

BS EN 61375-3-4:2014+A11:2017



BSI Standards Publication

Electronic railway equipment — Train communication network (TCN)

Part 3-4: Ethernet Consist Network (ECN)
(IEC 61375-3-4:2014)

bsi.

AVA Documents
Document Sharing Hub

National foreword

This British Standard is the UK implementation of EN 61375-3-4:2014+A11:2017. It is identical to IEC 61375-3-4:2014. It supersedes BS EN 61375-3-4:2014 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway Electrotechnical Applications, to Panel GEL/9/-/4, Railway applications - Train communication network and multimedia systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2017.

Published by BSI Standards Limited 2017

ISBN 978 0 580 98095 4

ICS 45.060.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

Amendments/corrigenda issued since publication

Date	Text affected
30 April 2017	Implementation of CENELEC amendment A11:2017: Annex ZZ added

English Version

Electronic railway equipment - Train communication network
(TCN) - Part 3-4: Ethernet Consist Network (ECN)
(IEC 61375-3-4:2014)

Matériel électronique ferroviaire - Réseau embarqué de
train (TCN) - Partie 3-4: Réseau Ethernet de Rame (ECN)
(CEI 61375-3-4:2014)

Elektronische Betriebsmittel für Bahnen - Zugbus - Teil 3-4:
ECN - Ethernet-Zugverband-Netzwerk
(IEC 61375-3-4:2014)

This European Standard was approved by CENELEC on 2014-04-23. 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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, 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: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 9/1873/FDIS, future edition 1 of IEC 61375-3-4, prepared by IEC/TC 9 "Electrical equipment and systems for railways" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61375-3-4:2014.

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) 2015-01-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-04-23

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

Endorsement notice

The text of the International Standard IEC 61375-3-4:2014 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A11

This document (EN 61375-3-4:2014/A11:2017) has been prepared by CLC/TC 9X "Electrical and electronic applications for railways".

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) 2018-02-01
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2020-02-01

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

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61076-2-101	-	Connectors for electronic equipment - Product EN 61076-2-101 requirements - Part 2-101: Circular connectors - Detail specification for M12 connectors with screw-locking		-
IEC 61076-3-104	-	Connectors for electronic equipment - Product EN 61076-3-104 requirements - Part 3-104: Detail specification for 8-way, shielded free and fixed connectors for data transmissions with frequencies up to 1000 MHz		-
IEC 61156-6	-	Multicore and symmetrical pair/quad cables for digital communications - Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz - Work area wiring - Sectional specification		-
IEC 61375-1	-	Electronic railway equipment - Train communication network (TCN) - Part 1: General architecture	EN 61375-1	-
IEC 61375-2-1	-	Electronic railway equipment - Train communication network (TCN) - Part 2-1: Wire Train Bus (WTB)	EN 61375-2-1	-
IEC 61375-2-5	-	Electronic railway equipment - Train backbone - Part 2-5: Ethernet Train Backbone	EN 61375-2-5	-
IEC 62439 series	-	High availability automation networks	EN 62439 ¹⁾	-
ISO/IEC 7498 series	-	Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model		-
ISO/IEC 8824 series	-	Information technology - Open Systems Interconnection - Specification of Abstract Syntax Notation One (ASN.1)		-
ISO/IEC 11801	-	Information technology - Generic cabling for customer premises		-

¹⁾ EN 62439 is superseded by EN 62439-6:2010, which is based on IEC 62439-6:2010.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEEE 802.3	-	IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) - Access Method and Physical Layer Specifications	-	-
IEEE 802.1Q	-	IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks	-	-
IEEE 802.1D	-	IEEE Standard for Local and Metropolitan Area Networks - Media Access Control (MAC) Bridges	-	-
ANSI/TIA/EIA 568-B.1	2001	Commercial Building Telecommunications Cabling Standard - Part 1: General requirements	-	-
ANSI X3.263	1995	EN-Information Technology - Fibre Distributed - Data Interface (FDDI) - Token Ring Twisted Pair Physical Layer Medium Dependent (TP-PMD)	-	-

Annex ZZ (informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Annex III of the EC Directive 2008/57/EC (also named as New Approach Directive 2008/57/EC Rail Systems: Interoperability).

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZZ.1 relating to the 'rolling stock - locomotives and passenger rolling stock' subsystem of the rail system in the European Union, confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZZ.1 – Correspondence between this European Standard, the RST LOC&PAS TSI (published in the Official Journal L 356 on 12 December 2014, p. 228) and Directive 2008/57/EC

Clauses of this European Standard	Chapter / § / points of RST LOC&PAS TSI	Essential Requirements (ER) of Directive 2008/57/EC	Comments
Clauses 1 to 4 are applicable.	4.2.4.9 Brake state and fault indication 4.2.5.2 Audible communication system 4.2.5.3 Passenger alarm 4.2.5.4 Communication devices for passengers 4.2.5.5 Exterior doors 4.2.12.2 General documentation: - description of computerised on board systems	2. Requirements specific to each sub-subsystem 2.4. Rolling Stock 2.4.1. Safety 2.4.2. Reliability and availability 2.4.3. Technical compatibility	The TSI does not impose any technical solution regarding physical interfaces between units. This standard offers a general multi-purpose solution for the digital communication network within railway vehicles and consists and it is relevant to equipment and vehicle interoperability.

WARNING: Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

CONTENTS

INTRODUCTION.....	13
1 Scope.....	14
2 Normative references	14
3 Terms, definitions, symbols, abbreviations and conventions	15
3.1 Terms and definitions.....	15
3.2 Symbols and abbreviated terms	16
3.3 Conventions.....	19
3.3.1 Bit numbering conventions.....	19
3.3.2 Byte order conventions	19
3.3.3 Data types	19
4 Common part.....	20
4.1 General.....	20
4.2 Architecture	20
4.2.1 Network structure	20
4.2.2 Network topology.....	21
4.2.3 End Device classes	22
4.2.4 Network Device types and Consist Switch classes	23
4.3 Data class.....	24
4.4 Functions and services	25
4.5 Redundancy.....	26
4.5.1 General	26
4.5.2 Definitions	27
4.5.3 Redundancy managed at network level.....	27
4.5.4 Redundancy managed at End Device level	28
4.6 Quality of service	29
4.6.1 General	29
4.6.2 Priority level	29
4.6.3 Assignment of priority level.....	30
4.6.4 Consist Switch behavior	30
4.6.5 Ingress rate limiting	30
4.6.6 Egress rate shaping.....	31
4.7 IP address and related definitions	31
4.7.1 Consist Network address	31
4.7.2 Train Network Address	31
4.7.3 Group Address	32
4.7.4 Name resolution and naming definitions	32
4.8 IP address and network configuration management	33
4.8.1 Consist Network address management	33
4.8.2 Train network address management	33
4.8.3 Static network configuration parameters	34
4.8.4 DHCP configuration parameters	34
4.8.5 IP address management for TBN redundancy	35
4.9 Network Device interface	36
4.9.1 General	36

4.9.2	Function requirements	36
4.9.3	Performance requirements.....	38
4.9.4	Physical Layer	38
4.9.5	Link Layer.....	41
4.9.6	Network Layer	41
4.9.7	Transport Layer	41
4.9.8	Application layers	42
4.10	End Device interface.....	42
4.10.1	General	42
4.10.2	Physical Layer	44
4.10.3	Link Layer.....	45
4.10.4	Network layer	45
4.10.5	Transport Layer	45
4.10.6	Application layer	45
4.11	Gateway functions	46
4.11.1	WTB gateway functions	46
4.11.2	ETB gateway functions	46
4.12	Network management	47
4.12.1	ECN network management	47
4.12.2	WTB network management	47
4.12.3	ETB network management	47
5	Conformance test	47
Annex A (informative) Reliability and availability comparison between ECN architectures.....		48
A.1	General.....	48
A.2	Failure cases	48
A.2.1	Definitions	48
A.2.2	Example of failure cases – Linear topology	49
A.2.3	Example of failure cases – Parallel networks	50
A.2.4	Example of failure cases – Ring topology	51
A.2.5	Example of failure cases – Ladder topology	52
A.3	Redundancy level of ECN architecture	54
A.4	Reliability analysis of redundancy level	55
A.5	Redundancy of End Devices	57
Annex B (informative) Railway-Network Address Translation (R-NAT)		59
B.1	General.....	59
B.2	Local Consist subnet IP address	59
B.3	TBN R-NAT	60
B.4	Interoperability issue between TBNs	60
Annex C (normative) Transceiver with amplified signals protocol definition		62
C.1	General.....	62
C.2	Type A: Transceiver with amplified signals for Physical Layer based on IEEE 802.3 (10BASE-T).....	62
C.2.1	General	62
C.2.2	Transceiver unit.....	62
C.2.3	Transmission signal characteristics	63
C.2.4	Reception signal characteristics	66
C.3	Type B: Transceiver with amplified signals for Physical Layer based on IEEE 802.3 (100BASE-TX).....	

C.3.1	General	67
C.3.2	Transceiver unit.....	67
C.3.3	Transmission signal characteristics	68
C.3.4	Reception signal characteristics	68
Annex D (informative)	Ladder topology protocol definition.....	70
D.1	General.....	70
D.2	Architecture of Consist Network Node	70
D.2.1	General	70
D.2.2	Concept of ladder topology	70
D.2.3	Configuration of ladder topology	71
D.2.4	Functional structure of Consist Network Node.....	72
D.2.5	Traffic Store for Process Data.....	74
D.2.6	Redundancy in ladder topology.....	75
D.2.7	Configuration parameters for ladder topology	77
D.2.8	Signal connection for trunk link	78
D.2.9	Local link connection	79
D.3	Link Layer.....	79
D.3.1	General	79
D.3.2	MAC – Media Access Control	80
D.3.3	IP address and IP address management.....	103
D.4	Consist Network Node management protocol	103
D.4.1	General	103
D.4.2	Architecture of CNN management.....	104
D.4.3	Individual CNN management information	104
D.4.4	CNN management database	107
D.4.5	Primitives for CNN management protocol	109
D.4.6	Parameters for CNN management protocol.....	109
D.4.7	Timers for CNN management protocol	110
D.4.8	Procedures for CNN management protocol	111
D.4.9	Operation of CNN management machine	114
D.4.10	Port number assignment for CNN management protocol	116
D.5	Failure cases in ladder topology.....	117
D.5.1	General	117
D.5.2	Failure cases	117
D.5.3	Restore of the network.....	121
Bibliography		122
Figure 1	– Logical view of the ECN	21
Figure 2	– Examples of ECN physical topologies	22
Figure 3	– Example of network components.....	27
Figure 4	– Examples of dual homing	29
Figure 5	– D-coded M12 connector	40
Figure 6	– Logical structure of the gateway between ECN and WTB	46
Figure A.1	– Example of single network component failure	48
Figure A.2	– Example of double network component failures	49
Figure A.3	– Example of a single component failure at a link on linear topology	49
Figure A.4	– Example of a single component failure at an active component on linear topology.....	50

Figure A.5 – Example of a single component failure at a link on parallel networks	50
Figure A.6 – Example of a single component failure at an active component on parallel networks	51
Figure A.7 – Example of a single component failure at a link on ring topology.....	51
Figure A.8 – Example of a single component failure at an active component on ring topology.....	52
Figure A.9 – Example of a single component failure at an active component on ring topology (with dual homing ED)	52
Figure A.10 – Example of a single component failure at a link on a ladder topology	53
Figure A.11 – Example of a single component failure at an active component on ladder topology.....	53
Figure A.12 – Example of double component failures at links on ladder topology	53
Figure A.13 – Example of double component failures at active components on ladder topology (with bypass)	54
Figure A.14 – Example of ECN architecture classified by redundancy level.....	55
Figure B.1 – Example of ECN local IP range, “shadow” of train IP range for R-NAT	59
Figure B.2 – Example of Railway Network Translation (R-NAT).....	60
Figure B.3 – From R-NAT TBN to TBN.....	61
Figure B.4 – From TBN to R-NAT TBN.....	61
Figure C.1 – Block diagram of transceiver unit for 10BASE-T MAU	63
Figure C.2 – Differential output voltage test	63
Figure C.3 – Twisted-pair model	64
Figure C.4 – Amplified voltage template.....	64
Figure C.5 – Amplified transmitter waveform for start of TP_IDL	65
Figure C.6 – Start-of-TP_IDL test load	66
Figure C.7 – Amplified transmitter waveform for link test pulse	66
Figure C.8 – Amplified receiver differential input voltage – narrow pulse.....	67
Figure C.9 – Amplified receiver differential input voltage – wide pulse	67
Figure C.10 – Block diagram of transceiver unit	68
Figure C.11 – Signal_detect assertion threshold	69
Figure D.1 – Concept of ladder topology	71
Figure D.2 – Configuration of ladder topology	71
Figure D.3 – Basic flows of data frames on trunk links and local links in ladder topology	72
Figure D.4 – Functional structure of Consist Network Node	74
Figure D.5 – Concept of Traffic Store in ladder topology	75
Figure D.6 – Example of configuration of ladder topology	76
Figure D.7 – Block diagram of the transceiver unit for a single twisted pair connection	79
Figure D.8 – Cable connection for a single twisted pair	79
Figure D.9 – Example of CNN number assignment in ladder topology	81
Figure D.10 – Frame format for the commands	82
Figure D.11 – Link establishment between two CNNs	84
Figure D.12 – Link establishment in ladder topology	85
Figure D.13 – Local links between redundant CNNs.....	85
Figure D.14 – Example of CNN modes	85
Figure D.15 – Structure and primitives of Real Time MAC sub-layer	87

Figure D.16 – TPCM state machine	92
Figure D.17 – ACM state machine.....	95
Figure D.18 – State diagram of USE_TOKEN.....	97
Figure D.19 – Example of sequence of transmission	101
Figure D.20 – Architecture of CNN management.....	104
Figure D.21 – State diagram for CNNMM	115
Figure D.22 – Normal configuration of transmission paths in ladder topology	117
Figure D.23 – Re-configuration of transmission paths with a single link failure in a sub-network.....	118
Figure D.24 – Re-configuration of transmission paths with a single CNN failure in a sub-network	118
Figure D.25 – Re-configuration of transmission paths with double failures of links in a sub-network	119
Figure D.26 – Re-configuration of transmission paths with double failures of links over both sub-networks	119
Figure D.27 – Re-configuration of transmission paths with double failures of CNNs over both sub-networks	120
Figure D.28 – Re-configuration of transmission paths with double failures of a link and a CNN over both sub-networks	120
Figure D.29 – Re-configuration of transmission paths with double failures of a link and a CNN over both sub-networks	121
Table 1 – End Device classes (1).....	23
Table 2 – End Device classes (2).....	23
Table 3 – Network Device types.....	24
Table 4 – Consist Switch classes	24
Table 5 – Data class service parameters	25
Table 6 – Typical values for data class service parameters.....	25
Table 7 – Mapping of priorities to data classes	30
Table 8 – End Device static network configuration parameters.....	34
Table 9 – DHCP options	35
Table 10 – Summary of Network Device interfaces	36
Table 11 – Pinning for D-coded M12 connector.....	40
Table 12 – Summary of End Device interfaces	43
Table A.1 – Redundancy level of ECN architecture	54
Table A.2 – Reliability of redundancy level.....	56
Table A.3 – Reliability when common cause failures are considered	56
Table A.4 – Parameters for reliability and availability calculation	57
Table A.5 – Reliability and availability example values.....	57
Table A.6 – Reliability with ED redundancy comparison	58
Table A.7 – Comparison of MTBFs ratios with ED redundancy	58
Table C.1 – Output voltage template table	65
Table C.2 – Twisted pair active output interface.....	68
Table D.1 – Configuration parameters for CNN in sub-network 1	77
Table D.2 – Configuration parameters for CNN in sub-network 2	77

Table D.3 – Configuration_Process_Data_Transmission_Substitute.....	78
Table D.4 – Type_Configuration_Substitute	78
Table D.5 – Signal connection between transceivers (single twisted pair)	79
Table D.6 – CNN number	80
Table D.7 – Contents of the Destination Address field	82
Table D.8 – Contents of the Source Address field	82
Table D.9 – Contents of the Length/Type field	82
Table D.10 – Contents of command and check code fields.....	83
Table D.11 – Contents of the Padding field	83
Table D.12 – CNN mode for CNN in ladder topology	86
Table D.13 – Physical layer primitives	87
Table D.14 – Variables and parameters for real time MAC protocol.....	88
Table D.15 – Frame name	89
Table D.16 – Timers for real time MAC protocol.....	89
Table D.17 – Procedures for real time MAC protocol.....	90
Table D.18 – Events for real time MAC protocol.....	90
Table D.19 – TRRC primitives.....	90
Table D.20 – TRRC operation on acceptance of request primitives	91
Table D.21 – TRRC operation on acceptance of physical indication primitives	91
Table D.22 – State transition table for TPCM	93
Table D.23 – Procedures in TPCM state machine	94
Table D.24 – TPCM primitives	94
Table D.25 – State transition table for ACM	96
Table D.26 – State transition table for USE_TOKEN	98
Table D.27 – Variable for ACM	99
Table D.28 – Configuration parameters for real time MAC.....	99
Table D.29 – Time elements for sequence of transmission.....	101
Table D.30 – Data class service parameters	102
Table D.31 – Notation for IP address fields	103
Table D.32 – Format of individual CNN management information.....	105
Table D.33 – Description of parameters for individual CNN management information.....	106
Table D.34 – Type_Connection_Status	107
Table D.35 – Type_CNN_Flags.....	107
Table D.36 – Type_Ip_Addr_3_4.....	107
Table D.37 – Parameters of CNN management database	108
Table D.38 – Type_Connection_Status_All	108
Table D.39 – Type_Ip_Addr_3_4_All.....	109
Table D.40 – Type_Healthy_Count_All.....	109
Table D.41 – Primitives to the lower protocol layer for CNN management	109
Table D.42 – Parameters for CNN management.....	110
Table D.43 – Timers for CNN management.....	111
Table D.44 – Procedures for CNN management.....	111
Table D.45 – Functions for substitution transmission by detecting bypassed CNN	112

Table D.46 – Functions for substitution transmission by detecting link failure.....	114
Table D.47 – Events for CNN management.....	114
Table D.48 – State transition table for CNNMM.....	116
Table D.49 – Default port number for CNN management protocol	117

INTRODUCTION

This part of IEC 61375 series of international standards specifies the Consist Network based on Ethernet technology, i.e. the Ethernet Consist Network (ECN) within the TCN architecture as defined in IEC 61375-1, and End Devices which can attach to the ECN. In addition gateway services between Train Backbone and ECN are specified.

The general architecture of the TCN (see IEC 61375-1) defines a hierarchical structure with two levels of networks, Train Backbone(s) and Consist Network(s). This hierarchical structure specifies Consist Networks based on different technologies such as MVB, CANopen and ECN interfacing one Train Backbone. ECNs based on different design and implementation may be interfaced to the same Train Backbone reaching the result that the Train Backbone ensures interoperability between Consist Networks with different implementations.

The common part, consisting of Clauses 1 to 4, defines requirements and specifications which are common to all ECN implementations and End Devices and gateways.

The common part defines

- the data communication interface of End Devices connected to the ECN,
- functions and services provided by the ECN to End Devices,
- the gateway functions for data transfer between Train Backbone and the ECN, and
- performances of the ECN.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

Part 3-4: Ethernet Consist Network (ECN)

1 Scope

This part of IEC 61375 specifies the data communication network inside a Consist based on Ethernet technology, the Ethernet Consist Network (ECN).

The applicability of this part of IEC 61375 to the Consist Network allows for interoperability of individual vehicles within Open Trains in international traffic.

This part of IEC 61375 may be additionally applicable to closed trains and Multiple Unit Trains when so agreed between purchaser and supplier.

2 Normative references

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

IEC 61076-2-101, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking*

IEC 61076-3-104, *Connectors for electronic equipment – Product requirements – Part 3-104: Detail specification for 8-way, shielded free and fixed connectors for data transmissions with frequencies up to 1 000 MHz*

IEC 61156-6, *Multicore and symmetrical pair/quad cables for digital communications – Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring – Sectional specification*

IEC 61375-1, *Electronic railway equipment – Train Communication Network (TCN) – Part 1: General architecture*

IEC 61375-2-1, *Electronic railway equipment – Train Communication Network (TCN) – Part 2-1: Wire Train Bus (WTB)*

IEC 61375-2-5, *Electronic railway equipment – Train Communication Network (TCN) – Part 2-5: Ethernet Train Backbone (ETB)*

IEC 62439 (all parts), *Industrial communication networks – High availability automation networks*

ISO/IEC 7498, *Information technology – Open Systems Interconnection (OSI) – The Basic reference model*

ISO/IEC 8824 (all parts), *Information technology – Abstract Syntax Notation One (ASN.1)*

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

TIA/EIA-568-B, *Commercial Building Telecommunications Cabling Standard – Part 1: General Requirements (ANSI/TIA/EIA-568-B.1-2001)*

ANSI X3.263:1995, *EN-Information Technology - Fibre Distributed Data Interface (FDDI) - Token Ring Twisted Pair Physical Layer Medium Dependent (TP-PMD) (order number ANSI INCITS 263)*

IEEE 802.1D, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges*

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks*

IEEE 802.3, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

3 Terms, definitions, symbols, abbreviations and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61375-1 and the following apply.

3.1.1

auto negotiation

auto negotiation function allows two network devices on a point-to-point link to choose the best possible configuration; e.g. full/half duplex mode, transmission speed

3.1.2

auto polarity

auto polarity function corrects the signal polarity automatically

3.1.3

crossover function

crossover function connects the transmitter of PHY to the receiver of PHY at the end of point-to-point transmit-receive-pair link

3.1.4

full duplex mode

full duplex mode allows both sending and receiving frames at a time between stations on a link

3.1.5

intra-car connection

connection (link) between communication devices inside a car

3.1.6

inter-car connection

connection (link) between communication devices at the interface between two cars excluding the interface between Consists

3.1.7

link layer

layer in the OSI model establishing point-to-point and broadcast and multicast connections between devices attached to the logical communication channel consisting of one or more physical links

3.1.8

physical layer

layer in the OSI model providing the means of transmitting raw bits over a physical link

3.1.9

power over ethernet

Power over Ethernet technology uses the Ethernet cable for both signalling and power supply, there are PSE (Power Sourcing Equipment) terminal and PD (Power Device) terminal

3.1.10

presentation layer

layer in the OSI model for representing and formatting information of applications

3.1.11

session layer

layer in the OSI model for managing a session between applications

3.1.12

tag

a field inserted in the MAC frame of IEEE 802.3, which is inserted after the source MAC address field

3.1.13

token

a signal that is used for medium access control to avoid collisions, and transmitted between communication devices

3.1.14

virtual LAN

virtual LAN technology divides one physical LAN into several logically separated networks on Link Layer; i.e. there are separated broadcast domains in one physical LAN

3.2 Symbols and abbreviated terms

ACK	Acknowledgement
ACM	Access Control Machine
ALG	Application Layer Gateway
ANSI	American National Standard Institute, a standardisation body in the United States
ARP	Address Resolution Protocol
ASN.1	Abstract Syntax Notation Number 1 on data presentation (ISO/IEC 8824)
AWG	American Wire Gauge
bps	bits per second
BT	Bit Time
CCF	Common Cause Failure
CI	Control In
CNN	Consist Network Node
CS	Consist Switch
DA	Destination Address
DHCP	Dynamic Host Configuration Protocol
DI	Data In
DNS	Domain Name System
DO	Data Out

DSCP	Differentiated Services Code Point, defined in RFC 2474
ECN	Ethernet Consist Network
ED	End Device
EIA	Electronics Industries Association, a standardisation body in the United States
EMC	electro-magnetic compatibility
EMU	Electric Multiple Unit
ETB	Ethernet Train Backbone
ExP	External Port
FCS	Frame Check Sequence
FTP	File Transfer Protocol
FQDN	Full Qualified Domain Name
HTTP	Hypertext Transfer Protocol
ICMP	Internet Control Message Protocol
IEEE	Institute of Electrical and Electronics Engineers, New York
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
InP	Internal Port
I/O	Input and Output
IP	Internet Protocol
LAN	Local Area Network
LPR	Local Port for Reception
LPT	Local Port for Transmission
LSB	Least Significant Bit
MAC	Medium Access Control, a sub-layer within the Link Layer ruling which device is entitled to send on the bus
MAU	Medium Attachment Unit
MD	Message Data
MDI	Media Dependent Interface
MDI-X	MDI implementing crossover function
MRP	Media Redundancy Protocol
MSB	Most Significant Bit
MTBF	Mean Time Between Failures
MVB	Multifunction Vehicle Bus
NAT	Network Address Translation
ND	Network Device
NTP	Network Time Protocol
OSI	Open System Interconnection, a universal communication model defined in the ISO/IEC 7498
OSPF	Open Shortest Path First
PC	Personal Computer
PCS	Physical Coding Sublayer
PD	Process Data
PHY	Physical Layer, Physical Layer device
PMA	Physical Media Attachment

PMD	Physical Medium Dependent
PoE	Power over Ethernet
QoS	Quality of service
RD	Receive Data
RDA	Receive Data Amplified
RFC	Request for Comments, Internet Standard published by the Internet Engineering Task Force (IETF)
R-NAT	Railway Network Address Translation
RX	Receive
SFD	Start Frame Delimiter
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
SS	Signal Status
STP	Shielded Twisted Pair cable, a cable in which each pair of two conductors are twisted together and shielded
TBN	Train Backbone Node
TCN	Train Communication Network, a set of communicating vehicle and Train Backbones
TCP	Transmission Control Protocol
TD	Transmit Data
TDA	Transmit Data Amplified
TDRD	Transmit Data and Receive Data
TFLPR	Timer for Failure of Local Port for Reception
TFTP	Trivial File Transfer Protocol
TFTPU	Timer for Failure of Trunk Port Up link
TIA	Telecommunications Industry Association
TLT	Timer for Limit Time
TNM	Train Network Management
TNMS	Timer for CNN Management Sending
TNORD	Timer for No Reception Down link
TNORU	Timer for No Reception Up link
TPCM	Trunk Port Control Machine
TPD	Trunk Port Down link
TPU	Trunk Port UP link
TPUD	Trunk Port Up link and Down link
TREQ	Timer for Transmit Request
TRLPR	Timer for Recovery of Local Port for Reception
TRTPD	Timer for Recovery of Trunk Port Down link
TRTPU	Timer for Recovery of Trunk Port Up link
TRRC	Transmission, Reception and Repeat Control
TTRT	Target Token Rotation Timer
TX	Transmit
UDP	User Datagram Protocol

UTP	Unshielded Twisted Pair cable, a cable in which each pair of two conductors are twisted together and not shielded
VLAN	Virtual LAN
VTLT	Value to Timer for Limit Time
VTREQ	Value to Timer for Transmit Request
VTTRT	Value to Target Token Rotation Timer
WTB	Wire Train Bus

3.3 Conventions

The conventions defined in IEC 61375-1 as well as the following apply.

3.3.1 Bit numbering conventions

In the representation of message formats defined in this standard the bit numbering follows the representation of power of two value in a byte or word.

3.3.2 Byte order conventions

In the representation of message formats defined in this standard encoding of integer values is big-endian if not otherwise stated.

The format of a message is specified in a graphical form followed by a table form to show the details. Octets in the format are ordered from left to right and from top to bottom when they are encoded in an Ethernet frame, if not otherwise stated.

3.3.3 Data types

3.3.3.1 General

In the representation of message formats defined in this standard data types are specified according to ASN.1. However, encoding rules of ASN.1 are not applied to ignore identifier, length, and end-of-contents octets. Data types which are added are as follows.

NOTE Most types are same as defined in IEC 61375-2-1.

3.3.3.2 Notation for the boolean type

A simple type with two distinguished values, TRUE and FALSE.

NOTE This is the same definition as IEC 61375-2-1.

Syntax is as follows.

BooleanType ::= BOOLEAN1

This shall be encoded as one bit, a value 1 for TRUE and a value 0 for FALSE.

3.3.3.3 Notation for the unsigned integer type

A simple type with two distinguished values which are positive numbers or zero. Three types are defined that have a fixed size in bits defined by the postfix #, which is 8, 16, or 32.

NOTE This is the same definition as IEC 61375-2-1, but # is limited to 8, 16, and 32.

Syntax is as follows.

UnsignedType::= UNSIGNED#, (# = {8,16,32})

Range of UNSIGNED8: 0..255

Range of UNSIGNED16: 0..65535

Range of UNSIGNED32: 0..2³²–1

They shall be encoded in a binary number consisting of 8, 16, or 32 bits.

3.3.3.4 Notation for the octetstring type

The definition of octetstring type shall conform to ASN.1.

This shall be encoded as successive octets in the order they appear in the data value.

4 Common part

4.1 General

Clause 4 defines common requirements and specifications for End Devices, Network Devices, TBNs, and whole ECNs.

4.2 Architecture

4.2.1 Network structure

The logical view of the ECN is shown in Figure 1. ECN interconnects End Devices located in one Consist. When an ECN is connected to a Train Backbone it shall be connected to the Train Backbone via one train backbone node (TBN) or one set of redundant TBNs of the Train Backbone. It is a common requirement that only one TBN can forward user data packets between the ECN and the Train Backbone. However, all the redundant TBNs could optionally forward user data packets between the ECN and the Train Backbone.

NOTE 1 In case of WTB, only one TBN is active for one ECN. In case of ETB, all the redundant TBNs are active. See IEC 61375-2-1 and 61375-2-5.

ECN shall be based on switched Ethernet. An ECN consists of Consist Switches, connectors, cables, and optionally repeaters and transmits data frames between End Devices and between End Devices and TBNs. ECN may have sub-networks inside it and routers connecting the subnetworks can be deployed.

One Consist can have one or more ECNs in it, and those ECNs may or may not interface the same Train Backbone(s). An End Device connects to one Consist Network or to one set of Consist Networks prepared for redundancy reasons. An End Device could connect to different Consist Networks via different interfaces on the device, but it is regarded that a physical End Device has multiple logical End Devices in it.

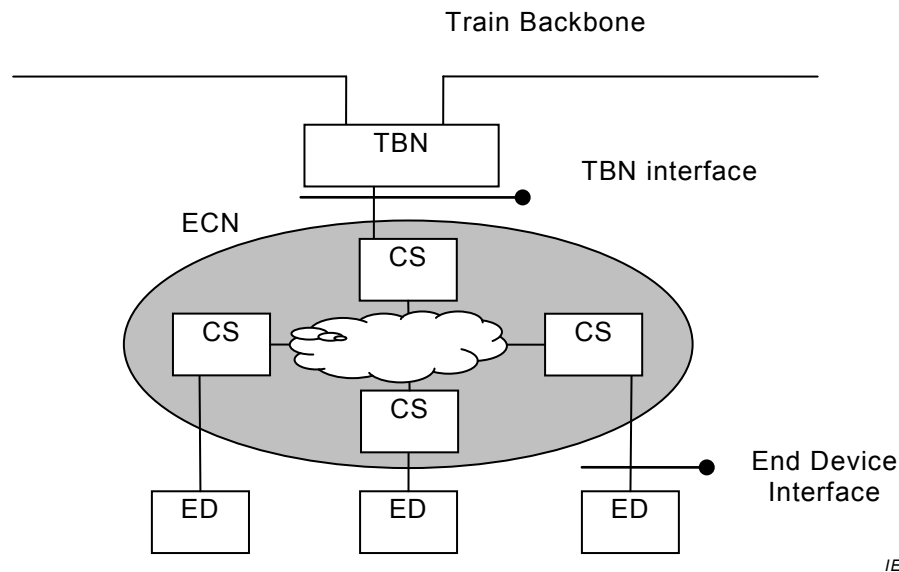
EXAMPLE An End Device can connect to a Consist Network for train monitoring services and connect to another Consist Network for multimedia services.

Ethernet ports between End Devices and Consist Switches and between TBNs and Consist Switches shall follow IEEE 802.3 standard. Ethernet ports which are used for connections between Consist Switches should conform to IEEE 802.3 standard, but they are not mandatorily required to conform to IEEE 802.3 standard for the purpose of achieving railway specific requirements.

Topology of ECN may vary with ECN implementations, but common requirements are defined in this part of the standard.

NOTE 2 This is why Consist Switches in Figure 1 are not connected directly.

The TBN to which the ECN attaches shall provide a gateway function which provides data transfer between the ECN and the Train Backbone. The Train Backbone to which an ECN attaches may be WTB or ETB. Communications between Consist Networks can be possible directly or indirectly over the Train Backbone; i.e. the gateway function may be implemented as a routing function in the network layer or as an Application Layer gateway.



IEC 0760/14

Figure 1 – Logical view of the ECN

4.2.2 Network topology

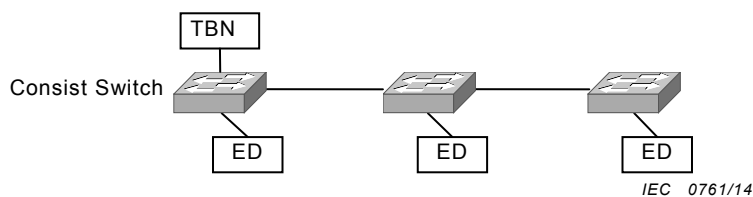
Any physical topology can be deployed according to the requirements from applications, but ECN shall not form a loop or loops in logical topology. The list below shows examples.

- The physical topology of the ECN could be linear or ring or ladder or others in order to implement different level of redundancy.
- An ECN could have one or more sub-networks.

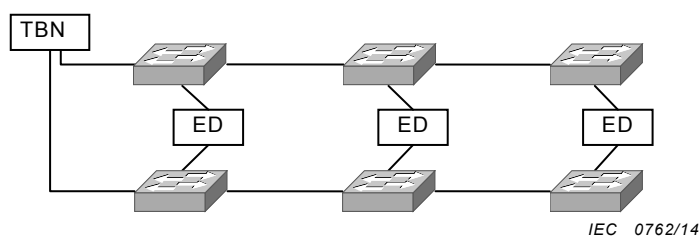
Linear, ring, and ladder topologies are typical topologies as introduced in IEC 61375-1. For End Device link redundancy, an End Device may be connected to two different Consist Switches by two independent communication links, which is introduced in IEC 61375-1 and also defined as dual homing in 4.5.4 of this standard. Figure 2 shows examples of ECNs with various physical topologies and End Device link redundancy.

NOTE See also 4.5 and Annex A with respect to topology from redundancy point of view.

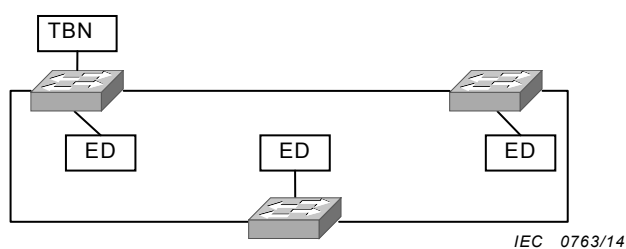
1) Linear topology



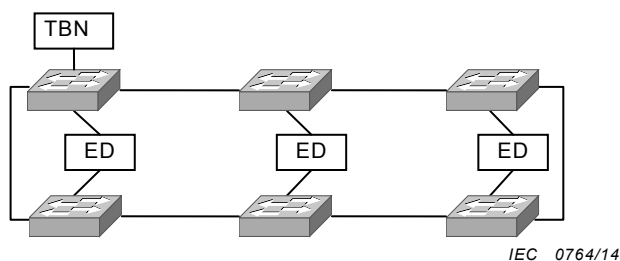
2) Linear topology (parallel network) with dual homing



3) Ring topology



4) Ring topology with dual homing



5) Ladder topology with dual homing

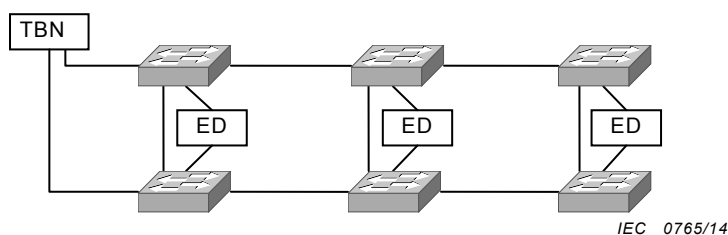


Figure 2 – Examples of ECN physical topologies

4.2.3 End Device classes

End Devices are classified from the viewpoint of installation as shown in Table 1.

Table 1 – End Device classes (1)

End Device class	Description
Temporary End Device	Temporary End Device is an End Device which is not fixedly mounted on the train, but it is connected to the ECN temporarily for the purpose of maintenance for example. A notebook PC which is used to retrieve operational status of equipments is a typical Temporary End Device.
Standard End Device	Standard End Device is an End Device which is fixedly mounted on the train. This is the main class of End Devices.

Standard End Device is furthermore classified from the viewpoint of communication requirements as shown in Table 2.

Table 2 – End Device classes (2)

End Device class	Description
Consist Local End Device	Consist Local End Device is an End Device which communicates with only devices in the same ECN. This class of End Device does not always need to know train topology.
Train Communication End Device	Train Communication End Device is an End Device which uses the Train Backbone and communicates with devices in other CNs or devices directly attached to TBNs. This class of End Device shall be able to know that train topology has been changed in order not to communicate with wrong devices after inauguration. However, it does not need to know train topology by itself; i.e. it does not initiate communications over the Train Backbone. Topography counter of the train backbone is the typical example of information of the train topology. Train Communication End Device shall meet the same requirements as Consist Local End Device.
Train Topology aware End Device	Train Topology aware End Device is an End Device which initiates communications over the Train Backbone and needs to know train topology; i.e. train network addresses on devices outside of the ECN. For example, a controller device (Train Topology aware End Device) makes connections to I/O devices (Train Communication End Devices) in remote ECN over the backbone. In this case, the controller device needs to know addresses of remote I/O devices by using the train topology database, but remote I/O devices does not always need to do so. Train Topology aware End Device shall meet the same requirements as Train Communication End Device.

NOTE Protocols delivering information regarding the train topology are specified in IEC 61375-2-3.

4.2.4 Network Device types and Consist Switch classes

Network Devices in ECN are classified from the viewpoint of functionality as shown in Table 3.

Table 3 – Network Device types

Network Device type	Description
Repeater	This type of Network Device could be used to respect Ethernet physical rules between two communication devices. The main characteristic for this Network Device is to be transparent as possible for all protocols, Link Layer and above.
Consist Switch	This type of Network Device is the main type for ECN. Consist Switch shall relay frames in Link Layer between two devices. Consist Switch is classified into managed and unmanaged Consist Switch as defined in Table 4.
Router	This is a Network Device which has at least two IP interfaces and ensures communication between multiple IP subnets in network layer. TBNs between ETB and ECN contain routers specialized for train on-board communication. TBN routers could implement some usual network applications like DHCP server, DNS server, NTP server, and so on. NOTE: TBNs between ETB and ECN could also be application gateways. DHCP, DNS, and NTP servers could also reside on other Network Devices and End Devices.

Consist Switches are classified from the viewpoint of the functions as shown in Table 4.

Table 4 – Consist Switch classes

Consist Switch class	Description
Unmanaged Consist Switch	Unmanaged Consist Switch is a Consist Switch which has only limited functions. As a minimum, this class of switch shall support IEEE 802.1D MAC bridging as defined in 4.9, but needs not support additional functions such as online management function and IP communication function.
Managed Consist Switch	Managed Consist Switch is a Consist Switch which has functions of MAC bridge, online management, IP communication and so on. Managed Consist Switch shall meet the same requirements as the Unmanaged Consist Switch.

4.3 Data class

IEC 61375-1 defines five principal data classes:

- Supervisory Data
- Process Data
- Message Data
- Stream Data
- Best Effort Data

EXAMPLE Messages exchanged between Consist Switches, for the purpose of network topology management, are typical examples of Supervisory Data used in ECN.

Table 5 shows typical service parameters for each data class and Table 6 shows typical service parameter values for each data class. However specific definition of the service parameters and values shall be determined according to the requirements from the specific applications, ECN should support these typical service parameter values for each data class.

NOTE QoS is used to realize the service parameters. See 4.6.

Table 5 – Data class service parameters

Service parameter	Description	Measuring Unit
Cycle time	Time between two successive frames which are cyclically transmitted.	Seconds
Data size	Length of data field (payload) in a frame transmitted in Link Layer.	Octets
Latency	Transmission time of a frame in Link Layer between two EDs. Transmission starting time shall not be later than the beginning to transmit data to Link Layer service in the communication protocol stack. Transmission ending time shall not be before receiving the entire data frame in Link Layer in the communication protocol stack.	Seconds
Jitter	Variance in transmission time for subsequent frame transmissions.	Seconds

Table 6 – Typical values for data class service parameters

Data class	Service Parameter	Value
Process Data	minimum cycle time	20 ms
	maximum data size	1 500 octets
	maximum latency	10 ms
	maximum jitter	10 ms
Message Data	minimum cycle time	Not applicable
	maximum data size	1 500 octets
	maximum latency	100 ms
	maximum jitter	Not applicable
Stream Data	minimum cycle time	Not applicable
	maximum data size	1 500 octets
	maximum latency	125 ms
	maximum jitter	25 ms
Best Effort Data	minimum cycle time	Not applicable
	maximum data size	1 500 octets
	maximum latency	Not applicable
	maximum jitter	Not applicable
Supervisory Data	minimum cycle time	10 ms
	maximum data size	1 500 octets
	maximum latency	10 ms
	maximum jitter	10 ms

4.4 Functions and services

ECN shall provide functions and services listed below.

- Frame relaying

ECN shall receive MAC frames defined in IEEE 802.3 from End Devices and forward the MAC frames to the designated End Devices identified by the destination address in the frame.

the MAC frames. For the purpose of implementing this function, specifications for Consist Switches are defined according to IEEE 802.1D in 4.9. Consist Switches shall be able to relay both basic (untagged) and tagged MAC frames .

- Virtual LAN

ECN shall be able to provide VLAN functions defined in IEEE 802.1Q. VLAN functions required in ECN are defined in 4.9.

NOTE 1 Careful configuration of VLAN is important, because configuration faults can easily isolate End Devices completely.

- Redundancy management

ECN shall be able to provide redundancy and redundancy management when it is necessary from application requirements. ECN redundancy is defined in 4.5.

An implementation of ECN may not provide redundancy when it is not necessary.

- Quality of service

ECN shall be able to provide QoS by prioritizing traffic when it is necessary from application requirements. Quality of service in ECN is defined in 4.6

- Gateway functions

When an ECN is attached to a Train Backbone, the TBN shall provide gateway functions for data transfer between the Train Backbone and the ECN. Gateway functions are defined in 4.11.

- Train network management

When an ECN is attached to a Train Backbone, the TBN shall provide train network management services according to that of the Train Backbone. Train network management is defined in 4.12.

ECN should provide functions and services listed below.

- Dynamic IP address assignment

ECN should provide functions for dynamic IP address assignment for devices. Devices can also use static IP address assignment. Requirements for IP address assignment and management are defined in 4.7 and 4.8.

- Name resolution

ECN should provide functions for name resolution between IP addresses and names such as hostnames and function names. Requirements for name resolution are defined in 4.7.

NOTE 2 Definition of functional addressing is out of the scope of this part of the standard.

4.5 Redundancy

4.5.1 General

This subclause describes requirements and definitions for redundancy in ECN.

Redundancy managed at network level and redundancy managed at ED level are described in this subclause. A specific implementation of ECN should select one or more redundancy method to fulfil application requirements. Supported failure cases and comparison in reliability and availability are described in Annex A to help the selection.

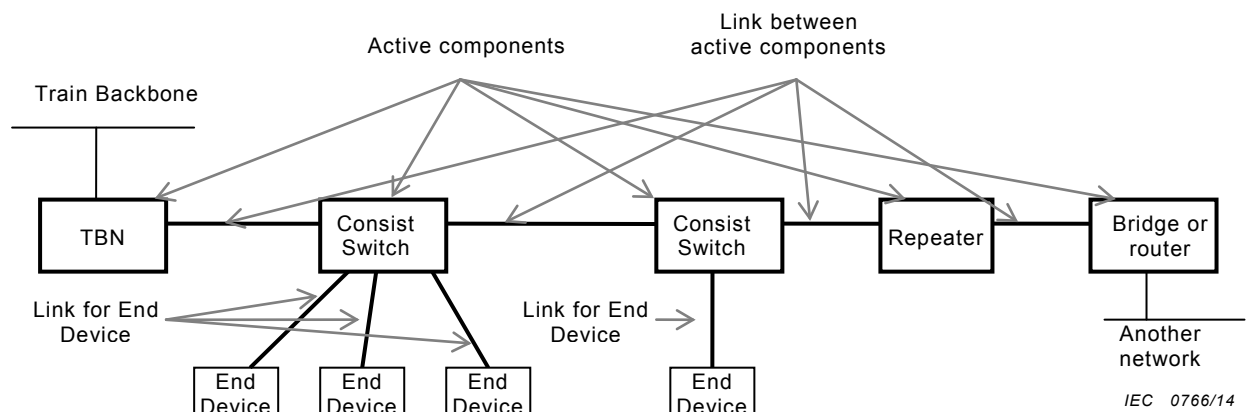
NOTE Redundancy of End Devices themselves is out of the scope of this part of the standard, but the advantage of End Device redundancy is also described in Annex A.

4.5.2 Definitions

4.5.2.1 Network component

A network component is defined as a unit affected by a component failure, which means an active component of network device, a link between the active components or a link for End Device interface in this part of the standard. An example of the network components is shown in Figure 3.

NOTE Active components of network devices are described in IEC 61375-1, 4.2.2 (Component types).



NOTE Bold boxes and bold lines indicate examples of network components.

Figure 3 – Example of network components

4.5.2.2 Recovery time

When redundancy scheme managed at network level is applied in the ECN, recovery time of network function of ECN in case of failure is expected to be shorter than the time during which operations of the Consist can be maintained without loss of train application functions.

In case of failure occurrence in an ECN, normal communication function of the ECN is interrupted and re-started after recovery time with redundancy.

Recovery time in ECN shall include

- time for detection of failure,
- redundancy switch over time (see NOTE), and
- time for re-configuration in ECN, if occurred.

NOTE Switch over time means time for switching its function from failed component to other component.

Recovery time of network shall be measured in the conformance test.

4.5.3 Redundancy managed at network level

Redundancy managed at network level, adopting network topology which has redundancy in it, is a method to recover network function in case of failure at network components. Examples of ECNs with typical network topologies are shown in 4.2.2.

Requirements for redundancy managed at network level are as follows.

- When redundancy scheme is applied in ECN, a single network component failure shall not prevent the rest of the network from working without separation of the network so that the application can maintain its function.
- When a network component comes up late or a network component comes up again (reboot), connectivity loss duration time caused by the reconfiguration of the network shall be equal to or less than the value of the recovery time requirement.
- Forwarding loop shall not be formed in any time to avoid broadcast storm for instance.

MRP defined in IEC 62439 may be used to manage ring topology. Ladder topology protocol defined in Annex D may be used to manage ladder topology.

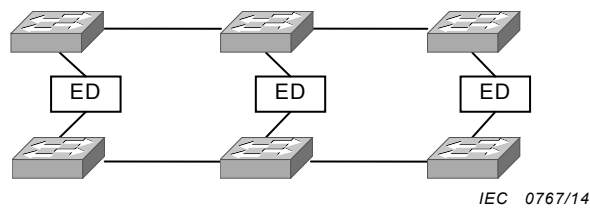
4.5.4 Redundancy managed at End Device level

Availability-critical End Devices should have redundancy managed at End Device level, having redundant links to the network. End Device can continue to communicate in case of failure on one of the redundant links. If redundant links are connected to multiple Consist Switches, the device can continue to communicate in case of a Consist Switch failure. End Device has typically two links, which is called dual homing. End Device in dual homing shall use separate physical network interfaces and shall not create loop on the ECN. Unmanaged switch shall not be used to emulate dual homing scheme. Examples with dual homing are shown in Figure 4.

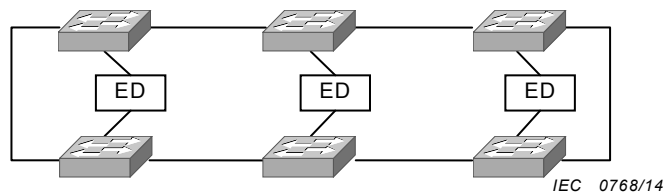
One example of using dual homing is that packets are duplicated and sent from both interfaces. On receiving the packets, the device accepts the packet that is received first and discards another one. In order to identify the duplicated packets, they may have the sequence number field in the messages. In case this method is used, disruption of communication does not happen in case of a failure.

It can be also possible that one of the redundant links of the End Device is used and the other link takes over in case of the link failure. In this case switch over between redundant links may be recognized as switch over between redundant devices from other devices. In case this method is used, disruption of communication may occur in case of a failure.

1) Dual homing in parallel networks



2) Dual homing in ring topology



3) Dual homing in ladder topology

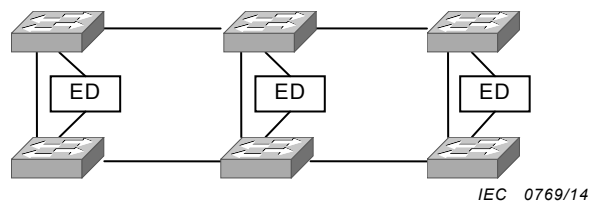


Figure 4 – Examples of dual homing

4.6 Quality of service

4.6.1 General

ECN shall be able to provide QoS by prioritizing traffic when it is necessary from application requirements.

Quality of service shall be provided by Consist Switches, and End Device can assign priorities to the packets which the End Device transmits if necessary.

NOTE Assigning priorities to the packets by Consist Switches, for example according to the ports, protocols, and addresses, is not prohibited.

4.6.2 Priority level

According to IEEE 802.1D there are 8 priority levels, the highest priority level is 7 and the lowest priority level is 0. Default priority level shall be 0.

Consist Switches shall support 2 priority queues at minimum when QoS is provided. When 2 priority queues are supported, priority levels from 0 to 3 and 4 to 7 can be grouped respectively. When 4 priority queues are supported, priority levels from 0 to 1, 2 to 3, 4 to 5, and 6 to 7 can be grouped respectively.

Mapping of priority levels to data classes shall be determined according to the requirements from applications used in the ECN since data classes to be used and their performance

parameters depend on applications. Table 7 shows a default mapping of priorities to each data class in case of four priorities.

In case of communication over ETB, priority level of a packet shall conform to IEC 61375-2-5.

Table 7 – Mapping of priorities to data classes

Priority	Priority level in binary (X: do not care)	Data class	Requirement (M: Mandatory R: Recommended)
Highest	11X	Supervisory Data	M
2nd highest	10X	Process Data	R
3rd highest	01X	Message Data and Stream Data	R
Lowest (default)	00X	Best Effort Data	M

NOTE 1 Priorities for specific Process Data, Message Data and Stream Data are defined in IEC 61375-2-3.

NOTE 2 If bandwidth of data classes with higher priorities is not limited, lower priority data can have no chance to be transmitted.

4.6.3 Assignment of priority level

When End Device assigns priorities to the sending packets, the End Device should use DSCP field in IP datagram as defined in RFC2474. End Device may use Priority Code Point field in tagged MAC frame.

The binary representation of DSCP field shall be as follows.

LLL000

where

LLL: priority level (0-7) defined in 4.6.2

4.6.4 Consist Switch behavior

When Consist Switch supports quality of service, Consist Switch shall be able to evaluate the priority level of the packet as defined 4.6.3 and queue the packet according to the priority level and number of queues it has as defined in IEEE 802.1D.

When Consist Switch supports quality of service, Consist Switch should support strict priority based switching on all of priority queues; i.e. all higher priority frames shall egress from port before the lower priority frames egress.

4.6.5 Ingress rate limiting

Ingress rate limiting is an optional feature of the Consist Switch. Consist Switch provides possibility to limit the rate of frames ingressing from End Devices or from TBNs.

If frames need to be discarded to keep the rate limit, low priority frames shall be discarded first.

NOTE Ingress rate limiting prevents the ECN from being unintentionally flooded with frames originating from one faulty ED for instance.

4.6.6 Egress rate shaping

Egress rate shaping is an optional feature of the Consist Switch. Consist Switch provides the possibility to limit the rate of frames egressing to End Devices or to TBNs.

If frames need to be discarded to keep the rate limit, low priority frames shall be discarded first.

4.7 IP address and related definitions

4.7.1 Consist Network address

Each communication device which supports IP communication and is connected to ECN shall have one or several IP address(es) as Consist Network address(es). The Consist Network address shall be unique within a Consist Network.

NOTE Communication devices connected to different Consist Networks can have identical or different Consist Network addresses.

Consist Network address shall use IPv4 private address space defined in IETF RFC1918, class A private address should be used.

When

- class A private address is used, and
- ECN is connected to ETB, and
- Consist Network address is not identical to train network address,

addresses from 10.0.0.0 to 10.127.255.255 (10.0/9) shall be used. The binary presentation shall be following.

00001010.0ddddddd.dddddddd.dddddddd / 9

Where:

Notation	Description
[d]	This field is used freely for host identification in the ECN. This field could be divided, for example; – ECN is divided into sub-networks, – uses same values of train network address in most three significant bits for identifying multiple ECNs, or – uses only lower 14 bits for ensuring NAT is possible. (R-NAT in Annex B is one example) NOTE When using R-NAT, devices have IP address rationally within only 14 bits. If within deterministic fixed EMU train, following assign method is helpful for unification without confusion. This method also contributes prefixed IP address assignment for End Devices. Lower 14 bits: r.ccccc.eeeeeeee r: Redundancy/Subnet identifier 0/1 c: Car Number 1 to 31 (sufficient number for fixed EMU) e: End Device identifier 1 to 255 (sufficient number within a car)

This subnet (10.0/9) applied in ECN is called a local ECN subnet.

4.7.2 Train Network Address

Train wide addressing of a communication device shall be possible with a train network address which is unique in the train if the ECN is connected to ETB. Train network address may change with each train inauguration. It is not mandatory for all communication devices to

be addressable train widely, for many of them local ECN address is enough. Source and destination addresses in the communication on ETB shall be train network addresses. Train network address and Consist Network address may be identical.

If train network address is not identical to Consist Network address, ECN shall support a service which maps train network addresses to Consist Network addresses. Addresses which do not conform to specifications for train network address shall not be used as source or destination addresses in ETB as defined in IEC 61375-2-5.

NOTE Network Address Translation (NAT) and Application Layer Gateway (ALG) including proxy are typical services for mapping addresses.

Train network address shall use IPv4 private address defined in IETF RFC 1918 and follow the definitions in IEC 61375-2-5. The binary presentation of train network address shall be as follows.

00001010.1bbxssss.sshhhhhh.hhhhhhhh / 18

Where:

Notation	Description
[b]	Identifier of the ETB which the ECN connects to.
[x]	Reserved. Shall be 0.
[s]	Consist Network identification assigned according to the results of inaugurations. Value 0 is reserved for ETB backbone subnet.
[h]	Unique host identification inside ECN, up to 16382 hosts by Consist. Some upper bits could be used to define internal dedicated Consist local subnets. In this case, address mask (at ECN side) should take in account this decomposition (shall be extended).

4.7.3 Group Address

Communication devices may be grouped on Consist level or train level. Communication devices may belong to several groups. On Consist level all members of the group belong to one Consist Network. Consist group addresses assigned to those groups shall be unique within the Consist Network. Memberships of Consist groups are normally static. On train level all members of the group belong to one or several Consist Networks. Train group addresses assigned to those groups shall be unique within the train. Memberships of train groups may change with each train inauguration.

Group address shall be IP multicast address defined in IETF RFC 2365.

When ECN is connected to ETB, IP multicast address at ECN level shall be 239.255.0.0/16 (local scope defined in RFC 2365).

IP multicast address at train level is 239.192.0.0/14 (organization scope defined in RFC 2365) as defined in IEC 61375-2-5.

TBN shall not forward IP multicast datagram to ETB if the destination address is an IP multicast address at ECN level.

4.7.4 Name resolution and naming definitions

4.7.4.1 Name resolution

Name resolution for Consist Network addresses and train network addresses should be implemented by local database in the communication device or by DNS.

ECN should provide DNS server function. Location of the server depends on implementation; servers could be implemented on any End Devices and Network Devices in the ECN or on TBNs which the ECN is attached to. In case that the ECN is attached to ETB, it is recommended that the server is implemented in TBN. DNS server should be redundant.

Each communication device which could be a destination device for communication over ETB shall be addressable in train wide domain name space.

NOTE Train wide domain name space is managed according to IEC 61375-2-5, "ltrain" for example.

4.7.4.2 End Device self-identification

For self-addressing End Device internal hostname shall be declared:

"localhost" 127.0.0.1

4.7.4.3 End Device local identification

By default, all hosts are declared in "lcst" domain which is local to each ECN.

EXAMPLE "mpu" or "mpu.lcst." are associated with the same local End Device "mpu" IP address.

4.8 IP address and network configuration management

4.8.1 Consist Network address management

Consist Network address in a device can be configured statically or dynamically.

When Consist Network address is configured dynamically, DHCP should be used.

When DHCP is used, ECN shall provide DHCP server function. Location of the server depends on implementation; servers could be implemented on any End Devices and Network Devices in the ECN or on TBNs which the ECN is attached to. In case that the ECN is attached to ETB, it is recommended to be implemented in TBN. DHCP server should be redundant.

4.8.2 Train network address management

When train network IP address is assigned to a device, the device may or may not configure the train network address to its Ethernet port.

TBN as a router shall support NAT to map the train network addresses to the Consist Network addresses for devices which do not configure the train network addresses at their own Ethernet interfaces. R-NAT defined in Annex B can be used to simplify the address translation algorithm at TBNs.

Since NAT may cause problems for specific protocols, e.g. necessity for replacing addresses in the payload of IP datagrams, an extended NAT dealing with the problems should be used for specific protocols. Otherwise, End Devices which are addressable by train network addresses should have IP alias function; i.e. two different IP addresses can be configured to one Ethernet interface. Local ECN addresses are used for communications local in ECN, and train network addresses are used for communications over ETB. TBN shall be able to forward IP datagram according to the destination address which is train network address.

After a new inauguration, renewal of train network address is mandatory. This is applied to train network addresses managed at each communication device and train network addresses managed in various services including routing, NAT, DHCP server, and DNS server.

In case that train network addresses are managed by End Devices with DHCP client, End Devices and DHCP servers shall support DHCP FORCERENEW message defined in IETF RFC 3203. DHCP servers shall send FORCERENEW message to DHCP clients with train

network addresses after inauguration, and DHCP clients shall renew train network addresses on receiving the FORCERENEW message.

NOTE Inauguration occurrence is limited to startup initialization, coupling and uncoupling time. Losing or finding a router at train level does not always have as consequence a new inauguration. Changing train IP address decision is always under train application responsibility acknowledgement. See IEC 61375-2-5.

4.8.3 Static network configuration parameters

Table 8 shows network configuration parameters for End Devices when static network address configuration is used.

Table 8 – End Device static network configuration parameters

(M: Mandatory, C: Conditional, O: Optional)

Parameter	Type	Description
Hostname	M	Hostname shall be unique in an ECN.
Default domain name	C	This is mandatory when DNS is used. For the definition of domain name, see 4.7.4.
IPv4 address	M	For the definition of Consist Network address, see 4.7.
IPv4 address mask	M	For the definition of Consist Network address, see 4.7.
IPv4 DNS server address	C	This is mandatory when DNS is used.
IPv4 default route	O	TBN is a typical default gateway.
IPv4 static route	O	Could be used to access specific devices and subnets.

4.8.4 DHCP configuration parameters

Table 9 shows requirements for DHCP options to be supported when DHCP is used.

Table 9 – DHCP options

(M: Mandatory, C:Conditional, O: Optional)

Option number	Requirement	Name	Description
1	M	Subnet mask	IPv4 address mask
3	M	Router option	List of IPv4 routers available on the subnet
6	C	Domain Name server option	List of DNS server addresses. This is mandatory for EDs when DNS is used.
12	O	Host Name option	Name of the DHCP client
28	O	Broadcast Address option	Broadcast address in use on the DHCP client's subnet
42	C	Network time protocol servers option	List of NTP server addresses. This is mandatory for EDs when NTP or SNTP is used.
43	O	Vendor Specific Information	This is used to exchange vendor specific information between servers and clients. This option may be supported.
51	M	IP address lease time	Allowed lease time for the assigned IP address
53	M	DHCP message type	Shall be used to identify the type of the DHCP message
54	M	Server Identifier	This option is used to identify the DHCP server address.
55	M	Parameter request list	Could be used for DHCP client to request specific configuration parameters.
56	O	Message	This option is used to send error message from the DHCP server to DHCP clients. DHCP client may use this option to indicate the reason of declining the offer.
61	O	Client-Identifier	DHCP client fills unique identifier. This option can be used to keep the same IP address for the DHCP client, see NOTE.
82	O	Relay Agent Information option	This option may be used to indicate the location of the DHCP client.
NOTE In order to keep always the same IP address from the DHCP server, depending on the location or device type of End Devices, End Device sends DHCP option 61 (client-identifier) or the Consist Switch where the End Device is connected inserts DHCP Option 82 defined in IETF RFC 3046.			

4.8.5 IP address management for TBN redundancy

To manage Train Backbone connection redundancy inside an ECN, ECN could be connected by more than one TBN to the Train Backbone.

TBN redundancy is managed conforming to WTB or ETB.

When a redundant TBN group is implemented and the TBNs are routers between ECN and Train Backbone, the redundant TBN group shall export a common Consist Network address for the routing service at ECN side. When a new TBN is elected as an active router, the TBN shall send a gratuitous ARP to the ECN in order to update ARP tables in End Devices.

4.9 Network Device interface

4.9.1 General

Subclause 4.9 defines interfaces for Network Devices; i.e. repeaters, Consist Switches, and routers. A Consist Switch and a router could act as an End Device; in that case they also shall conform to End Device interfaces in network layer and other upper layers defined in 4.10.

There are two classes of Consist Switches as defined in 4.2.4; Unmanaged Consist Switches and Managed Consist Switches. Managed Consist Switch shall support all the requirements for the Unmanaged Consist Switch.

4.9.2 Function requirements

Table 10 shows the summary of Consist Switch interfaces; details are described in the following subclauses.

Table 10 – Summary of Network Device interfaces

Status in (M: Mandatory, O: Optional, C: Conditional, -: Not available or not required)

Layer	Requirements	Status				References and notes
		Repeater	Unmanaged CS	Managed CS	Router	
Physical Layer for ED connection	100BASE-TX	-	M	M	-	IEEE 802.3
	10BASE-T	-	O	O	-	IEEE 802.3
	Full Duplex Mode	-	M	M	-	IEEE 802.3
	Auto Negotiation	-	C	C	-	IEEE 802.3 For Temporary ED only
	MDI/MDI-X auto crossover	-	O	O	-	
	Power over Ethernet (PoE)	-	O	O	-	IEEE 802.3
	Class D (Category 5e), STP cable with 2 twisted pairs	-	O	O	-	ISO/IEC 11801 IEC 61156-6
	Class D (Category 5e), UTP cable with 2 twisted pairs	-	O	O	-	ISO/IEC 11801 IEC 61156-6
	M12 D-coded connector (socket)	-	O	O	-	IEC 61076-2-101
	IEC 61076-3-104 socket (outlet)	-	O	O	-	IEC 61076-3-104
Physical Layer for ND connection	IEEE 802.3 physical layer	C	C	C	C	IEEE 802.3 Mandatory if transceiver with amplified signals is not used 100BASE-TX is recommended
	Transceiver with amplified signals	O	O	O	O	Annex B See NOTE 1
	Full Duplex Mode	-	M	M	M	IEEE 802.3

Layer	Requirements	Status				References and notes
		Repeater	Unmanaged CS	Managed CS	Router	
	Auto Negotiation	-	O	O	O	IEEE 802.3
	MDI/MDI-X auto crossover	O	O	O	O	
	Class D (Category 5e), STP cable with 2 twisted pairs	O	O	O	O	ISO/IEC 11801 IEC 61156-6 For 100BASE-TX and 10BASE-T
	Class D (Category 5e), UTP cable with 2 twisted pairs	O	O	O	O	ISO/IEC 11801 IEC 61156-6 For 100BASE-TX and 10BASE-T
	M12 D-coded connector (socket)	C	C	C	C	IEC 61076-2-101 For 100BASE-TX and 10BASE-T
Link Layer	MAC services with basic/tagged MAC frame	-	M	M	M	IEEE 802.3
	Flow control	-	O	O	-	IEEE 802.3
	Frame relaying	-	M	M	-	IEEE 802.1D
	Frame filtering	-	M	M	-	IEEE 802.1D
	VLAN services	-	M	M	-	IEEE 802.1Q
	Frame queueing	-	M	M	-	IEEE 802.1D
	Frame tagging/untagging	-	M	M	-	IEEE 802.1D
	Management and remote management	-	-	M	-	IEEE 802.1D
	Ingress rate limiting	-	O	O	-	
	Egress rate shaping	-	O	O	-	
	Port mirroring	-	O	O	-	
Network Layer	IP version 4	-	-	M	M	IETF RFC 791
	IPv4 forwarding	-	-	-	M	
	ICMP	-	-	M	M	IETF RFC 792
	ARP	-	-	M	M	IETF RFC 826
Transport Layer	UDP	-	-	M	M	IETF RFC 768
	TCP	-	-	M	M	IETF RFC 793
	IGMP version 2/3 (router)	-	-	-	O	IETF RFC 2236,3376
	IGMP version 2 (host)	-	-	M	O	IETF RFC 2236
	IGMP version 3 (host)	-	-	O	O	IETF RFC 3376
	IGMP snooping	-	-	M	-	IETF RFC 4541
Application Layer	DHCP (client)	-	-	C	C	IETF RFC 2131
	DHCP Relay Agent Information option	-	-	O	-	IETF RFC 3046
	DHCP (server)	-	-	O	O	IETF RFC 2131
	DNS (client)	-	-	C	C	IETF RFC 1034,1035
	DNS (server)	-	-	O	O	IETF RFC 1034,1035
	SNTP (client)	-	-	O	O	IETF RFC 1361
	NTP version 3 (client)	-	-	O	O	IETF RFC 1305