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

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Foreword

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

Modal verbs terminology

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Executive summary

The present document specifies media-dependent functionalities for the GeoNetworking protocol when using the ITS access technology ITS-G5. These functionalities represent ITS-G5 specific extensions of the GeoNetworking protocol.

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 TS 103 836-4-1 [i.1]. The present document specifies media-dependent functionalities for GeoNetworking when using the ITS access technology ITS-G5 (see ETSI EN 303 797 [i.2]). The specification in the present document should be regarded as ITS-G5 specific extensions of the GeoNetworking protocol specified in ETSI TS 103 836-4-1 [i.1] and does not represent a distinct protocol entity.

1 Scope

The present document specifies the media-dependent functionalities for GeoNetworking defined in ETSI TS 103 836-4-1 [i.1] over ITS-G5 defined in ETSI EN 303 797 [i.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.

Referenced documents which are not found to be publicly available in the expected location might be found in the ETSI docbox.

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

Not applicable.

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.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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 TS 103 836-4-1: "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; Release 2".

[i.2] ETSI EN 303 797: "Intelligent Transport Systems (ITS); ITS-G5 Access layer in the 5 GHz frequency band; Release 2".

[i.3] ETSI TS 103 898: "Intelligent Transport Systems (ITS); Communications Architecture; Release 2".

[i.4] 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".

[i.5] IEEE™ Registration Authority.

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

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 836-4-1 [i.1], ETSI EN 303 797 [i.2] 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 TS 103 836-4-1 [i.1], ETSI EN 303 797 [i.2] 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 TS 103 836-4-1 [i.1], ETSI EN 303 797 [i.2] 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 TS 103 836-4-1 [i.1] over the ITS-G5 access technology defined in ETSI EN 303 797 [i.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 TS 103 898 [i.3]. The present document specifies ITS-G5 specific, media-dependent functionalities for the GeoNetworking protocol, which are found in the Networking & Transport layer.

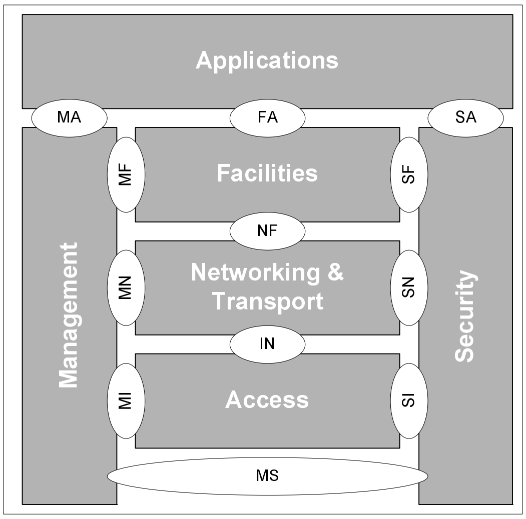

Figure 1: ITS-S reference architecture as specified in ETSI TS 103 898 [i.3]

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 303 797 [i.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 303 797 [i.2]).

3) The *GeoNetworking header* is the header of the GeoNetworking packet as defined in ETSI TS 103 836-4-1 [i.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 packet types 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. 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).

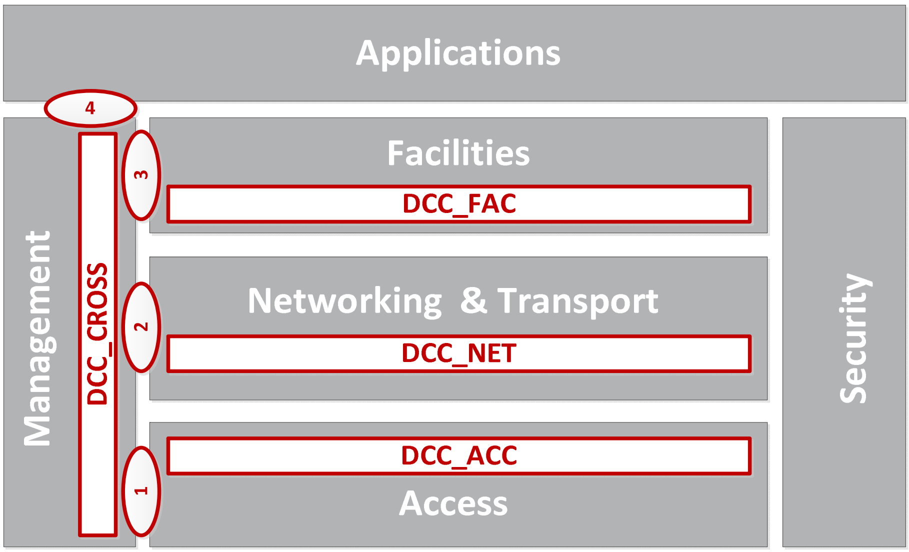

Figure 4: DCC architecture

The GeoNetworking protocol over the ITS-G5 access technology 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.
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)

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

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)

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

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 at the access layer.

5.4 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.

The service primitives and parameters for the interface between DCC_NET and the DCC_CROSS entity.

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

6.1 GeoNetworking address

As specified in ETSI TS 103 836-4-1 [i.1], clause 6, every GeoAdhoc router shall have a unique GeoNetworking address and use the format in figure 5.

0			1	2	3
0	1 2 3 4 5 6	7 0 1 2 3 4 5 6 7		0 1 2 3 4 5 6 7	0 1 2 3 4 5 6 7
M	ST	Reserved		MID	
MID					

Figure 5: GeoNetworking address format as specified in ETSI TS 103 836-4-1 [i.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 TS 103 836-4-1 [i.1], clause 8.1.

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 TS 103 836-4-1 [i.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 TS 103 836-4-1 [i.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).
- Disseminated local channel busy ratio received from GN_ADDR, *CBR_R_0_Hop* (see clause 5.2), i.e. *CBR_R_0_HOP(GN_ADDR)*.
- Disseminated 1-hop channel busy ratio received from GN_ADDR, *CBR_R_1_Hop* (see clause 5.2), i.e. *CBR_R_1_HOP(GN_ADDR)*.

6.2.3 Maintenance of additional data elements for the location table entry

The data elements in the LocTEX-G5 shall be updated as specified in ETSI TS 103 836-4-1 [i.1], clause 7.1 and the following additions:

- The data elements in the LocTEX-G5 shall only be updated for received GeoNetworking SHB packets as specified in ETSI TS 103 836-4-1 [i.1], clause 8.8.4.
- The data elements in the LocTEX-G5 shall **not** be updated if the packet causing the update is a duplicate packet or a packet received on an interface that is not of ITS-G5 type.
- The data elements in the LocTEX-G5 shall **not** be updated if the packet causing the update does **not** contain the optional DCC_MCO field as specified in clause 6.3 of the present document.
- Upon an update of the LocTE, data elements in the LocTEX-G5 shall be determined as follows:
    - *TST_G5* shall be determined from the local time source.

NOTE 1: Details are beyond the scope of the present document.

- *TST_SO_PV_G5* shall be copied from the SO PV field in the SHB packet header (see ETSI TS 103 836-4-1 [i.1], clause 9.8.4 "SHB packet header") using the TST subfield of the Long Position Vector LPV (see ETSI TS 103 836-4-1 [i.1], clause 9.5.2 "Long Position Vector").
- *TX_POWER_G5, CBR_R_0_Hop* and *CBR_R_1_Hop* shall be copied from the DCC_MCO field of the SHB packet header as specified in clause 6.3 of the present document.

- The LocTEX-G5 shall be discarded following the same procedure as for the media-independent fields specified in ETSI TS 103 836-4-1 [i.1], clause 8.2.3 "Maintenance of the Location Table".
- The LocTEX-G5 shall be soft-state, i.e. entries are added with a lifetime *T(LocTEX)* set to the value of the GN protocol constant `itsGnLifetimeLocTEX`. When the lifetime expires, the complete LocTEX-G5 shall be removed.

NOTE 2: The GeoNetworking protocol constants for ITS-G5 are specified in annex H of ETSI TS 103 836-4-1 [i.1], and in annex A of the present document.

6.3 Field settings in the GeoNetworking header

6.3.1 General

The present clause specifies setting and encoding of GN header fields specific for ITS-G5 access technology, i.e.:

- Traffic Class (TC) field in the *Common Header* (clause 6.3.2);
- DCC-MCO field in the *Extended Header* of the SHB packet (clause 6.3.3).

6.3.2 Field settings in the *Common Header*

As specified in ETSI TS 103 836-4-1 [i.1], the *Common Header* consists of the fields shown in figure 6. The Traffic Class Identifier (TC ID) is transmitted in the *TC* field.

<table>
<tr><td colspan="8">0</td><td colspan="8">1</td><td colspan="8">2</td><td colspan="8">3</td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td colspan="4">NH</td><td colspan="4">Reserved</td><td colspan="4">HT</td><td colspan="4">HST</td><td colspan="8">TC</td><td colspan="8">Flags</td></tr>
<tr><td colspan="16">PL</td><td colspan="8">MHL</td><td colspan="8">Reserved</td></tr>
</table>

Figure 6: *Common Header* format as specified in ETSI TS 103 836-4-1 [i.1]

As specified in ETSI TS 103 836-4-1 [i.1], clause 9.7.5, the *TC* field consists of three sub-fields, i.e. *SCF*, *Reserved* and *TC ID* (see table 2).

Table 2: *TC* field in the *Common Header*

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1 to 4	See table 4 in ETSI TS 103 836-4-1 [i.1].					
5	*TC*	Octet 2 Bit 0	Octet 2 Bit 7	Three sub-fields: • 1 bit selector; • 1 bit selector; • 6 bit selector.	n/a	Traffic class represents facility layer requirements on packet transport. Bit 0: **SCF** Flag indicating whether the packet shall be buffered when no neighbour exists (store-carry-forward). Bit 1: **Reserved** Bit 2 to Bit 7: **TC ID** *TC ID* as specified in the present document.
6 to 9	See table 7 in ETSI TS 103 836-4-1 [i.1].					

The mapping between *TC ID* and transmission parameters for ITS-G5 is specified in clause 8.

6.3.3 Field settings in the *Extended Header* of the SHB packet

As specified in ETSI TS 103 836-4-1 [i.1], clause 9.8.4, the SHB packet header carries a 4-byte, reserved field for media-dependent functionality (figure 7).

0 1 2 3

0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7

Basic Header
Common Header
SO PV
Reserved by ETSI TS 103 836-4-1 [i.1] and specified in the present document

Figure 7: The SHB packet header format as specified in ETSI TS 103 836-4-1 [i.1]

The present document replaces the field *Reserved* in ETSI TS 103 836-4-1 [i.1], table 15 by the field *DCC-MCO* (see table 3). The DCC-MCO consists of several sub-fields and shall be encoded as shown in table 3.

Table 3: Fields of the SHB packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1 to 3	See ETSI TS 103 836-4-1 [i.1], table 13.					
4	*DCC-MCO (was Reserved)*	Octet 40	Octet 43	32-bit unsigned integer	n/a	**Octet: 40** Bit 0 to Bit 7: Current *CBR_L_0_Hop* encoded as *floor(CBR_L_0_Hop × 255)* **Octet 41** Bit 0 to Bit 7: Current *CBR_L_1_Hop* encoded as *floor(CBR_L_1_Hop × 255)* **Octet 42** Bit 0 to Bit 4: Transmit power of the current packet, E.I.R.P. [0 dBm to 31 dBm, unit 1 dBm, values higher than 31 dBm shall be set to 31 dBm] Bit 5 to Bit 7: Reserved for future use **Octet 43** Reserved for MCO

NOTE: The present document specifies fields in the *Extended Header* only for the SHB packet header and not for other packet header types.

6.4 EtherType

The GeoNetworking protocol over ITS-G5 access technology as specified in ETSI TS 103 836-4-1 [i.1] and in the present document shall use the EtherType 0x8947.

NOTE: According to ETSI EN 303 797 [i.2] clause 4.5, for ITS-G5 the Subnetwork Access Protocol (SNAP) and the EtherType Protocol Discrimination (EPD) are used. EtherTypes are assigned by the IEEE Registration Authority [i.5] and a full list of all Ethertypes can be found in [i.6]. The Ethertype value assigned to the GeoNetworking protocol is in this list.
Both, SNAP and EPD, provide the possibility to distinguish between different network protocols through EtherTypes. SNAP is applied for packets encoded as per IEEE 802.11™-2020 [i.4] or IEEE 802.11bd™-2022 with FORMAT having value different than 'NGV' (i.e. 'NON_NGV_10'). EPD is applied for packets encoded as per IEEE 802.11bd™-2022 with FORMAT having the value 'NGV'.

7 Extensions of packet handling algorithms for ITS-G5

7.1 General

ETSI TS 103 836-4-1 [i.1], clause 10.3 "Packet handling" defines the behaviour of the GN protocol for handling of packets. The present clause specifies extensions for the packet handling of SHB packets for the transmission of ITS-G5 access technology.

NOTE: For other packet types than SHB, packet handling extensions are not defined.

7.2 Extensions of SHB packet handling

7.2.1 Extensions for source operations

If DCC_NET is present, on reception of a service primitive *GN DATA.request* with a *Packet transport type* parameter set to *SHB,* the source shall execute the following operation in step 5b) of ETSI TS 103 836-4-1 [i.1], clause 10.3.10.2 "Source operations"):

- Set the DCC-MCO field, more specifically:
  - *CBR_L_0_Hop*;
  - *CBR_L_1_Hop*;
  - Transmit power of the current packet.

Further details are specified in clauses 5.2 "Maintenance of DCC variables", 6.2 "Location table extensions for ITS-G5" and 6.3.3 "Field settings in the *Extended Header* of the SHB packet" of the present document.

7.2.2 Extensions for receiver operations

If DCC_NET is present, on reception of a SHB packet, the GeoAdhoc router shall execute the following operations between step 6) and step 7) of ETSI TS 103 836-4-1 [i.1], clause 10.3.10.3 "Receiver operations":

- Update the LocTEX-G5, more specifically:
  - *TST_G5(GN_ADDR)*;
  - *TST_SO_PV_G5 (GN_ADDR)*;
  - *TX_POWER_G5(GN_ADDR)*;
  - *RSSI_G5(GN_ADDR)*;
  - *CBR_R_0_Hop*;
  - *CBR_R_1_Hop*.

Further details are specified in clauses 5.2 "Maintenance of DCC variables", 6.2 "Location table extensions for ITS-G5" and clause 6.3.3 "Field settings in the *Extended Header* of the SHB packet" of the present document.

8 Mapping of traffic classes to transmission parameters for ITS-G5

As specified in ETSI TS 103 836-4-1 [i.1] (annex G "GeoNetworking traffic classification") and clause 6.3.2 "Field settings in the *Common Header*" in the present document, GeoNetworking prioritizes packets using the traffic class identifier *TC ID* in the *TC* field of the *Common Header*.

The *TC ID* is set by the facilities layer for every packet and is used by the GeoNetworking protocol to categorize the packet into a traffic class. The *TC ID* is used to assign packets to DCC queues. The *TC ID* is also mapped to a User Priority (UP) and an Access Category (AC) value (see ETSI EN 303 797 [i.2], clause 4.4, "MAC").

GeoNetworking shall use the mapping between *TC ID*, UP and AC for ITS-G5 as specified in table 4.

Table 4: Mapping between *TC ID*, UP and AC for ITS-G5

TC ID	**UP in 802.1D**	**AC in 802.11**
0	7	AC_VO
1	5	AC_VI
2	3	AC_BE
3	1	AC_BK

Annex A (normative): GeoNetworking protocol constants for ITS-G5

The GeoNetworking protocol constants as specified in ETSI TS 103 836-4-1 [i.1], annex H "GeoNetworking protocol constants" shall be extended by the protocol constants in table A.1.

The protocol constants represent MIB attributes specified in annex B of the present document.

Table A.1: GeoNetworking protocol constants for ITS-G5

Item	GeoNetworking protocol constant	Default/initial value	Comment
1	itsGnLifetimeLocTEX	1	Lifetime for the ITS-G5 extensions of the location table entry [s].
2	itsGNCBRTarget	0,62	Value for the intended global channel busy ratio *CBR_Target*.
3	itsGNCBRGTriggerInterval	100	Trigger interval for calculation of CBR_G (see clause 5.3) [ms].
4	itsGNCBRLifetime	1 000	Lifetime for the received CBR value (*T_Cbr*, see clause 5.2), i.e. duration of time in which the value received from a neighbouring ITS-S is regarded as valid [ms].

Annex B (informative): Extensions of the GeoNetworking MIB

The ASN.1 encoding of the GeoNetworking MIB, as specified in ETSI TS 103 836-4-1 [i.1], annex I "ASN.1 encoding of the GeoNetworking MIB", is extended by the `issGnITSG5` sub group and the MIB attributes `itsGnLifetimeLocTEEX`, `itsGNCBRTarget`, `itsGNCBRGTriggerInterval` and `itsGNCBRLifetime` as follows:

```
-- ***************************************************************************
-- * SUB SUB GROUPS
-- ***************************************************************************

   itsGnSystem           OBJECT IDENTIFIER ::= { itsGnMgmt 1 }
   itsGnConfig           OBJECT IDENTIFIER ::= { itsGnMgmt 2 }
   itsGnLocationService  OBJECT IDENTIFIER ::= { itsGnMgmt 3 }
   itsGnBeaconService    OBJECT IDENTIFIER ::= { itsGnMgmt 4 }
   itsGnPacketForwarding OBJECT IDENTIFIER ::= { itsGnMgmt 5 }
   itsGnITSG5            OBJECT IDENTIFIER ::= { itsGnMgmt 6 }

-- ***************************************************************************
-- * GN ITS-G5 SUB GROUP
-- ***************************************************************************

itsGnLifetimeLocTEEX OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "Seconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Location table maintenance: Lifetime for the ITS-G5 extensions of the location table
      entry in s."
::= { itsGnITSG5 1 }

itsGNCBRTarget OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "percent"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Value for the intended global channel busy ratio CBR_Target in percent [%]."
::= { itsGnITSG5 2 }

itsGNCBRGTriggerInterval OBJECT-TYPE
   SYNTAX      Integer32(0..1000)
   UNITS       "milliseconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Trigger interval for calculation of CBR_G in ms."
::= { itsGnITSG5 3 }

itsGNCBRLifetime OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "milliseconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Lifetime of the received CBR value in ms."
::= { itsGnITSG5 4 }
```

Annex C (informative): Extensions of forwarding algorithms for ITS-G5

C.1 General

ETSI TS 103 836-4-1 [i.1], clauses E.3 and F.3 specify non-area and area Contention-Based Forwarding (CBF), respectively. In principle, CBF works with timers to reduce the number of redundantly sent packets. When a node receives a packet, it is stored in the CBF packet buffer. Then, a CBF timer is started, which depends on the distance to the sender. After the timer expires, the packet is re-broadcasted to all neighbours. If a duplicate is received in a node while the first packet waits in the CBF packet buffer, both packets are dropped. With this overhearing mechanism, redundant packets are refused from being re-broadcasted.

NOTE: A duplicate is a second received packet at the same node with the same sequence numbers, i.e. $SN(P(t_1)) = SN(P(t_2))$.

Decentralized Congestion Control (DCC) allows several techniques, including Transmit Power Control (TPC), Transmit Rate Control (TRC) and Transmit Data rate Control (TDC). Two approaches can be considered, a reactive and an adaptive DCC approach. With the reactive approach, an ITS-S enters a DCC state that depends on the current CBR, whereas in each state one of a combination of the techniques (TPC, TRC or TDC). The adaptive approach applies TRC. In TRC, the packet rate of an ITS-S is controlled by adapting the time T_{off} between two consecutive packets in the access layer. If the CBR grows, T_{off} increases, leading to longer queuing times of packets in the transmit queues.

Under high CBR conditions, the queuing time of the packets in the access layer exceeds the CBF timers, which leads to a failure of CBF's overhearing. As a result, all packets with the same sequence numbers are re-broadcasted. The reason is that all CBF timers expire and then the packets are passed to the access layer. In the access layer, packets cannot be refused from re-broadcasting. In other words, if TRC is applied under high channel busy ratio conditions, CBF does not work properly anymore, and the channel is flooded with redundant packets.

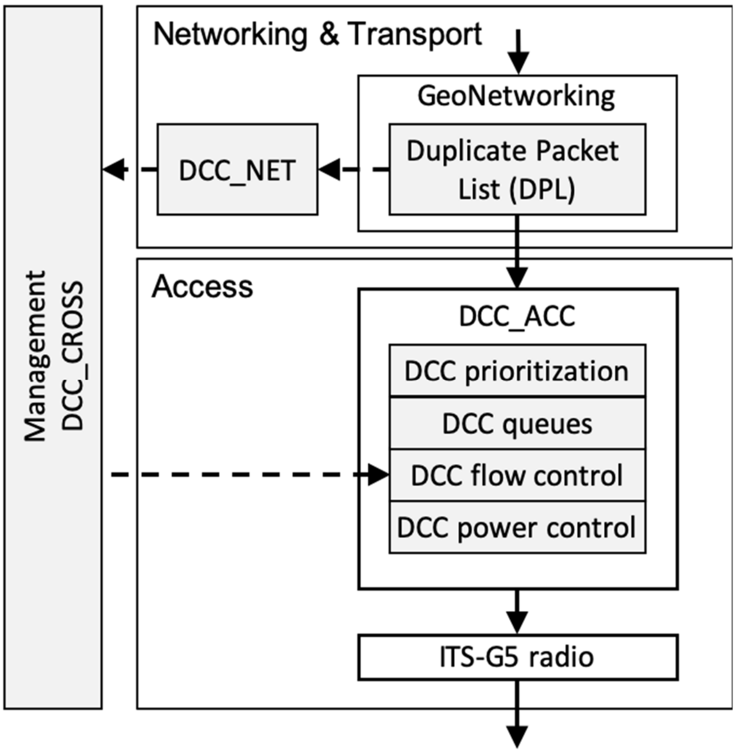

Figure C.1: Mechanism to recover CBF's overhearing

To restore CBF's overhearing, the overhearing mechanism is extended to the DCC flow control at the access layer. As illustrated in figure C.1, the Duplicate Packet List (DPL) of GeoNetworking is linked with the flow control of DCC_ACC. Then, if a duplicate was received at the networking & transport layer, the DCC flow control at DCC_ACC can discard the corresponding packets.

In detail, if a duplicate arrives at the networking & transport layer, an entry is generated in the DPL. The flow control of DCC_ACC retrieves this information through DCC_NET and DCC_CROSS. When the flow control takes a packet from the transmit queues, it checks the packet whether it is a duplicate. If no entry in the DPL exists, the packet is sent immediately. If during the packet's queuing time in the transmit queues a duplicate arrives at the networking & transport layer, the flow control of DCC_ACC discards the packet and schedules the next packet for transmission.

C.2 Enhancements of non-area and area Contention-Based Forwarding (CBF) algorithms

If non-area and area Contention-Based Forwarding (CBF), as specified in ETSI TS 103 836-4-1 [i.1], clauses E.3 and F.3, is used, DCC_ACC should process a packet as follows: when DCC_ACC dispatches a packet from the transmit queues, it retrieves information from the DPL at the networking layer via DCC_NET and DCC_CROSS. If the processed packet is a duplicate, DCC_ACC drops the packet. Otherwise, DCC_ACC continues processing the packet.

Annex D (informative): Bibliography

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Annex E (informative): Change history

Date	Version	Information about changes
March 2023	V0.0.1	Initial Version based on ETSI TS 102 636-4-2
March 2024	V0.0.4	Updates as agreed in ITSWG3#65
October 2024	V0.0.5	Updated clause 8 as discussed in ITS WG3#68 Updated several references to clauses in ETSI TS 103 836-4-1 [i.1]
January 2025	V0.0.6	Clean up for ABC

History

Document history		
V2.1.1	April 2025	Publication