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Industrial communication networks – Fieldbus specifications – Part 4-2: Data-link layer protocol specification – Type 2 elements



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Part 4-2: Data-link layer protocol specification – Type 2 elements

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NOTE Combinations of protocol types are specified in the IEC 61784-1 series and the IEC 61784-2 series.

IEC 61158-4-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2019. This edition constitutes a technical revision.

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

a) update of normative and bibliographic references;
b) use of more inclusive terminology ("master" and "slave" replaced, mainly in 7.3 and 7.7;
c) new STIME, UTIME, NTIME, STRINGI and EPATH data types in 6.1.3;
d) updates, addition of diagnostics connection points and new service for TCP/IP interface object in 7.5;
e) addition of diagnostics connection points and new service for Ethernet Link object in 7.6;
f) update of Get/Set_Attributes_All parameters for the Connection Configuration object in 7.8;
g) addition of diagnostics connection points and new service for DLR object in 7.9;
h) extensions and clarifications of Port object in 7.11;
i) addition of diagnostics connection points and new service for PRP/HSR Protocol object in 7.12;
j) addition of LLDP Management and LLDP Data Table objects in 7.1, 7.14 and 7.15;
k) addition of LLDP protocol support in Clause 12;
l) addition of a combined module/network indicator in A.2.4.5;
m) removal of all references to CPF and CPs (material moved to profile documents);
n) miscellaneous editorial corrections.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1202/FDIS	65C/1243/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 61158-1.

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this document 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) 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 document is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this document together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems could work together in any combination.

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-2: Data-link layer protocol specification – Type 2 elements

1 Scope

1.1 General

The data-link layer provides basic time-critical messaging communications between devices in an automation environment.

This part of IEC 61158 specifies a main protocol with the following characteristics.

- This protocol provides communication opportunities to all participating data-link entities, sequentially and in a cyclic synchronous manner. Foreground scheduled access is available for time-critical activities together with background unscheduled access for less critical activities.
- Deterministic and synchronized transfers can be provided at cyclic intervals up to 1 ms and device separations of 25 km. This performance is adjustable dynamically and on-line by re-configuring the parameters of the local link whilst normal operation continues. By similar means, DL connections and new devices can be added or removed during normal operation.
- This protocol provides means to maintain clock synchronization across an extended link with a precision better than 10 µs.
- This protocol optimizes each access opportunity by concatenating multiple DLSDUs and associated DLPCI into a single DLPDU, thereby improving data transfer efficiency for data-link entities that actively source multiple streams of data.
- The maximum system size is an unlimited number of links of 99 nodes, each with 255 DLSAP-addresses. Each link has a maximum of 2^{24} related peer and publisher DLCEPs.

This document specifies additional lower layers protocols or implementations of additional lower layers protocols for use in combination with ISO/IEC/IEEE 8802-3.

This document specifies a set of corresponding objects providing a consistent management interface to the lower layers.

1.2 Specifications

This document specifies

a) procedures for the timely transfer of data and control information from one data-link user entity to a peer user entity, and among the data-link entities forming the distributed data-link service provider;

b) the structure of the fieldbus DLPDUs used for the transfer of data and control information by the protocol of this document, and their representation as physical interface data units.

1.3 Procedures

The procedures are defined in terms of

a) the interactions between peer DL-entities (DLEs) through the exchange of fieldbus DLPDUs;

b) the interactions between a DL-service (DLS) provider and a DLS-user in the same system through the exchange of DLS primitives;

c) the interactions between a DLS-provider and a Ph-service provider in the same system through the exchange of Ph-service primitives.

1.4 Applicability

These procedures are applicable to instances of communication between systems which support time-critical communications services within the data-link layer of the OSI or fieldbus reference models, and which require the ability to interconnect in an open systems interconnection environment.

Profiles provide a simple multi-attribute means of summarizing capabilities of an implementation, and thus its applicability to various time-critical communications needs.

1.5 Conformance

This document also specifies conformance requirements for systems implementing these procedures. This document does not contain tests to demonstrate compliance with such requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE All parts of the IEC 61158 series, as well as the IEC 61784-1 series and the IEC 61784-2 series are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 61131-3, *Programmable controllers – Part 3: Programming languages*

IEC 61158-3-2:2023, *Industrial communication networks – Fieldbus specifications – Part 3-2: Data-link layer service definition – Type 2 elements*

IEC 61158-5-2:2023, *Industrial communication networks – Fieldbus specifications – Part 5-2: Application layer service definition – Type 2 elements*

IEC 61158-6-2:2023, *Industrial communication networks – Fieldbus specifications – Part 6-2: Application layer protocol specification – Type 2 elements*

IEC 61588, *Precision clock synchronization protocol for networked measurement and control systems*

IEC 61784-3-2, *Industrial communication networks – Profiles – Part 3-2: Functional safety fieldbuses – Additional specifications for CPF 2*

IEC 62026-3:2014, *Low-voltage switchgear and controlgear – Controller-device interfaces (CDIs) – Part 3: DeviceNet*

IEC 62439-3:2016[1], *Industrial communication networks – High availability automation networks – Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR)*

[1] A newer edition of this standard has been published, but only the cited edition applies.

ISO/IEC 13239, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures*

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

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

ISO/IEC/IEEE 8802-3, *Telecommunications and exchange between information technology systems − Requirements for local and metropolitan area networks – Part 3: Standard for Ethernet*

ISO 11898-1:2015, *Road vehicles – Controller area network (CAN) – Part 1: Data link layer and physical signalling*

IEEE Std 802.1AB-2016, *IEEE Standard for local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE Std 802.1ABcu-2021, *Standard for local and metropolitan area networks – Station and Media Access Control Connectivity Discovery Amendment: YANG Data Model*

IEEE Std 802.1Q-2018, *IEEE standard for local and metropolitan area networks – Bridges and bridged networks*

IEEE Std 802.3-2018, *IEEE Standard for Ethernet*

IETF RFC 951, W.J. Croft, J. Gilmore, *Bootstrap Protocol*, September 1985, available at https://www.rfc-editor.org/info/rfc951 [viewed 2022-02-18]

IETF RFC 1213, K. McCloghrie, M. Rose, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II*, March 1991, available at https://www.rfc-editor.org/info/rfc1213 [viewed 2022-02-18]

IETF RFC 1542, W. Wimer, *Clarifications and Extensions for the Bootstrap Protocol*, October 1993, available at https://www.rfc-editor.org/info/rfc1542 [viewed 2022-02-18]

IETF RFC 1643, F. Kastenholz, *Definitions of Managed Objects for the Ethernet-like Interface Types*, July 1994, available at https://www.rfc-editor.org/info/rfc1643 [viewed 2022-02-18]

IETF RFC 2131, R. Droms, *Dynamic Host Configuration Protocol*, March 1997, available at https://www.rfc-editor.org/info/rfc2131 [viewed 2022-02-18]

IETF RFC 2132, S. Alexander, R. Droms, *DHCP Options and BOOTP Vendor Extensions*, March 1997, available at https://www.rfc-editor.org/info/rfc2132 [viewed 2022-02-18]

IETF RFC 2863, K. McCloghrie, F. Kastenholz, *The Interfaces Group MIB*, June 2000, available at https://www.rfc-editor.org/info/rfc2863 [viewed 2022-02-18]

IETF RFC 3418, R. Presuhn, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)*, December 2002, available at https://www.rfc-editor.org/info/rfc3418 [viewed 2022-02-18]

IETF RFC 3635, J. Flick, *Definitions of Managed Objects for the Ethernet-like Interface Types*, September 2003, available at https://www.rfc-editor.org/info/rfc3635 [viewed 2022-02-18]

IETF RFC 4541, M. Christensen, K. Kimball, F. Solensky, *Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches*, May 2006, available at https://www.rfc-editor.org/info/rfc4541 [viewed 2022-02-18]

IETF RFC 5227:2008, S. Cheshire, *IPv4 Address Conflict Detection*, July 2008, available at https://www.rfc-editor.org/info/rfc5227 [viewed 2022-02-18]

3 Terms, definitions, symbols, abbreviated terms and conventions

For the purposes of this document, the following terms, definitions, symbols and abbreviated terms apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Reference model terms and definitions

This document 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	**called-DL-address**	[ISO/IEC 7498-3]
3.1.2	**calling-DL-address**	[ISO/IEC 7498-3]
3.1.3	**centralized multi-end-point-connection**	[ISO/IEC 7498-1]
3.1.4	**correspondent (N)-entities** **correspondent DL-entities (N=2)** **correspondent Ph-entities (N=1)**	[ISO/IEC 7498-1]
3.1.5	**demultiplexing**	[ISO/IEC 7498-1]
3.1.6	**DL-address**	[ISO/IEC 7498-3]
3.1.7	**DL-address-mapping**	[ISO/IEC 7498-1]
3.1.8	**DL-connection**	[ISO/IEC 7498-1]
3.1.9	**DL-connection-end-point**	[ISO/IEC 7498-1]
3.1.10	**DL-connection-end-point-identifier**	[ISO/IEC 7498-1]
3.1.11	**DL-connection-mode transmission**	[ISO/IEC 7498-1]
3.1.12	**DL-connectionless-mode transmission**	[ISO/IEC 7498-1]
3.1.13	**DL-data-sink**	[ISO/IEC 7498-1]
3.1.14	**DL-data-source**	[ISO/IEC 7498-1]
3.1.15	**DL-duplex-transmission**	[ISO/IEC 7498-1]
3.1.16	**DL-facility**	[ISO/IEC 7498-1]
3.1.17	**DL-local-view**	[ISO/IEC 7498-3]
3.1.18	**DL-name**	[ISO/IEC 7498-3]
3.1.19	**DL-protocol**	[ISO/IEC 7498-1]
3.1.20	**DL-protocol-connection-identifier**	[ISO/IEC 7498-1]
3.1.21	**DL-protocol-control-information**	[ISO/IEC 7498-1]
3.1.22	**DL-protocol-data-unit**	[ISO/IEC 7498-1]
3.1.23	**DL-protocol-version-identifier**	[ISO/IEC 7498-1]
3.1.24	**DL-relay**	[ISO/IEC 7498-1]

3.1.25	**DL-service-connection-identifier**	[ISO/IEC 7498-1]
3.1.26	**DL-service-data-unit**	[ISO/IEC 7498-1]
3.1.27	**DL-simplex-transmission**	[ISO/IEC 7498-1]
3.1.28	**DL-subsystem**	[ISO/IEC 7498-1]
3.1.29	**DL-user-data**	[ISO/IEC 7498-1]
3.1.30	**flow control**	[ISO/IEC 7498-1]
3.1.31	**layer-management**	[ISO/IEC 7498-1]
3.1.32	**multiplexing**	[ISO/IEC 7498-3]
3.1.33	**naming-(addressing)-authority**	[ISO/IEC 7498-3]
3.1.34	**naming-(addressing)-domain**	[ISO/IEC 7498-3]
3.1.35	**naming-(addressing)-subdomain**	[ISO/IEC 7498-3]
3.1.36	**(N)-entity** **DL-entity** **Ph-entity**	[ISO/IEC 7498-1]
3.1.37	**(N)-interface-data-unit** **DL-service-data-unit (N=2)** **Ph-interface-data-unit (N=1)**	[ISO/IEC 7498-1]
3.1.38	**(N)-layer** **DL-layer (N=2)** **Ph-layer (N=1)**	[ISO/IEC 7498-1]
3.1.39	**(N)-service** **DL-service (N=2)** **Ph-service (N=1)**	[ISO/IEC 7498-1]
3.1.40	**(N)-service-access-point** **DL-service-access-point (N=2)** **Ph-service-access-point (N=1)**	[ISO/IEC 7498-1]
3.1.41	**(N)-service-access-point-address** **DL-service-access-point-address (N=2)** **Ph-service-access-point-address (N=1)**	[ISO/IEC 7498-1]
3.1.42	**peer-entities**	[ISO/IEC 7498-1]
3.1.43	**Ph-interface-control-information**	[ISO/IEC 7498-1]
3.1.44	**Ph-interface-data**	[ISO/IEC 7498-1]
3.1.45	**primitive name**	[ISO/IEC 7498-3]
3.1.46	**reassembling**	[ISO/IEC 7498-1]
3.1.47	**recombining**	[ISO/IEC 7498-1]
3.1.48	**reset**	[ISO/IEC 7498-1]
3.1.49	**responding-DL-address**	[ISO/IEC 7498-3]
3.1.50	**routing**	[ISO/IEC 7498-1]
3.1.51	**segmenting**	[ISO/IEC 7498-1]
3.1.52	**sequencing**	[ISO/IEC 7498-1]
3.1.53	**splitting**	[ISO/IEC 7498-1]
3.1.54	**synonymous name**	[ISO/IEC 7498-3]
3.1.55	**systems-management**	[ISO/IEC 7498-1]

3.2 Service convention terms and definitions

This document 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 DL-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 Common terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Many definitions are common to more than one protocol Type; they are not necessarily used by all protocol Types.

3.3.1
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

3.3.2
DLSAP
distinctive point at which DL-services are provided by a single DL-entity to a single higher-layer entity

Note 1 to entry: Definition is provided in a generic manner "(N)-SAP" in ISO/IEC 7498-1.

3.3.3
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 1 to entry: 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.

3.3.4
(individual) DLSAP-address
DL-address that designates only one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP.

3.3.5
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 1 to entry: An extended link may be composed of just a single link.

3.3.6
frame
denigrated synonym for DLPDU

3.3.7
group DL-address
DL-address that potentially designates more than one DLSAP within the extended link

Note 1 to entry: 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.

3.3.8
node
single DL-entity as it appears on one local link

3.3.9
receiving DLS-user
DL-service user that acts as a recipient of DL-user-data

Note 1 to entry: A DL-service user can be concurrently both a sending and receiving DLS-user.

3.3.10
sending DLS-user
DL-service user that acts as a source of DL-user-data

3.4 Additional Type 2 definitions

3.4.1
actual packet interval
API
measure of how frequently a specific connection produces its Lpacket data

3.4.2
allocate
take a resource from a common area and assign that resource for the exclusive use of a specific entity

3.4.3
application
function or data structure for which data is consumed or produced

3.4.4
application objects
multiple object classes that manage and provide the run time exchange of messages across the network and within the device

3.4.5
attribute
description of an externally visible characteristic or feature of an object

Note 1 to entry: The attributes of an object contain information about variable portions of an object. Typically, they provide status information or govern the operation of an object. Attributes can also affect the behavior of an object. Attributes are divided into class attributes and instance attributes.

3.4.6
behavior
indication of how the object responds to particular events

Note 1 to entry: Its description includes the relationship between attribute values and services.

3.4.7
bit
unit of information consisting of a 1 or a 0

Note 1 to entry: This is the smallest data unit that can be transmitted.

3.4.8
blanking or blanking time
length of time required after transmitting before the node is allowed to receive

3.4.9
client
1) object which uses the services of another (server) object to perform a task
2) initiator of a message to which a server reacts

3.4.10
communication objects
components that manage and provide run time exchange of messages across the network such as the ControlNet object, the Unconnected Message Manager (UCMM)

3.4.11
connection
logical binding between two application objects within the same or different devices

3.4.12
connection ID
CID
identifier assigned to a transmission, associated with a particular connection between producers and consumers, that identifies a specific piece of application information

Note 1 to entry: Within the data link this is a generic tag.

3.4.13
cyclic redundancy check
CRC
residual value computed from an array of data and used as a representative signature for the array

3.4.14
cyclic
term used to describe events which repeat in a regular and repetitive manner

3.4.15
deafness
situation where the node cannot hear the moderator DLPDU but can hear other link traffic

3.4.16
device
physical hardware connection to the link

Note 1 to entry: A device may contain more than one node.

3.4.17
DLPDU
data-link protocol data unit

Note 1 to entry: A DLPDU consists of a source MAC ID, zero or more Lpackets and an FCS as transmitted or received by an associated PhE.

3.4.18
end delimiter
unique set of M_symbols that identifies the end of a DLPDU

3.4.19
error
discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition

3.4.20
extended link
links connected by DL-routers (sometimes called a local area network)

3.4.21
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

3.4.22
fixed tag
two octet identifier (tag) which identifies a specific service to be performed by either

a) that receiving node on the local link which has a specified MAC ID, or

b) all receiving nodes on the local link

Note 1 to entry: Identification of the target node(s) is included in the two octet tag.

3.4.23
frame
denigrated synonym for DLPDU

3.4.24
Frame Check Sequence
FCS
redundant data derived from a block of data within a DLPDU (frame), using a hash function, and stored or transmitted together with the block of data, in order to detect data corruption

3.4.25
generic tag
three octet identifier (tag) which identifies a specific piece of application information

3.4.26
guardband
time slot allocated for the transmission of the moderator DLPDU

3.4.27
implicit token
mechanism that governs the right to transmit

Note 1 to entry: No actual token message is transmitted on the medium. Each node keeps track of the MAC ID of the node that it believes currently holds the right to transmit. The right to transmit is passed from node to node by keeping a record of the node that last transmitted. A slot time is used to allow a missing node to be skipped in the rotation.

3.4.28
implicit token register
register that contains the MAC ID of the node that holds the right to transmit

3.4.29
instance
actual physical occurrence of an object within a class, identifying one of many objects within the same object class

EXAMPLE California is an instance of the object class state.

Note 1 to entry: The terms object, instance, and object instance are used to refer to a specific instance.

3.4.30
instance attribute
attribute whose value is unique to an object instance and whose definition is shared by all instances of an object

3.4.31
instantiated
object that has been created in a device

3.4.32
Keeper
object responsible for distributing link configuration data to all nodes on the link

3.4.33
link
collection of nodes with unique MAC IDs, attached to Ph-segments connected by Ph-repeaters

3.4.34
little endian
model of memory organization which stores the least significant octet at the lowest address, and of transmission organization which transfers the least significant octet first on the medium

3.4.35
Lpacket
well-defined sub-portion of a DLPDU consisting of

a) size and control information,

b) a fixed tag or a generic tag, and

c) DLS-user data or, when the tag has DL-significance, DL-data

3.4.36
M_symbol(s)
symbols that represent the data bits and related information encoded and transmitted by the PhL

3.4.37
maximum scheduled node
node with highest MAC ID that can use scheduled time on a link

3.4.38
maximum unscheduled node
node with highest MAC ID that can use unscheduled time on a link

3.4.39
Message Router
object within a node that distributes messaging requests to the appropriate application objects

3.4.40
moderator
node with the lowest MAC ID that is responsible for transmitting the moderator DLPDU

3.4.41
moderator DLPDU
DLPDU transmitted by the node with the lowest MAC ID for the purpose of synchronizing the nodes and distributing the link configuration parameters

3.4.42
multipoint connection
connection from one node to many

Note 1 to entry: Multipoint connections allow messages from a single producer (publisher) to be received by many consumer (subscriber) nodes.

3.4.43
network
series of nodes connected by some type of communication medium

Note 1 to entry: The connection paths between any pair of nodes can include repeaters, routers and gateways.

3.4.44
network access monitor
NAM
component within a node that manages communication with a temporary node connected to the nodes local NAP

3.4.45
network access port
NAP
PhL variant that allows a temporary node to be connected to the link by connection to the NAP of a permanent node

3.4.46
network address or node address
node's address on the link

Note 1 to entry: This is also called MAC ID.

3.4.47
network status indicators
indicators on a node indicating the status of the Physical and Data Link Layers

3.4.48
network update time
NUT
repetitive time interval in which data can be sent on the link

3.4.49
node
logical connection to a local link, requiring a single MAC ID

Note 1 to entry: A single physical device can appear as many nodes on the same local link. For the purposes of this protocol, each node is considered to be a separate DLE.

3.4.50
non-concurrence
situation where a transmission is received from an unexpected MAC ID, which appears to violate the time based access protocol

Note 1 to entry: This can occur when a connection is made between two working links that are not synchronized with each other but who have the same configuration information.

3.4.51
non-data symbol
PhL symbol which violates the requirements of Manchester biphase L encoding

3.4.52
object
abstract representation of a particular component within a device

Note 1 to entry: An object can be

1) an abstract representation of a computer's capabilities. Objects can be composed of any or all of the following components:
   a) data (information which changes with time);
   b) configuration (parameters for behavior);
   c) methods (things that can be done using data and configuration);
2) a collection of related data (in the form of variables) and methods (procedures) for operating on that data that have clearly defined interface and behavior.

3.4.53
object specific service
service defined by a particular object class to perform a required function which is not performed by a common service

Note 1 to entry: An object specific service is unique to the object class which defines it.

3.4.54
originator
client responsible for establishing a connection path to the target

3.4.55
permanent node
node whose connection to the network does not utilize the network access port (NAP) PhL variant

Note 1 to entry: This node may optionally support a NAP PhL variant to allow temporary nodes to connect to the network.

3.4.56
produce
act of sending data to be received by a consumer

3.4.57
producer
node that is responsible for sending data

3.4.58
redundant media
system using more than one medium to help prevent communication failures

3.4.59
requested packet interval
RPI
measure of how frequently the originating application requires the transmission of Lpackets or data packets from the target application

3.4.60
rogue
node that has received a moderator DLPDU that disagrees with the link configuration currently used by this node

3.4.61
scheduled
data transfers that occur in a deterministic and repeatable manner on predefined NUTs

3.4.62
server
object which provides services to another (client) object

3.4.63
service
operation or function than an object and/or object class performs upon request from another object and/or object class

Note 1 to entry: A set of common services is defined and provisions for the definition of object-specific services are provided. Object-specific services are those which are defined by a particular object class to perform a required function which is not performed by a common service.

3.4.64
slot time
maximum time required for detecting an expected transmission

Note 1 to entry: Each node waits a slot time for each missing node during the implied token pass.

3.4.65
start delimiter
unique set of M_symbols that identifies the beginning of a DLPDU

3.4.66
supernode
DLE with a MAC ID of zero

Note 1 to entry: This DLE DL-address is reserved for special DLL functions

3.4.67
table unique identifier
TUI
unique reference code used by the ControlNet object and the Keeper object to reference a consistent set of link configuration attribute

3.4.68
tag
shorthand name for a specific piece of application information, two or three octets in length

3.4.69
target
end-node to which a connection is established

3.4.70
temporary node
same as transient node

3.4.71
tMinus
number of NUTs before a new set of link configuration parameters are to be used

3.4.72
tone
instant of time which marks the boundary between two NUTs

3.4.73
tool
executable software program which interacts with the user to perform some function

EXAMPLE Link scheduling software (LSS).

3.4.74
transaction id
field within a UCMM header that matches a response with the associated request, which a server echoes in the response message

3.4.75
transient node
node that is only intended to be connected to the network on a temporary basis using the NAP PhL medium connected to the NAP of a permanent node

3.4.76
Unconnected Message Manager
UCMM
component within a node that transmits and receives unconnected explicit messages and sends them directly to the Message Router object

3.4.77
unconnected service
messaging service which does not rely on the set up of a connection between devices before allowing information exchanges

3.4.78
unscheduled
data transfers that use the remaining allocated time in the NUT after the scheduled transfers have been completed

3.4.79
vendor ID
identification of each product manufacturer/vendor by a unique number

Note 1 to entry: Vendor IDs are assigned by the ODVA, Inc. organization (see <www.odva.org>).

3.5 Type 2 symbols and abbreviated terms

ACD	Address Conflict Detection	
ACM	Access control machine	
BOOTP	Bootstrap Protocol	[IETF RFC 951]
CA	Clock accuracy	
CAN	Controller Area Network	[ISO 11898-1]
CCITT	Consultative Committee for International Telephony and Telegraphy	
COP	Connection originator password	
DANP	Doubly Attached Node operating PRP	
DHCP	Dynamic Host Configuration Protocol	[IETF RFC 2131]
DLR	Device level ring	
DSCP	DiffServ code point	
FCS	Frame Check Sequence	
HSR	High-availability Seamless Redundancy	[IEC 62439-3]
IP	Internet Protocol	[IETF RFC 791]
LAN	Local Area Network	
LED	Light emitting diode	
LRE	Link Redundancy Entity (associated with PRP)	
LSS	Link scheduling software	
MAC ID	MAC address of a node	
MSTP	Multiple spanning tree protocol	[IEEE Std 802.1Q-2018]
NAM	Network attachment monitor	
NAP	Network access port	
ND	Non-data symbol	
PRP	Parallel Redundancy Protocol	[IEC 62439-3]
NUT	Network update time	
PT	Programming terminal (a temporary network connection)	
PTP	Precision Time Protocol	[IEC 61588]
QoS	Quality of service	
Rcv	Receive	
RedBox	PRP Redundancy Box (for attaching non-PRP nodes)	
RPI	Requested Lpacket interval	
RSTP	Rapid spanning tree protocol	[IEEE Std 802.1Q-2018]
Rx	Receive	

RxLLC	Receive logical link control	
RxM	Receive machine	
SAN	Singly Attached Node (in a PRP topology)	
SEM	State event matrix	
SMAX	MAC ID of the maximum scheduled node	
STD	State transition diagram, used to describe object behavior	
STP	Spanning tree protocol	[IEEE Std 802.1Q-2018]
TCP	Terminal Control Protocol	[IETF RFC 793]
TFTP	Trivial File Transfer Protocol	[IETF RFC 1350]
TUI	Table unique identifier	
Tx	Transmit	
TxLLC	Transmit logical link control	
TxM	Transmit machine	
UCCM	Unconnected Message Manager	
UMAX	MAC ID of maximum unscheduled node	
USR	Unscheduled start register	
VLAN	Virtual LAN	

3.6 Conventions for station management objects

Objects for station management are specified in Clause 7, using attributes, services and behavior.

Object attributes are specified in tables formatted according to Table 1.

Table 1 – Format of attribute tables

Attribute ID	Need in implementation	Access rule	NV	Name	Data type	Description of attribute	Semantics of values
See a)	See b)	See c)	See d)	See e)	See 6.1.3	See f)	See g)

a) "Attribute ID" is the identification value assigned to an attribute.

b) "Need in implementation" specifies whether or not the attribute is necessary in the implementation. An attribute may be optional, required or conditional.

   A conditional attribute is required if certain object behaviors and/or attributes are implemented as defined by the class.

   If an Attribute is optional, then a default value shall be defined in the semantics. An optional attribute's default value shall provide the same behavior as if the attribute was not implemented. If the default value of an optional attribute does not match the behavior of the object when the object does not implement the attribute, the object definition shall declare the behavior.

   In all cases, the term "default" indicates a "factory default" as shipped from the vendor.

c) "Access rule" specifies how a requestor can access an attribute. The definitions for access rules are:

   - Settable (Set) – The attribute shall be accessed by at least one of the set services. For enumerated attributes, if the device supports only one of the values and the object definition does not require more than one value to be supported, then the attribute may be implemented as Get only.

Settable attributes, unless otherwise specified by the object definition, shall be also accessed by get services.

- Gettable (Get) – The attribute shall be accessed by at least one of the get services.

d) "NV" indicates whether an attribute value is maintained through power cycles. This column is used in object definitions where non-volatile storage of attribute values is required. An entry of "NV" indicates value shall be saved, "V" means not saved.

e) Name refers to the attribute.

f) Description of Attribute provides general information about the attribute.

g) Semantics of Values specifies the meaning of the value of the attribute.

4 Overview of the data-link protocol

4.1 General

4.1.1 DLL architecture

The Type 2 DLL is modeled as an integrated Access Control Machine (ACM), with scheduling support functions, designed for reliable and efficient support of higher-level connection-mode and connectionless data transfer services. Interoperating with these higher level functions are DLL management functions.

PhL framing and delimiters are managed by DLL functions for serializing and deserializing M_symbol requests and indications.

Within the Data Link Layer, the Access Control Machine (ACM) has the primary responsibility for detecting and recovering from network disruptions. The major objectives of the ACM are

– to make sure that the local node detects and fully utilizes its assigned access slots in the schedule;

– to make sure that the local node does not interfere with the transmissions of other nodes, especially the moderator node;

– to start the next NUT (see 4.1.2) on schedule, whether the moderator DLPDU is heard or not;

– if the local node is the moderator, to transmit each moderator DLPDU strictly on schedule.

The Data Link Layer is comprised of the components listed in Table 2: