identified explicitly. Rather, they are identified indirectly as subscribers or publisher of the identified variable. Each variable has only one publisher.

For message transfer of Sporadic Message Data service: One or more DLSAP-addresses are defined within each DLE. These DLSAP-addresses give access to a message transfer service. Each DLSAP-address identifies an access point to a message service linked to a DLS-user entity. During the message transaction two DLSAP-addresses are indicated in order to establish contact between the communicating entities. Each DLSAP-address specifies a DLS-user of the message link service (for both emission and reception). This DL-address is unique within the extended link.

Variable addressing is restricted to the local link. The addressing mechanism makes it possible to identify variables and exchanges independent of the producing and consuming DLEs. For buffer transfers all relationships between the various DLS-users are known and defined when the system is configured. Each DLCEP-identifier characterizes a single system variable and thus establishes a relationship between the unique publisher of the variable and the subscribers of the variable.

Buffer transfers use the local broadcast medium and are restricted to the local link: the DLCEP-identifier and the value of a variable are made available to all DLEs on the local link. The DLCEP-identifier associated with the variable allows each DLE to recognize whether or not it is the publisher or a subscriber of the value associated with the identified variable.

The relationship of peer to peer and multi-peer DLCs and their DLCEPs is shown in Figure 8. DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers. 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. A single DL-entity may have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP. This figure also shows the relationships of DL-paths and PhSAPs.

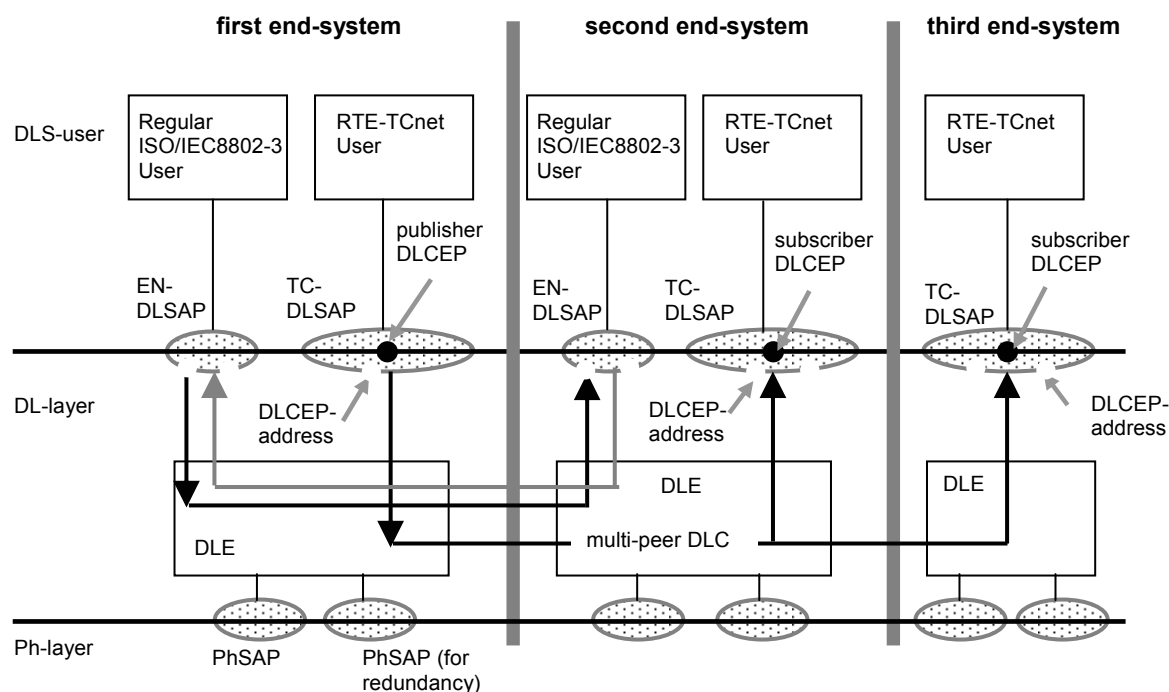


Figure 8 – Relationship of DLSAP, DLCEP and DLCEP-address

6.7.2 Time critical cyclic data service

6.7.2.1 General

This DLS provides connection-oriented buffer transfers between pre-established point-to-multipoint DLCEPs on the same local link.

6.7.2.2 Sequence of primitives

The Time-critical Cyclic Data service primitives and the parameters are summarized in Table 1, and the primitive sequence is shown in Figure 6.

