

INTERNATIONAL STANDARD

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**Electronic railway equipment – Train communication network (TCN) –
Part 2-5: Ethernet train backbone**

**Matériel électronique ferroviaire – Réseau embarqué de train (TCN) –
Partie 2-5: Réseau central de train Ethernet**



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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Electronic railway equipment – Train communication network (TCN) –
Part 2-5: Ethernet train backbone**

**Matériel électronique ferroviaire – Réseau embarqué de train (TCN) –
Partie 2-5: Réseau central de train Ethernet**

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TRAIN COMMUNICATION NETWORK (TCN) –****Part 2-5: Ethernet train backbone****FOREWORD**

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

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INTRODUCTION

IEC 61375-2-5 defines the Ethernet Train Backbone so as to achieve interoperability between Consists of different types when coupled in the same train composition.

The standard follows the ISO-OSI model and specifies the whole protocols stack from the physical layer up to the application layer.

A Protocol Implementation Conformance Statement (PICS) pro-forma allows suppliers to state their conformity to this standard. The PICS pro-forma specification and the related conformity test are not in the scope of this standard.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

Part 2-5: Ethernet train backbone

1 Scope

This part of IEC 61375 defines Ethernet Train Backbone (ETB) requirements to fulfil open train data communication system based on Ethernet technology.

Respect of this standard ensures interoperability between local Consist subnets whatever Consist network technology (see IEC 61375-1 for more details).

All Consist network definitions should take into account this standard to preserve interoperability.

This standard 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 61076-2-101:2012, *Connectors for electronic equipment – Product requirements – Part 2-101: Circular connectors – Detail specification for M12 connectors with screw-locking*

IEC 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 61156-1:2007, *Multicore and symmetrical pair/quad cables for digital communications – Part 1: Generic specification*

IEC 61156-5, *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring – Sectional specification*

IEC 61375-1:2012, *Electronic railway equipment – Train communication network (TCN) – Part 1: General architecture*

IEC 61375-2-3, *Electronic railway equipment – Train communication network (TCN) – Part 2-3: TCN communication profile (to be published)*

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

IEC 62236-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

ISO/IEC 7498 (all parts), *Information technology – Open System Interconnection – Basic Reference Model*

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

ISO/IEC 9646 (all parts), *Information technology – Open Systems Interconnection – Conformance testing methodology and framework*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*

IEEE 802.1AB, *IEEE Standard for Local and metropolitan area networks – Station and Media Access Control Connectivity Discovery*

IEEE 802.1AX:2008, *IEEE Standard for Local and metropolitan area networks – Link Aggregation*

IEEE 802.1D:2012, *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 802.2, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control*

IEEE 802.3:2012, *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 following terms and definitions apply.

3.1.1

application layer

upper layer in the OSI model, interfacing directly to the Application

3.1.2

application process

element within a real open system which performs the information processing for a particular application

3.1.3

bridge

device which stores and forwards frames from one bus to another on the base of their Link Layer addresses

3.1.4

broadcast

nearly simultaneous transmission of the same information to several destinations

Note 1 to entry: Broadcast in the TCN is not considered reliable, i.e. some destinations may receive the information and others not.

3.1.5

bus

communication medium which broadcasts the same information to all attached participants at nearly the same time, allowing all devices to obtain the same sight of its state, at least for the purpose of arbitration

3.1.6

closed train

train composed of one or a set of Consists, where the configuration does not change during normal operation, for instance metro, sub-urban train, or high speed train units

3.1.7

communication devices

devices connected to Consist Network or Train Backbone with the ability to source and sink data

3.1.8

composition

number and characteristics of the vehicles forming a train

3.1.9

configuration

definition of the topology of a network, the devices connected to it, their capabilities and the traffic they produce; by extension, the operation of loading the devices with the configuration information before going to regular operation

3.1.10

consist

train set

rake of coaches

single vehicle or a group of vehicles which are not separated during normal operation. A Consist contains no, one or several Consist networks.

3.1.11

Consist Network

CN

communication network interconnecting communication devices in one Consist

3.1.12

End Device

ED

unit connected to one Consist Network or to one set of Consist Networks prepared for redundancy reasons

3.1.13

end node

node which terminates the Train Backbone

3.1.14

function

Application Process which exchanges messages with another Application Process

3.1.15

gateway

connection between different communication technologies

3.1.16**group address**

address of a multicast group to which a device belongs

3.1.17**host**

any addressable unit connected to the network: End Devices, Network Devices, etc.

3.1.18**inauguration**

operation executed in case of composition change, which gives all Nodes of the Train Backbone their Train Backbone address, their orientation and information about all named Nodes on the same backbone

3.1.19**integrity**

property of a system to recognize and to reject wrong data in case of malfunction of its parts

3.1.20**intermediate node**

node which establishes continuity between two bus sections connected to it, but does not terminate them

3.1.21**linear topology**

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

3.1.22**Local Area Network**

part of a network characterized by a common medium access and address space

3.1.23**Medium Access Control**

sublayer of the Link Layer, which controls the access to the medium (arbitration, mastership transfer, polling)

3.1.24**medium**

physical carrier of the signal: electrical wires, optical fibers, etc.

3.1.25**message**

data item transmitted in one or several packets

3.1.26**Mobile Train Unit**

part of a train which shall be uniquely addressable from ground. A mobile train unit provides one active mobile communication gateway for train to ground communication.

3.1.27**multicast**

transmission of the same message to a group of receivers, identified by their Group Address

Note 1 to entry: The word "multicast" is used even if the group includes all receivers.

3.1.28

network

set of possibly different communication systems which interchange information in a commonly agreed way

3.1.29

network address

address which identifies a communication device on network layer

3.1.30

network device

ND

components used to set up Consist Networks and Train Networks

Note 1 to entry: These may be passive components such as cables or connectors, active unmanaged components such as repeaters, media converters or (unmanaged) switches, or active managed components such as gateways, routers and (managed) switches.

3.1.31

network layer

layer in the OSI model responsible for routing between different busses

3.1.32

network management

operations necessary to remotely configure, monitor, diagnose and maintain the network

3.1.33

node

device on the Train Backbone, which may act as a gateway between Train Backbone and Consist Network

3.1.34

open train

train composed of a set of Consists, where the configuration may change during operation, for instance international trains

3.1.35

operator

enterprise or organization which operates trains

3.1.36

packet

unit of a message (information, acknowledgement or control) transmitted by protocols on network or transport layer

3.1.37

receiver

electronic device which may receive signals from the physical medium

3.1.38

repeater

connection at the Physical Layer between bus segments, providing an extension of the bus beyond the limits permitted by passive means

Note 1 to entry: The connected segments operate at the same speed and with the same protocol. The delay introduced by a repeater is in the order of one bit duration.

3.1.39**router**

connection between two busses at the Network Layer, which forwards datagrams from one bus to another on the base of their Network Address

3.1.40**service**

capabilities and features of a sub-system (e.g. a communication layer) provided to a user

3.1.41**switch**

MAC bridge as defined in IEEE 802.1D

3.1.42**topology**

possible cable interconnection and number of devices a given network supports

3.1.43**topology counter**

counter in a node which at each Inauguration memorises CRC of Train Network Directory

3.1.44**train communication network**

data communication network for connecting programmable electronic equipment on-board rail vehicles

3.1.45**train backbone**

bus connecting the vehicles of a train and which conforms to the TCN protocols

3.1.46**train backbone node**

node device on the Train Backbone which receives a train backbone node number during Inauguration. A train backbone node can be used to connect an End Device or a Consist Network to the Train Backbone.

3.1.47**train backbone node number****node address****node number**

each active train backbone node is assigned a number during Inauguration, which indicates the position of the train backbone node on the Train Backbone

3.1.48**transport layer**

layer of the OSI model responsible for end-to-end flow control and error recovery

3.2 Symbols and abbreviations

CAN	Controller Area Network
CCTV	Closed Circuit Television
CIDR	Classless Inter Domain Routing
CN	Consist Network
CRC	Cyclic Redundancy Check
CSTINFO	ConSisT INformation
CstUUID	Consist Universally Unique Identifier

DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
ECN	Ethernet Consist Network
ED	End Device
EMC	Electro Magnetic Compatibility
ETB	Ethernet Train Backbone
ETBN	Ethernet Train Backbone Node
FLR	Frame Loss Rate
FQDN	Fully Qualified Domain Name
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation Group
LLDP	Link Layer Discovery Protocol
LLDPDU	LLDP Data Unit
MAC	Medium Access Control
MCG	Mobile Communication Gateway
MDI	Media Dependent Interface
MTU	Maximum Transmission Unit
MVB	Multifunction Vehicle Bus
NAT	Network Address Translation
ND	Network Device
NTP	Network Time Protocol
OSI	Open System Interconnection
PCS	Physical Coding Sublayer
PD	Powered Device (about PoE)
PD/MD	Process Data/Message Data
PICS	Protocol Implementation Conformance Statement
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent
PoE	Power Over Ethernet
PSE	Power Source Equipment (about PoE)
RFC	Request For Comments
TBN	Train Backbone Node
TCMS	Train Control and Monitoring System
TCN	Train Communication Network
TCP	Transport Control Protocol
TLV	Type/Length/Value
TNDir	Train Network Directory
TTDP	Train Topology Discovery Protocol
UDP	User Data protocol
UML	Unified Modeling Language

VLAN	Virtual Local Area Network
WTB	Wire Train Bus
XML	eXtensible Markup Language

3.3 Conventions

3.3.1 Base of numeric values

This standard uses a decimal representation for all numeric values unless otherwise noted.

Analog and fractional values include a comma.

EXAMPLE The voltage is 20,0 V.

Binary and hexadecimal values are represented using the ASN.1 (ISO/IEC 8824) convention.

EXAMPLE Decimal 20 coded on 8 bits = '0001 0100'B = '14'H.

3.3.2 Naming conventions

Keywords are written with a capital letter at the beginning.

If the keyword name is composed, the different parts of the name are united with a space, and all parts begin with a capital letter.

EXAMPLES "Train Backbone", "Consist", "Consist Network".

Parameters are written with a capital letter at the beginning.

If the parameter name is composed, the different parts of the name are united without a space, and all parts begin with a capital letter.

EXAMPLE "NumberOfConsists".

3.3.3 State diagram conventions

State diagrams are defined following the notation of UML state machines.

3.3.4 Annotation of data structures

Data structures are defined following ISO ASN.1 syntax. A superset of ASN.1 defined in IEC 61375-2-1:2012, 6.4 "Presentation and encoding of transmitted and stored data" is also used.

All data within a data structure are organized in big-endian format (most significant octet of a data item first).

4 ETB physical layer

4.1 Train regions

ETB use physical lines along the train to connect the active network devices together (ETBN, Repeater, etc.). These lines are also called physical segments, and shall use passive components such as cables and connectors, dedicated to Ethernet.

Along the train, three regions shall be distinguished for the ETB network (see Figure 1 below):

- **Intra Car:** Passive components (cabling) and active network devices inside a car (or locomotive, etc.).

- **Inter Car:** Passive components (cabling) at the interface between 2 cars. This category refers also to optional active network devices outside the car (such as under body, etc.).
- **Inter Consist:** Passive components (cabling) at the interface between 2 Consists using a manual coupler, or auto coupler. This category refers also to optional active network devices outside the car.

These regions are characterized by different train contexts and environments (mechanical, thermal, EMC, etc.). As a consequence, cabling (cables and connectors) are different on these 3 regions.

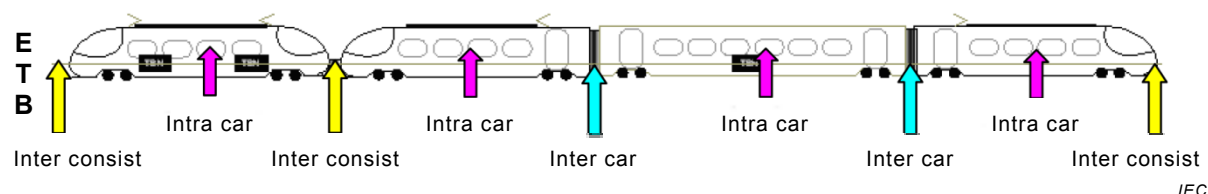


Figure 1 – ETB train regions

4.2 Physical characteristics

4.2.1 General

The following tables summarize network physical layer requirements for passive components (cables and connectors) and active network devices (ETBN, Repeater, etc.) depending on the 3 regions defined.

4.2.2 Intra car physical layer

Table 1 below defines the physical layer requirements.

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

Table 1 – ETB Intra car physical layer interface (1 of 2)

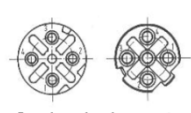
ETB Intra car physical layer interface																							
OSI Layers	Requirements	Type	Description																				
Application	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 24 and 25																				
Presentation																							
Session																							
Transport																							
Network																							
Data																							
Physical																							
	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet																				
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28 Prohibited on the ETB backbone.																				
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.)																				
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution																				
	By-pass relay on ETBN ports	M	If ETB switch is out of order (e.g. powerless) train backbone ports are bypassed																				
	Power over Ethernet (PoE)	O	Conformance to IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported See 4.3 for more details																				
	Connector for active Network Devices M12 D coded	M	Crimped contacts recommended Female connector on active network device, male connector on train cable Conformance to IEC 61076-2-101, which defines the pin out: <table border="1"> <thead> <tr> <th>Signal</th><th>Function</th><th>Cable wire colour</th><th>M12 D-coding contact number</th></tr> </thead> <tbody> <tr> <td>TD+</td><td>Transmission Data +</td><td>Yellow</td><td>1</td></tr> <tr> <td>TD-</td><td>Transmission Data -</td><td>Orange</td><td>3</td></tr> <tr> <td>RD+</td><td>Receiver Data +</td><td>White</td><td>2</td></tr> <tr> <td>RD-</td><td>Receiver Data -</td><td>Blue</td><td>4</td></tr> </tbody> </table>  Female and male connector	Signal	Function	Cable wire colour	M12 D-coding contact number	TD+	Transmission Data +	Yellow	1	TD-	Transmission Data -	Orange	3	RD+	Receiver Data +	White	2	RD-	Receiver Data -	Blue	4
Signal	Function	Cable wire colour	M12 D-coding contact number																				
TD+	Transmission Data +	Yellow	1																				
TD-	Transmission Data -	Orange	3																				
RD+	Receiver Data +	White	2																				
RD-	Receiver Data -	Blue	4																				
	Connector for interior cabling (between walls, cabinets, container, etc.)	O	Ethernet circular cell arranged in a quartet distribution. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4																				
	Cables CAT5e	M	Conformance to ISO/IEC 11801 and IEC 61156-5 Two pairs shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible to connecting hardware																				

Table 1 (2 of 2)

ETB Intra car physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) include cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002 • ;The Telecommunication outlet (TO) is the M12 instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002. Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

It has to be noted that the number of connectors on an Ethernet physical segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

Inside a car, all shields of cables and connectors shall be connected to the mechanical earth of the car. To prevent EMC influences, a cable shield shall be connected on a 360° circular basis in the connector.

4.2.3 Inter car physical layer

4.2.3.1 General

Table 2 below defines the physical layer requirements.

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

Table 2 – ETB Inter car physical layer interface (1 of 2)

ETB Inter car physical layer interface			
OSI Layers	Requirements	Type	Description
Application	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3:2012, Clauses 24 and 25
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3:2012, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3:2012, Clause 28. Prohibited on the ETB backbone
	Physical Layer crossover	M	Conformance to IEEE 802.3:2012, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN,etc.)
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Ethernet (PoE)	O	IEEE 802.3:2012, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported. See 4.3 for more details.
	Connector for inter car	O	Specific connector different from M12 connector. Ethernet circular cell arranged in a quartet. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4
	Cables CAT5e	M	ISO/IEC 11801, IEC 61156 Shielded or unshielded: See screening practices ISO/IEC 11801:2002, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1:2007 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible to connecting hardware.

Table 2 (2 of 2)

ETB Inter car physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) includes cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 of ISO/IEC 11801:2002 • Connectors shall be compliant with Clause 10 of ISO/IEC 11801:2002; The Telecommunication outlet (TO) is the inter-car connector instead of the RJ45 • Channel shall be compliant with Clause 6 of ISO/IEC 11801:2002 Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.

It has to be noted that the number of connectors on an Ethernet physical segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

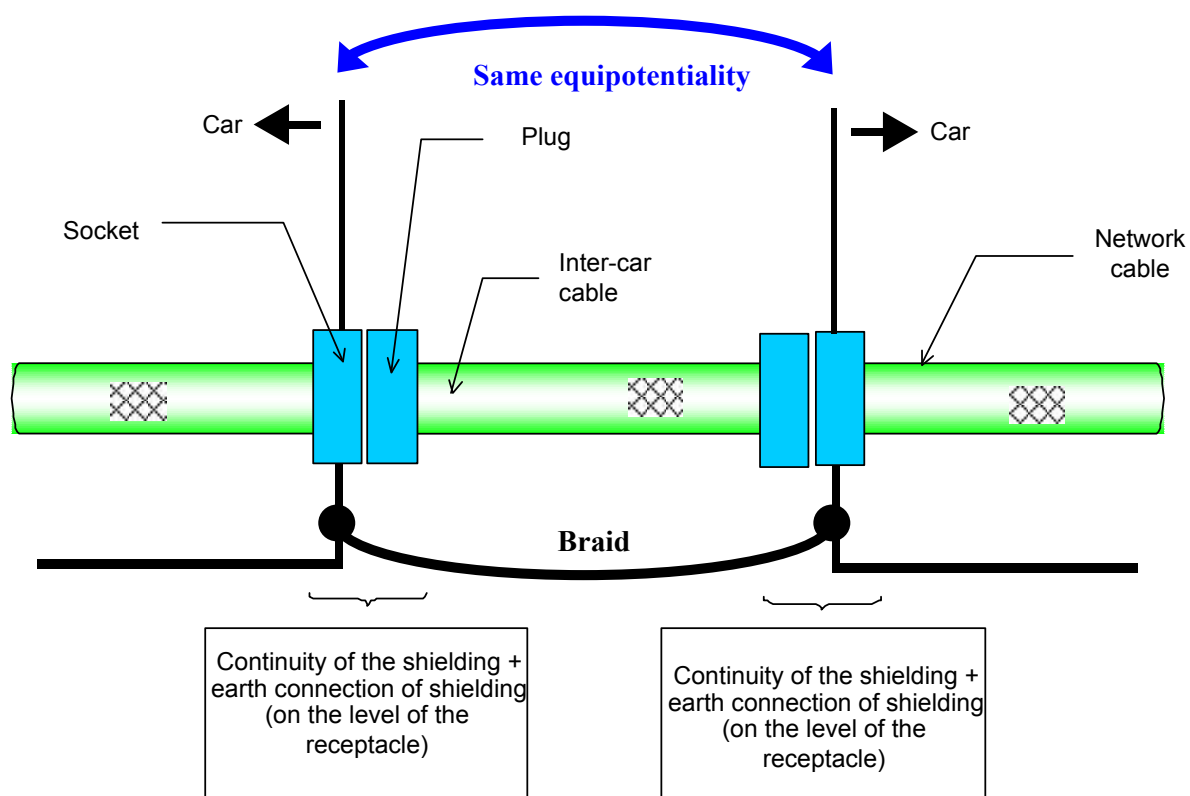
Two use cases have to be considered:

- The two adjacent cars are at the same potential.
- The two adjacent cars are at a different potential.

4.2.3.2 Inter Car at same potential

For information only:

A braid connects two adjacent cars which therefore are at the same potential. The Ethernet shield could have the continuity from car N to car N+1; in this case, no interruption of shielding is necessary (see Figure 2).



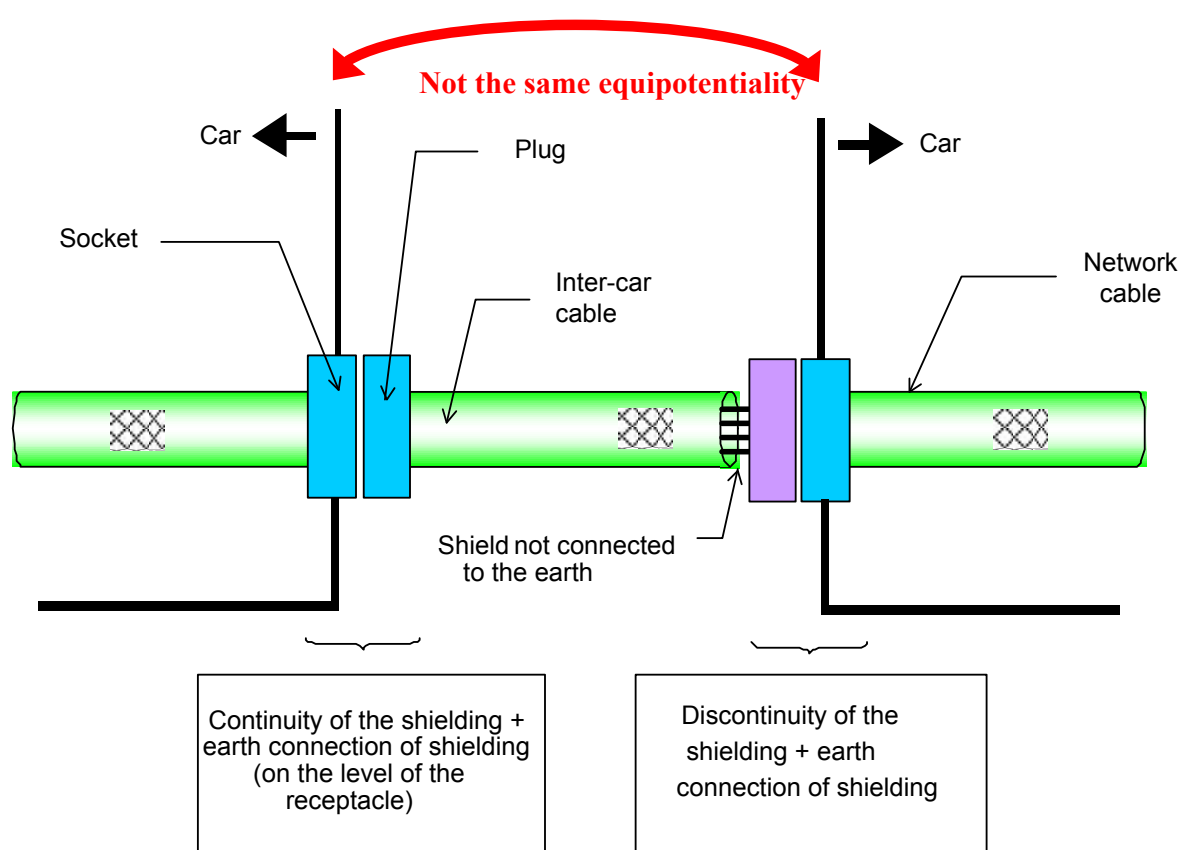
IEC

Figure 2 – ETB Inter car at same potential

4.2.3.3 Inter Car not at the same potential

For information only:

In some cases, the inter car cannot be at the same potential: Refurbishment, etc. Therefore, the Ethernet cable shield could be interrupted to avoid ground current flowing between cars (see Figure 3).



IEC

Figure 3 – ETB Inter car not at the same potential

NOTE The implementation of the shielding solution is not in the scope of this standard.

4.2.4 Inter Consist physical layer

Table 3 below defines the physical layer requirements.

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

Table 3 – ETB Inter consist physical layer interface (1 of 2)

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
Application	100 BASE TX Physical Layer Coding, Medium attachment and Medium Dependent Access (PCS, PMA, PMD) for Copper cables	M	Conformance to IEEE 802.3, Clauses 24 and 25
Presentation			
Session			
Transport			
Network			
Data			
Physical	Full Duplex Mode	M	Conformance to IEEE 802.3, Clause 25 Bidirectional data flow at the same time on TX and RX double pair Ethernet
	Physical Layer auto-Negotiation	X	Conformance to IEEE 802.3, Clause 28. Prohibited on the ETB backbone
	Physical Layer crossover	M	Conformance to IEEE 802.3, 25.4.8 Just one crossover shall be made on a line between 2 ports (ETBN, etc.) Straight (MDI) on the male connector auto coupler side, crossover (MDI-X) on the female connector auto coupler side
	Physical layer auto-polarity/auto-sensing	X	Prohibited due to fixed cabling, and non-normalized solution
	Power over Ethernet (PoE)	O	IEEE 802.3, Clause 33 Called also: Data terminal equipment (DTE) Power via Medium Dependent Interface (MDI) PSE or PD mode supported. See 4.3 for more details.
	Connector for inter Consist	O	Specific connector different from M12 connector. Ethernet circular cell arranged in a quartet. Pin out distribution identical to M12: TD+: Contact 1, TD-: Contact 3 RD+: Contact 2, RD-: Contact 4
	Cables CAT5e	M	ISO/IEC 11801, IEC 61156 Shielded or unshielded: See screening practices ISO/IEC 11801, Clause 11. The conductor shall be an annealed copper stranded conductor, in accordance with 5.2.1 of IEC 61156-1 and should have a nominal diameter between 0,5 mm and 0,65 mm. A conductor diameter of up to 0,8 mm may be used if compatible with connecting hardware

Table 3 (2 of 2)

ETB Inter consist physical layer interface			
OSI Layers	Requirements	Type	Description
	Segment performance	M	Segment (D-class) includes cables, connectors, and port devices – EMC IEC 62236-3-2 for immunity and emission referred to rolling stock apparatus; Criteria acceptance type A: During test, Frame Loss Rate (FLR) shall be below a trigger value. To be defined depending on application. – Ethernet Certification compliant to ISO/IEC 11801 (conformance test category) • Cables shall be compliant with Clause 9 • Connectors shall be compliant with Clause 10; The Telecommunication outlet (TO) is the inter-Consist connector instead of the RJ45 • Channel shall be compliant with Clause 6 Channel comprises sections of cable, connecting hardware, work area cords, equipment cords and patch cords.
	Consist orientation Reversing	C	Refers to the change of orientation of a Consist In order to provide Consists reversing capability, physical connection between two Consists requires two lines (see Figure 4 below).

It has to be noted that the number of connectors on a physical Ethernet segment and the length of the cable are not indicated in the table. Instead, a minimum requirement of electric performance and compliance to ISO/IEC 11801 is defined. It means that the electric parameters of a cabling depend not only on the number of connectors and the cable length, but also on some more complex parameters like shield, type of connectors, quality of cabling, installation, etc. As a consequence, it is proposed a global concept of verification in being compliant to the electric Ethernet parameters ISO/IEC 11801.

Figure 4 below illustrates the Consist reversing connection constraint: connectors shall be placed on Consist extremities with a central symmetry. When using male/female connectors, they shall be placed in an alternate / inversed way and be an even number.

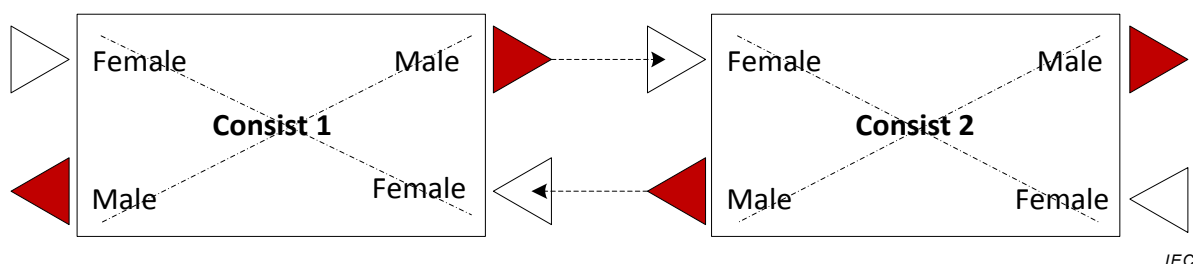
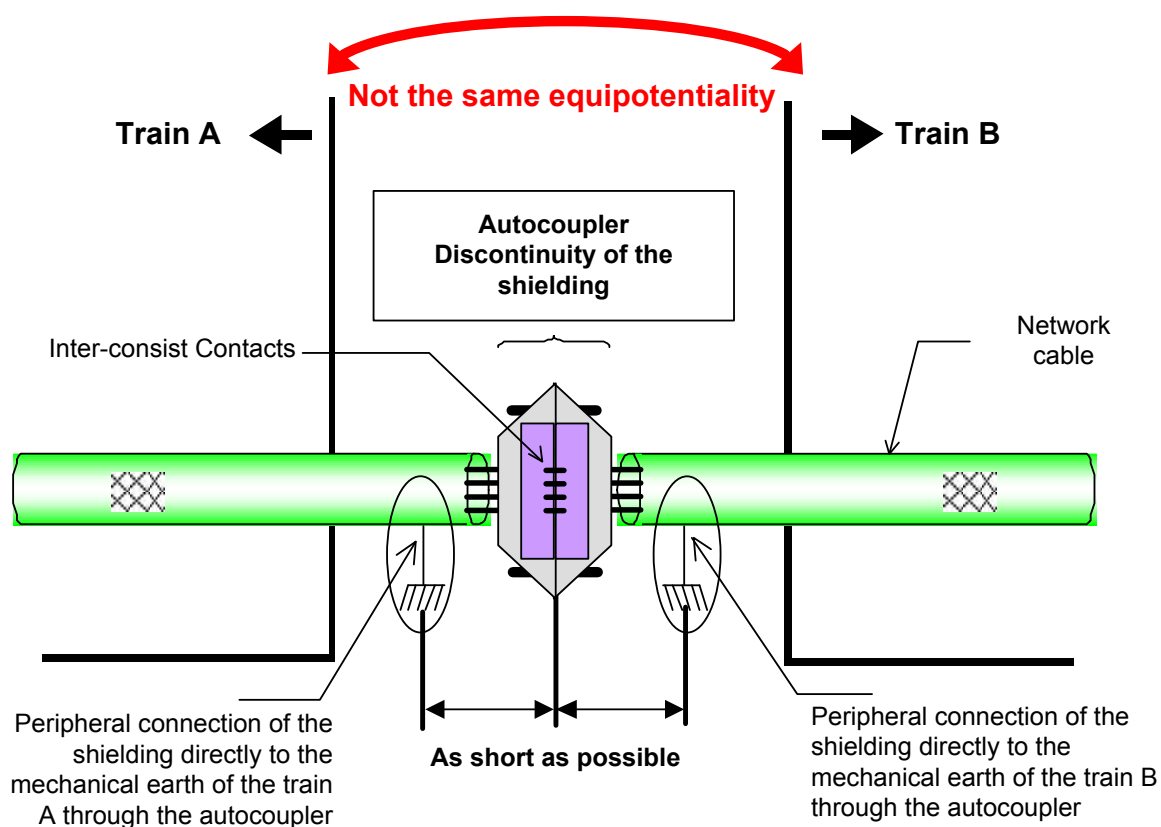


Figure 4 – ETB Consist reversing

For information only:

Typically, the same potential between 2 Consists cannot be ensured. In this case, the interruption of the Ethernet cable shield could be required (see Figure 5).



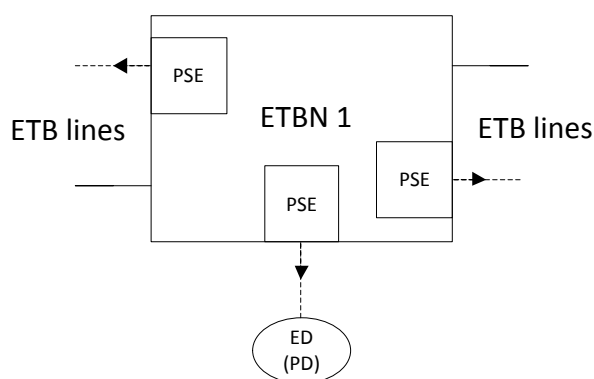
IEC

Figure 5 – ETB Inter Consist segment

NOTE The implementation of the shielding solution is not in the scope of this standard.

4.3 Power over Ethernet (PoE)

Figure 6 and Figure 7 give some use cases of PoE usage in ETBN:



IEC

Figure 6 – ETBN PSE PoE use case

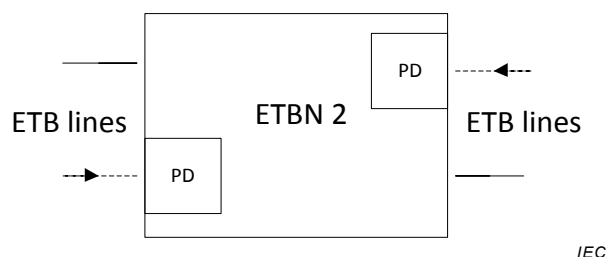


Figure 7 – ETBN PD PoE use case

In intra-car PoE could be used to power an ED (CCTV, etc.). The ND Ethernet port acts as a PSE (Power Source Equipment).

In inter-car and inter-Consist, PoE could be used to power a ND. A PSE interface shall be connected to a PD interface. In case of ETB link redundancy, PSE and PD interfaces shall be alternated in order to keep a symmetrical rotation of car (see Figure 8 below). PSE interfaces shall be associated with female connectors and PD interfaces shall be associated with male connectors if male/female connectors are used for inter-Consist interface (see Figure 4).

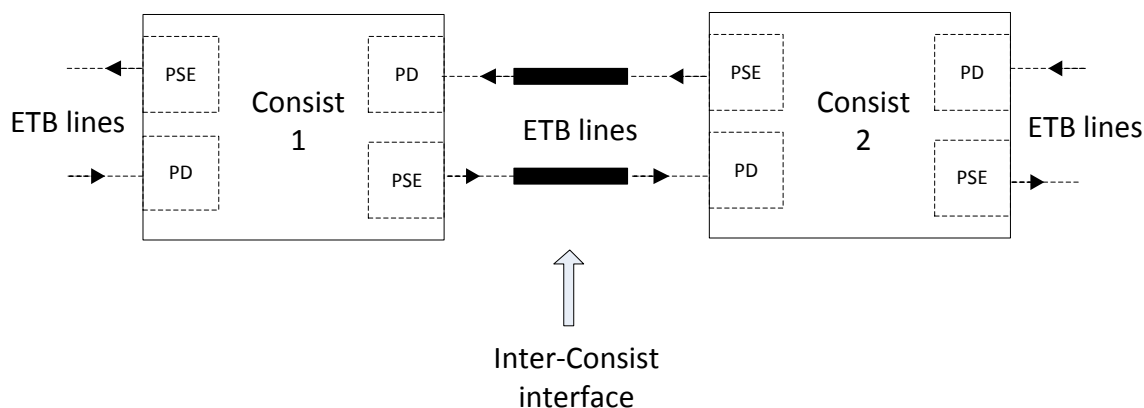


Figure 8 – PoE in inter-Consist

Figure 9 shows the connection between PSE and PD. The alternative A of PoE IEEE 802.3 Clause 33 shall be used because only two pairs are used (Tx/Rx).

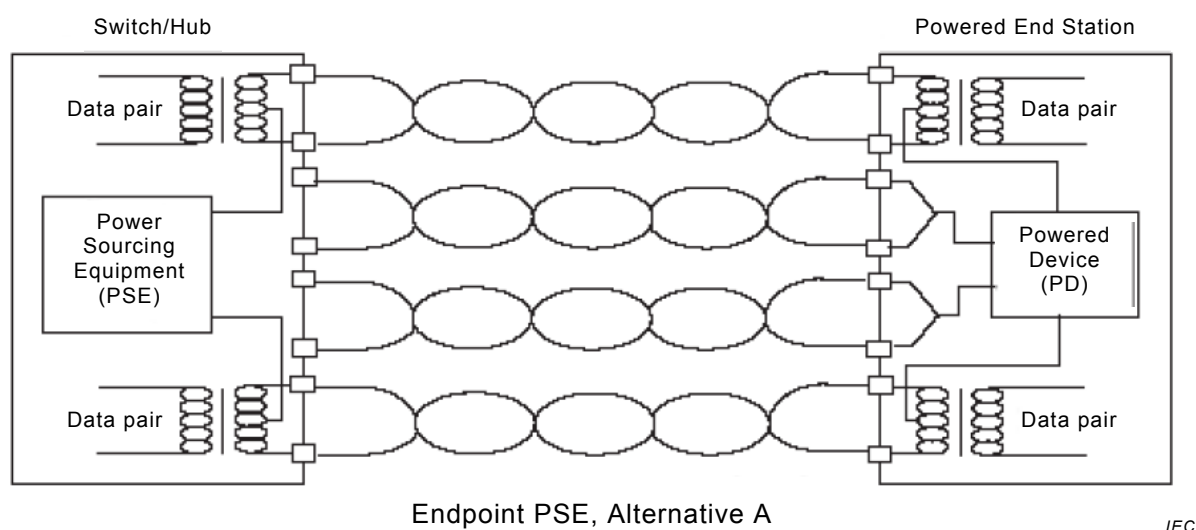


Figure 9 – PoE PSE alternative A

4.4 ETB physical architecture and redundancy

4.4.1 General

IEC 61375-1 describes the general architecture applicable to ETB, with an optional requirement of redundancy (see 5.2.3 “Train Backbone based on switched technology”). An illustration is shown on Figure 10 below:

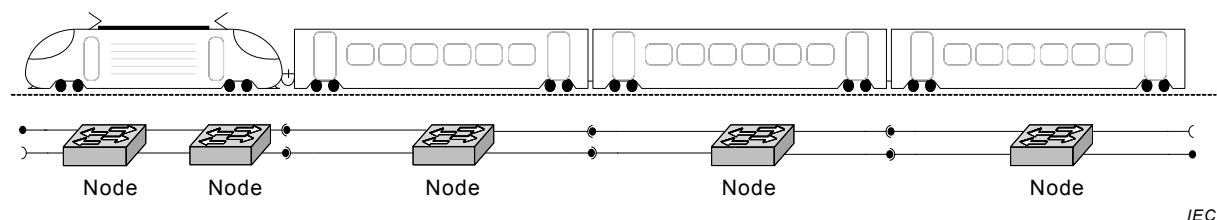


Figure 10 – Redundant train backbone architecture

The general requirements for the ETB physical layer architecture are the following:

- As a switched technology is used, nodes shall provide a data transmission medium to each of their direct neighbour nodes, if present. Each ETBN has at least one ETB forward port and one ETB backward port statically defined.
- When optional redundancy is required, data transmission medium shall be at least doubled.
- Even without redundancy requirement, the link between 2 ETBNs shall be doubled using normal switch ports when Consist reversing capability is required. Physical connection between two Consists needs two cables in this case (see 4.2.4).
- A bypass relay function shall bridge a node if the node is powerless or not operating.

4.4.2 Link aggregation architecture

When there are multiple lines between 2 ETBNs (e.g. when redundancy or Consist reversing is required), link aggregation layer from IEEE 802.1AX shall be used.

As having a single, non-redundant line for ETB communications can be considered as a degraded mode of link aggregation, it will be assumed (and so described) in the rest of the this standard that link aggregation is used.

Link aggregation described in IEEE 802.1AX is managed at OSI layer 2, and allows one or more lines to be aggregated together to form a logical group, able to manage the link redundancy (see Figure 11 below).

Link aggregation combines several individual lines, each having a physical and MAC layer. From the MAC client, a single MAC interface is provided.

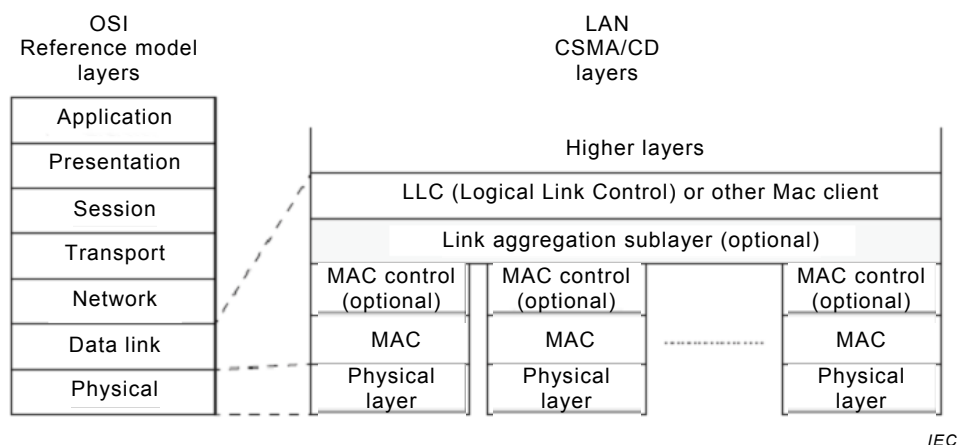


Figure 11 – Link aggregation model

On an ETB node, up to four physical ports are allowed to provide redundancy for a communication link, and will be defined as a link aggregation group (also called hereinafter logical link).

When Consist reversing is required, for symmetry reasons (see 4.2.4), 2 or 4 physical lines shall be used in each aggregation group. As stated before, the special case of a single line (no symmetry needed when Consist reversing not required) is considered as a degraded mode of link aggregation. So, a link aggregation group on ETB may contain 1, 2 or 4 physical lines.

Between 2 ETB nodes, there is only one link aggregation group which contains the redundant Ethernet segments. The link aggregation process is only defined as a relation between 2 ETB nodes.

In some cases, due to the specific railway context, some repeaters could be placed on lines between two ETBNs (e.g. to regenerate electric signal). This requires the use of a protocol that can take into account this architecture (see Figure 12 below and 4.4.3.2), because the only use of the “line status” becomes insufficient: only a frame exchange can solve this problem. According to IEEE 802.1AX, the usual way to perform this function is to implement LACP (Link Aggregation Control Protocol). For this ETB specification, and in order to limit network load, instead of using LACP, line port status are managed by Train Topology Discovery Protocol (TTDP) described below using LLDP frame with a specific organizational HELLO TLV (TTDP HELLO frame).

A logical link is usable as long as at least one of its physical lines is ok (as in standard link aggregation). The degraded state information of a link when it loses a physical line can be retrieved by SNMP.

An intermediate repeater Network Device shall transfer LLDP frames without any change between these two interfaces.

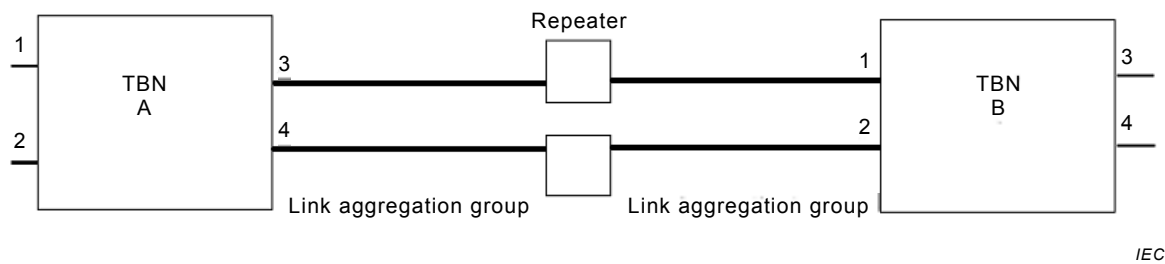


Figure 12 – Link aggregation group

NOTE Link aggregation supports the way to optionally add ports and lines between ETBNs, in order to improve reliability and performances (allocating more bandwidth).

4.4.3 Functions

4.4.3.1 Data flow principles

A load sharing is supported on the train backbone, meaning that MAC client traffic is distributed across the lines.

IEEE 802.1AX does not specify any particular distribution algorithm. To ensure interoperability between different systems, this algorithm shall cause neither disordering of any given conversation (TCP, IP, etc.), nor duplication of frames.

Each conversation uses only one line at a time. This ensures the interoperability between 2 train nodes even with different algorithms. Figure 13 below illustrates different conversations, but each on the same line:

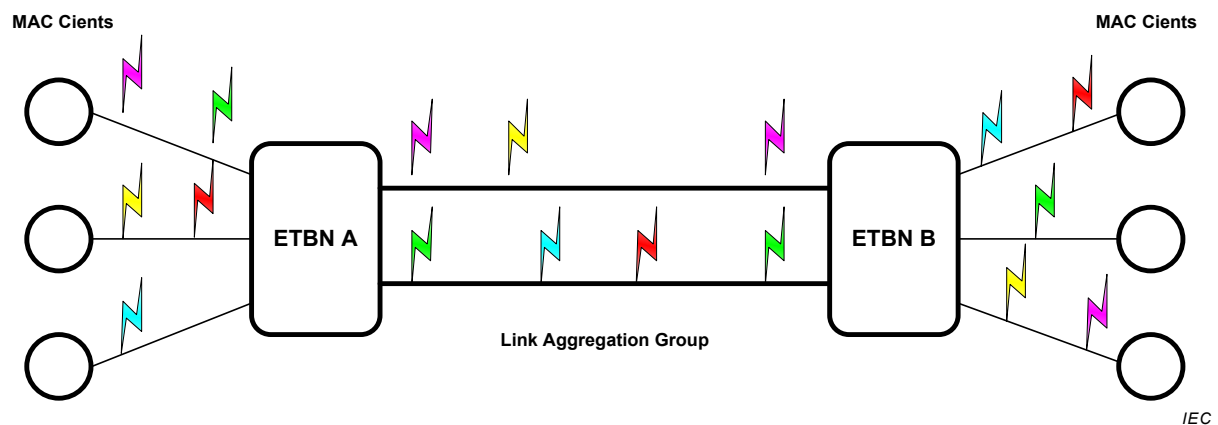


Figure 13 – Conversations over LAG

4.4.3.2 Configuration

Link aggregation configuration is set statically at initialisation time of ETBN. Configuration shall follow link availability. Link logical status is computed using TTDP HELLO frame and Ethernet port status.

4.4.3.3 Reconfiguration

The reconfiguration of the redundant lines shall be made in case of change of physical connectivity (failover). The link aggregation process shall quickly converge to a new configuration of the redundant lines in a time below or equal to 200 ms (see 8.9.1).

Reconfiguration is managed by TTDP HELLO frames and ETB ports statuses.

4.4.3.4 Compliance

Backwards compatibility with aggregation unaware communication devices shall be supported. Lines that cannot take part in aggregation shall operate as normal.

Link aggregation shall never add or change the content of frames exchanged between devices.

Compliance is defined in PICS, coming from IEEE 802.1AX:2008, 5.7.

5 ETB data link layer

Table 4 summarizes network data link layer requirements for a switch device connected to the train backbone subnet.

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

Table 4 – ETB Switch data link layer interface (1 of 2)

ETB Switch data link layer interface			
OSI Layers	Requirements	Type	Description
Application	MAC services and addressing IEEE 802.3	M	
Presentation			
Session	LLC services IEEE 802.2	X	802.3 Ethernet frames with Ethernet II framing used (with 16-bit EtherType field)
Transport			
Network	Frame Relaying IEEE 802.1D PICS A.7	M	Frame reception, Frame transmission, Forwarding process which comprises: Queuing, QoS Priority mapping, FCS calculation, etc.
Data	Frame Filtering (layer 2 filtering) IEEE 802.1D, Clause 7, PICS A.8	M	Learning process, Filtering data base (Mac addresses, ports, VLAN association), static/dynamic entries
Physical	Frame Queuing IEEE 802.1D, 7.7.3, 7.7.4 PICS A16- Annex G	M	Multiple traffic classes (TC) for relaying frames; assign ingress frames a defined priority.
	Frame tagging/untagging IEEE 802.3, 3.5, IEEE 802.1Q (VLAN)	M	Ethernet frames can be tagged during switch port ingress. The tag can then remain within the frame or can be removed during port egress.
	VLAN Services IEEE 802.1Q (VLAN), PICS A.21	M	Helps subdividing the physical LAN in different virtual LANs.
	Port mirroring	O	Configures one switch port to mirror the traffic from another switch port.
	Flow Control IEEE 802.3, Part 2 Annex	O	
	Ingress rate limiting (policing)	O	Limit the reception rate of selected incoming frames
	Egress rate shaping	O	Limit the transmission rate of selected outgoing frames

Table 4 (2 of 2)

ETB Switch data link layer interface			
OSI Layers	Requirements	Type	Description
	Spanning Tree Protocol (STP), Rapid Spanning Tree Protocol (RSTP) IEEE 802.1D	X	
	Link Aggregation IEEE 802.1AX	C	NOTE To manage ETB link redundancy Link Aggregation is mandatory TTDP HELLO frames shall be used to manage link group.
	LLDP protocol Link Layer Discovery Protocol IEEE 802.1AB	M	Used by Train Topology Discovery Protocol between trains.
	Management and Remote Mgt IEEE 802.1D, Clause 14 PICS A.14, A.15	M	Configuration of the switch, Fault management (detection / diagnostic / correction), Performance management (statistics, bandwidth measurement capability). Only supported on managed ND.

6 ETB network layer: IPv4 subnets definition

6.1 General

Table 5 summarizes network layer requirements for all devices connected to the train backbone subnet.

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

Table 5 – ETB OSI Network layer

ETB OSI Network layer			
OSI Layers	Requirements	Type	Description
Application	ARP Address Resolution Protocol IETF RFC 826	M	
Presentation			
Session	IPv4 Internet Protocol IETF RFC 791	M	
Transport			
Network	Hostname	M	Name of ED, shall be unique in its owner Consist whatever the ETBN is connected to. Should be statically defined: read from a local permanent memory, an external coding key, etc.
Data	Default Domain Name	C	If DNS client is enabled, shall be set to "ltrain" Should be statically defined: read from a local permanent memory, an external coding key, etc.
Physical	IPv4 address	M	In range 10.128/9 (see 6.4.2). Dynamically defined following Inauguration (see 6.5.2).

Table 5 (2 of 2)

ETB OSI Network layer			
OSI Layers	Requirements	Type	Description
	IPv4 mask	M	255.255.192.0
	IPv4 static routes	O	Could be used to ground communication or other Consist sub-subnets access. Could be statically defined.
	IPv4 DNS address	C	If DNS client is enabled, shall be set to IPv4 address of the DNS server.
	Management of IP Differentiated Services Field (DSCP: Differentiated Services CodePoint Field) IETF RFC 2474	O	Application should be able to set DSCP IP field to set traffic priority.

6.2 IP mapping introduction

The following paragraphs describe mandatory and minimum network IP addressing definitions to ensure communication interoperability between open trains.

Open trains are composed of Consists from heterogeneous origins, this standard gives minimum requirements to connect them together.

No hypothesis is done about how to put in place IP mapping (how to set IP address), only IP address plan is described (for Ethernet application inside Consist, see IEC 61375-3-4).

6.3 Topology

6.3.1 General

As described in IEC 61375-1, Consist topology shall be hierarchical with one or more train backbone subnet (ETB, Ethernet Train Backbone) and one or more Consist Network subnets (see Figure 14).

ED (End Device) could be connected directly to ETBN (Ethernet Train Backbone Node).

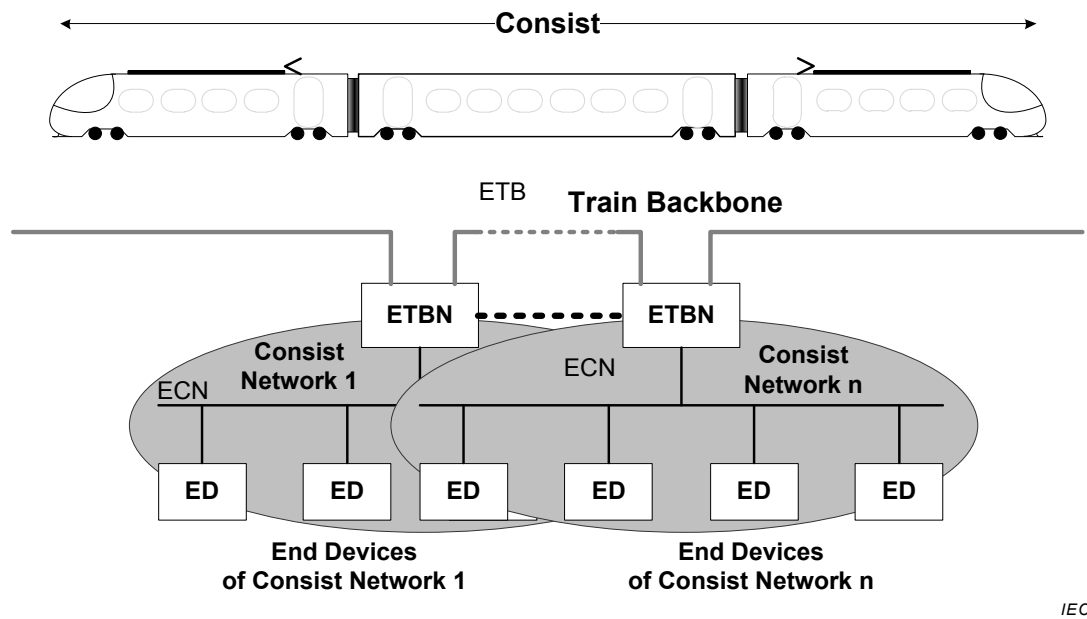


Figure 14 – Hierarchical Consist topology

NOTE 1 The following paragraphs suppose that ETB OSI layer 1 (connectors, cables, etc.) and layer 2 interfaces are interoperable.

NOTE 2 Due to hierarchical topology, Consist network interoperability interface is localized between ETBN (Ethernet Train Backbone Node) on ETB subnet.

NOTE 3 On ETB subnet, links redundancy is assumed at OSI layer 2, without requirements at IP level definition (see IEEE 802.1AX Link Aggregation).

NOTE 4 Inside a train, after initialization and Inauguration process, any communication device (ED, ETBN, ...) should be joined by an unambiguous IP train address.

NOTE 5 IP address mapping could be the same between different open trains. Each open train is considered as a little independent private network.

NOTE 6 Local internal Consist traffic is out of interoperability scope.

6.3.2 Closed train

The definition of a closed train according to IEC 61375-1 is a train composed of one or a set of Consists, where the configuration does not change during normal operation, for instance metro, suburban train or high speed train units (see Figure 15).

Additional Requirements from operators regarding Closed Trains are:

- Flexible composition of Closed Trains, i.e. varying number of intermediate cars.
- Automatic configuration without commissioning.
- Addressable as a unit from inside and from outside of the unit.

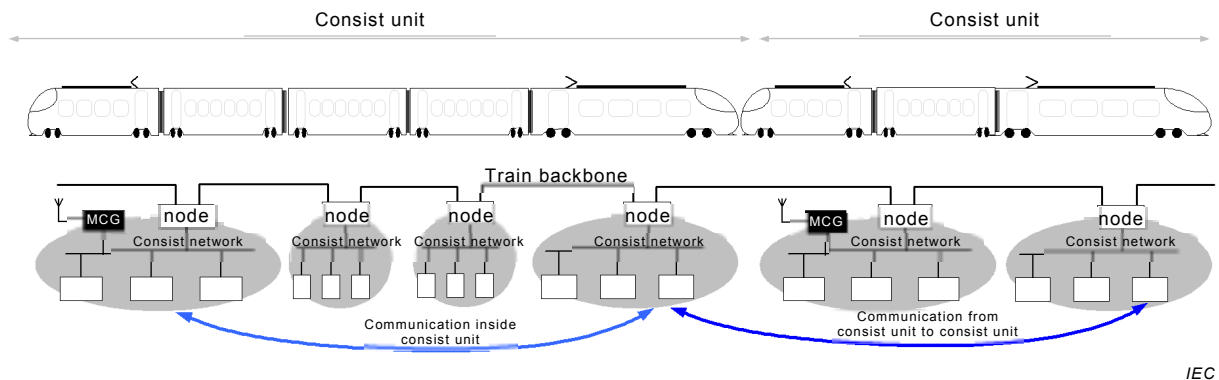


Figure 15 – Closed train

To support closed train architecture, the same CstUUID shall be used for all Consists which constitute the closed train. At ETB level, a Closed Train can be seen as a single "virtual Consist" with its associated CstUUID and the Consists which form the Closed Train are not seen as Consists anymore when integrated as an IEC 61375 interoperable Closed Train. Closed train internal description is out of the scope of this standard and is specified in IEC 61375-2-3: communication profile.

6.4 Network IP address map

6.4.1 Global IPv4 address space

First rule is to use inside the train, IPv4 address space **10.0.0.0/8**, reserved by the Internet Assigned Numbers Authority (IANA) for private network (see IETF RFC 1597, Address Allocation for Private Internets for more details).

Second rule is using CIDR (Classless Inter-Domain Routing) capability, according to IETF RFC 1519, to define subnets (split and/or aggregate).

6.4.2 Train subnet definition

6.4.2.1 General

To not use all 10.0/8 address space and reserve a range for local communication usage or supplier specific usage, train subnet address space is limited to **10.128.0.0/9** (see Table 6).

00001010.txxxxxxx.xxxxxxxx.xxxxxxxx/9

Table 6 – Train subnet definition

[t]	Notation	Description
0	10.0.0.0/9 or 10.0/9	localized subnets
1	10.128.0.0/9 or 10.128/9	train subnets

Localized subnets address space could be used to define local subnets: inside a Consist, on ETB level, outside the train, etc. This address space is free of use and out of interoperability scope.

6.4.2.2 Train subnet decomposition

Train subnet (t=1) is split using following rules:

00001010.1**bbxssss.sshhhhhh.hhhhhhhh**/18

with fields explained in Table 7:

Table 7 – Train subnet decomposition

Subnet number part:	
[b]	« Backbone Id », between[0,3]. Identify some train backbone subnets. Up to 4 ETB could be defined. Statically assigned, wiring rules between Consist shall ensure good connection between same ETB backbone. This Id is not dynamically computed during Inauguration phase. 0, for TCMS 1, for multimedia 2, not specialized 3, not specialized
[x]	« reserved bit ». Shall be clear (x = 0).
[s]	« Subnet Id », Inauguration result, identify each Consist network subnet (CN) of the train. Null value is reserved for the train backbone subnet (ETB).
Host number part:	
[h]	« Host Id », unique host identification inside CN, up to 16 382 hosts by Consist. Some upper bits could be used to define internal dedicated Consist subnets. In this case, address mask (at CN side) should take into account this decomposition and shall be extended.

As consequences:

- ETB0 (TCMS) Ethernet Train Backbone subnet is 10.128.0.0/18
- Broadcast IP address on ETB0 is: 10.128.63.255

6.4.2.3 CN identification, « Subnet Id »

6.4.2.3.1 General

To identify each Consist Network subnet (CN) inside a train, a “Subnet Id” value is necessary. This value is determined using results of Inauguration process (see TTDP, Clause 8). “Subnet Id” is coded as an unsigned integer with 6 bits precision. Null value is reserved for ETB and shall never be returned by Inauguration process. Up to 63 CN subnets could be defined inside a train.

After Inauguration, each ETBN is also numbered, from 1 to n, from one end of the train (top ETBN node) to the other (bottom ETBN node). The result is an “ETBN Id” with 6 bits precision, inside [1..63] range. Null value is excluded and shall never be returned by Inauguration process (in fact, inside a single Consist, minimum number of ETBN is one). Up to 63 ETBNs could be connected on ETB.

Do not confuse “Subnet Id” and “ETBN Id”. “Subnet Id” identifies a CN subnet inside the train, where “ETBN Id” identifies an ETBN on the backbone.

Both values, “Subnet Id” and “ETBN Id” are used to build train IP addresses.

6.4.2.3.2 Single Consist Network (CN) per Consist

When a Consist is composed of only one Consist Network subnet without ETBN redundancy, “Subnet Id” is equal to the “ETBN Id” (see Figure 16 and Figure 17).

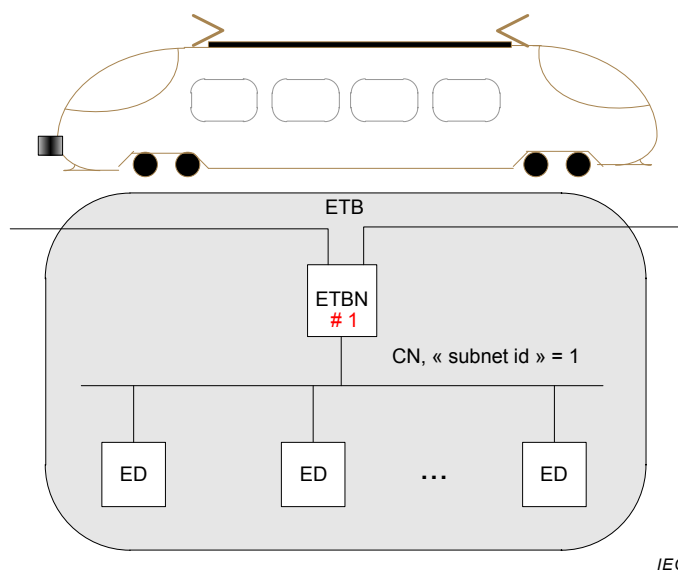


Figure 16 – "Subnet Id" with single Consist Network

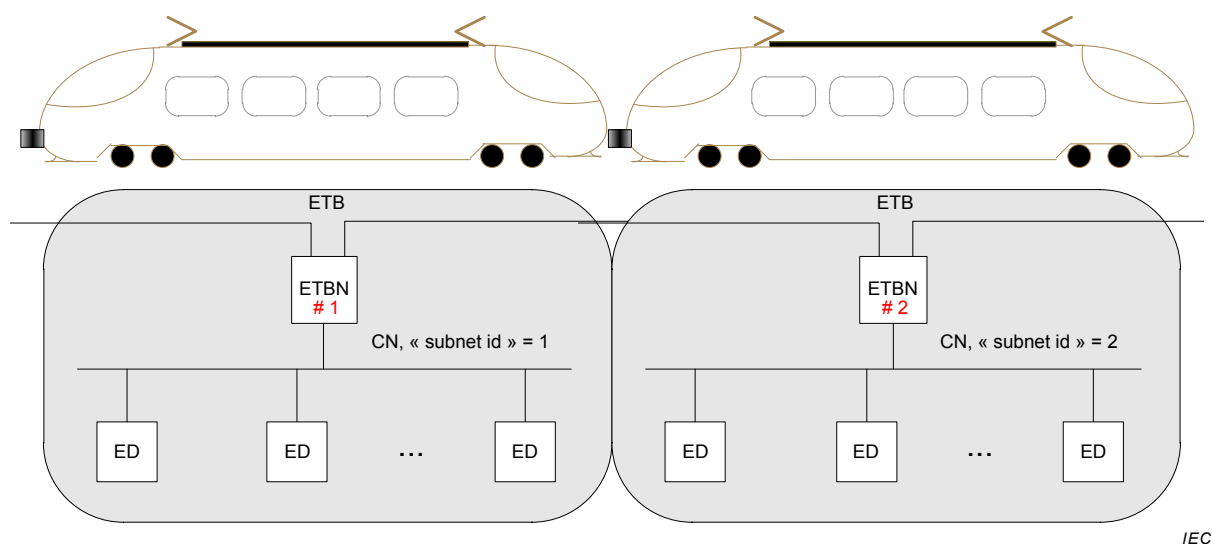


Figure 17 – "Subnet Id" with two single Consist Networks

6.4.2.3.3 Multiple CN per Consist

As many Consist network subnets (CN) could be present inside a same Consist (more than one ETBN by Consist), "Subnet Id" value follows ETBN numbering in the same order (see Figure 18).

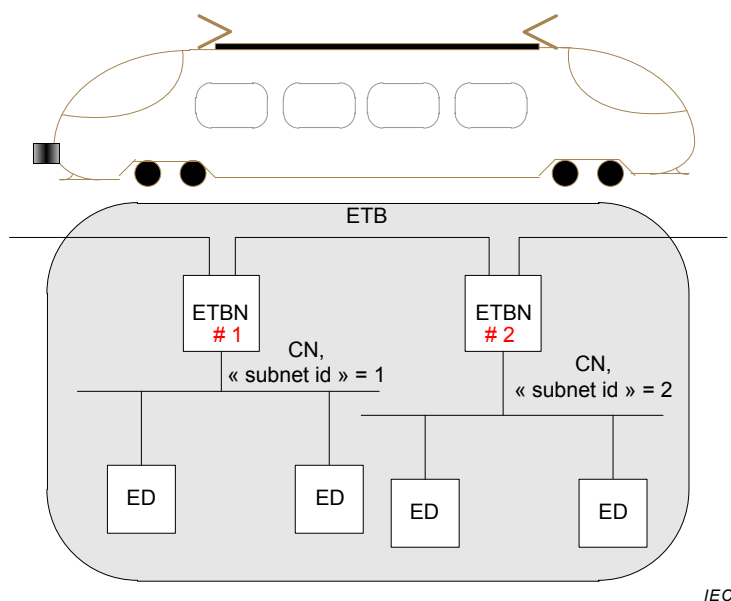


Figure 18 – Multiple Consist Networks, without fault tolerance

6.4.2.3.4 ETBN redundancy

In case of ETBN redundancy, two ETBN connected to the same Consist network subnet, have two “ETBN Id” but shall share the same “Subnet Id” (see Figure 19).

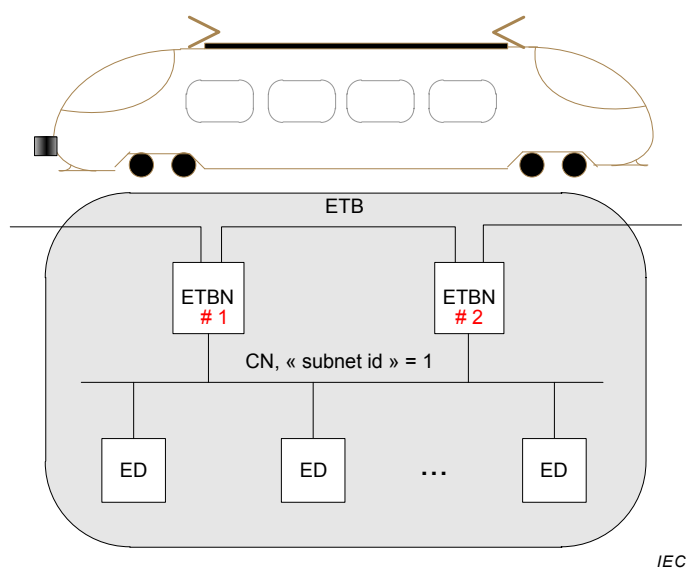


Figure 19 – "Subnet Id" with ETBN redundancy

Depending on configuration and train composition, “Subnet Id” shall be incremented following CN subnet occurrence in the same order as ETBN numbering (see Figure 20).

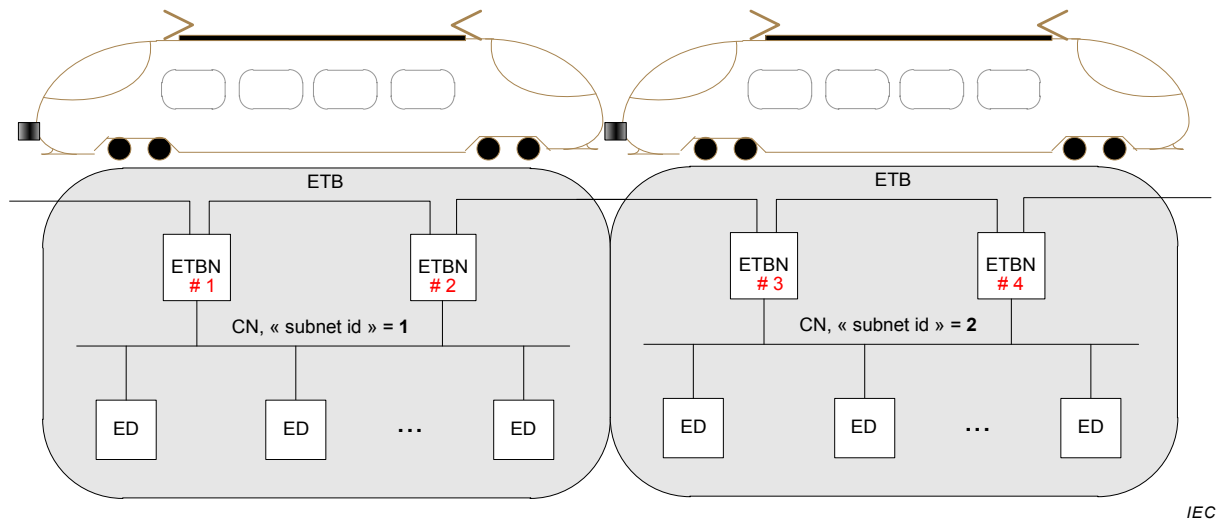


Figure 20 – "Subnet Id" in multiple units with ETBN redundancy

6.4.3 Train IP address map summary

Train IP address map is summarized in Figure 21:

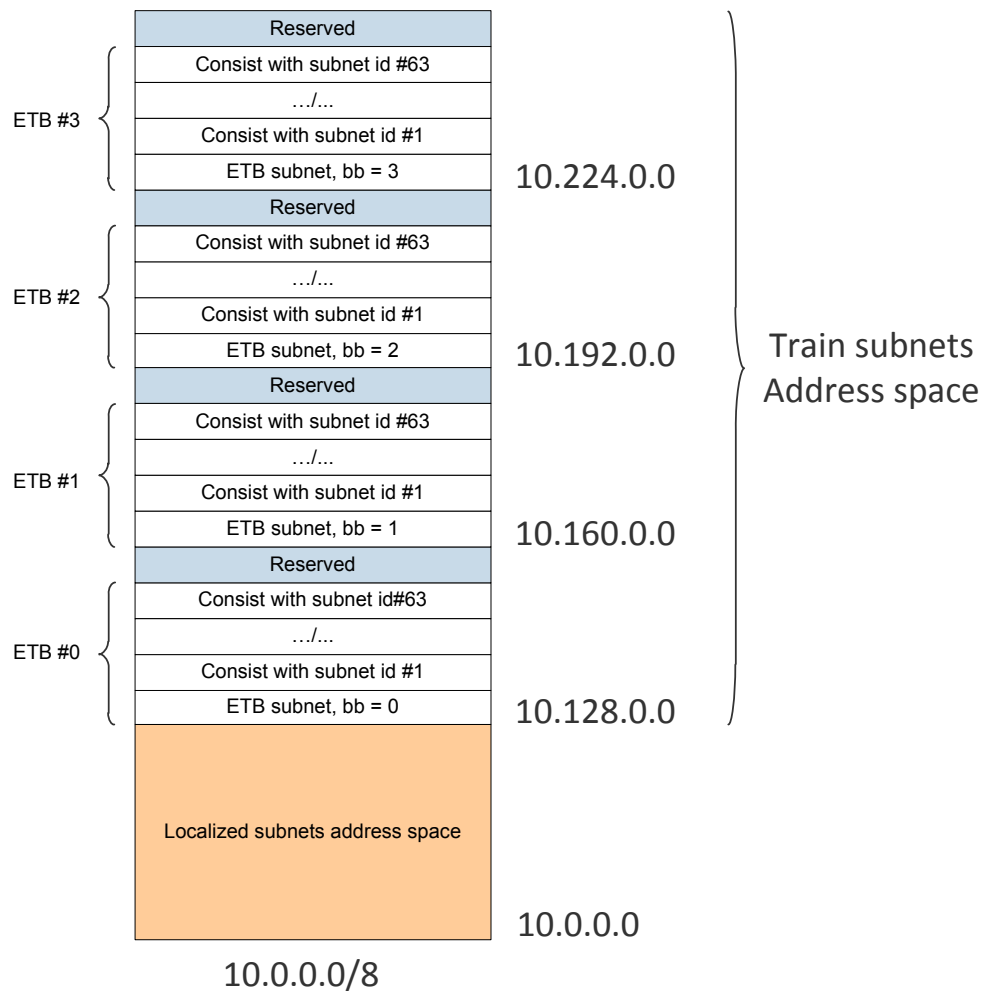


Figure 21 – IP train address space summary

6.4.4 Train IP group addresses (multicast)

At train level, IETF RFC 2365 range **239.192.0.0/14 (organization scope)** shall be used for multicast addressing (see Table 8).

When CN is based on Ethernet (ECN) another multicast address range should be defined for local ECN usage, proposed range is **239.255.0.0/16 (local scope)**, see IETF RFC 2365 and IEC 61375-3-4.

Interoperability reserved range is (255 group addresses):

239.192.0.0 to 239.192.0.255

Table 8 – Train IP group addresses reserved range

Group	Description	Routable
239.192.0.0	All Consists: enables addressing all nodes of all Consists	Yes
239.192.0.X	All hosts on Consist in position X according to Train Network Directory, X between 1 to 63	Yes
239.192.0.64 to 239.192.0.127	Reserved for future use (ex.: leading, lead Consist)	Yes
239.192.0.128	All hosts on ETB subnet	No
239.192.0.129	All ETBN on ETB subnet	No
239.192.0.130 to 239.192.0.255	Reserved for future use	No

So:

- All ETBNs shall subscribe to 239.192.0.129.
- All hosts on ETB subnet shall subscribe to 239.192.0.128.
- EDs needing to receive train scope messages shall subscribe to 239.192.0.0.

6.5 Particular hosts IP addresses

6.5.1 ETBN (Ethernet Train Backbone Node)

6.5.1.1 General

If CN subnet attached to ETBN is IP based (this is the case for ECN), ETBN has at least two interfaces and takes two train IP addresses, one on ETB side, and another on CN side.

NOTE 1 As a same ETBN could be used to connect multiple CNs, an ETBN could have multiple IP addresses, one on ETB side, and one on each connected CNs.

NOTE 2 If ETBN is used to directly connect several EDs on the backbone (acting as a switch), ETBN has only one IP address on ETB side.

6.5.1.2 ETBN ETB IP address

ETBN IP addresses on ETB side are defined as follows:

00001010.1**bb**00000.00000000.v0tttttt/18

with fields described in Table 9:

Table 9 – ETBN ETB IP address

Subnet number part:	
[b]	« Backbone Id », between[0,3]. Identify some train backbone subnets. Up to 4 ETBs could be defined. Proposal: 0, for TCMS 1, for multimedia 2, not specialized 3, not specialized
Host number part:	
[v]	« Virtual Bit », if set, defines virtual IP address for ETBN redundancy.
[t]	« ETBN Id », Inauguration result, it is the ETBN number inside the train. Never Null, between [1,63]. If “Virtual Bit” is set, “Subnet Id” shall be used in place of “ETBN Id”.

6.5.1.3 ETBN CN IP address

Train IP address of ETBN on CN side is like any Consist ED IP address and follows CN subnet definition (see 6.4.2.2). ETBN host part number could take any value.

As common convention, ETBN train IP host part number should be set to 1 for the master or virtual router.

6.5.2 Hosts on train subnet

In case of ETBN acts as a switch, EDs can be connected on ETB. They have to take a train IP address inside ETB subnet, like ETBNs. This standard defines only an IP address range. The method to set IP addresses for such devices is left open but shall not generate extra ETB traffic. Up to 254 hosts by ETBN could be directly connected on ETB.

Host IP addresses on ETB side are defined as follows:

00001010.1**bb**00000.00**tttttt**.hhhhhhhh/18

with fields described in Table 10:

Table 10 – Hosts IP on train subnet

Subnet number part:	
[b]	« Backbone Id », between [0,3]. Identify some train backbone subnets. Up to 4 ETBs could be defined. 0, for TCMS 1, for multimedia 2, not specified 3, not specified
Host number part:	
[t]	« ETBN Id », Inauguration result, it is the ETBN number inside the train. Never Null, between [1,63].
[h]	« Host Id », unique host identification for this ETBN node. Range [1,254] due to 254 hosts maximum by ETBN node available.

6.5.3 Host inside a closed train

6.5.3.1 General

In case of use of closed train, additional addressing plan can be put in place in order to address communication needs inside the closed train.

Such an addressing plan provides to an ECN host an IP address to join another host in the closed train whatever the topology state is. This addressing plan shall be part of the localized subnets and out of interoperability scope.

The same constructional rules than these defined for train subnet definition shall apply.

To identify each Consist Network subnet inside the closed train, a “Closed train Subnet Id” value is necessary. This value is determined during train preparation dynamically with private protocol or statically as closed train topology does not vary in normal operation.

“Closed Train Subnet Id” is coded as an unsigned integer with 6 bits precision. Null value is reserved to closed train backbone Subnet Id. Up to 63 CN subnets could be defined inside a closed train. During closed train composition, a direction number (1 or 2) is allocated to each closed train end.

Each ETBN is numbered, from 1 to n inside the closed train, from direction 1 to direction 2 of the closed train. The result is a “closed train ETBN Id” with 6 bits precision, inside [1,63] range.

6.5.3.2 IP relative addressing plan (optional)

Consist networks are enumerated in consecutive way during inauguration. Due to the linear structure of the ETB, each Consist Network can be addressed by a specific offset from the local Consist Network.

When trains are coupling or uncoupling, only new Consist Networks appear or existing Consist Networks will disappear, but the offsets of the remaining Consist Networks do not change. So the relative addressing is not affected by address changes of the ETB as a consequence of inauguration.

An IP addressing plan relative to the local Consist Network can be defined as below:

00001010.0sstoooo.ooodddddd.ddddddd /12

with:

- s 0..3, scope (3 = train, 2 = closed train, 1 = Consist, 0 = Consist Network; currently relative IP addresses are only defined in the train scope)
- t 0..1, type (0 = absolute, 1 = relative; always 1 for relative IP addresses)
- o 0..63, offset of the destination Consist Network
- d 1 .. 16383, device address

This addressing plan is relative to the local Consist Subnet Id to which the end device belongs. The same addressing plan is available at each Consist Network level but according to the position of the Consist Network inside the train, it identifies different Consist Networks.

The offset of the destination Consist Network is calculated according to the following rule:

$$O = (\text{Consist Network Id of source device} - \text{Consist Network Id of destination device} + 64) \bmod 64$$

By convention, it is assumed that the ETB node belongs to the local subnet and that its offset is equal to 0. Its IP relative address is:

00001010.01110000.00000000.v0ttttt/18

with:

[v]	« Virtual Bit », if set, defines virtual IP address for ETBN redundancy.
[t]	« Closed train ETBN Id », configuration result, it is the ETBN number inside the closed train. Never Null, between [1,63]. If “Virtual Bit” is set, “closed train Subnet Id” shall be used in place of “ETBN Id”.

Due to the use of localized subnet address space for the relative IP address, the ETBN shall implement a NAT mechanism in order to convert the relative IP address.

The ETBN of the source device shall convert:

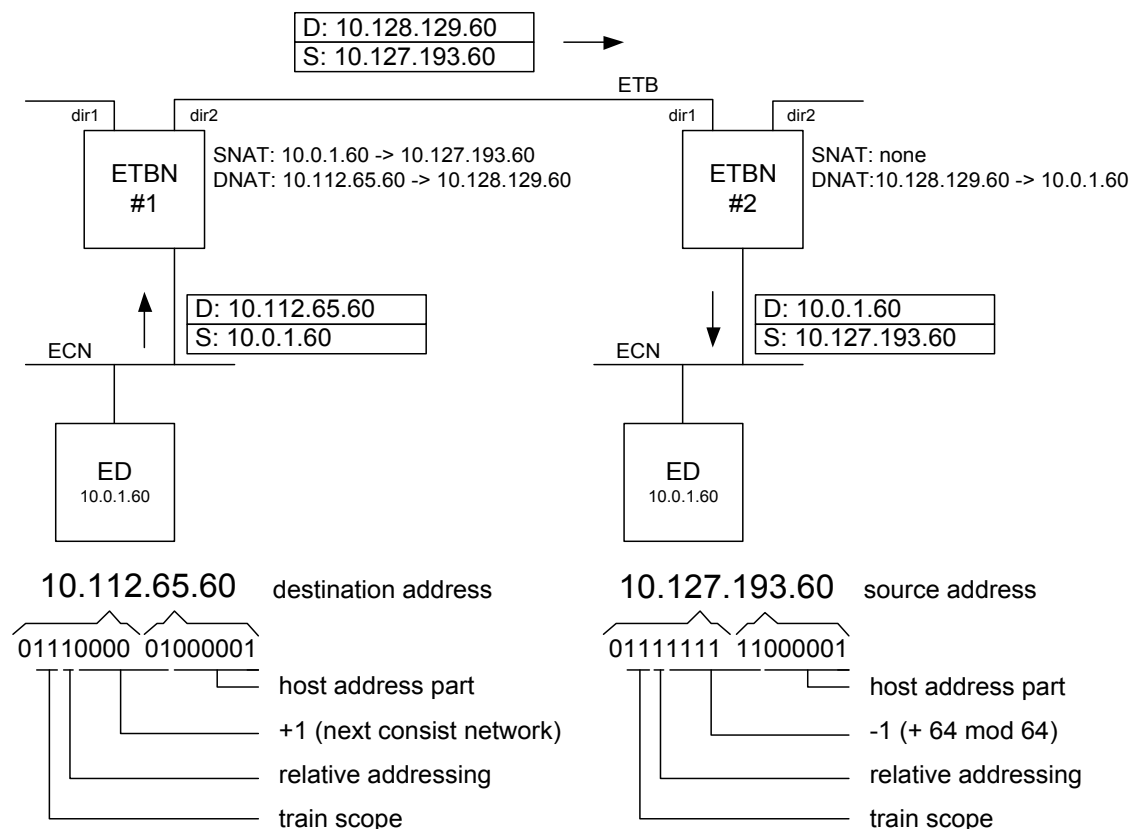
- a) the relative destination IP address to a train wide IP address,
- b) the source IP address to a relative source IP address regarding the orientation of the ETBN of the destination device.

NOTE All destination IP addresses at ETB level belong to the train subnet address space 10.128.0.0/9. The relative source IP addresses belong to the localized subnet address space.

The ETBN of the destination device shall convert:

- a) the train wide destination address to the localized IP address of the destination device only,
- b) and leave the source IP address as it is.

Figure 22 shows an example of the source and destination NAT in the affected ETBNs.



IEC

Figure 22 – Relative addressing example

The conversion of the relative source IP address in ETBN #1 takes care of the orientation of ETBN #2. Since both ETBNs have the same orientation the relative offset is converted from +1 to -1. If both ETBNs have different orientations, then the relative offset does not change. If the orientation of ETBN #2 in example (Figure 22) was reversed, then the relative source address would change to 10.112.65.60.

This addressing plan can be extended outside the closed train. In this case, due to the use of localized subnet address space, a mechanism like NAT shall be available at ETBN in order to convert localized address to train subnet address space at ETBN level. Each frame from an end device to another end device shall appear on the backbone train with destination IP address in train subnet address space. In this case, communication can be disturbed during inauguration phase as NAT mechanism depends on train topology.

6.6 Some use cases

Figure 23, Figure 24, Figure 25, Figure 26, Figure 27 show some train IP address mapping resulting from different use cases. Consist networks (CN) are not only ECNs but could use another technology: MVB, CAN, etc. All IP addresses on figures are train addresses, each ED shall have to be contacted at train level using this address (do not confuse with local IP address when CN is an ECN).

In the following, ED train IP address could be managed by ETBN or directly by ED. Ethernet Layer 2 ND (switches) are not shown.

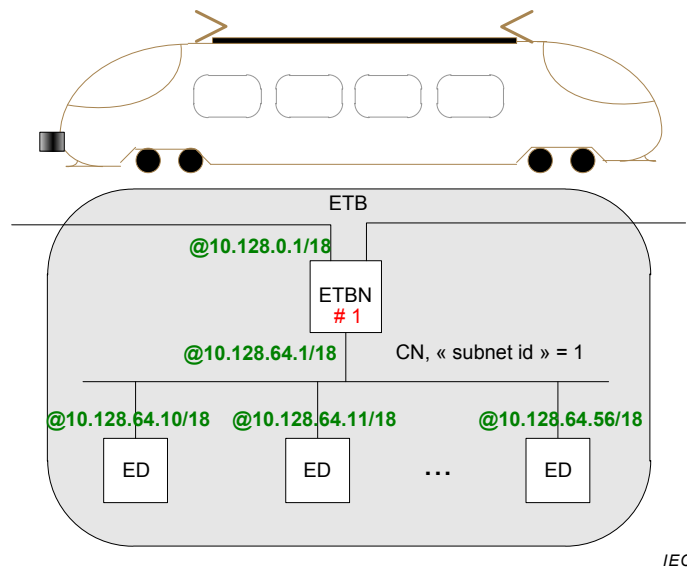


Figure 23 – Train composed of a single Consist Network

Figure 23 shows a single and simple Consist. As there is only one ETBN connected to one CN, after Inauguration (alone on ETB), ETBN takes the number 1 (“ETBN Id” = 1), and CN the number one (“Subnet Id” = 1). Using tables above, train IP mapping is deduced from these two numbers. For example, ETBN on ETB takes the IP 10.128.0.1/18. Note that, if a train IP address is associated for each ED, these ED do not necessarily manage it directly. Train IP address shall be used to address any ED inside the train (inside or outside the Consist). Conversion rules shall be defined if CN is not based on Ethernet (ECN).

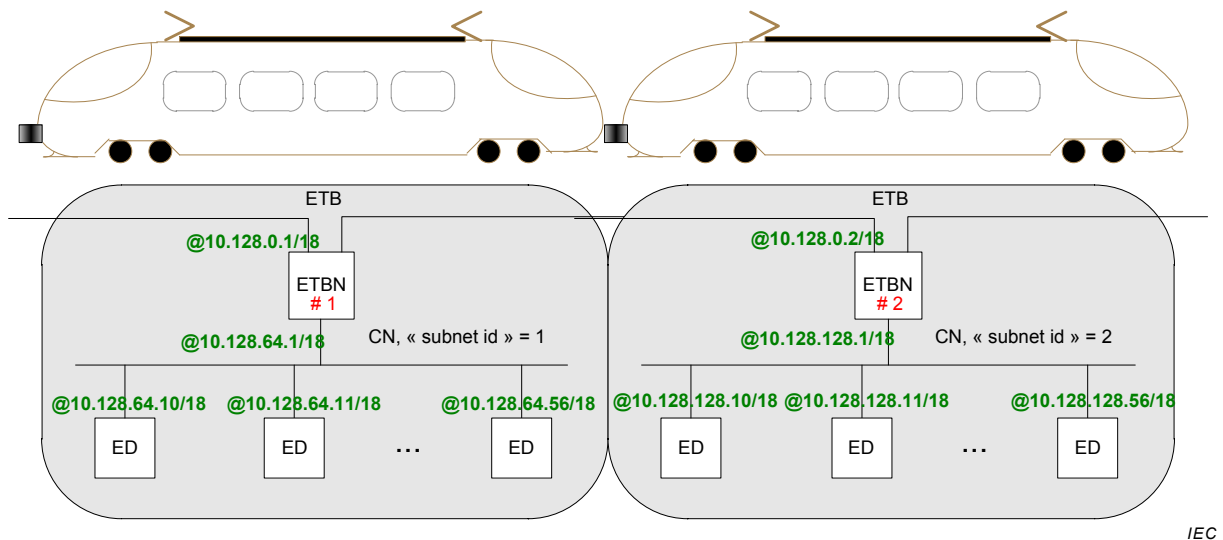
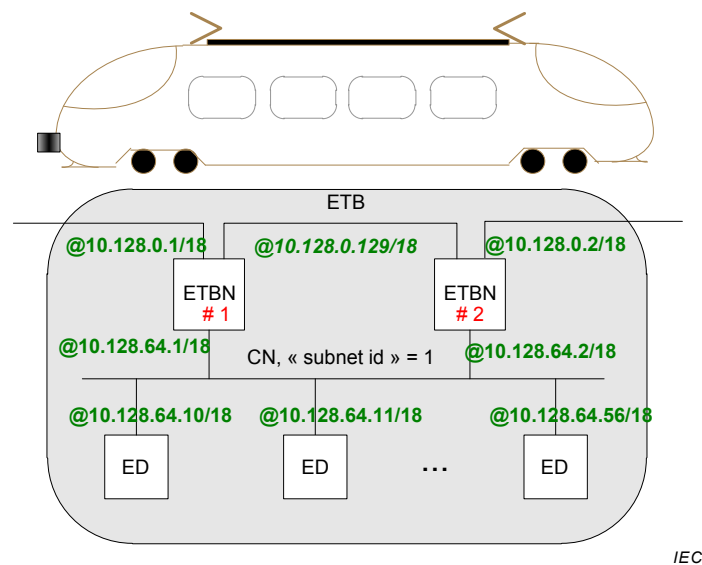


Figure 24 – Train composed of two single Consist Networks

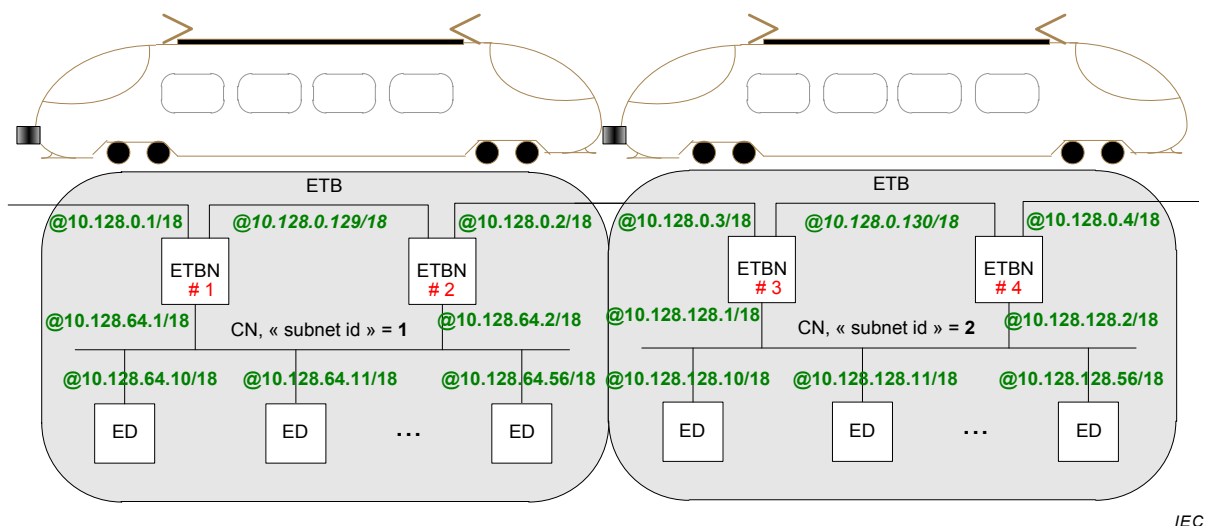
Figure 24 shows a train composed of two Consists. Each Consist includes one CN without ETBN redundancy. After Inauguration, ETBNs are numbered and take number one and two. The lowest number is affected to the train ending ETBN inside the Consist having the lowest CstUUID (see the following for more detail). CNs are also numbered in the same manner. “ETBN Id” and “Subnet Id” are used to calculate the train address mapping.



NOTE About ETBN redundancy and virtual IP address see Clause 9.

Figure 25 – Train composed of single Consist Network with ETBN redundancy

Figure 25 shows a train, limited to a single Consist, but CN is connected to ETB using both ETBNs. After Inauguration each ETBN takes a number. Number one for ETBN train ending is set by static configuration (like the “master” and “backup” role). Here, the unique CN takes the number one. Without failure, both ETBNs are active, but by static configuration one is “master” and the other “backup”. The “master” defines one train IP address more: a virtual IP address (here the address 10.128.0.129/18). This single address shall be used by other ETBNs to set a route to the CN. A life sign algorithm shall take place inside CN between both ETBNs: the “backup” node asks cyclically the “master”. In case of silence, the “backup” node becomes “master” and publishes the virtual IP address (a gratuitous ARP shall be sent on ETB by the new “master”). In the other ETBN, route does not change.



NOTE About ETBN redundancy and virtual IP address see Clause 9.

Figure 26 – Train composed of two Consist Networks with ETBN redundancy

Figure 26 shows a train composed of two Consists with ETBN redundancy in both. Using CstUUID, ETBN and CN are numbered. As TTDP TOPOLOGY frame describes each CN inside Consist, it is possible to give consecutive CN subnet number without hole. ETBN#3 and ETBN#4 have an IP route to the subnet 10.128.64.0/18 (CN with the “Subnet Id”

the virtual IP address 10.128.0.130/18. Respectively ETBN#1 and ETBN#2 have an IP route to subnet 10.128.128.0/18 using virtual IP address 10.128.0.129/18.

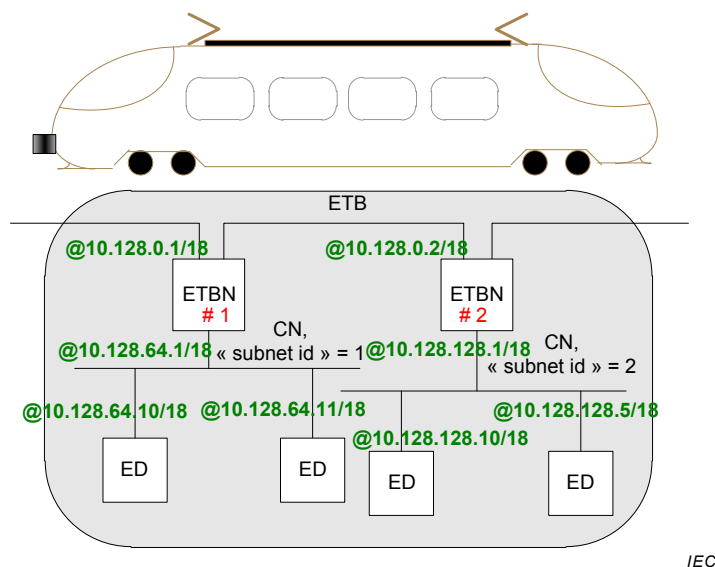


Figure 27 – Train with two Consist Networks in single Consist

Figure 27 shows a train composed of a single Consist with two CNs inside, without redundancy. ETBN#1 has an IP route to 10.128.128.0/18 using ETBN#2 as gateway. Respectively, ETBN#2 has an IP route to 10.128.64.0/18 using ETBN#1 as gateway.

6.7 Dynamic IP routing management

6.7.1 Unicast routes

Train Topology Discovery Protocol (TTDP) results shall be used to update IP routing table inside ETBNs.

All ETBNs are active. In case of ETBN redundancy, only the master ETBN owns the ETBN virtual IP address. This address is used by other ETBNs as gateway. See Clause 9.

6.7.2 Multicast routes

6.7.2.1 General

To forward multicast traffic between CNs, ETBNs need to be configured to do it, especially if CN is based on Ethernet (ECN).

To perform this task, multicast routing table of ETBNs shall be set. Each line of this table contains a couple of IP addresses (MG, US):

- MG: Multicast Group IP destination address,
- US: Unicast Source IP address of the multicast source address ED. US address shall be in Train subnet address range as defined in 6.4.2.1.

Multicast routing table shall be updated whenever:

- a new Inauguration occurs (to take into account new IP unicast mapping),
- an ED wants to use a new IP group destination address.

Main requirements are: