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Vehicular Communications;
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Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications;
Sub-part 2: Media-dependent functionalities for ITS-G5

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Foreword

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

The present document is part 4, sub-part 2 of a multi-part deliverable. Full details of the entire series can be found in part 1 [i.1].

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 GeoNetworking protocol is a network protocol that provides packet routing in an ad hoc network. It makes use of geographical positions for packet transport. GeoNetworking supports the communication among individual ITS-Ss as well as the distribution of packets in geographical areas.

GeoNetworking can be executed over different ITS access technologies for short-range wireless technologies, such as ITS-G5. In order to reuse the GeoNetworking protocol specification for multiple ITS access technologies, the specification is separated into media-independent and media-dependent functionalities. Media-independent GeoNetworking functionalities are those which are common to all ITS access technologies for short-range wireless communication and are specified in ETSI EN 302 636-4-1 [1]. The present document specifies media-dependent functionalities for GeoNetworking when using the ITS access technology ITS-G5 (see ETSI EN 302 663 [2]). The specification in the present document should be regarded as ITS-G5 specific extensions of the GeoNetworking protocol specified in ETSI EN 302 636-4-1 [1] and does not represent a distinct protocol entity.

1 Scope

The present document specifies the media-dependent functionalities for GeoNetworking defined in ETSI EN 302 636-4-1 [1] over ITS-G5 defined in ETSI EN 302 663 [2] as a network protocol for ad hoc routing in vehicular environments.

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.

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

[1] ETSI EN 302 636-4-1 (V1.4.1): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality".

[2] ETSI EN 302 663 (V1.3.1): "Intelligent Transport Systems (ITS); ITS-G5 Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[3] ETSI TS 103 175 (V1.1.1): "Intelligent Transport Systems (ITS); Cross Layer DCC Management Entity for operation in the ITS G5A and ITS G5B medium".

[4] ETSI TS 102 687 (V1.2.1): "Intelligent Transport Systems (ITS); Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part".

[5] ETSI TS 103 301 (V1.3.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services".

[6] Car-2-Car Communication Consortium Version 1.5.2: "Basic System Profile".

NOTE: Available at https://www.car-2-car.org/documents/basic-system-profile.

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] ETSI EN 302 636-1 (V1.2.1): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 1: Requirements".

[i.2] ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications Architecture".

[i.3] ETSI EN 302 571 (V2.1.1): "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".

[i.4] IEEE 802.11™-2016: "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".

[i.5] IEEE™ Registration Authority.

NOTE: Available at https://standards.ieee.org/content/ieee-standards/en/products-services/regauth/index.html.

[i.6] List of assigned EtherTypes at the IEEE™ Registration Authority.

NOTE: Available at http://standards-oui.ieee.org/ethertype/eth.txt.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI EN 302 636-4-1 [1], ETSI EN 302 663 [2], ETSI TS 103 175 [3], ETSI TS 102 687 [4] and the following apply:

1-hop channel busy ratio: highest local channel busy ratio that the ego ITS station has received from its 1-hop neighbourhood over a certain time

2-hop channel busy ratio: highest 1-hop channel busy ratio that the ego ITS station has received from its 1-hop neighbourhood over a certain time

channel busy ratio: time-dependent value between zero and one (both inclusive) representing the fraction of time that the channel was busy

global channel busy ratio: maximum of the local channel busy ratio, the 1-hop channel busy ratio and the 2-hop channel busy ratio

local channel busy ratio: time-dependent value between zero and one (both inclusive) representing the channel busy ratio as perceived locally by a specific ITS station

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 302 636-4-1 [1], ETSI EN 302 663 [2], ETSI TS 103 175 [3], ETSI TS 102 687 [4] and the following apply:

CBR_L_0_Hop	Local channel busy ratio for a specific frequency channel for ego ITS station
CBR_L_1_Hop	Highest received value of *CBR_R_0_Hop*
CBR_L_2_Hop	Highest received value of *CBR_R_1_Hop*
CBR_R_0_Hop	Local channel busy ratio *CBR_L_0_Hop* disseminated in single-hop broadcast packets
CBR_R_1_Hop	Highest received *CBR_L_1_Hop* disseminated in single-hop broadcast packets
CBR_Target	Intended global channel busy ratio
CBR_G	Global channel busy ratio for a specific frequency channel
T_Cbr	Lifetime of the channel busy ratio
T_Trig	Trigger interval to update *CBR_G*

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 302 636-4-1 [1], ETSI EN 302 663 [2], ETSI TS 103 175 [3], ETSI TS 102 687 [4] and the following apply:

LocTEX Location Table Entry eXtension

4 Overview

The present document specifies the media-dependent functionalities necessary to run the GeoNetworking protocol defined in ETSI EN 302 636-4-1 [1] over the ITS-G5 access technology defined in ETSI EN 302 663 [2]. The functionalities are:

- Decentralized congestion control (DCC) at the networking & transport layer for the ITS-G5 access technology, specifically information sharing for DCC (DCC_NET) (clause 5).
- Addressing, data structure extensions and field settings in the GeoNetworking headers for ITS-G5 (clause 6).
- Extensions for packet handling of the GeoNetworking protocol for ITS-G5 (clause 7).
- Mapping of traffic classes to transmission parameters for ITS-G5 (clause 8).

The present document also proposes extensions for forwarding algorithms of the GeoNetworking protocol for ITS-G5 (annex C).

Figure 1 illustrates the ITS reference architecture as specified in ETSI EN 302 665 [i.2]. The present document specifies ITS-G5 specific, media-dependent functionalities for the GeoNetworking protocol, which are found in the networking & transport layer.

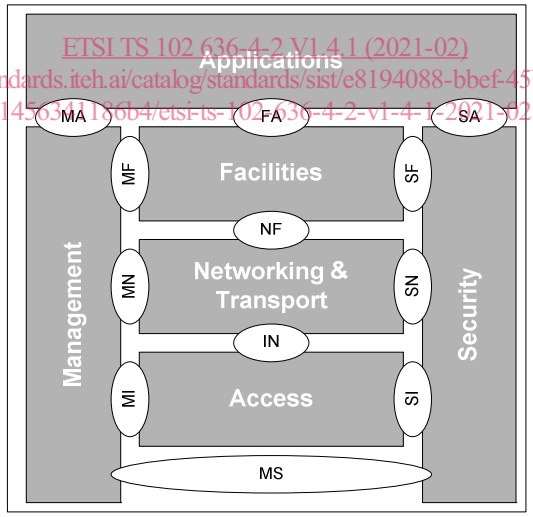

Figure 1: ITS-S reference architecture as specified in ETSI EN 302 665 [i.2]

A GeoNetworking packet transmitted over the ITS-G5 access technology is part of the overall frame/packet structure depicted in figure 2 (without security) and figure 3 (with security), respectively:

1) The *MAC header* is the header of the MAC protocol of the ITS-G5 access technology. The MAC protocol adds an additional protocol element for the trailer for the MAC FCS as specified in ITS-G5 defined in ETSI EN 302 663 [2].

NOTE 1: The MAC header is not specified by the present document. However, the GeoNetworking protocol sets the MAC address, or more generally the link layer address, in order to define and identify the next hop of a GeoNetworking packet.

2) The LLC header is the header of 802.2 LLC (see ETSI EN 302 663 [2]).

3) The *GeoNetworking header* is the header of the GeoNetworking packet as defined in ETSI EN 302 636-4-1 [1] extended for media-dependent GeoNetworking functionality over ITS-G5 as specified in the present document.

4) The optional payload represents the user data that are created by upper protocol entities, i.e. the T-SDU or GN6-SDU. It is passed to the GeoNetworking protocol for transmission.

NOTE 2: The general packet structure is shown as seen by the MAC protocol of the ITS-G5 access technology.

NOTE 3: Some GeoNetworking packets do not carry a payload, such as Beacon.

MAC Header	LLC Header	GeoNetworking Header	Payload (optional)

Figure 2: GeoNetworking packet structure over ITS-G5 (without security)

MAC Header	LLC Header	GeoNetworking Basic Header	GeoNetworking Secured Packet with Common Header, Optional Extended Header and Optional Payload

Figure 3: GeoNetworking packet structure over ITS-G5 (with security)

5 DCC functionality at networking & transport layer (DCC_NET) for ITS-G5

5.1 General

An ITS-S operating the ITS-G5 access technology supports Decentralized Congestion Control (DCC) to ensure that the radio channel is not congested by too many transmissions within a certain geographical range (see ETSI EN 302 571 [i.3]. As specified in ETSI TS 103 175 [3], clause 5 "DCC architecture", the DCC functionality is distributed among the entities DCC_FAC, DCC_NET, DCC_ACC and DCC_CROSS at the different layers and entities of the ITS reference architecture (see figure 4).

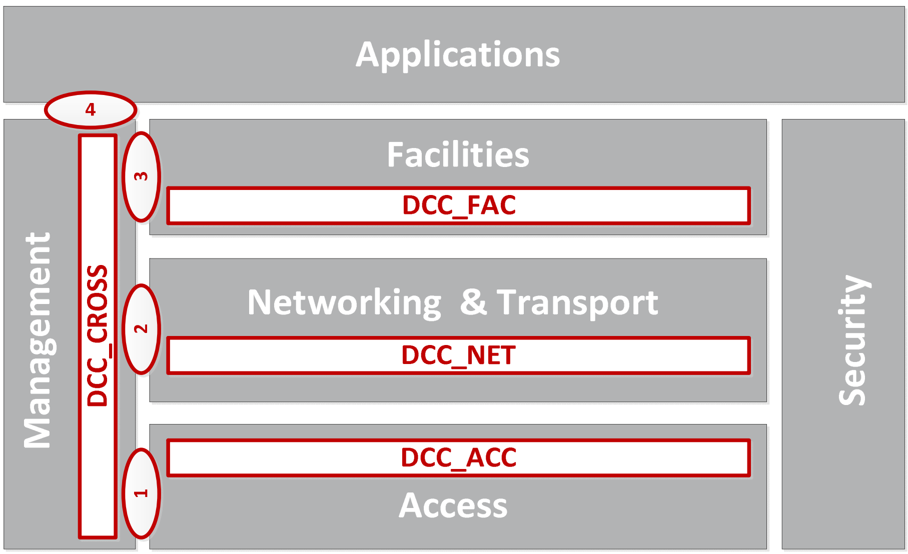

Figure 4: DCC architecture as specified in ETSI TS 103 175 [3]

The GeoNetworking protocol (see ETSI EN 302 636-4-1 [1]) over the ITS-G5 access technology (see ETSI EN 302 663 [2]) provides the DCC functionality over ITS-G5 access technology (DCC_NET). DCC_NET shall support the following functionality:

- maintain DCC state variables as specified in clause 5.2;
- periodically calculate the global Channel Busy Ratio *CBR_G* as specified in clause 5.3;
- process and provide DCC-related information to the DCC_CROSS entity as specified in clause 5.4;
- store and maintain DCC-related information using the Location Table Entry Extension for ITS-G5 (LocTEX-G5) as specified in clause 6.2;
- transmit and receive DCC-related information to other GeoNetworking routers using the extensions for GeoNetworking packet handling as specified in clause 7.2.

In addition, DCC_NET may provide DCC-related information to the GN forwarding algorithm as specified in annex C.

5.2 Maintenance of DCC variables

If DCC_NET is present, it shall maintain the following DCC variables:

- *CBR_L_0_Hop*,
- *CBR_L_1_Hop*,
- *CBR_L_2_Hop*,
- *CBR_R_0_Hop*,
- *CBR_R_1_Hop*,
- *CBR_G*, and
- *CBR_Target*.

The CBR variables are described in detail in table 1.

Table 1: Description of DCC variables in DCC_NET

Parameter	Description
CBR_L_0_Hop	Measured local channel busy ratio CBR, disseminated to neighbouring ITS-S as *CBR_R_0_Hop*.The local CBR measurement is performed in the access layer and specified in ETSI TS 102 687 [4].
CBR_L_1_Hop	*CBR_L_1_Hop* is the maximum *CBR_R_0_Hop* value received from a neighbouring ITS-S in a given *T_Cbr* interval, i.e. it is the 1-hop channel busy ratio. It is subsequently disseminated to neighbours as *CBR_R_1_Hop.*
CBR_L_2_Hop	*CBR_L_2_Hop* is the maximum *CBR_R_1_Hop* value received from a neighbouring ITS-S in a given *T_Cbr* interval, i.e. it is the 2-hop channel busy ratio. It is calculated locally and not disseminated directly by an ITS-S.
CBR_R_0_Hop	Disseminated (measured) local channel busy ratio (*CBR_L_0_Hop*), i.e. *CBR_L_0_Hop* becomes *CBR_R_0_Hop* when disseminated. At the receiving ITS-S, it becomes *CBR_L_1_Hop.*
CBR_R_1_Hop	Disseminated 1-hop channel busy ratio (*CBR_L_1_Hop*), i.e. *CBR_L_1_Hop* becomes *CBR_R_1_Hop* when disseminated. At the receiving ITS-S it becomes *CBR_L_2_Hop.*
CBR_G	Global channel busy ratio at ego ITS-S, used in the DCC algorithm (maximum over *CBR_L_0_Hop*, *CBR_L_1_Hop* and *CBR_L_2_Hop*), see clause 5.3.
CBR_Target	Intended global channel busy ratio that DCC tries to achieve. *CBR_Target* is constant and its value shall be the same at DCC_NET and DCC_ACC.

The DCC variables *CBR_R_0_Hop* and *CBR_R_1_Hop* are per ITS-S in the location table (see clause 6.2 "Location table extensions for ITS-G5" in the present document), i.e. for every ITS-S, *i*, in the location table:

- *CBR_R_0_Hop*(*i*) is the remote *CBR_L_0_Hop* received from *i*,
- *CBR_R_1_Hop*(*i*) is the remote *CBR_L_1_Hop* received from *i*.

5.3 Calculation of the global channel busy ratio *CBR_G*

To calculate *CBR_G*, the following steps shall be executed at every *T_Trig*:

The value of *T_Trig* equals the GeoNetworking protocol constant `itsGNCBRGTriggerInterval`. Within the trigger interval *T_Trig*, all ITS-S shall start with a random time offset.

The values of *CBR_L_1_Hop(0)* and *CBR_L_2_Hop(0)* shall be initialized to 0.

NOTE: The time offset prevents that all ITS-Ss to trigger the calculation of *CBR_G* at the same time.

Step 1: Calculate the average of *CBR_R_0_Hop*(*i*), i.e. (1)

$$\overline{CBR\_R\_0\_Hop} := \frac{1}{n_0}\sum_i CBR\_R\_0\_Hop(i) \ \ \forall i \text{ where } CBR\_R\_0\_Hop(i) \text{ is not older than } T\_Cbr$$

where n_0 is the total number of the *CBR_R_0_Hop* entries that are not outdated (older than *T_Cbr)*

Step 2: **If** $\overline{CBR\_R\_0\_Hop} > CBR\_target$ (2)

CBR_L_1_Hop := $\max_i$ { *CBR_R_0_Hop* (i) } during the last CBR lifetime *T_Cbr*

Else

set *CBR_L_1_Hop* to the second largest *CBR_R_0_Hop* (i) during the last CBR lifetime *T_Cbr*

Step 3: Calculate the average of *CBR_R_1_Hop*(*i*), i.e. (3)

$$\overline{CBR\_R\_1\_Hop} := \frac{1}{n_1}\sum_i CBR\_R\_1\_Hop(i) \ \ \forall i \text{ where } CBR\_R\_1\_Hop(i) \text{ is not older than } T\_Cbr$$

where n_1 is the total number of the *CBR_R_1_Hop* entries that are not outdated (older than *T_Cbr)*

Step 4: **If** $\overline{CBR\_R\_1\_Hop} > CBR\_target$ (4)

CBR_L_2_Hop := $\max_i$ { *CBR_R_1_Hop* (i) } during the last CBR lifetime *T_Cbr*

Else

Set *CBR_L_2_Hop* to the second largest *CBR_R_1_Hop* (i) during the last CBR lifetime *T_Cbr*

Step 5: Calculate the global channel busy ratio CBR_G (5)

CBR_G (*n*) := max (*CBR_L_0_Hop* (*n*-1), *CBR_L_1_Hop* (*n*), *CBR_L_2_Hop* (*n*))

where n corresponds to the *n*th trigger interval, *T_trig*

The *CBR_G* value is passed from the DCC_NET entity to the DCC_CROSS entity (see clause 5.4) and input to the DCC algorithm running at the access layer as specified in ETSI TS 102 687 [4].

5.4 DCC_NET

As specified in ETSI TS 103 175 [3], clause 5.3 "DCC_NET", if GeoNetworking over ITS-G5 is used, a DCC_NET entity shall be present.

The DCC_NET entity shall process the local CBR value, the CBR target value, and optionally the TX power level upper limit of each individual used radio channel as specified in ETSI TS 103 175 [3], clause 6.2 "DCC parameter evaluation" REQ008.

The service primitives and parameters for the interface between DCC_NET and the DCC_CROSS entity via the MN SAP are defined in ETSI TS 103 175 [3], clause 8.3 "Interface (2) with DCC_NET (MN SAP)".

NOTE: ETSI TS 103 175 [3] also specifies the parameters idle time T_{off} per radio channel (REQ012), the available resources that can be allocated per radio channel CBR_a, (REQ019), and the time when the last message was forwarded to the ITS-G5 radio (REQ019). These parameters are not used in the present document.

6 Addressing, data structure extensions and field settings for ITS-G5

6.1 GeoNetworking address

As specified in ETSI EN 302 636-4-1 [1], clause 6, every GeoAdhoc router shall have a unique GeoNetworking address and use the format in figure 5.

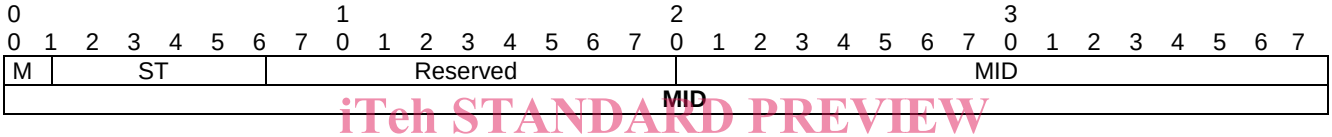

Figure 5: GeoNetworking address format as specified in ETSI EN 302 636-4-1 [1]

For the MID field in the GeoNetworking address, the 48-bit MAC address of the ITS-G5 network interface shall be used.

6.2 Location table extensions for ITS-G5

6.2.1 General

This clause specifies media-dependent extension to the Location Table Entry (LocTE) for GN over ITS-G5, following the structure specified in ETSI EN 302 636-4-1 [1], clause 7.1.

6.2.2 Definition of additional data elements for the location table entry

If DCC_NET (see clause 5) is present, the location table of the GeoAdhoc router shall include the extensions - named Location Table Entry Extension for ITS-G5 (LocTEX-G5) - for GN neighbours on ITS-G5 interfaces, as follows:

- Timestamp (local to ego station) of the last update of the LocTEX-G5, *TST_G5(GN_ADDR)*.
- Timestamp in the SO PV of the SHB packet header as specified in ETSI EN 302 636-4-1 [1], clause 9.5.2 "Long Position Vector", *TST_SO_PV_G5(GN_ADDR)*.

NOTE: *TST_SO_PV_G5* is only updated when a received packet updates the LocTEX-G5; therefore it does not necessarily equal the media-independent counterpart TST (POS, GN_ADDR) as specified in ETSI EN 302 636-4-1[1], clause 7.1.2.

- Transmit power of the packet that updated the LocTEX-G5 entry, as specified in clause 6.3.3, table 3 (field *DCC-MCO* octet 42, Bit 0 to Bit 4), *TX_POWER_G5(GN_ADDR)*.
- Received signal-strength indicator RSSI of the packet that updated the LocTEX-G5 entry, RSSI_G5(GN_ADDR).