

DIN EN IEC 61158-4-21

ICS 35.100.20; 35.160

Ersatz für
DIN EN 61158-4-21:2013-01
Siehe Anwendungsbeginn

**Industrielle Kommunikationsnetze –
Feldbusse –
Teil 4-21: Protokollspezifikation des Data-Link Layer
(Sicherungsschicht) – Typ 21-Elemente
(IEC 61158-4-21:2019);
Englische Fassung EN IEC 61158-4-21:2019, nur auf CD-ROM**

Industrial communication networks –
Fieldbus specifications –
Part 4-21: Data-link layer protocol specification – Type 21 elements
(IEC 61158-4-21:2019);
English version EN IEC 61158-4-21:2019, only on CD-ROM

Réseaux de communication industriels –
Spécifications des bus de terrain –
Partie 4-21: Spécification du protocole de la couche de liaison de données – Eléments de
Type 21
(IEC 61158-4-21:2019);
Version anglaise EN IEC 61158-4-21:2019, seulement en CD-ROM

Gesamtumfang 117 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE

Anwendungsbeginn

Anwendungsbeginn für die von CENELEC am 2019-05-15 angenommene Europäische Norm als DIN-Norm ist 2020-08-01.

Für DIN EN 61158-4-21:2013-01 besteht eine Übergangsfrist bis 2022-05-15.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN EN 61158-400:2017-12.

Dieser Entwurf betrifft auch die Normen DIN EN IEC 61158-4-2:2020-08, DIN EN IEC 61158-4-3:2020-08, DIN EN IEC 61158-4-4:2020-08, DIN EN IEC 61158-4-12:2020-08, DIN EN IEC 61158-4-19:2020-08, DIN EN IEC 61158-4-24:2020-08 und DIN EN IEC 61158-4-25:2020-08.

Für dieses Dokument ist das nationale Arbeitsgremium K 956 „Industrielle Kommunikation“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom SC 65C „Industrial networks“ erarbeitet und unterliegt dem Copyright der IEC .

Das IEC-Komitee hat entschieden, dass der Inhalt dieses Dokuments bis zu dem Datum (stability date) unverändert bleiben soll, das auf der IEC-Website unter „<http://webstore.iec.ch>“ zu diesem Dokument angegeben ist. Zu diesem Zeitpunkt wird entsprechend der Entscheidung des Komitees das Dokument

- bestätigt,
- zurückgezogen,
- durch eine Folgeausgabe ersetzt oder
- geändert.

Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf ein Dokument ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils aktuellste Ausgabe des in Bezug genommenen Dokuments.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe des Dokuments.

Der Zusammenhang der zitierten Dokumente mit den entsprechenden deutschen Dokumenten ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Das Präsidium des DIN hat mit Präsidialbeschluss 1/2004 festgelegt, dass DIN-Normen, deren Inhalt sich auf internationale Arbeitsergebnisse der Informationsverarbeitung gründet, unter bestimmten Bedingungen allein in englischer Sprache veröffentlicht werden dürfen. Diese Bedingungen sind für die vorliegende Norm erfüllt.

Da sich die Benutzer der vorliegenden Norm der englischen Sprache als Fachsprache bedienen, wird die Englische Fassung der EN IEC 61158-4-21 veröffentlicht. Zu deren Abschnitt 1, der den Anwendungsbereich festlegt und Abschnitt 3 (außer Unterabschnitte 3.1, 3.2, 3.5 und 3.6), der die Begriffe festlegt, wurde eine Übersetzung angefertigt und als informativer Nationaler Anhang NA der vorliegenden Norm hinzugefügt. Für die meisten der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen. Diese Norm steht nicht in unmittelbarem Zusammenhang mit Rechtsvorschriften und ist nicht als Sicherheitsnorm anzusehen.

Das Original-Dokument enthält Bilder in Farbe, die in der Papierversion in einer Graustufen-Darstellung wiedergegeben werden. Elektronische Versionen dieses Dokuments enthalten die Bilder in der originalen Farbdarstellung.

Ein Feldbus ist ein digitaler serieller Datenbus für die Kommunikation zwischen Geräten der industriellen Automatisierungstechnik wie beispielsweise Messeinrichtungen, Stellgliedern, Reglern und speicherprogrammierbaren Steuerungen. Die Normen der Reihe DIN EN IEC 61158 legen eine Anzahl von Feldbus-Protokolltypen fest. Die vorliegende Norm legt das Protokoll des Data-Link Layer für die einzelnen Typen fest.

Änderungen

Gegenüber DIN EN 61158-4-21:2013-01 wurden folgende Änderungen vorgenommen:

- a) Änderung von NCM_RETRY_RNMS zu NCM_CHECK_NET_INTEGRITY_REQ;
- b) Aktualisierung der DLM Statustabelle;
- c) sonstige redaktionelle Verbesserungen.

Frühere Ausgaben

DIN EN 61158-4-21: 2013-01

Nationaler Anhang NA (informativ)

Auszugsweise Übersetzung

Reihenfolge und Inhalt der folgenden Abschnitte sind identisch mit denen in den jeweiligen Abschnitten der Englischen Fassung.

EINLEITUNG

Dieses Dokument gehört zu einer Normenreihe, die zur Erleichterung der Verbindung von Komponenten von Automatisierungssystemen erstellt wurde. Es ist mit anderen Normen der Reihe verbunden, wie durch das in IEC 61158-1 beschriebene „dreischichtige“ Feldbus-Referenzmodell definiert.

Das Datenverbindungsprotokoll stellt den Datenverbindungsdienst bereit, indem es die Dienste nutzt, die in der physikalischen Schicht verfügbar sind. Das vorrangige Ziel dieses Dokuments ist es, eine Reihe von Regeln für die Kommunikation zu erstellen, die sich auf die Verfahren beziehen, die von den Peer Data-Link Entities (DLE) zum Zeitpunkt der Kommunikation durchzuführen sind. Diese Regeln für die Kommunikation sollen eine stabile Grundlage für die Weiterentwicklung bilden, damit sie einer Vielzahl von Zwecken dienen können:

- a) als Leitfaden für Implementierer und Konstrukteure;
- b) zur Verwendung bei der Prüfung und Beschaffung von Ausrüstung;
- c) als Teil einer Vereinbarung über die Zulassung von Systemen in der offenen Systemumgebung;
- d) als eine Erweiterung des Verständnisses von zeitkritischer Kommunikation innerhalb der OSI.

Dieses Dokument befasst sich insbesondere mit der Kommunikation und dem Zusammenwirken von Sensoren, Effektoren und anderen Automatisierungsgeräten. Durch die Verwendung dieses Dokuments zusammen mit anderen Normen, die innerhalb der OSI- oder Feldbus-Referenzmodelle vorhanden sind, können andernfalls inkompatible Systeme in beliebiger Kombination zusammenarbeiten.

ANMERKUNG Die Verwendung einiger der zugehörigen Protokolltypen ist durch die Inhaber ihrer geistigen Eigentumsrechte eingeschränkt. In allen Fällen erlaubt die Verpflichtung zur begrenzten Freigabe von Rechten an geistigem Eigentum, die von den Inhabern dieser Rechte eingegangen wurde, die Verwendung eines bestimmten Protokolltyps der Daten Verbindungsschicht mit Protokollen der physikalischen Schicht und der Anwendungsschicht in Typkombinationen, wie sie in den Profileilen ausdrücklich festgelegt sind. Die Verwendung der Protokolltypen in anderen Kombinationen kann die Genehmigung der jeweiligen Inhaber der geistigen Eigentumsrechte erfordern.

