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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

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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

The present document outlines the two lowest OSI layers - physical layer and data link layer - for the Cooperative ITS (C-ITS) direct ITS-S to ITS-S wireless AdHoc Networking communication protocol stack used in the 5,9 GHz frequency band as allocated in Europe in compliance with Commission Decision 2008/671/EC [i.1], ECC/DEC/(08)01 [i.2] and ECC/REC/(08)01 [i.3] and specified in the COMMISSION IMPLEMENTING DECISION (EU) 2020/1426 of 7 October 2020 [i.1]. The two lowest layers together form the access layer. The technology specified in the present document is part of the so called ITS-G5 stack.

In the ITS-G5 access layer, the data link layer is divided into two sublayers: Medium Access Control (MAC) and Logical Link Control (LLC). The physical layer and the medium access control layer are specified in IEEE 802.11™-2020 [1] and corresponding extension IEEE 802.11bd™-2022 [2]. The logical link control is based on the IEEE/ISO/IEC 8802-2-1998 [3].

ITS-G5 realizes AdHoc peer-to-peer mode communication functionality as defined in IEEE 802.11™-2020 [1] and corresponding extension IEEE 802.11bd™-2022 [2]. Operating profiles requiring synchronization and authentication as specified in IEEE 802.11™-2020 [1] or any other version of 802.11™ are not supported. To manage congestion, ITS-G5 provides Decentralized Congestion Control (DCC) mechanisms as specified in clause 4.6. How to ensure coexistence with other systems is handled in clause 4.7.

1 Scope

The present document defines the access layer for ITS-G5 consisting of the physical layer and the data link layer, as part of the ITS station architecture.

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.

[1] 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".

[2] IEEE 802.11bd™-2022: "IEEE Standard for Information technology- Tele- communications 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". .

[3] IEEE/ISO/IEC 8802-2-1998: "Information technology -- Telecommunications and information exchange between systems -- Local and metropolitan area networks -- Specific requirements -- Part 2: Logical Link Control".

[4] IEEE 802™-2014: "IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture".

[5] ETSI EN 302 571: "Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[6] ETSI TS 102 792: "Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range".

2.2 Informative 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.

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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] Commission Implementing Decision (EU) 2020/1426 of 7 October 2020 on the harmonised use of radio spectrum in the 5 875-5 935 MHz frequency band for safety-related applications of intelligent transport systems (ITS) and repealing Decision 2008/671/EC.

[i.2] ECC/DEC/(08)01: "ECC Decision (08)01 on the harmonised use of the band 5875-5925 MHz for Intelligent Transport Systems (ITS)".

[i.3] ECC/REC/(08)01: "ECC Recommendation (08)01 on the use of the band 5855-5875 MHz for Intelligent Transport Systems (ITS)".

[i.4] ETSI TS 103 695: "Intelligent Transport Systems (ITS); Access layer specification in the 5 GHz frequency band; Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS); Release 2".

[i.5] ETSI TS 102 687: "Intelligent Transport Systems (ITS); Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

basic service set: smallest building block of an IEEE 802.11™ network

channel: instance of a Wireless Medium (WM) use for the purpose of passing physical layer (PHY) Protocol Data Units (PDUs) between two or more ITS-S's

NOTE: Unless otherwise stated the channel refers to a 10 MHz bandwidth.

Channel Busy Ratio (CBR): ratio between the time a receiver perceives a radio channel as busy and the total time, expressed as a percentage

coexistence: situation in which one radio system operates in an environment where another radio system having potentially different characteristics may be using the same or different channels, and radio systems are able to operate with some tolerable impact to each other

data rate: number of user data bits which can be transmitted in a stream per unit of time (EG/Mbs)

duty cycle: ratio between the transmitter T_{on} time and the total time, expressed as a percentage

ethertype: identifier to the network protocol above the data link layer

ITS-G5 access layer: access layer technology to be used in frequency bands dedicated for European Intelligent Transport Systems (ITS)

spectrum band: specific range of frequencies in the electromagnetic frequency spectrum assigned to specific applications

3.2 Symbols

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

aCWmax	Maximum value of Contention Window
aCWmin	Minimum value of Contention Window
AIFS	Arbitration InterFrame Space
AIFSN	Arbitration InterFrame Space Number
aSIFSTime	Short InterFrame Space defined by the physical layer
aSlotTime	A slot time defined by the physical layer

CW	Contention Window
CW_{max}	Maximum value of Contention Window
CW_{min}	Minimum value of Contention Window
CBR_{CH}	Channel busy ratio for a specific channel used by the MAC
Cth	congestion threshold
G^{+}_{max}	control parameter
G^{-}_{max}	control parameter
$GCBR$	Channel busy ratio provided by upper layers derived from all ITS-Ss active in the AdHoc network
$GCBR_{CH}$	Channel busy ratio for a specific channel provided by upper layers derived from all ITS-Ss active in the AdHoc network
$LCBR$	Channel busy ratio measured by the ITS-S
$LCBR_{CH}$	Channel busy ratio for a specific channel measured by the ITS-S
T_{Lbusy}	period of time the channel is busy for a given ITS-S
T_{LCBR}	period of time for a given ITS-S
T_{on}	duration of a transmission
T_{on_pp}	duration of the previous transmission
T_{off}	minimum time between two transmissions
Nss	Number of spatial streams
δ	$T_{on}/(T_{on} + T_{off})$
α	control parameter α
β	control parameter β
δ_{max}	maximum value of δ
δ_{min}	minimum value of δ
δ_{offset}	offset value of δ
t	current system time
t_{go}	time when gate keeper opens
t_{pg}	time when the gate keeper closes

3.3 Abbreviations

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

BPSK	Binary Phase Shift Keying
BSS	Basic Service Set
CAM	Coopearative Awareness Message
CBR	Channel Busy Ratio
CEN	European Committee for Standardization
CH	Channel
C-ITS	Cooperative Intelligent Transport Systems
DC	Duty Cycle
DCC	Decentralized Congestion Control
DCM	Dual Sub-Carier Modulation
DSRC	Dedicated Short-Range Communication
DUT	Device Under Test
ECC	Electronic Communication Committee
EN	European Norm
EPD	EtherType Protocol Discrimination
FiFo	First in First out
GCBR	Global CBR
HalfBT	Half Bathtub
HDR	High Data Rate
ID	IDentifier
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transport Systems
ITS-S	Intelligent Transport Systems Station
LCBR	Local CBR
LLC	Logical Link Control
LOS	Line-Of-Sight
LPD	Low Probability of Detection

LTF	Long Training Field
MAC	Medium Access Control
MCO	Multi Channel Operation
MCS	Modulation and Coding Scheme
MIB	Management Information Base
MIMO	Multiple-Input and Multiple-Output
NGV	Next Generation V2X
NLOS	Non Line-Of-Sight
NUM_SS	Number of Spetial Streams
N&T	Networking & Transport
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open Systems Interconnection
PDU	Protocol Data Unit
PER	Packet Error Rate
PHY	Physical layer
PSDU	PLCP Service Data Unit
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RLAN	Radio Local Area Network
RSSI	Received Signal Strength Indicator
SNAP	SubNetwork Access Protocol
SPATEM	Signal Phase And Timing Extended Message
TDL	Tapped Delay Line
TH	Thress Hold
TS	Technical Specification
TX	Transmitter
VNC	Vehicular Networking Conference

4 Access layer requirements

4.1 Introduction

The access layer bundles the data link layer and the physical layer and is situated at the bottom of the protocol stack, (see Figure 1) for the ITS protocol stack is part of the ITS-S reference architecture. The data link layer includes the Logical Link Control (LLC) entity and the Medium Access Control (MAC) entity.

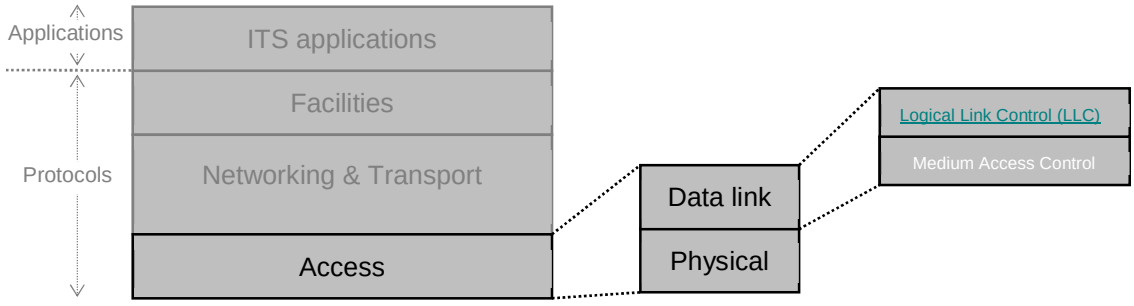

Figure 1: Access layer in the ITS-S reference architecture

For ITS-G5, the access layer is based on IEEE 802.11™-2020 [1], IEEE802.11bd™-2022 [2], IEEE/ISO/IEC 8802-2-1998 [3] and IEEE 802 ™-2014 [4] specifications.

The Management Information Base (MIB) parameter `dot11OCBActivated` as specified in IEEE 802.11™-2020 [1] shall be set to true, with the result that the system communicates outside the context of a Basic Service Set (BSS), by which neither authentication/association specified procedures nor security specified mechanisms are used. Further, no access point functionality is present. It also disables the requirement that ITS-Ss should share a common clock and scanning of available frequency channels for joining a BSS. The effect of operating outside the context of the BSS, implies that additional functionality is required to manage the congestion in a channel (see clause 4.6).

As the C-ITS operates in a spectrum band where also other systems may be active possible mitigation measures are identified in clause 4.7.

An ITS-S may support C-ITS data dissemination via multiple radio channels operating in different spectrum bands.

4.2 Access layer architecture

An overview of the functionalities is depicted in Figure 1.

An ITS-G5 Access layer shall be based on the IEEE 802.11™-2020 [1] with the band-specific operating requirements in Annex E.2.4 [1], and optionally includes NGV operations as specified in the amendment IEEE 802.11bd™-2022 [2].

An Access layer shall be implemented according at least one of the profiles as defined in Table 1.

Table 1: Access layer profiles

Profile number	MAC-PHY specification	Comment
Profile 1	IEEE 802.11™-2020 [1]	Profile for ITS low-data rate type of messages.
Profile 2	IEEE 802.11™-2020 [1] amended by IEEE 802.11bd™[2]	Profile for ITS low-data rate type of messages, with enhanced performance.

When Access layer Profile 2 with NGV format is supported, channel bonding as defined in the IEEE 802.11bd™-2022 [2] amendment that supports 20 MHz channel access with a 10 MHz primary and 10 MHz secondary channels can be implemented as an option.

An example of how the Management and Data interface could look like is given in Annex B.

4.3 Physical layer

4.3.1 Introduction

The ITS-G5 physical layer can operate with different Modulation and Coding Schemes (MCSs) and comply to specific Transmitter and Receiver performance requirements. Some of these MCSs including the transmitter and receiver performance requirements are mandatory as specified in clause 4.3.

4.3.2 Mandatory MCSs

The MCSs BPSK, QPSK, and 16-QAM with coding rate 1/2 and one spatial stream (*Nss* = 1) shall be supported. 10 MHz bandwidth shall be supported in profile 1 and in profile 2. If channel bonding is supported in profile 2 then those MCSs are mandatory for a bandwidth of 20 MHz.

4.3.3 Transmitter requirements

For the operation in 10 MHz mode the transmitter requirements shall be as specified in ETSI EN 302 571 [5], clause 4.2.1, clause 4.2.2, clause 4.2.3, clause 4.2.4 and clause 4.2.5.

For operation with profile 2 with NGV format in 20 MHz channel bonding mode the transmitter requirements as given in ETSI EN 302 571 [5], clause 4.2.5.2 shall be as given in Table 2.