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Release 2

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

ETSI EN 302 663 [i.1] specifies the access layer for ITS-G5 for Release 1 and ETSI EN 303 613 [i.2] specifies the access layer for LTE-V2X for Release 1.

The present document provides Release 2 C-ITS access layer updates and extensions specific to Multi-Channel Operation (MCO).

Where possible the specifications are access layer agnostic.

1 Scope

The present document specifies Release 2 C-ITS access layer MCO extensions based on Release 1 backward compatibility.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

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The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

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The following referenced documents are not necessary for the application of the present document, but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 302 663: "Intelligent Transport Systems (ITS); ITS-G5 Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.2] ETSI EN 303 613: "Intelligent Transport Systems (ITS); LTE-V2X Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.3] ETSI TS 103 697: "Intelligent Transport Systems (ITS); Architecture; Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS); Release 2".

[i.4] IEEE 802.11bd™: "IEEE Draft Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Next Generation V2X".

NOTE: Available at https://standards.ieee.org/ieee/802.11bd/7451/.

[i.5] IEEE 802.11™-2020: "IEEE Standard for Information technology-Telecommunications and information exchange between systems Local and metropolitan area networks-Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

access layer instance: fully parametrized (service channel, technology, TX power, …) transceiver entity in the access layer

access layer instance ID: Unique Identifier for an access layer instance

access layer instance group: set of access layer instances using the same service channel and access layer technology

access layer instance Group ID: Unique Identifier for an access layer instance group

access layer technology: consistent set of protocols covering the physical layer and link layer functionalities of the ISO/OSI model defined in an independent specification or set of specifications

AliID generation: process of extracting the AliID from a received frame

AliID processing: operation of receiving an AliID from higher layers and configuring the transceiver correspondingly

instance: fully parametrized entity

instantiation: process of parametrizing an entity

channel load ratio: channel load value per ALI group evaluated at the receiving C-ITS-S

cooperative-Intelligent Transport System: ITS system that realize applications bringing awareness of road user behaviour by sharing static and dynamic information of its behaviour and recognized behaviour of others based on a wireless communication system

ITS-G5 with 11bd capabilities: ITS-G5 based access layer supporting the functionality provided by the IEEE 802.11bd [i.4] and IEEE 802.11p [i.5] access layer specification

entity: singular, identifiable, and separate object realizing a function or set of functions

function: self-contained module that accomplishes a specific task

Intelligent Transport Systems (ITS): systems which aim to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer, more coordinated, and "smarter" use of transport networks

plane: in a networking context, logical grouping of functions over different layers

subchannel: technology dependent group of contiguous Physical Resource Blocks (PRBs) representing the minimum granularity for the allocation of a packet in the frequency domain

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ALI	Access Layer Instance
AliGroupID	Access layer instance Group IDentifier

NOTE: The abbreviation AliGroupID is compliant with an ASN.1 representation of an identifier.

AliID Access layer instance IDentifier

NOTE: The abbreviation AliID is compliant with an ASN.1 representation of an identifier.

ALN Access Layer Notification
BPSK Binary Phase Shift Keying
CC Convolutional Coder
C-ITS Cooperative Intelligent Transport System
C-ITS-S Cooperative Intelligent Transport System Station
CLR Channel Load Ratio
DCM Dual Carrier Modulation
ID Identifier
ITS Intelligent Transport Systems
LDPC Low Density Parity Check codes
LTE-V2X Long Term Evolution based Vehicle-to-Everything
MCO Multi-Channel Operation
MCS Modulation and Coding Scheme
NR-V2X New Radio (5^{th} generation) Vehicle to Everything
PPDU Physical Protocol Data Unit
QAM Quadrature Amplitude Modulation
QPSK Quadrature Phase Shift Keying
RID Reliability Indicator
RX Receiver
SCH Service Channel
TC Turbo-Code
TRX Transceiver
TX Transmitter
V2X Vehicle to Everything

NOTE: All transport equipment used or implemented in or by, vehicle, truck, PTW, bike, pedestrian, train, ship, and other transport equipment.

4 Background

An access layer implementation of a C-ITS-S capable of handling more than a single channel simultaneously requires specific multi-channel functionalities. These functionalities are needed to allow the higher layers to take efficiently advantage of the available resources to transmit and receive packets over the air. An access layer supporting multiple channels will have to implement more than one transceiver including all required building blocks like channel coding, multiplexing, potential input queues, channel load estimation entity and power amplifier. Each of these transceivers may be switched or configured to different operational channels and may be parametrized to deploy different combinations of the available access layer resources.

For proper multichannel operation of a C-ITS-S the different possible configurations of the transceivers need to be accessible to the higher layer entities for the control of the channel load and the related transmission properties.

5 Access layer MCO operation

5.1 Introduction

The access layer of an MCO capable C-ITS-S implements and operates more than a single transceiver active simultaneously. This set of transceivers may be capable of implementing different access layer technologies (e.g. ITS-G5, LTE-V2X, etc.). Each of which may be parametrized to be adapted to the requirements of the applications and the related message dissemination. A single transceiver may be instantiated using a set of different access layer parameters. These parameters are:

- Access layer technology (ITS-G5, LTE-V2X, NR-V2X, etc.)
- Used physical channel (SCH0, …, SCH6)

- Modulation and coding scheme (MCS) or reliability indicator:
  - Channel coder (CC, TC, LDPC, etc.)
  - Channel Coding rate
  - Modulation scheme
- TX power

A parametrized transceiver called "Access Layer Instance" (ALI) represents a specific access layer instantiation of a transceiver. The ALI implements the access layer technology (ITS-G5, LTE-V2X, NR-V2X), the used channels, the channel coding, the modulation and the transmit power. The ALI may be changed from message-to-message dissemination.

A specific set of parameters is identifiable by a unique Access layer instance IDentifier, AliID.

The combination of the access layer technology and the used physical channel is called "Access Layer Instance Group" (ALI group). Each ALI group is identified by a unique access layer instance group identifier, AliGroupID.

The data flow and management flow of the MCO capable access layer are depicted in Figure 1, Figure 2 and Figure 3 and are described in the following clauses.

5.2 Access layer data flow

The access layer data plane as depicted in Figure 1 provides all functionalities required to transmit a PPDU over the physical channel defined as part of the AliID. In the presented figure it is assumed that the set of transceivers may be flexibly parametrized to provide different access layer technology functionalities, thus may be instantiated as technology agnostic transceivers based on the actual AliID.

Another representation of an MCO technology agnostic C-ITS-S is depicted in Figure 2, where the different access layer technologies are limited to a technology specific set of transceivers. Here, an access layer instance may only run on a transceiver that may implement the access layer technology associated to that ALI.

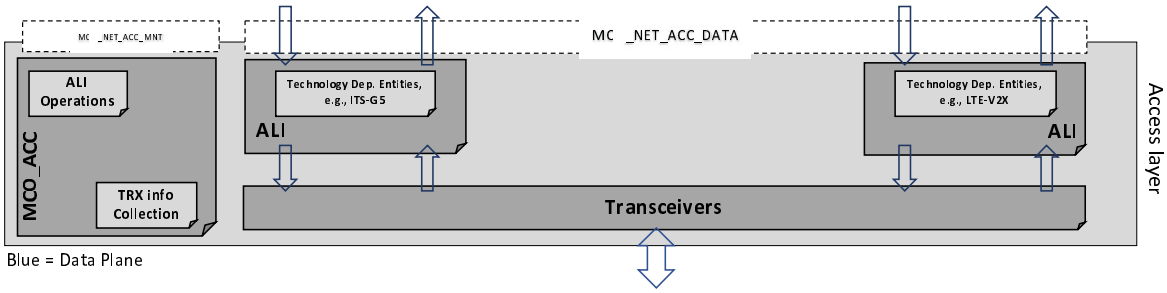

Figure 1: MCO Access layer, Data flow with full flexible transceiver design

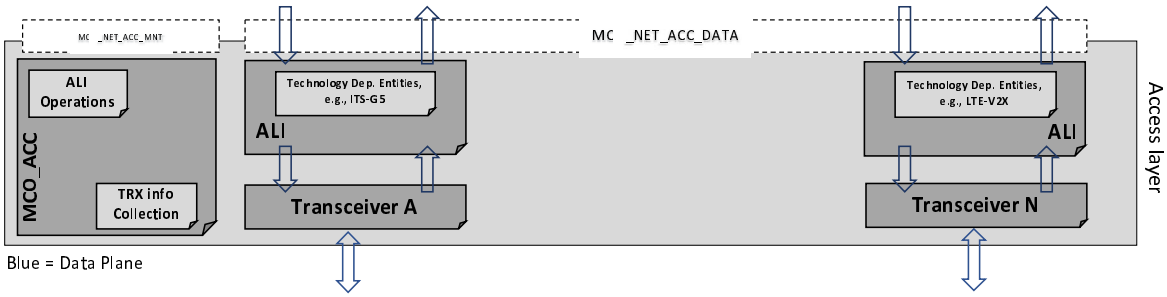

Figure 2: MCO Access layer, Data flow with separate set of transceiver design

5.3 Access layer management flow

As identified in the ETSI TS 103 697 [i.3] at the management plane there are two Access layer entities as part of MCO_ACC depicted in Figure 3.

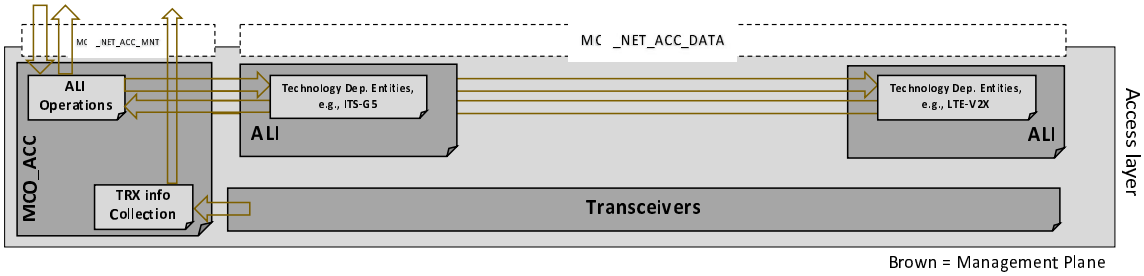

Figure 3: MCO Access layer Management Plane, combined and separate TRXs

ALI Operations: In case higher layers provide an AliID to the ALI Operations, this entity shall configure the corresponding transceivers. The used channel and the access layer technology (ALI group) are semi dynamic characteristics whereas the other parameters (MCS, TX power) may change on a message-by-message basis. Semi dynamic means that these parameters need a longer configuration time. The actual required configuration time for the semi dynamic characteristics is implementation dependent. The ALI operation entity shall provide the actual state of all transceivers to the higher layer.

TRX Info Collection: Transceiver information collection entity; this entity collects all status and measurement information from the available transceivers and provide this information to higher layer. This information are the Access Layer Notifications per transceiver (ALN) and the Channel Load Ratio per transceiver (CLR).

As part of the TRX Info Collection, an **Access Layer Notifications (ALN) function** collects the communication conditions flags and provide them to higher layers. The ALN provides information about the following events at the access layer related to the delivery of the data frames:

- Queue overflow
- Drop of packets
- Time out of packets

The generated notifications shall be specific for a data frame. The ALN shall be provided to the Networking & Transport layer.

As part of the TRX Info Collection, a **received AliID generation function** shall generate an AliID for each received data frame based on the access layer information contained in the physical layer control of the frame. The generated AliID shall be provided to the higher layers. The format of the received AliID shall be as defined in clause 6.2.

As part of the TRX Info Collection, the **Channel Load Ratio (CLR)** measurement function estimates the actual channel load ratio for a specific ALI group for a given technology. This function is not MCO specific and thus will not be further specified in the present document. This technology specific ratio is as such provided to higher layers.

The AliID for the frames to be transmitted and the AliID of the received frames may be transferred between the layers as part of the data packets. This would simplify the required synchronization between the configuration information contained in the AliID and the related data frame.

6 MCO Access layer extension

6.1 Introduction

An MCO enabled access layer needs to support certain functionalities to permit the distribution of the C-ITS traffic onto the available physical channels with a specific set of parameters as defined by the AliID. These extensions shall be fully backward compatible with the Release 1 devices.

6.2 Access layer instance IDentifier (AliID)

The Access layer instance IDentifier (AliID) shall represent a unique identifier for the access layer instance. Based on the AliID it shall be possible to set all relevant parameters of a transceiver. A specific transceiver might not be capable of supporting all possible parameter combinations.

The AliID may consist of eight positions (1 letter and 8 decimal digit numerical positions):

- AliID contains a letter to identify the access layer technology, first position of the AliID:
  - A: ITS-G5;
  - B: ITS-G5 with 11bd capabilities;
  - C: LTE-V2X;
  - D: NR-V2X.
- The first and second figure specify the used physical channel, 2 and 3 position:
  - 00: SCH0;
  - 01: SCH1;
  - …
  - 06: SCH6;
  - 07: ….

NOTE 1: Two figures are required to cover future extension like 60 GHz, 2 570 MHz to 2 620 MHz, channel bounding.

- Third and fourth figure specify Reliability Indicator (RID):
  - In the case of ITS-G5, the RID figure indicates directly the MCS, following Annex A, Table A.1;
  - In the case of ITS-G5 with 11bd capabilities, the RID figure indicates directly the MCS, following Annex A, Table A.2;
  - In the case of LTE-V2X, see clause A.3;
  - In the case of NR-V2X, see clause A.4.
- The fifth figure specifies the number of access layer repetitions: 0 to 9.
- The sixth and seventh figure specify the TX power:
  - 00: 0 dBm
  - 01: 3 dBm
  - 02: 6 dBm
  - ...
  - 07: 21 dBm
  - 08: 24 dBm
  - ...
  - 99: not known

NOTE 2: In the AliID corresponding to a received message, the power level is set to 99 (not known).

- The eighth figure may be used for specific configurations:
  - 0: received message.
  - 1: standard configuration.

6.3 ALI groups

An ALI group represent the access layer technology and the used channel. An ALI group shall be identified by a locally unique identifier called AliGroupID. The AliGroupID is composed of the first letter of the AliID and the two following digits of the AliID.

A transceiver may be switched between the different ALI groups. This switching process may take some time and thus could lead to a significant delay. A transceiver already active on an ALI group may be easily configured with the MCS/RDI and TX power parameters on a message-by-message basis.

Thus, two different sets of ALI parameters exist, highly dynamically configurable parameters (MCS, TX power, etc.) and quasi static parameters (channel, technology: ALI group). For the higher layers, an information about the available ALI groups shall be provided. To capture this behaviour and the related information flow to higher layers different states of an ALI group are defined:

- 0: Not Active
- 1: RX only active
- 2: TX/RX active
- 3: not available

The actual state of an ALI group shall be set by higher layers. The setting of the ALI group state may be signalled to higher layers.

6.4 MCO_ACC Interfaces

6.4.1 Overview

The MCO_ACC entity shall support the MCO related interfaces illustrated in Figure 1 to Figure 3. All MCO related specified interfaces in the present document are station internal only. The detailed format of the parameters to be exchanged are implementation specific and need not to be specified in the present document.

6.4.2 Input parameters from higher layers

Table 1: List of M-Param for the ACC_NET_MMT interface

M-Param.No	Name of M-Param	Access	Format	Description
0	AliID	R	not relevant (internal parameter, see Annex B)	AliID per message to be transmitted to ALI operation entity
1	AliGroupStatus	R	not relevant (internal parameter, see Annex B)	Set the status of the available ALI groups in the access layer. 0: Not defined 1: activate RX only 2: activate TX/RX

6.4.3 Output parameter to higher layers

Table 2: List of M-Param for the ACC_NET_MMT interface

M-Param.No	Name of M-Param	Access	Format	Description
2	CLR	W	not relevant (internal parameter, see Annex B)	Channel load ratio per ALI group, to "higher layers every [100] ms: Channel Load Ratio as value 0 to 1 with a resolution of 0,01 The parameter shall contain the CLR value and the AliGroupID
3	ALN	W	not relevant (internal parameter, see Annex B)	Access layer notification per message to higher layers
4	AliID	W	not relevant (internal parameter, see Annex B)	AliID of received message
5	AliGroupStatus	W	not relevant (internal parameter, see Annex B)	Status of the available ALI groups in the access layer. 0: Not Active 1: RX only active 2: TX/RX active

Annex A (normative): AliID reliability indicators

A.1 ITS-G5

Table A.1 shows the reliability indicators and related modulation and coding schemes for ITS-G5.

Table A.1: MCS for ITS-G5

RID_Nr (figure 3 and 4 of AliID)	Modulation	Rate R	Channel Coder
00	BPSK	1/2	CC
01	BPSK	3/4	CC
02	QPSK	1/2	CC
03	QPSK	3/4	CC
04	16-QAM	1/2	CC
05	16-QAM	3/4	CC
06	64-QAM	2/3	CC
07	64-QAM	3/4	CC

A.2 ITS-G5 with 11bd capabilities

Table A.2 shows the reliability indicators and related modulation and coding schemes for ITS-G5 with 11bd capabilities.

Table A.2: MCS for ITS-G5 with 11bd capabilities

RID_Nr (figure 3 and 4 of AliID)	Modulation	Rate R	Channel Coder
ITS-G5 compatible RIDs			
00	BPSK	1/2	CC
01	BPSK	3/4	CC
02	QPSK	1/2	CC
03	QPSK	3/4	CC
04	16-QAM	1/2	CC
05	16-QAM	3/4	CC
06	64-QAM	2/3	CC
07	64-QAM	3/4	CC
ITS-G5 with 11bd capabilities RIDs			
08	BPSK	1/2	LDPC
09	QPSK	1/2	LDPC
10	QPSK	3/4	LDPC
11	16-QAM	1/2	LDPC
12	16-QAM	3/4	LDPC
13	64-QAM	2/3	LDPC
14	64-QAM	3/4	LDPC
15	64-QAM	5/6	LDPC
16	256-QAM	3/4	LDPC
17	256-QAM	5/6	LDPC
18 to 22	Reserved		
23	BPSK with DCM	1/2	LDPC

A.3 LTE-V2X

The reliability indicators and related modulation and coding schemes for LTE-V2X are not defined yet.

A.4 NR-V2X

The reliability indicators and related modulation and coding schemes for NR-V2X are not defined yet.

Annex B (informative): Output and inputs formats

B.1 Input parameters from higher layers

Table B.1: List of M-Param for the MCO_ACC_NET interface, Ali related

M-Param.No	Name of M-Param	Access	Format	Description
1	AliID	R	One letter, 8 decimal digits See clause 6.2	AliID per message to be transmitted, to ALI operation entity

Table B.2: List of M-Param for the MCO_ACC_NET interface, AliGroup related

M-Param.No	Name of M-Param	Access	Format	Description
	AliGroupID	R	One letter, 2 decimal digits See clause 6.3	AliGroupID represent the access layer technology and the used channel See clause 6.3
2	AliGroupStatus	R	One decimal digit: 0: Not Active 1: RX only active 3: TX/RX active 4 to 9: reserved	Set the status of the available ALI groups in the access layer

B.2 Output parameter to higher layers

Table B.3: List of M-Param for the MCO_ACC_NET interface

M-Param.No	Name of M-Param	Access	Format	Description
5	ALN	W	8 bit vector:	Access layer notification per message to higher layers
6	AliID	W	One letter, 8 decimal digits See clause 6.2	AliID of received message
7	AliGroupStatus	W	One decimal digit: 0: Not Active 1: RX only active 3: TX/RX active 4 to 9: reserved	Status of the available ALI groups in the access layer. 0: Not Active 1: RX only active 3: TX/RX active

Table B.4: List of M-Param for the MCO_ACC_NET interface. Channel load ratio

M-Param.No	Name of M-Param	Access	Format	Description
	AliGroupID	W	One letter, 2 decimal digits See clause 6.3	AliGroupID represent the access layer technology and the used channel See clause 6.3
4	CLR	W	Number between 0 and 1 with a resolution of 0,01	Channel load ratio per ALI group, to higher layers every [100] ms: Channel Load Ratio as value 0 to 1 with a resolution of 0,01

Annex C (informative): Bibliography

EN/ISO 17419:2018: "Intelligent transport systems - Cooperative systems - Globally unique identification".

Annex D (informative): Change History

Date	Version	Information about changes
06/2021	0.0.1_0.0.1	Initial skeleton created as early draft
09/2021	0.0.1_0.0.1	Some details have been added, still early draft version
03/2022	0.0.6	Stable draft version
04/2022	0.0.7_V01	Update based in STF feedback
04/2022	0.0.7 V02	Update after STF meeting 4.4.2022
05/2022	0.0.7_V04	Updated after STF meeting 2.5.2022
05/2022	0.0.7_V05	Updated from Paul
05/2022	0.0.7_V07	Updated after STF call 9.5.2022
06/2022	0.0.9	Updated after RC based on received comments
10/2022	0.0.10	Version after TC RC

History

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