Die Internationale Elektrotechnische Kommission (IEC) macht auf die Tatsache aufmerksam, dass beansprucht wird, dass die Anwendung dieses Dokuments die Verwendung von Patenten hinsichtlich der Elemente des Typs 21 und möglicherweise anderer Typen, die in den Unterabschnitt 4.1, 4.2 und 7.3 wie folgt angegeben sind, umfassen kann:

- | | | |
|------------|------|--|
| KR 0789444 | [LS] | A communication packet processing apparatus and method for ring topology Ethernet network capable of preventing permanent packet looping |
| KR 0732510 | [LS] | Network system |
| KR 0870670 | [LS] | Method for determining a Ring Manager Node |

Die IEC nimmt keine Stellung zur Rechtmäßigkeit, Gültigkeit und Tragweite dieser Patentrechte.

Der Halter dieser Patentrechte hat IEC zugesichert, dass er bereit ist, entweder kostenfrei oder über Lizenzen zu vernünftigen und nicht diskriminierenden Geschäftsbedingungen mit Antragstellern in der ganzen Welt zu verhandeln. In diesem Zusammenhang ist die Erklärung des Halters dieser Patentrechte bei der IEC registriert. Informationen sind erhältlich bei:

[LS]: LS Industrial Systems Co., Ltd.
 LS Tower 1026-6
 Hogle-dong, Dongan-gu,
 Anyang-si, Gyeonggi-do 431-848
 Republic of Korea

Es wird auf die Möglichkeit hingewiesen, dass einige Elemente dieses Dokuments Patentrechte berühren können. Die IEC ist nicht dafür verantwortlich, einige oder alle diesbezüglichen Patentrechte zu identifizieren.

ISO (www.iso.org/patents) und IEC (<http://patents.iec.ch>) stellen online Datenbanken mit den für ihre Normen relevanten Patenten bereit. Anwender werden ermutigt, sich diese Datenbanken anzusehen, um die aktuellsten Informationen hinsichtlich Patente zu erhalten.

1 Anwendungsbereich

1.1 Allgemeines

Die DLL stellt grundlegende zeitkritische Datenkommunikationen zwischen Geräten in einem automatisierten Umfeld bereit. Typ 21 stellt prioritätsbasierte zyklische und azyklische Datenkommunikation unter Verwendung einer internen kollisionsfreien, Vollduplex-Dual-Port-Ethernet-Switch-Technologie bereit. Für breite Verwendung in verschiedenen Automatisierungsanwendungen beschränkt Typ 21 nicht die zyklische/azyklische Zeitplanungsstrategie.

1.2 Spezifikationen

Dieses Dokument beschreibt:

- a) Verfahren für den rechtzeitigen Transfer von Daten und Steuerinformationen von einer Data-Link-Benutzerinstanz zu einer Peer-Benutzerinstanz und unter den Data-Link-Instanzen, die den verteilten Data-Link-Dienstanbieter bilden;
- b) Verfahren zum Erteilen von Kommunikationsmöglichkeiten basierend auf ISO/IEC/IEEE 8802-3 MAC mit Bestimmungen für während Normalbetrieb hinzuzufügende oder zu entfernende Knoten;
- c) die Struktur der Feldbus-Data-Link-Protokolldateneinheiten (DLPDU), die für den Transfer von Daten und Steuerinformationen durch das Protokoll dieses Dokuments verwendet werden, und deren Darstellung als physische Schnittstellendateneinheiten.

1.3 Verfahren

Die Verfahren sind definiert hinsichtlich:

- a) der Interaktionen zwischen Peer-Data-Link-Instanzen (DLE, DL-entities) über den Austausch von Feldbus-DLPDU;
- b) der Interaktionen zwischen einem Data-Link-Dienst-(DLS, data link service)-Anbieter und einem DLS-Benutzer in demselben System über den Austausch von DLS-Primitiven;
- c) der Interaktionen zwischen einem DLS-Anbieter und einem Physical-Layer-Dienstanbieter in demselben System über den Austausch von Ph-Dienstprimitiven.

1.4 Anwendbarkeit

Diese Verfahren sind anwendbar auf Kommunikationsvorgänge zwischen Systemen, die zeitkritische Kommunikationsdienste innerhalb des Data-Link Layer des OSI- oder Feldbus-Referenzmodells unterstützen und die die Fähigkeit des Durchverbindens in einem Umfeld der Kommunikation offener Systeme erfordern. Profile stellen eine einfache multiattributive Einrichtung zum Zusammenfassen des Vermögens einer Implementierung bereit und somit deren Anwendbarkeit auf verschiedene zeitdeterministische Kommunikationsanforderungen.

1.5 Konformität

Dieses Dokument legt außerdem Konformitätsanforderungen für Systeme fest, die diese Verfahren umsetzen. Dieses Dokument enthält keine Prüfungen zum Darlegen der Erfüllung solcher Anforderungen.

3 Begriffe, Symbole, Abkürzungen und Vereinbarungen

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe, Symbole, Abkürzungen und Vereinbarungen.

ISO und IEC stellen terminologische Datenbanken für die Verwendung in der Normung unter den folgenden Adressen bereit:

- IEC Electropedia: verfügbar unter <http://www.electropedia.org/>
- ISO Online Browsing Platform: verfügbar unter <http://www.iso.org/obp>

3.3 Allgemeine Begriffe

Für die Anwendung dieses Dokuments gelten auch die folgenden Definitionen.

ANMERKUNG Viele Definitionen treffen auf mehr als einen Protokoll-Typ zu; sie werden nicht zwangsweise von allen Protokoll-Typen verwendet.

3.3.1

aktives Netzwerk

(en: active network)

Netzwerk, in dem die Datenübertragung zwischen nicht direkt verbundenen Geräten von aktiven Elementen in den zwischengelagerten Geräten abhängt, die die Verbindung herstellen

[QUELLE: IEC 61918, 3.1.3]

3.3.2

DL-Segment

(en: DL-segment)

Verbindungsweig

(en: link)

lokaler Verbindungsweig

(en: local link)

einzelnes Subnetzwerk des Data-Link Layer (DL-Subnetzwerk), in dem alle angeschlossenen Instanzen des Data-Link Layer (DLE) direkt, ohne zwischengeschaltete DL-Weitergabe, kommunizieren dürfen, solange alle diese an einem Kommunikationsvorgang teilnehmenden DLE während der Dauer(n) der Kommunikationsversuche gleichzeitig auf das DL-Subnetzwerk reagieren können

3.3.3

Zugangspunkt zu Diensten des Data-Link Layer

(en: data-link service access point) (DLSAP)

eindeutiger Punkt, an dem eine einzelne DLE an eine einzelne Instanz einer höheren Schicht DL-Dienste bereitstellt

Anmerkung 1 zum Begriff: Begriff abgeleitet aus ISO/IEC 7498-1:1994, Abschnitt 5.

3.3.4

DL(SAP)-Adresse

(en: DL(SAP)-address)

entweder eine individuelle DLSAP-Adresse, die einen einzelnen DLSAP eines einzelnen DLS-Benutzers kennzeichnet, oder eine DL-Gruppenadresse, die möglicherweise mehrere DLSAP, jeweils eines einzelnen DLS-Benutzers, kennzeichnet

Anmerkung 1 zum Begriff: Diese Terminologie wird gewählt, da ISO/IEC 7498-3 die Verwendung des Begriffs "DLSAP-Adresse" zur Bezeichnung von mehr als einem einzelnen DLSAP bei einem einzelnen DLS-Benutzer nicht zulässt.

3.3.5

(individuelle) DLSAP-Adresse

(en: (individual) DLSAP-address)

DL-Adresse, die nur einen DLSAP innerhalb des erweiterten Verbindungszweigs kennzeichnet

Anmerkung 1 zum Begriff: Eine einzelne DL-Instanz darf mehrere DLSAP-Adressen, die einem einzelnen DLSAP zugeordnet sind, aufweisen.

3.3.6

Adresse des Verbindungsendpunktes des Data-Link Layer (DLCEP-Adresse)

(en: Data-link connection endpoint address (DLCEP-address))

DL-Adresse, entweder kennzeichnend:

- a) einen DL-Verbindungsendpunkt eines Peers;
- b) einen DL-Verbindungsendpunkt mehrerer Peer-Publisher und implizit den entsprechenden Satz von DL-Verbindungsendpunkten der Subscriber, wobei jeder DL-Verbindungsendpunkt innerhalb eines eindeutigen DLSAP vorhanden ist und einer entsprechenden eindeutigen DLSAP-Adresse zugeordnet ist.

3.3.7

DL-Instanz-Bezeichner

(en: DL-entity identifier)

Adresse, die die (einzelne) DLE kennzeichnet, die einem einzelnen Gerät auf einem lokalen Verbindungszweig zugeordnet ist

3.3.8

Gerät

(en: device)

einzelne DLE, wie sie auf einem lokalen Verbindungszweig existiert

3.3.9

Endstation

(en: end-station)

an ein Netzwerk angeschlossenes System, das eine erste Quelle oder ein letztes Ziel von MAC-Rahmen, die über dieses Netzwerk übertragen werden, ist

Anmerkung 1 zum Begriff: Aus der Sicht des Netzwerks ist ein Router der Netzwerkschicht eine Endstation. Ein Switch stellt in seiner Funktion der Weiterleitung von MAC-Rahmen von einem Verbindungszweig an einen anderen keine Endstation dar.

[QUELLE: IEC 61784-2, 3.1.5]

3.3.10

Rahmen

(en: frame)

Datenübertragungseinheit auf einer auf ISO/IEC/IEEE 8802-3 basierenden MAC (en: Media Access Control), die eine Protokolldateneinheit (PDU) zwischen MAC-Dienstbenutzern übermittelt

[QUELLE: IEEE 802.1Q-2011]

3.3.11

Fehler der Blockprüfzeichenfolge (BPF)

(en: frame check sequence (FCS) error)

Fehler, der auftritt, wenn der berechnete Wert der Blockprüfzeichenfolge nach Empfang aller Oktette in einer Protokolldateneinheit auf der DLL (en: data link protocol data unit, DLPDU) nicht mit dem erwarteten Rest übereinstimmt

3.3.12

lineare Topologie

(en: linear topology)

Topologie, in der die Knoten hintereinander geschaltet sind, wobei zwei Knoten lediglich mit einem weiteren Knoten verbunden sind und alle anderen Knoten mit zwei weiteren Knoten verbunden sind (d. h. in Form einer Linie verbunden)

Anmerkung 1 zum Begriff: Diese Topologie entspricht der eines offenen Rings.

[QUELLE: IEC 61918, 3.1.44]

3.3.13

Verbindungsweig

(en: link)

Übertragungsweg zwischen zwei benachbarten Knoten

[QUELLE: abgeleitet von ISO/IEC 11801]

3.3.14

Netzwerkmanagement

(en: network management)

Verwaltungsfunktionen und -dienste, die die Netzwerkinitialisierung, Konfiguration und Fehlerbehandlung durchführen

3.3.15

Knoten

(en: node)

Netzwerkinstanz, die mit einem oder mehreren Verbindungsweigen verbunden ist

Anmerkung 1 zum Begriff: Ein Knoten kann entweder ein Switch, eine Endstation oder eine RTE-Endstation sein.

[QUELLE: IEC 61784-2, 3.1.17]

3.3.16

Paket

(en: packet)

logische Gruppierung von Informationen, die zur Beschreibung einer Dateneinheit auf einer beliebigen Schicht verwendet wird, um die Benutzerdaten der höheren Schicht an die entsprechende Peer-Schicht zu übermitteln

Anmerkung 1 zum Begriff: Im Sinne des OSI-Referenzmodells entspricht ein Paket auf jeder Schicht der PDU. Ein Data-Link Layer Paket ist ein Rahmen.

[QUELLE: IEC 61784-2, 3.1.18]

3.3.17

Protokoll

(en: protocol)

Vereinbarung bezüglich Datenformaten, Zeitabfolgen und Fehlerkorrektur für Datenaustausch in Kommunikationssystemen

3.3.18

Echtzeit

(en: real-time)

Fähigkeit eines Systems, ein erforderliches Ergebnis in einer begrenzten Zeit bereitzustellen

[QUELLE: IEC 61784-2, 3.1.19]

3.3.19**Echtzeit-Kommunikation**

(en: real-time communication)

Übertragung von Daten in Echtzeit

[QUELLE: IEC 61784-2, 3.1.20]

3.3.20**Echtzeit-Ethernet**

(en: real-time Ethernet) (RTE)

Netzwerk, das auf ISO/IEC 8802-3 basiert und Echtzeit-Kommunikation umfasst

Anmerkung 1 zum Begriff: Sofern die Echtzeit-Kommunikation nicht beeinträchtigt wird, können andere Kommunikationsarten unterstützt werden.

Anmerkung 2 zum Begriff: Diese Definition bezieht sich auf ISO/IEC/IEEE 8802-3, ist aber nicht darauf beschränkt. Sie könnte auf andere IEEE-802-Spezifikationen, z. B. IEEE 802.11, anwendbar sein.

[QUELLE: IEC 61784-2, 3.1.21]

3.3.21**Ring**

(en: ring)

aktives Netzwerk, bei dem jeder Knoten in Reihe mit zwei anderen Knoten verbunden ist

[QUELLE: IEC 61918, 3.1.71]

3.3.22**RTE-Endgerät**

(en: RTE end device)

Gerät mit mindestens einer RTE-Endstation

[QUELLE: IEC 61784-2, 3.1.26]

3.3.23**RTE-Endstation**

(en: RTE end-station)

Endstation mit RTE-Funktion

[QUELLE: IEC 61784-2, 3.1.27]

3.4 Zusätzliche Typ-21-Definitionen**3.4.1****eindeutige Geräte-Identifikation**

(en: device unique identification)

eindeutige 8-Oktett-Identifikation zur Identifizierung eines Typ-21-Geräts in einem Netzwerk

Anmerkung 1 zum Begriff: Diese ID ist eine Kombination aus einer MAC-Adresse mit 6 Oktetten nach ISO/IEC/IEEE 8802-3 und einer DL-Adresse mit 2 Oktetten.

3.4.2**R-Port**

(en: R-port)

Port in einem Kommunikationsgerät, das Teil einer ringförmigen Struktur ist

– Leerseite –

English Version

Industrial communication networks - Fieldbus specifications -
Part 4-21: Data-link layer protocol specification -
Type 21 elements
(IEC 61158-4-21:2019)

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 4-21: Spécification du protocole de la
couche de liaison de données - Eléments de Type 21
(IEC 61158-4-21:2019)

Industrielle Kommunikationsnetze - Feldbusse -
Teil 4-21: Protokollspezifikation des Data-Link Layer
(Sicherheitsschicht) - Typ 21-Elemente
(IEC 61158-4-21:2019)

This European Standard was approved by CENELEC on 2019-05-15. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 65C/946/FDIS, future edition 2 of IEC 61158-4-21, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61158-4-21:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-02-15
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-05-15

This document supersedes EN 61158-4-21:2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61158-4-21:2019 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61158-1:2019	NOTE	Harmonized as EN IEC 61158-1:2019 (not modified).
IEC 61158-2:2014	NOTE	Harmonized as EN 61158-2:2014 (not modified).
IEC 61158-5-21:2019	NOTE	Harmonized as EN IEC 61158-5-21:2019 (not modified).
IEC 61784-2:2019	NOTE	Harmonized as EN IEC 61784-2:2019 (not modified).
IEC 61918:2018	NOTE	Harmonized as EN IEC 61918:2018 (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61158-3-21	2019	Industrial communication networks - Fieldbus specifications - Part 3-21: Data-link layer service definition - Type 21 elements	EN IEC 61158-3-21	2019
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 10731	-	Information technology - Open Systems-Interconnection - Basic Reference Model - Conventions for the definition of OSI services		-
ISO/IEC/IEEE 8802-3:2017		Standard for Ethernet	-	-

CONTENTS

European foreword	2
Annex ZA (normative) Normative references to international publications with their corresponding European publications	3
INTRODUCTION	9
1 Scope.....	10
1.1 General	10
1.2 Specifications.....	10
1.3 Procedures.....	10
1.4 Applicability	10
1.5 Conformance	10
2 Normative references	11
3 Terms, definitions, symbols and abbreviations	11
3.1 Reference model terms and definitions	11
3.2 Service convention terms and definitions	13
3.3 Common terms and definitions	14
3.4 Additional Type 21 definitions.....	17
3.5 Common symbols and abbreviations.....	17
3.6 Additional Type 21 symbols and abbreviations	18
4 Overview of the data-link protocol	19
4.1 General	19
4.2 Overview of medium access control.....	19
4.3 Service assumed from the physical layer	19
4.4 DLL architecture.....	20
4.4.1 General	20
4.4.2 DLL management (DLM) interface support function	21
4.5 Data type.....	22
4.5.1 General	22
4.5.2 Boolean.....	22
4.5.3 Unsigned integer.....	22
4.5.4 Signed integer.....	23
4.5.5 Octet String.....	23
4.5.6 Visible String.....	23
4.5.7 Time of day	24
4.6 Local parameters and variables.....	24
4.6.1 General	24
4.6.2 DLE configuration parameters.....	24
4.6.3 Queues to support data transfer.....	25
4.6.4 Variables to support SAP management	26
4.6.5 Variables to support local device information management.....	27
4.6.6 Variables and counter to support network information management.....	31
4.6.7 Variables and counter to support a device path information management.....	35
4.6.8 Variables, counters, timers, and queues to support path table management.....	39
5 General structure and encoding	39
5.1 Overview	39
5.2 MAPDU structure and encoding	39

5.3	Common MAC frame structure, encoding and elements of procedure	39
5.3.1	MAC frame structure	39
5.3.2	Elements of the MAC frame	40
5.3.3	Elements of the Type 21 DLPDU	41
5.4	Order of bit transmission	49
5.5	Invalid DLPDU	49
6	DLPDU structure and procedure	49
6.1	General	49
6.2	Common DLPDU Field	49
6.2.1	General	49
6.2.2	Version	50
6.2.3	Length	50
6.3	DL-DATA Transfer	50
6.3.1	DT DLPDU	50
6.4	DL-SPDATA Transfer	53
6.4.1	SPDT DLPDU	53
6.5	Network control messages	54
6.5.1	General	54
6.5.2	NCM_LA DLPDU	54
6.5.3	NCM_AT DLPDU	56
6.5.4	NCM_LS DLPDU	57
6.5.5	NCM_RS DLPDU	58
6.5.6	NCM_AR_DLPDU	59
6.5.7	NCM_AR DLPDU structure	59
7	DLE elements of procedure	60
7.1	Overall structure	60
7.2	DL-protocol machine (DLPM)	60
7.2.1	Overview	60
7.2.2	Primitive definitions	60
7.2.3	DLPM state table	63
7.2.4	DLPM functions	67
7.3	DLL management Protocol	68
7.3.1	Overview	68
7.3.2	Primitive definitions	68
7.3.3	DLM state table	71
7.3.4	DLM functions	95
8	Constants and error codes	104
8.1	General	104
8.2	Constants	104
8.3	Data-link layer error codes	106
	Bibliography	107
	Figure 1 – Interaction of PhS primitives with DLE	19
	Figure 2 – Data-link layer architecture	21
	Figure 3 – Relationships of DLSAPs, DLSAP-addresses, and group DL-addresses	26
	Figure 4 – Common MAC frame format for Type 21 DLPDU	40
	Figure 5 – MAC frame format for other protocols	40

Figure 6 – Version and Length field.....	41
Figure 7 – DST_addr field.....	42
Figure 8 – SRC_addr field	43
Figure 9 – Frame Control Field.....	43
Figure 10 – Extension field	46
Figure 11 – DSAP field	47
Figure 12 – Source service access point field	48
Figure 13 – Length of group mask and extension information	48
Figure 14 – Group mask option field.....	48
Figure 15 – Common DLPDU field	49
Figure 16 – Building a DT DLPDU.....	50
Figure 17 – DT DLPDU structure.....	50
Figure 18 – SPDT DLPDU structure.....	53
Figure 19 – NCM_LA DLPDU structure.....	55
Figure 20 – DLL structure and elements	60
Figure 21 – State transition diagram of the DLPM	63
Figure 22 – State transition diagram of DLM.....	72
Table 1 – DLL components.....	20
Table 2 – UNSIGNEDn data type	22
Table 3 – INTEGERn data type	23
Table 4 – DLE configuration parameters.....	25
Table 5 – Queues to support data transfer	25
Table 6 – Variables to support SAP management	26
Table 7 – Variables to support device information management	27
Table 8 – DL–entity identifier	27
Table 9 – Device Flags	28
Table 10 – DLM state	28
Table 11 – Device Unique Identification	28
Table 12 – Unique identification of device connected to R-port1	29
Table 13 – Unique identification of device connected to R-port2	29
Table 14 – MAC address	29
Table 15 – Port information	30
Table 16 – Protocol version	30
Table 17 – Device type	31
Table 18 – Device description	31
Table 19 – Hop count	31
Table 20 – Variables to support managing network information	32
Table 21 – Topology	32
Table 22 – Collision count	32
Table 23 – Device count	33
Table 24 – Topology change count	33

Table 25 – Last topology change time	33
Table 26 – RNMP device UID	33
Table 27 – RNMS device UID	34
Table 28 – LNM device UID for R-port1	34
Table 29 – LNM device UID for R-port2	34
Table 30 – Network flags.....	35
Table 31 – Variables and counter to support managing path information	36
Table 32 – Hop count for R-port1 direction	36
Table 33 – Hop count for R-port2 direction	37
Table 34 – Preferred R-port.....	37
Table 35 – Destination R-port	37
Table 36 – In net count.....	38
Table 37 – In net time.....	38
Table 38 – Out net count.....	39
Table 39 – Out net time	39
Table 40 – Version and Length	42
Table 41 – Destination DL–entity identifier.....	42
Table 42 – Source DL–entity identifier	43
Table 43 – Frame control	44
Table 44 – Extension.....	47
Table 45 – Destination service access point.....	47
Table 46 – source service access point	48
Table 47 – DT DLPDU parameters	51
Table 48 – Primitives exchanged between DLS-user and DLE to send a DT DLPDU	52
Table 49 – Primitives exchanged between DLS-user and DLEs to receive a DT DLPDU	53
Table 50 – SPDT DLPDU Parameters	53
Table 51 – Primitive exchanged between DLS-User and DLEs to send an SPDT DLPDU.....	54
Table 52 – Primitives exchanged between DLS-user and DLEs to receive an SPDT DLPDU.....	54
Table 53 – NCM_LA DLPDU parameters	55
Table 54 – NCM_AT DLPDU parameters	56
Table 55 – NCM_LS DLPDU parameters	57
Table 56 – NCM_RS DLPDU parameters.....	58
Table 57 – NCM_AR DLPDU parameters.....	59
Table 58 – Primitives exchanged between DLPM and DLS-user	61
Table 59 – Parameters exchanged between DLPM and DLS-user	61
Table 60 – Primitives exchanged between DLPM and DLM.....	62
Table 61 – Parameters used with primitives exchanged between DLPM and DLM	63
Table 62 – DLPM state table	64
Table 63 – DLPM functions table	67
Table 64 – Primitives exchanged between DLM and DLS-user.....	69
Table 65 – Parameters used with primitives exchanged between DLM and DLS-user.....	70
Table 66 – Primitive exchanged between DLM and DMAC	70

Table 67 – Parameters used with primitives exchanged between DLM and DMAC 71

Table 68 – Primitive exchanged between DLM and DPHY 71

Table 69 – Parameters used with primitives exchanged between DLM and DPHY 71

Table 70 – DLM state table..... 73

Table 71 – DLM function table..... 95

Table 72 – DLL constants 105

Table 73 – Type 21 DLL error codes 106

INTRODUCTION

This document 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 implementors 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 may work together in any combination.

NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in type combinations as specified explicitly in the profile parts. Use of the various protocol types in other combinations may require permission of their respective intellectual-property-right holders.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning Type 21 elements and possibly other types given in Subclause 4.1, 4.2 and 7.3 as follows:

KR 0789444	[LS]	A communication packet processing apparatus and method for ring topology Ethernet network capable of preventing permanent packet looping
KR 0732510	[LS]	Network system
KR 0870670	[LS]	Method for determining a Ring Manager Node

IEC takes no position concerning the evidence, validity and scope of these patent rights.

The holder of these patent rights has assured the IEC that he/she is willing to negotiate licences either free of charge or under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of these patent rights is registered with IEC. Information may be obtained from:

[LS]: LS Industrial Systems Co., Ltd.
 LS Tower 1026-6
 Hogye-dong, Dongan-gu,
 Anyang-si, Gyeonggi-do 431-848
 Republic of Korea

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

ISO (www.iso.org/patents) and IEC (http://www.iec.ch/tctools/patent_decl.htm) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-21: Data-link layer protocol specification – Type 21 elements

1 Scope

1.1 General

The DLL provides basic time-critical data communications between devices in an automated environment. Type 21 provides priority-based cyclic and acyclic data communication using an internal collision-free, full-duplex dual-port Ethernet switch technology. For wide application in various automation applications, Type 21 does not restrict the cyclic/acyclic scheduling policy in the DLL.

1.2 Specifications

This document describes:

- 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) procedures for giving communication opportunities based on ISO/IEC/IEEE 8802-3 MAC, with provisions for nodes to be added or removed during normal operation;
- c) structure of the fieldbus data link protocol data units (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 data link entities (DLEs) through the exchange of fieldbus DLPDUs;
- b) the interactions between a data link 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 physical layer 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 that support time-critical communications services in the data link layer of the OSI or fieldbus reference models, and that require the ability to interconnect in an open systems interconnection environment. Profiles provide a simple multi-attribute means of summarizing an implementation's capabilities, and thus its applicability to various time-deterministic 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 IEC 61784 1 and IEC 61784 2 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 61158-3-21:2019, *Industrial Communication Networks – Fieldbus specifications – Part 3-21: Data-link layer service definition – Type 21 elements*

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

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

ISO/IEC/IEEE 8802-3:2017, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

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

3 Terms, definitions, symbols and abbreviations

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://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-protocol-machine
- 3.2.11 DL-provider-initiated-facility
- 3.2.12 DL-provider-optional-facility
- 3.2.13 DL-service-primitive;
primitive
- 3.2.14 DL-service-provider
- 3.2.15 DL-service-user
- 3.2.16 DLS-user-optional-facility
- 3.2.17 indication (primitive);
acceptor.deliver (primitive)
- 3.2.18 multi-peer
- 3.2.19 request (primitive);
requestor.submit (primitive)
- 3.2.20 requestor
- 3.2.21 response (primitive);
acceptor.submit (primitive)
- 3.2.22 submit (primitive)
- 3.2.23 symmetrical service

3.3 Common terms and definitions

For the purpose of this document, the following definitions also apply.

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

3.3.1

active network

network in which data transmission between non-immediately-connected devices is dependent on active elements within those intervening devices that form the connection path

[SOURCE: IEC 61918, 3.1.3]

3.3.2

DL-segment

link

local link

single data link (DL) subnetwork in which any of the connected data link entities (DLEs) may communicate directly, without any intervening data link relaying, whenever all of those DLEs that are participating in an

instance of communication are simultaneously attentive to the DL-subnetwork during the period(s) of attempted communication

3.3.3

data-link service access point (DLSAP)

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

Note 1 to entry: Definition derived from ISO/IEC 7498-1:1994, Clause 5.

3.3.4

DL(SAP) -address

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

Note 1 to entry: This terminology was chosen because ISO/IEC 7498-3 does not permit the use of the term DLSAP-address to designate more than a single DLSAP at a single DLS-user.

3.3.5

(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.

3.3.6

Data-link connection endpoint address

DLCEP-address

DL-address that designates either:

- a) one peer DL-connection-end-point;
- b) one multi-peer publisher DL-connection-end-point, and implicitly the corresponding set of subscriber DL-connection-end-points, where each DL-connection-end-point exists within a distinct DLSAP and is associated with a corresponding distinct DLSAP-address.

3.3.7

DL-entity identifier

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

3.3.8

device

single DLE as it appears on one local link

3.3.9

end-station

system attached to a network that is an initial source or a final destination of MAC frames transmitted across that network

Note 1 to entry: A network layer router is, from the perspective of the network, an end-station. A switch, in its role of forwarding MAC frames from one link to another, is not an end-station.

[SOURCE: IEC 61784-2, 3.1.5]

3.3.10

frame

a unit of data transmission on an ISO/IEC/IEEE 8802-3 MAC (Media Access Control) that conveys a protocol data unit (PDU) between MAC service users

[SOURCE: IEEE 802.1Q-2011]

3.3.11

Frame check sequence (FCS) error

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

3.3.12

linear topology

topology where the nodes are connected in series, with two nodes connected to only one other node and all others each connected to two other nodes (that is, connected in the shape of a line)

Note 1 to entry: This topology corresponds to that of an open ring.

[SOURCE: IEC 61918, 3.1.51]

3.3.13

link

transmission path between two adjacent nodes

[SOURCE: derived from ISO/IEC 11801]

3.3.14

network management

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

3.3.15

node

network entity connected to one or more links

Note 1 to entry: A node may be either a switch, an end-station or an RTE end-station.

[SOURCE: IEC 61784-2, 3.1.17]

3.3.16

packet

logical grouping of information used to describe a unit of data at any layer to convey the upper layer user data to its peer layer

Note 1 to entry: A packet is identical to the PDU at each layer in terms of the OSI reference model. A data-link layer packet is a frame.

[SOURCE: IEC 61784-2, 3.1.18]

3.3.17

protocol

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

3.3.18

real-time

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

[SOURCE: IEC 61784-2, 3.1.19]

3.3.19

real-time communication

transfer of data in real-time

[SOURCE: IEC 61784-2, 3.1.20]

3.3.20

Real-time Ethernet

RTE

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

Note 1 to entry: Other communications can be supported, providing that the real-time communication is not compromised.

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

[SOURCE: IEC 61784-2, 3.1.21]

3.3.21

ring

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

[SOURCE: IEC 61918, 3.1.71]

3.3.22

RTE end device

device with at least one RTE end-station

[SOURCE: IEC 61784-2, 3.1.26]

3.3.23

RTE end-station

end-station with RTE capability

[SOURCE: IEC 61784-2, 3.1.27]

3.4 Additional Type 21 definitions

3.4.1

device unique identification

unique 8 octet identification to identify a Type 21 device in a network

Note 1 to entry: This ID is a combination of a 6 octet ISO/IEC/IEEE 8802-3 MAC address and 2 octet DL-address.

3.4.2

R-port

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

3.5 Common symbols and abbreviations

DL	data link (used as a prefix or adjective)
DLC	data link connection
DLCEP	data link connection endpoint
DLE	data link entity (the local active instance of the DLL)
DLL	data link layer
DLPDU	data link protocol data unit
DLPM	data link protocol machine
DLM	data link management
DLME	data link management entity (the local active instance of DLM)
DLMS	data link management service

DLS	data link service
DLSAP	data link service-access-point
DLSDU	data link service-data-unit
FIFO	first-in, first-out (queuing method)
NMT	network management
OSI	Open Systems Interconnection
Ph-	physical layer (as a prefix)
PHY	physical interface transceiver
PhL	physical layer
RTE	Real-time Ethernet
IEC	International Electrotechnical Commission
IP	Internet Protocol (see RFC 791)
ISO	International Organization for Standardization
MAC	media access control
NRT	non-real-time
PDU	protocol data unit
SAP	service access point
RT	real-time
TCP	Transmission Control Protocol (see RFC 793)
UDP	User Datagram Protocol (see RFC 768)

3.6 Additional Type 21 symbols and abbreviations

EFR	extremely fast recovery
GD	general device
LNМ	line network manager
PO	power on
PnP	plug and play
RNM	ring network manager
RNMP	primary ring network manager
RNMS	secondary ring network manager
RNAC	ring network auto configuration
UID	device unique identification
Type 21 NMIB	Type 21 network management information base

4 Overview of the data-link protocol

4.1 General

Type 21 extends Ethernet according to the ISO/IEC/IEEE 8802-3 with mechanisms to transfer data with predictable timing demands typical of high-performance automation. It does not change the basic principles of the Ethernet according to ISO/IEC/IEEE 8802-3 but extends it toward RTE. Thus, it is possible to continue to use standard Ethernet hardware, infrastructure components, or test and measurement equipment, such as network analyzers.

4.2 Overview of medium access control

A Type 21 device requires an integrated switch with two ports (ring ports) connected to the ring. A Type 21 network system is constructed with full-duplex, collision-free Ethernet switching devices as a ring or a line network. Type 21 guarantees collision-free data transmission between two devices linked by a full-duplex Ethernet connection. Thus, the Type 21 data link layer provides reliable, transparent and collision-free data transmission among DLS-users.

A Type 21 connection provides collision-free, full-duplex data communication between two devices. Therefore, a Type 21 device can transmit a frame at any time without restriction of media access rights. Type 21 data link layer does not restrict the scheduling method to use for data link resources, but each device can be individually scheduled by the application program so that Type 21 can be applied flexibly in various applications.

A Type 21 frame is delivered to the destination device in one of the following two ways:

- A frame is initiated by a source device and directly transmitted to the neighboring destination device;
- A frame is initiated by a source device and forwarded to the destination device by intermediate devices.

When a frame is forwarded by the intermediate device, the frame forwarding procedure is processed by the internal hardware switch to minimize the processing time, and it does not affect the performance of Type 21 DLL.

4.3 Service assumed from the physical layer

This document describes the assumed physical layer service (PhS) and the constraints used by the DLE. The physical service is assumed to provide the following service primitives specified by ISO/IEC/IEEE 8802-3:2017, Clause 2.

The assumed primitives of PhS are MA-DATA.request and MA-DATA.indication.

The temporal relationship of the primitives is shown in Figure 1.

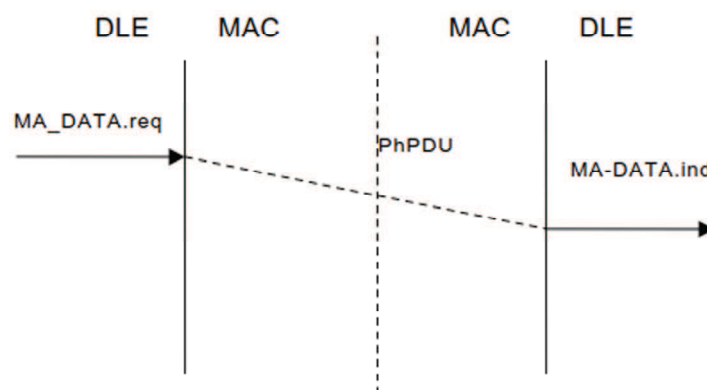


Figure 1 – Interaction of PhS primitives with DLE

The MA-DATA request primitive defines the transfer of data from a MAC client entity to a single peer entity or multiple peer entities in the case of group addresses.

The MA-DATA indication primitive defines the transfer of data from the MAC sublayer entity (through the optional MAC control sublayer, if implemented) to the MAC client entity or entities in the case of group addresses.

4.4 DLL architecture

4.4.1 General

The Type 21 DLL provides reliable and efficient higher-level data transfer service using a full-duplex ring or line topology without any specific access control scheme. The Type 21 DLL is modeled as a combination of control components of the data link protocol machine (DLPM) and the DLL management interface.

The DLPM transmits the data link service data unit (DLSDU) generated by the local DLS-user to the appropriate R-port according to the data link service policy. The DLPM also examines the received frame and delivers the received DLPDU to the appropriate DLS-user.

The DLL management interface provides DLL management functions to maintain the network management information base (NMIB). The NMIB includes local device information, network information and the path table. The DLL is comprised of the components listed in Table 1.

Table 1 – DLL components

Components	Description
DL-protocol machine (DLPM)	Transmits the DLSDU received from local DLS-user through the real-time queue (RT-queue) or non-real-time queue (NRT-queue). Examines the received frame and delivers the DLPDU to the appropriate DLS-user.
DLL management interface (DLM-interface)	Holds the station management variables that belong to the DLL, and manages synchronized changes of the link parameters.

The internal arrangement of these components, and their interfaces, are shown in Figure 2. The arrowheads illustrate the primary direction of the flow of data and control.

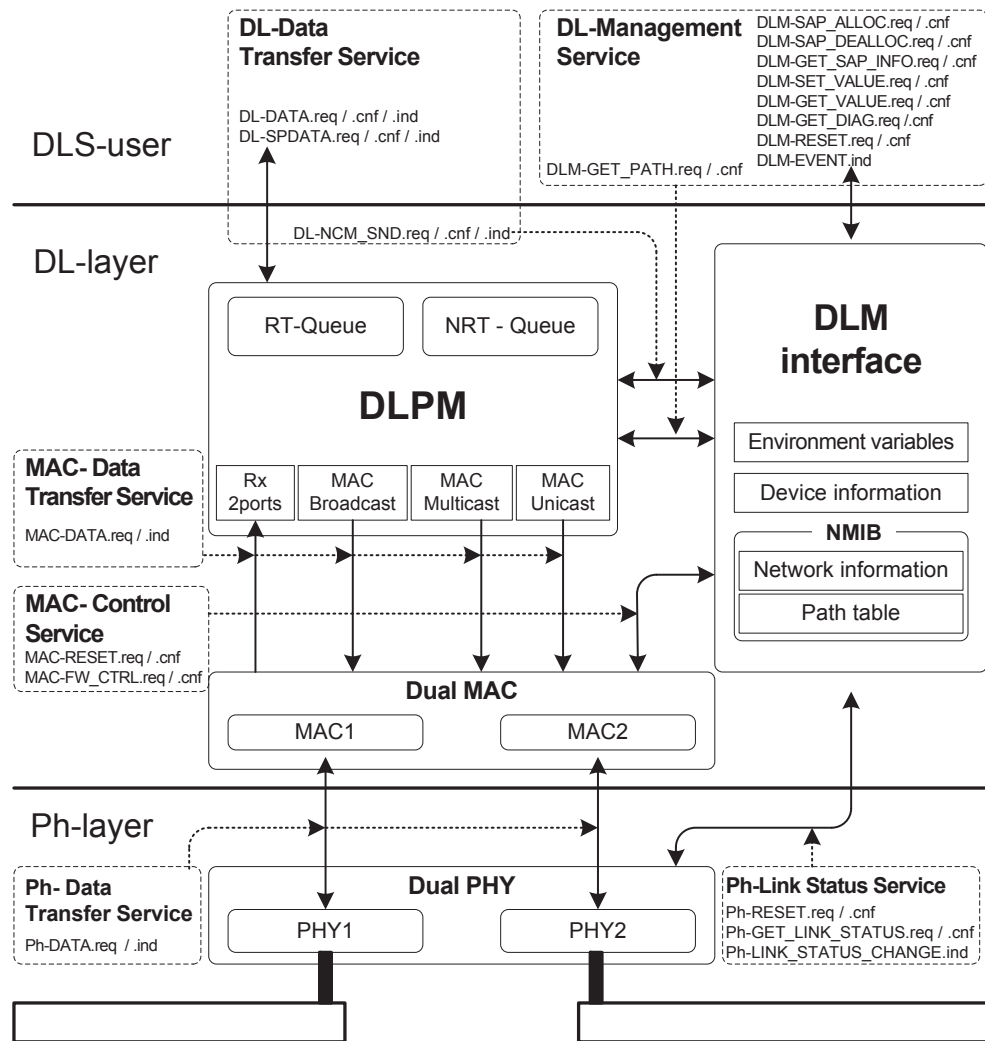


Figure 2 – Data-link layer architecture

4.4.2 DLL management (DLM) interface support function

DLM is one of the key Type 21 features that enables the Plug and Play (PnP), Network Auto Configuration (NAC), and Extremely Fast Recovery (EFR) functions. DLM spontaneously maintains and shares local device information and network-related information with every device on the network.

- Type 21 NMIB management

The DLM interface maintains the NMIB including the local device information that indicates the physical and logical status of the device, the network information that indicates the current network configuration status, and the path table that indicates the path information to the other devices and their profiles.

- Plug and Play (PnP)

When a device joins the existing network, it is automatically detected and configured without extra manual configuration of parameters so that the new device can communicate directly with the other devices on the network.

- Network auto configuration (NAC)

Type 21 supports ring and line network topologies. When the network is changed from ring to line or from line to ring topology, the change is automatically detected and broadcast to every device on the network, and then the network information and path table entries are automatically updated.

- Extremely fast recovery (EFR)

When the network is changed from ring to line topology, network information and path information are automatically updated within 10 ms.

- System diagnostic services

The DLM interface also provides system diagnostic service.

4.5 Data type

4.5.1 General

This document describes the basic Type 21 data types. The data types described in this document are only the normative references to represent Type 21 data type formats. The implementation issues are not covered in this document.

4.5.2 Boolean

Data of basic data type BOOLEAN can have the values TRUE or FALSE. The values are represented as bit sequences of length 1. The value TRUE is represented by a 1 and the value FALSE is represented by a 0.

4.5.3 Unsigned integer

Data of basic data type UNSIGNED n have values of non-negative integers. The value range is $0, \dots, 2^n - 1$. The data are represented as bit sequences of length n . The bit sequence

$$b = b_0 \sim b_{n-1}$$

is assigned the value

$$\text{UNSIGNED}_n = b_0 2^0 + b_1 2^1 + \dots + b_{n-1} 2^{n-1}$$

The bit sequence starts on the right with the least significant octet as shown in Table 2.

Table 2 – UNSIGNED n data type

Octet number	1	2	3	4	5	6	7	8
UNSIGNED8	$b_0..b_7$							
UNSIGNED16	$b_0..b_7$	$b_8..b_{15}$						
UNSIGNED24	$b_0..b_7$	$b_8..b_{15}$	$b_{16}..b_{23}$					
UNSIGNED32	$b_0..b_7$	$b_8..b_{15}$	$b_{16}..b_{23}$	$b_{24}..b_{31}$				
UNSIGNED40	$b_0..b_7$	$b_8..b_{15}$	$b_{16}..b_{23}$	$b_{24}..b_{31}$	$b_{32}..b_{39}$			
UNSIGNED48	$b_0..b_7$	$b_8..b_{15}$	$b_{16}..b_{23}$	$b_{24}..b_{31}$	$b_{32}..b_{39}$	$b_{40}..b_{47}$		
UNSIGNED56	$b_0..b_7$	$b_8..b_{15}$	$b_{16}..b_{23}$	$b_{24}..b_{31}$	$b_{32}..b_{39}$	$b_{40}..b_{47}$	$b_{48}..b_{55}$	
UNSIGNED64	$b_0..b_7$	$b_8..b_{15}$	$b_{16}..b_{23}$	$b_{24}..b_{31}$	$b_{32}..b_{39}$	$b_{40}..b_{47}$	$b_{48}..b_{55}$	$b_{56}..b_{63}$

4.5.4 Signed integer

Data of basic data type INTEGER_n has values of integers. The value range is from -2^{n-1} to 2^{n-1} . The data are represented as bit sequences of length n . The bit sequence

$$b = b_0 \sim b_{n-1}$$

is assigned the value

$$\text{INTEGER}_n = b_0 2^0 + b_1 2^1 + \dots + b_{n-2} 2^{n-2}, \text{ when } b_{n-1} \text{ is 0, and}$$

$$\text{INTEGER}_n = -\text{Complement}(b) - 1, \text{ when } b_{n-1} \text{ is 1.}$$

The bit sequence starts on the right with the least significant octet as shown in Table 3.

Table 3 – INTEGER_n data type

Octet number	1	2	3	4	5	6	7	8
INTEGER8	$b_0 \dots b_7$							
INTEGER16	$b_0 \dots b_7$	$b_8 \dots b_{15}$						
INTEGER24	$b_0 \dots b_7$	$b_8 \dots b_{15}$	$b_{16} \dots b_{23}$					
INTEGER32	$b_0 \dots b_7$	$b_8 \dots b_{15}$	$b_{16} \dots b_{23}$	$b_{24} \dots b_{31}$				
INTEGER40	$b_0 \dots b_7$	$b_8 \dots b_{15}$	$b_{16} \dots b_{23}$	$b_{24} \dots b_{31}$	$b_{32} \dots b_{39}$			
INTEGER48	$b_0 \dots b_7$	$b_8 \dots b_{15}$	$b_{16} \dots b_{23}$	$b_{24} \dots b_{31}$	$b_{32} \dots b_{39}$	$b_{40} \dots b_{47}$		
INTEGER56	$b_0 \dots b_7$	$b_8 \dots b_{15}$	$b_{16} \dots b_{23}$	$b_{24} \dots b_{31}$	$b_{32} \dots b_{39}$	$b_{40} \dots b_{47}$	$b_{48} \dots b_{55}$	
INTEGER64	$b_0 \dots b_7$	$b_8 \dots b_{15}$	$b_{16} \dots b_{23}$	$b_{24} \dots b_{31}$	$b_{32} \dots b_{39}$	$b_{40} \dots b_{47}$	$b_{48} \dots b_{55}$	$b_{56} \dots b_{63}$

4.5.5 Octet String

The data type OCTET_STRING_n is defined below. The n represents the octet length of the octet string.

ARRAY[n] of UNSINGED8 OCTET_STRING_n

4.5.6 Visible String

The data type VISIBLE_STRING_n is defined below. The admissible values of data of type VISIBLE_CHAR are 0x00 and the range 0x20–0x7E. The data are interpreted as 7-bit coded characters. The n indicates the octet length of the visible string.

UNSINGED8 VISIBLE_CHAR

ARRAY[n] of VISIBLE_CHAR VISIBLE_STRING_n

There is no 0x00 necessary to terminate the string.

4.5.7 Time of day

The data type TIMEOFDAY is defined below. TIMEOFDAY consists of UNSIGNED16 date counting and UNSIGNED32 millisecond fields.

TIMEOFDAY

UNSIGNED32 milliseconds: the count from time 00:00 in milliseconds.

UNSIGNED16 date count: the number of days from 1984-01-01.

4.6 Local parameters and variables

4.6.1 General

This document uses DLS-user request parameters P(...) and local variables V(...) as a means of clarifying the effects of certain actions and the conditions under which those actions are valid. This document also uses local timers T(...) as a means of monitoring the actions of the distributed DLS-provider and of ensuring a local DLE response to the absence of those actions. This document uses local counters C(...) for performing rate measurement functions. It also uses local queues Q(...) as a means of ordering certain activities, of clarifying the effects of certain actions, and of clarifying the conditions under which those activities are valid.

Unless otherwise specified, at the moment of their creation or of DLE activation:

- a) all variables shall be initialized to their default value, or to their minimum permitted value if no default is specified;
- b) all counters shall be initialized to zero;
- c) all timers shall be initialized to inactive.

DLM may change the values of configuration variables.

Local parameters and variables include DLE configuration parameters, local device information, and NMIB variables. The DLE operational condition is stored in DLE configuration parameters and the DLE configuration parameters are configured locally or remotely according to the application. Local data link information, such as DL-entity identifier and the status of each R-port, are stored in the local device information. NMIB includes network information and the path table. Network topology and the network-related variables are stored in the network information, and the device profile and path information of the other devices on the network are summarized in the path table.

4.6.2 DLE configuration parameters

4.6.2.1 General

These parameters are required to configure the local DLE operation, and they are managed by DLM. Every device on the same network segment has the same DLE configuration parameters. DLM-GET_VALUE service and DLM-SET_VALUE service are used to read or write the DLE configuration parameters. Table 4 shows the list of DLE configuration parameters.

Table 4 – DLE configuration parameters

Parameter	Data type	Default value	Description
Max DL–entity identifier	UNSIGNED16	255	Maximum DL–entity identifier 256 to 65 535: reserved
DLPM scheduling policy	UNSIGNED8	0	0: First-In, First-Out 1: Fixed priority 2: to 255: reserved

4.6.2.2 P(MAX_ADDR): Maximum DL–entity identifier

This variable holds the maximum device address and is set by the DLM. The range of this variable is 1 to 255. The default value of this variable is 255. This variable also indicates the maximum number of path table entries in the NMIB. The values in the range 256 to 65 535 are reserved.

4.6.2.3 P(DLPMSP): data link protocol machine scheduling policy

This variable holds the scheduling policy of the local DLPM, which dictates how to serve the concurrent DLSDUs in the RT-queue. The NRT-queue is not scheduled by the DLPMSP. DLPMSP can have one of the following values:

- a) 0: first-in, first-out. The first received frame is served first. In this case, the message priority in the DLSDU is ignored;
- b) 1: Fixed priority. The DLSDU with high priority is served first. If many DLSDUs are stacked with the same priority, the frame received first is served first;
- c) 2 to 255: reserved.

4.6.3 Queues to support data transfer

4.6.3.1 General

When a DLS-user generates a DLSDU to be transmitted by the DLPM, the DLSDU is encapsulated by the DLPDU. The DLPDU is then stored in the RT-queue or the NRT-queue according to its application and service type. Table 5 shows the queue list for Type 21 data transfer.

Table 5 – Queues to support data transfer

Parameter	Data type	Default value	Description
RT-queue	—	—	Transmit queue to store the real-time data
NRT-queue	—	—	Transmit queue to store the non-real-time data

4.6.3.2 Q(RTQ): RT-queue

The RT-queue stores the real-time DLPDUs generated by a DLS-user to be transmitted by the DLPM. The size of the RT-queue is not restricted in this document and it is considered a detail of the local implementation. The RT-queue is scheduled by the DLPM.

4.6.3.3 Q(NRTQ): NRT-queue

The NRT-queue stores non-real-time DLPDUs generated by a DLS-user. The size of the NRT-queue is not restricted in this document and it is considered a detail of the local implementation. Messages in the RT-queue are transmitted first. Messages in the NRT-queue are transmitted only when the RT-queue is empty.

4.6.4 Variables to support SAP management

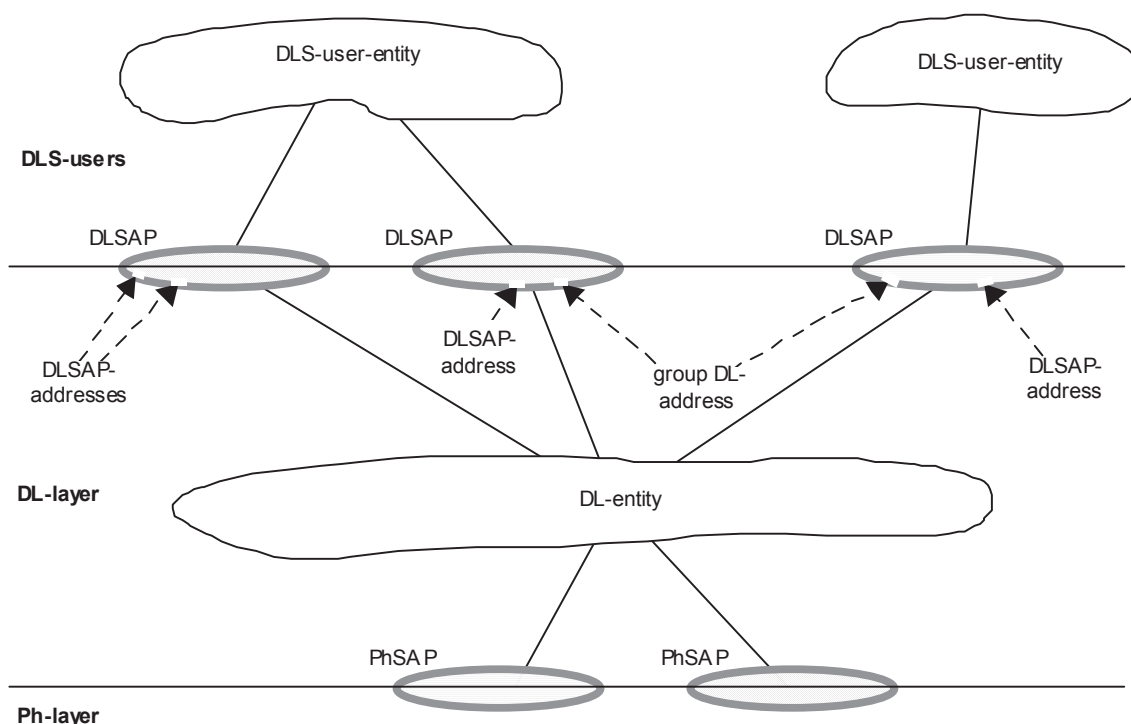
4.6.4.1 General

Allocation and de-allocation of the data link service access point (DLSAP) is managed by the DLM. When a frame is received, the DLPM examines the destination service access point (DSAP) in the DLSDU. If the DSAP is already allocated to a DLS-user, the DLM returns the appropriate DLS-user ID equivalent for the received DSAP address, and the DLPM delivers the received DLSDU to the DLS-user. If the service access point (SAP) is not allocated and no appropriate DLS-user ID is found in the DLM, the received DLSDU is discarded by the DLPM. Therefore, to receive a DLSDU from a certain peer DLS-user, a DLS-user shall first obtain a SAP allocation using the DLM-SAP_ALLOC service. Once the SAP is allocated to a DLS-user, it is used to send and receive data until the SAP is deallocated and returned to the DLM. The deallocated SAP can be used again after reallocation. The SAP address and its appropriate DLS-user ID are stored together and maintained by the DLM. The maximum number of SAP management items is 65 535 but the method to allocate and de-allocate the SAP address is not restricted in this document. Table 6 shows the list of SAP management variables.

Table 6 – Variables to support SAP management

Parameter	Data type	Default value	Description
SAP	UNSIGNED16	—	Service access point
DLS-user ID	UNSIGNED32	—	Numeric identification of the DLS-user that owns the SAP allocation

NOTE The definition of DLSAP, derived from ISO/IEC 7498-1, is explained here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses (see Figure 3).



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

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

Figure 3 – Relationships of DLSAPs, DLSAP-addresses, and group DL-addresses