Table 1 – Primitives and parameters used on time critical cyclic data service

Function	Location	Primitive	Direction	Parameters
Notify publisher DLS-user	Publisher	DL_DATA_REQ indication	from DLE	DLCEP-identifier DLSDU-length
Put buffer	Publisher	DL_Put request	to DLE	DLCEP-identifier DLSDU-length DLSDU
Put confirm to publisher DLS-user	Publisher	DL_Put confirm	from DLE	DLCEP-identifier Status
Notify subscriber DLS-user	Subscriber(s)	DL_Buffer_Received indication	from DLE	DLCEP-identifier DLSDU-length
Get buffer	Subscriber(s)	DL_Get request	to DLE	DLCEP-identifier DLSDU-length
Confirm to publisher DLS-user	Subscriber(s)	DL_Get confirm	from DLE	DLCEP-identifier DLSDU-length DLSDU Status
NOTE In this table, time increases from top to bottom.				

6.7.2.3 Data request

6.7.2.3.1 Function

DL_DATA_REQ service informs the DLS-user that initiates the transfer using the DL-Put service from the corresponding DLS-user buffer associated with a specified DLCEP to the Send_buffer of local DLE for publishing the data.

6.7.2.3.2 Types of primitives and the parameters of Data request

Table 2 indicates the parameters of Data request service.

Table 2 – Data request primitives and the parameters

DL-DATA_REQ Parameter name	Indication
	output
DLCEP-identifier	M
DLSDU-length	M

6.7.2.3.2.1 DLCEP-identifier

This parameter specifies from which buffer the DLS-user reads and transfers the data into the Send_buffer of the local DLE for publishing.

6.7.2.3.2.2 DLSDU-length

This parameter indicates the length of the identified buffer, that is the actual length of the contents in a DLSDU.

6.7.2.4 Put Buffer

6.7.2.4.1 Function

DL_Put request, which responds to DL_DATA_REQ indication, allows the DLS-user to transfer data of the corresponding DLS-user buffer associated with the specified DLCEP by the DL_DATA_REQ indication to the Send_buffer of the local DLE where the DLE is the publisher.

6.7.2.4.2 Types of primitives and parameters of Put buffer

Table 3 indicates the types of primitives and parameters for Put buffer.

Table 3 – Put buffer primitives and parameters

DL-Put Parameter name	Request	Confirm
	input	output
DLCEP-identifier	M	M(=)
DLSDU-length	M	M(=)
DLSDU	M	
Status		M

6.7.2.4.2.1 DLCEP-identifier

This parameter indicates from which buffer DLS-user reads and writes data into the Send_buffer of the local DLE.

6.7.2.4.2.2 DLSDU-length

This parameter indicates the length of the identified buffer, that is the actual length of the contents in a DLSDU.

6.7.2.4.2.3 DLSDU

This parameter specifies the information that is transferred by buffer transfer from the local DLE as a publisher to the remote multi-peer DLEs as subscribers.

6.7.2.4.2.4 Status

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

- a) "success"
- b) "failure – invalid requested parameter"

6.7.2.5 Get Buffer

6.7.2.5.1 Function

DL_Get request which responds to DL_Buffer_Received indication allows the DLS-user to get and transfer the data from the Receive_buffer of the local DLE to the corresponding DLS-user buffer associated with the specified DLCEP by DL_Buffer_Received indication by the DLE where the DLE is the subscriber.

6.7.2.5.2 Type of primitives and parameters of the Get buffer

Table 4 indicates the types of primitives and parameters for Get buffer.

Table 4 – Get buffer primitives and parameters

DL-Get	Request	Confirm
Parameter name	input	output
DLCEP-identifier	M	M(=)
DLSDU-length	M	M(=)
DLSDU		M
Status		M

6.7.2.5.2.1 DLCEP-identifier

This parameter unambiguously designates to which buffer DLS-user reads and transfers data from the Receive_buffer of the local DLE.

6.7.2.5.2.2 DLSDU-length

This parameter indicates the length of the data to be transferred from the Receive_buffer of the local DLE to the identified buffer of the DLS-user.

6.7.2.5.2.3 DLSDU

This parameter specifies the information that is transferred by buffer transfer by the remote DLE as a publisher to the local DLE as subscribers.

6.7.2.5.2.4 Status

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

- a) "success"
- b) "failure -- invalid requested parameter"

6.7.2.6 Notify Buffer Received

6.7.2.6.1 Function

DL_Buffer_Received indication informs the DLS-user that a subscribed identified data has just correctly received. The data in Receive_buffer of the local DLE is updated and is available, and is read by the DLS-user using the DL_Get request primitive.

6.7.2.6.2 Types of primitives and parameters of the Notify buffer received

Table 5 indicates the types of primitives and parameters for Notify buffer received.

Table 5 – Notify buffer received primitives and parameters

DL-Buffer_Received	Indication
Parameter name	output
DLCEP-identifier	M
DLSDU-length	M

6.7.2.6.2.1 DLCEP-identifier

This parameter unambiguously designates to which buffer DLS-user reads and transfers the data from the receive_buffer of the local DLE.

6.7.2.6.2.2 DLSDU-length

This parameter indicates the length of the identified buffer that is the actual length of the contents in a DLSDU.

6.7.3 Detail description of Sporadic Message Data service

6.7.3.1 General

This DLS provides unacknowledged connectionless message transfers between single DLSAPs, or unacknowledged connectionless message transfer from a single DLSAP to a group of DLSAPs on the extended link.

A pair set of DL_SPDATA request and DL_SPDATA indication corresponds to that of the MA_DATA request and MA_DATA indication defined by ISO/IEC 8802-3 respectively.

6.7.3.2 Sequence of primitives

The Sporadic Message Data service primitives and the parameters are summarized in Table 6, and the primitive sequence is shown in Figure 7.

Table 6 – Primitives and parameters used on Sporadic message data service

Function	Location	Primitive	Direction	Parameters
Send DLSDU	Sender	DL_SPDATA request	to DLE	DA(destination_address) SA(source_address) MSDU(m_sdu) Service_class
Send confirmation to calling DLS-user	Sender	DL_SPDATA confirm	from DLE	Status
Notify and provide MA_SDU received to peer called DLS-user	Receiver(s)	DL-SPDATA indication	from DLE	DA(destination_address) SA(source_address) MSDU(m_sdu) Rec_Status(reception_status)
NOTE 1 In this table, time increases from top to bottom.				
NOTE 2 DL_SPDATA service primitives respond to the MA_DATA service primitives defined by ISO/IEC 8023:2003.				

6.7.3.3 Send Sporadic message

6.7.3.3.1 Function

DL_SPDATA service primitives allow the DLS-user to transfer message data to a single peer DLS-user or multi-peer DLS-users in remote nodes.

6.7.3.3.2 Types of primitives and parameters of the Send sporadic message

Table 7 indicates the types of primitives and parameters for Send sporadic message.

Table 7 – Submit sporadic message primitives and parameters

DL-SPDATA	Request	Indication	Confirm
Parameter name	input	output	output
DA(destination address)	M	M(=)	M(=)
SA(source address)	U	M(=)	
Service_class	U		
MSDU (m_sdu)	M	M(=)	
Rec-Status (reception status)		M	
Status			M

6.7.3.3.2.1 DA (destination address)

This parameter indicates the DLE(s) for which the DLPDU is intended. It may be an individual or multicast (including broadcast) address.

6.7.3.3.2.2 SA (source address)

This parameter indicates an individual DLE from which the DLPDU is sending.

6.7.3.3.2.3 MSDU (MAC service data unit)

This parameter specifies the MAC service data unit to be transmitted by MAC sublayer entity.

6.7.3.3.2.4 Service_Class

This parameter indicates a quality of service requested by DLS-user.

NOTE The RTE-TCnet DL protocol as well as the CSMA/CD (ISO/IEC 8802-3) MAC protocol provides a single quality of service regardless of the service_class.

6.7.3.3.2.5 Rec_Status

This parameter is used to pass status information upon the DLPDU received to the DLS-user.

- a) "success – received without error "
- b) "failure – received but with error "

6.7.3.3.2.6 Status

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

- a) "success – successfully completed "

- b) "failure – invalid requested parameter"

6.8 DL-management services

6.8.1 General

The interface between a DLE and a DL-management user (DLMS-user) is described. The services of this interface are needed for the protocol which implements the DLS specified in 6.7 Data link service and concept.

6.8.2 Facilities of the DL-Management service

DL-management service 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 of 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 and for the Common Memory configuration of the local DLE
- e) Activation and deactivation of the Cyclic Data transmission of the local DLE

6.8.3 Service of the DL-management

6.8.3.1 Overview

DL-management provides the following services to DLMS-user.

- a) Reset
- b) Set Value
- c) Get Value
- d) Event
- e) Set Publisher configuration
- f) Get Publisher configuration
- g) Activate Publisher
- h) Deactivate Publisher

The services Reset, Set Value, Event, Set Publisher configuration and Activate Publisher are considered mandatory. Other services are considered optional.

6.8.3.2 Reset

The DLMS-user employs this service to cause DL-management to reset the DLE. A reset is equivalent to power on. The DLMS-user receives a confirmation thereof.

6.8.3.3 Set value

The DLMS-user employs this service to assign new values to the variables of the DLE. The DLMS-user receives a confirmation whether the specified variables have been set to the new values.

6.8.3.4 Get value

This service allows the DLMS-user to read variables of the DLE. The response of the DL-management returns the actual value of the specified variables.

6.8.3.5 Event

DL-management employs this service to inform the DLMS-user about certain events or error in the DLL.

6.8.3.6 Set Publisher configuration

The DLMS-user employs this service to assign new Publisher configuration parameters to the Time-critical cyclic data of the DLE. DLS-user receives a confirmation whether the specified parameters have been set to the new one.

6.8.3.7 Get Publisher configuration

This service enables DL-management to read Publisher configuration parameters of the Time-critical cyclic data. The response of the DL-management returns the actual value of Publisher configuration parameters.

6.8.3.8 Activate Time-critical Cyclic data service

This service allows the DLMS-user to activate the Time-critical Cyclic data transmission service. The DLMS-user receives the confirmation whether the designated Time-critical Cyclic data transmission has been started or this request has been completed unsuccessfully.

6.8.3.9 Deactivate Time-critical Cyclic data service

This service allows the DLMS-user to deactivate the Time-critical Cyclic data transmission service. The DLMS-user receives the confirmation whether the designated Time-critical Cyclic data transmission has been terminated or this request has been completed unsuccessfully.

Overview of interactions

The DL-management services and their primitives are summarized in Table 8.

Table 8 – Summary of DL-management primitives and parameters

Service	Primitive	Parameter
Reset	DLM-Reset request	(<none>)
	DLM-Reset confirm	(out Status)
Set value	DLM-Set-Value request	(in Variable-name, Desired-value)
	DLM-Set-Value confirm	(out Status)
Get value	DLM-Get-Value request	(in Variable-name)
	DLM-Get-Value confirm	(out Status, Current-value)
Event	DLM-Event indication	(out Event-identifier, Additional-information)
Set Publisher configuration parameters	DLM-Set-Publisher-Configuration request	(in Desired-speed-class, Desire-configuration)
	DLM-Set-Publisher-Configuration confirm	(out Status)
Get Publisher configuration parameters	DLM-Get-Publisher-Configuration request	(in Desire-speed-class)
	DLM-Get-Publisher-Configuration confirm	(out Status, Current-configuration)
Activate Time-Critical Cyclic service	DLM-Activate-TCC request	(in Desired-speed-class)
	DLM-Activate-TCC confirm	(out Status)
Deactivate Time-Critical Cyclic service	DLM-Deactivate-TCC request	(in Desired-speed-class)
	DLM-Deactivate-TCC confirm	(out Status)

The sequence of the DL-management primitives are shown in Figure 9 and Figure 10.

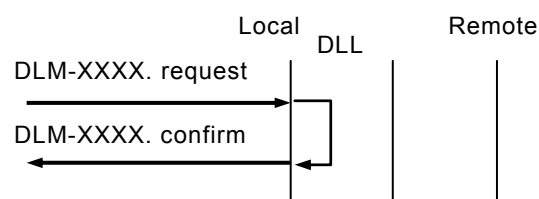


Figure 9 – Sequence diagram of Reset, Set value, Get value, Set CM configuration, Get CM configuration, Activate Time-critical cyclic data and Deactivate Time-critical Cyclic data service primitives

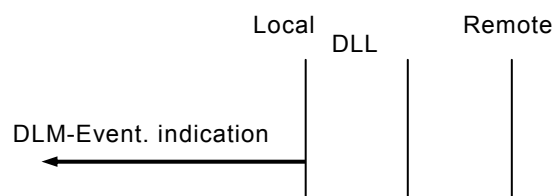


Figure 10 – Sequence diagram of Sporadic Message service

6.8.4 Detail specification of service and interactions

6.8.4.1 Reset

6.8.4.1.1 Function

The DLM-Reset request primitive causes DLMS to reset the DLE. The DLE assumes the “Offline” status after carried out in the same manner as at a power on, and all DLE variables are cleared. The DLMS-user receives DLM-Reset confirmation primitive with the status of the result in success or failure.

6.8.4.1.2 Type of primitives and parameters of DLM-Reset

Table 9 indicates the primitive and parameters of the Reset service.

Table 9 – DLM-Reset primitives and parameters

DLM-Reset	Request	Confirm
Parameter name	input	output
Status		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.1.2.1 Status

This parameter allows the DLMS-user to determine whether the requested DLMS was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) “OK – successfully completed”
- b) “Failure – terminated before completion”.

6.8.4.2 Set value

6.8.4.2.1 Function

This service is used to assign new values to the variables of the DLE. The DLMS-user receives the confirmation whether the specified variables has been set to the new values.

6.8.4.2.2 Type of primitives and parameters of DLM-Set-value

Table 10 indicates the primitive and parameters of the set service.

Table 10 – DLM-Set-value primitives and parameters

DLM-Set value	Request	Confirm
Parameter name	input	output
Variable-name	M	
Desired-value	M	
Status		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.2.2.1 Variable-name

This parameter specifies the variable within the DLE whose value is to be set. The selectable variables are defined in the corresponding part of clause 7 Data Link Layer Protocol specification.

Table 11 – Mandatory DLE-variables and the permissible values

Operating parameters		
Variable-name	Description	Permissible values
Th	High-speed transmission period	value 1 to 160 (in 0,1millisecond)
Tm	Medium-speed transmission period	value 10 to 1000 (in 1 millisecond)
Tl	Low-speed transmission period	value 100 to 10000 (in 1 millisecond)
ST	Slot-time is the fundamentally observational time unit, using in DLME for observing to initiate action such for re-initialisation in sending out CLM packet, for sending out the CMP packet specifically by the current SYN node in substitute for the node missed to send out the CMP packet.	Value 1 to 255 (in 512 bits physical symbol time identical to ISO/IEC 8802-3. Default value is 20 (= 100 µs).)
MHTT	Maximum-token-hold-time for high-speed cyclic data transmission	Value 1 to $2^{16}-1$ (in octet time. Default value is 0x30B4 (= 900 µs).)
TISPD	Time-interval cyclically processed for Sporadic message data service	Value is 1 to 1000 (in 1 millisecond. Default value is 100.)
MD	Maximum distance on the connection path between any 2 nodes	Value 1 to 100 (in kilometre. Default value is 8.)
MDD	Maximum difference of the distance of two redundant physical mediums on the connection path between any 2 nodes	Value 0 to 2000 (in metre. Default value is 500.)
MPD	Maximum difference of the signal delay time propagating over two redundant physical mediums on the connection path between any 2 nodes	Value 1 to 0x7c (in 0,04 µs. Default value is 0x7c (≈ 5 µs).)
MN	Maximum node number	254 (Default value)
IA	Individual address of this node	Individual address in 48 bits length identical to ISO/IEC 8802-3.
MGA	Multicast group address	Multicast address in 48 bits length identical to ISO/IEC 8802-3, for logically associated TCnet nodes. Default value is 0x01-0x00-0x5e-0x50-0x00-0x01.
MRT	Maximum number of the repeater units on the connection path between any 2 nodes	Value 0 to N (Default value is 3.)
BW	Length of Time-critical Cyclic Data word in a DLPDU.	Value is 32 to 128. (in octet. Default value is 128.)
SCMPL	Permissible repetitive count of the CMP packet sent by SYN node in substitution for the corresponding node in order to detect a node out of service.	Value 1 to 16. (Default value is 3)

Table 11 – (continued)

Operating parameters		
Variable-name	Description	Permissible values
RCS	Receive- channel switching control for receiving packets	Designates the switching control for receiving packets out of one of two receive-channel A and B corresponding to each of the redundant medium A and B. "Automatic": Automatically switch to the proper receive-channel. "Force A", "Force B": Force to switch Receive-channel A or B respectively. Default is "Automatic".
RMGP	Maximum time-interval for one receive-channel, which has already completed one packet received and has waited for IGP time, to wait the completion of a packet to be received on the other receive-channel in order to detect the other receive-channel disrupted.	Value is 250. (In 0,04 μ s. Value 250 is equal to 10 μ s)
PBh	List of the data buffers using for sending out High-speed time-critical cyclic data	Max. number of the buffers is 2048.
PBm	List of the data buffers using for sending out Medium-speed time-critical cycle data	Max. number of the buffers is 2048.
PBl	List of the data buffers using for sending out Low-speed time-critical cyclic data	Max. number of the buffers is 2048.

6.8.4.2.2.2 Desired-value

This parameter specifies the desired value for the selected variable. The permitted values or value ranges are defined particularly in clause 7. Though a part of the mandatory DLE-variables and the permissible vales are shown for the information in Table 11.

6.8.4.2.2.3 Status

This parameter allows the DLMS-user to determine whether the requested DLMS was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) "OK – success – the variable could be update"
- b) "Failure – the variable does not exist or could not assume the new value"
- c) "Failure – invalid parameters in the request"

6.8.4.3 Get value

6.8.4.3.1.1 Function

This service can be used to read the value of a DLE variable. The response of the DLMS returns the actual value of the specified variable.

6.8.4.3.2 Type of primitives and parameters of DLM-Get-value

Table 12 indicates the primitive and parameters of the DLM-Get-value service.

Table 12 – DLM-Get-value primitives and parameters

DLM-Get value	Request	Confirm
Parameter name	input	output
Variable-name	M	
Desired-value		M
Status		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.3.2.1 Variable-name

This parameter specifies the variable within the DLE whose value is being requested. The selectable variables are defined in the corresponding part of clause 7.

6.8.4.3.2.2 Status

This parameter allows the DLMS-user to determine whether the requested service was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) "OK – success – the variable could be read"
- b) "Failure – the variable does not exist or could not be read"
- c) "Failure – invalid parameters in the request"

6.8.4.3.2.3 Current-value

This parameter is present when the status parameter indicates that the requested service was performed successfully. This parameter specifies the current value of the selected variable. A part of the observational DLE-variables and the range of values are shown for the information in Table 13.

Table 13 – Observational variables and the range of values

Operating parameter		
Variable-name	Description	Range of value
ATSYN	The observed time period from SYN packet arrival to SYN packet arrival	Value is indicated in octet time.
ATTRT2	The observed time period of the TTRT2	Value is decremented in the range of $2^{16}-1$ to 1.
ATTRT1	The observed time period of the TTRT1	Value is decremented in the range of $2^{16}-1$ to 1.
ATTRT0	The observed time period of the TTRT0	Value is decremented in the range of $2^{16}-1$ to 1.
ATHT	The observed time period of the MHTT	Value is decremented in the range of MHTT to 0.
ASL	The observed time period of the SL	Value is decremented in the range of $V(SL) * 1$ to 0.

Table 13 – (continued)

Operating parameter		
Variable-name	Description	Range of value
ARMGP	The observed time period for one receive-channel, which has already completed one packet received and has waited for IGP time (0.96µsec), to wait the completion of a packet received on the other receive-channel in order to detect the other receive-channel disrupted.	Value is decremented in the range of 250 to 0. Value 250 is equal to 10 µs.
ASCMP	Observed repetitive count of the CMP packet sent out by SYN node in substitution for the corresponding node which has missed to send out the CMP packet. The number counted is indicated and is incremented coincidentally at each DLME.	Value 1 to 16. Default value is 3 and is equal to the value of SCMPL.
NONC	Permissible repetitive count of no CMP packet received by the SYN node within the corresponding consecutive Tsyn cycles, that is 256 times by SCMPL, in order to detect no other node except the SYN node in the TCnet domain.	Value 1 to 16. Default value is 3.
ROK _A , ROK _B	Cumulative count of DLPDU received without error on the receive-channel A or B.	Value is in the range of $2^{32}-1$ to 0.
NCD _A , NCD _B	Cumulative count of Non-Carrier detected on the receive-channel A or B. As to NCD _A it is incremented at the time Non-Carrier happens on the receive-channel A while Carrier occurs on the receive-channel B. NCD _B is as well.	Value is in the range of $2^{32}-1$ to 0.
RE _A , RE _B	Cumulative count of DLPDU received error on the receive-channel A or B. In the case of RE _A , it is incremented at the time there happens error on the receive-channel A while on the receive-channel B there is no error happens.	Value is in the range of $2^{32}-1$ to 0.
CDh	Cumulative count of High-speed-cyclic data packet sent out on the medium.	Value is in the range of $2^{32}-1$ to 0.
CDm	Cumulative count of Medium-speed-cyclic data packet sent out on the medium.	Value is in the range of $2^{32}-1$ to 0.
CDl	Cumulative count of Low-speed-cyclic data packet sent out on the medium.	Value is in the range of $2^{32}-1$ to 0.
SD	Cumulative count of Sporadic data packet sent out on the medium.	Value is in the range of $2^{32}-1$ to 0.
LL	Live list indicating whether or not the corresponding node, at this moment, is connecting to and running in the TCnet domain in the received SYN frame.	True: Connecting and working. False: not connecting and working. Live list is a collection of 8 words of 32 bits length, of which bit is corresponding to each node in the TCnet domain and is indicating the current status in operation or not.
LN	Extracted number from LL at each node and used by each node to decide whether the node is able to send the data frame out over the medium.	Value 1 to 255.
CDH _{blk}	Information data block of "blk" indicating the corresponding time-critical cyclic data being active(health) or inactive(un-healthy)	True: Active False: inactive

NOTE 1 SL(Silence time) for detecting the current SYN node out of order, following to initiate sending the CLM packet out from the nodes which are designated to be a SYN node.

6.8.4.4 Event

6.8.4.4.1.1 Function

This service is used to inform the DLMS-user about certain events or errors in the DLL.

6.8.4.4.1.2 Type of primitives and parameters of DLM-Event

Table 14 indicates the primitive and parameters of the DLM-Event service.

Table 14 – Event primitives and parameters

DLM-Event	
Parameter name	Indication
DLM-event-identifier	M
Additional-information	C

6.8.4.4.1.2.1 DLM-event-identifier

This parameter specifies the primitive or composite event within the DLE whose occurrence is being announced. The possible values are defined in the corresponding part of clause 7 Data Link Layer Protocol specification. Though a part of the state change parameters related to various events are shown for information in Table 15.

Table 15 – Event related state change variables

Operating parameters		
Variable name	Description	Additional-information
RCS _A , RCS _B	Receive-channel A, Receive-channel B selected for receiving packets	True: the receive-channel A or B selected for receiving packets respectively. False: Not selected for receiving packets on channel A or B respectively.
SEN _A , SEN _B	Transmitter A, Transmitter B enabled to send out packets	True: Enabled to send out packets from Transmitter A or B respectively. False: Disabled to send out packets from Transmitter A or B respectively. Default value is "True".
IS	IN or out of service of total node operation	True: In service False: Out of service
FE	Fatal error occurred	True: Fatal error occurred and system entered into out of service. False: under normal operation
TCIS	IN or out of service of Time-critical Cyclic data transmission	True: In service of Time-critical cyclic data transmission False: out of Time-critical cyclic data transmission service
CRCC	Receive-channel changed	True: Receive-channel changed. Receiving channel can be checked out using RCS _A and RCS _B . Is this indicator momentary action? If not when / how is it changed to False state?

Table 15 – (continued)

Operating parameters		
Variable name	Description	Additional-information
LINK _A , LINK _B	Ethernet link Channel A or B is running or not.	True: Ethernet link is running. False: Ethernet link is out of service.
CTCC	Transmit-channel changed	True: Transmit-channel changed. Transmitting channel can be checked out using SENA and SENB. Is this indicator momentary action? If not when / how is it changed to False state?
CLLC	Live-list content changed	True: LL content changed.
DDLE	Duplicate DLEs detected with same node identifier number of TN.	True: Duplicate DLEs detected with same node identifier number of TN. False: Only one DLE with this number of TN.
CCDHS	State, indicating active (healthy) or inactive (unhealthy) of the corresponding time-critical cyclic data, is changed. State is reflected on the corresponding information data block "CDH _{blk} "	True: State changed active from/to inactive. False: No state changed.

6.8.4.4.1.2.1.1 Additional-information

This optional parameter provides event-specific additional information.

6.8.4.5 Set Publisher Configuration

6.8.4.5.1 Function

This service allows the DLMS-user to set up the Publisher configuration information related to the DLCEP in the DLL. The DLMS-user receives the confirmation when this service has been completed.

6.8.4.5.2 Type of primitives and parameters of Set Publisher Configuration

Table 16 indicates the primitive and parameters of the Set Publisher configuration service.

Table 16 –Set Publisher Configuration primitives and parameters

DLM-Set-Publisher-Configuration	Request	Confirm
Parameter name	input	output
Desired-Speed-class	M	
Desired-configuration	M	
Status		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.5.2.1 Desired-Speed-class

This parameter specifies the speed class for the Time-critical Cyclic data transmission. The DMLS-user can specify High-speed, Medium-speed or Low-speed for the speed class.

- a) High-speed
- b) Medium-speed
- c) Low-speed

6.8.4.5.2.2 Desired-configuration

This parameter specifies a set of the DLCEP-identifiers as a publisher for the Time-critical Cyclic data transmission with the desired-Speed-class. The DLCEP-identifiers may be specified within the range of 0 to 2047, though the maximum number can be specified in the limitation of $V(PB_h)$, $V(PB_m)$ or $V(PB_l)$ for the corresponding speed-class of High-speed, Medium-speed or Low-speed respectively.

6.8.4.5.2.3 Status

This parameter allows the DLMS-user to determine whether the requested service was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) "OK –success – the Publisher configuration is updated"
- b) "Failure – terminated unsuccessfully"
- c) "Failure – invalid parameters in the request".

6.8.4.6 Get Publisher Configuration

6.8.4.6.1.1 Function

This option service allows the DLMS-user to read the Publisher configuration information in the DLL. The DLMS-user receives the confirmation with the current Publisher configuration when this service has been completed.

6.8.4.6.2 Type of primitives and parameters of Get Publisher Configuration

Table 17 indicates the primitive and parameters of the Get Publisher configuration service.

Table 17 – DLM-Get-Publisher-Configuration primitives and parameters

DLM-Get-Publisher-Configuration	Request	Confirm
Parameter name	input	output
Desire-speed-Class	M	
Status		M
Current-configuration		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.6.2.1 Desire-speed-Class

This parameter specifies the speed class for the Time-critical Cyclic data transmission. The DMLS-user can specify High-speed, Medium-speed or Low-speed for the speed class.

- a) High-speed
- b) Medium-speed
- c) Low-Speed

6.8.4.6.2.2 Status

This parameter allows the DLMS-user to determine whether the requested service was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) "Success – the current configuration could be read"
- b) "Failure – the current configuration does not exist or terminated unsuccessfully"
- c) "Failure – invalid parameters in the request"

6.8.4.6.2.3 Current-Configuration

This parameter is present when the status parameter indicates that the requested service was performed successfully. This parameter indicates a set of the current values of the DLCEP-identifiers for the Time-critical Cyclic data transmission of the corresponding desired-Speed-class.

6.8.4.7 Activate Time-critical Cyclic data transmission

This service allows the DLMS-user to activate the Time-critical Cyclic data transmission service. The DLMS-user receives the confirmation whether the designated Time-critical Cyclic data transmission has been started or this request has been terminated unsuccessfully.

6.8.4.7.1 Type of primitives and parameters of DLM-Activate-TCC

Table 18 indicates the primitive and parameters of the DLM-Activate-TCC service.

Table 18 – DLM-Activate-TCC primitives and the parameters

DLM-Activate-TCC Parameter name	Request	Confirm
	input	output
Desired-speed-class	M	
Status		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.7.2 Desire-speed-Class

This parameter specifies the speed class for the Time-critical Cyclic data transmission. The DMLS-user can specify High-speed, Medium-speed or Low-speed for the speed class.

- a) High-speed
- b) Medium-speed
- c) Low-Speed

6.8.4.7.3 Status

This parameter allows the DLMS-user to determine whether the requested service was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) "Success – the Time-critical Cyclic data transmission is activated"
- b) "Failure – terminated unsuccessfully"

6.8.4.8 Deactivate Time-critical Cyclic data transmission

This service allows the DLMS-user to deactivate Time-critical Cyclic data transmission service. The DLMS-user receives the confirmation whether the designated Time-critical Cyclic data transmission has been terminated or this request has been completed unsuccessfully.

6.8.4.8.1 Type of primitives and parameters of DLM-Deactivate-TCC

Table 19 indicates the primitive and parameters of the DLM-Deactivate-Publisher service.

Table 19 – DLM-Deactivate-TCC primitives and the parameters

DLM-Deactivate-TCC	Request	Confirm
Parameter name	input	output
Desired-speed-class	M	
Status		M
NOTE The method by which a confirm primitive is correlated with its corresponding preceding request primitive is a local matter.		

6.8.4.8.2 Desire-speed-Class

This parameter specifies the speed class for the Time-critical Cyclic data transmission. The DMLS-user can specify High-speed, Medium-speed or Low-speed for the speed class.

- a) High-speed
- b) Medium-speed
- c) Low-Speed

6.8.4.8.3 Status

This parameter allows the DLMS-user to determine whether the requested service was provided successfully, or failed for the reason specified. The value conveyed in this parameter is as follows:

- a) "Success – the Time-critical Cyclic data transmission is deactivated "
- b) "Failure – terminated unsuccessfully"

7 Data Link Layer Protocol specification

7.1 Introduction

The Data Link Protocol of RTE-TCnet is specified in this section. This section of the Data Link Protocol is to be one of type of IEC 61158-4 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, which is based in part on the Basic 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.

This section of the Data Link Protocol provides the Data Link Service specified in section 6 by making use of the services available from Fieldbus Physical Layer. This section defines the Data Link Protocol functions and the characteristics for the interactions between the peer nodes. The relationship between the International Standards for Fieldbus Data Link Service, Fieldbus Data Link Protocol, Fieldbus Physical Service and Systems Management is illustrated in Figure 11.

NOTE Systems Management, as used in this PAS, is a local mechanism for managing the layer protocols.

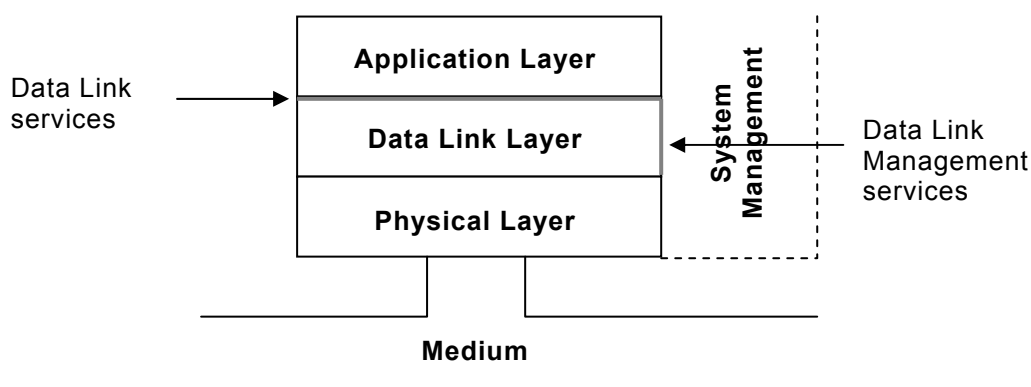


Figure 11 – Relationship of RTE-TCnet Data Link Protocol to other RTE layers and to users of RTE Data link service

The primary aim of this section is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer Data Link entities (DLEs) of RTE-TCnet at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

- a) As a guide for implementers and designers;
- b) For use in the testing and procurement of equipment;
- c) As part of an agreement for the admittance of systems into the open systems environment;
- d) As a refinement to the understanding of time-critical communications within OSI

This section is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using the Data Link Protocol of RTE-TCnet together with other standards positioned within the OSI or Fieldbus Reference Models, otherwise incompatible systems may work together in any combination.