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Technical Specification

Intelligent Transport Systems (ITS); 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

Reference

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Keywords

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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 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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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].

Introduction

The GeoNetworking protocol is a network layer 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 EN 302 636-4-1 [1]. The present document specifies media-dependent functionalities for GeoNetworking when using the ITS access technology ITS-G5 [2]. It covers an information sharing strategy for the decentralized congestion control (which is situated in the ITS access layer) and it provides multichannel operation.

The specification in the present document should be regarded as ITS-G5 specific extensions of the GeoNetworking protocol specified in [1] and does not represent a distinct protocol entity.

1 Scope

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

2 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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2.1 Normative references

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

[1] ETSI EN 302 636-4-1 (V1.2.0): "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 (V1.2.1): "Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

[3] 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".

[4] ETSI TS 102 792 (V1.1.1): "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".

[5] ETSI TS 102 724: "Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band".

2.2 Informative references

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 (V1.2.0): "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 (V1.2.1): "Intelligent Transport Systems (ITS); Radio communications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE directive".

[i.4] IEEE Vehicular Networking Conference (VNC) (2011): "Design Methodology and Evaluation of Rate Adaptation Based Congestion Control for Vehicle Safety Communications", pp. 116 -123, T. Tielert, D. Jiang, Q. Chen, L. Delgrossi and H. Hartenstein.

[i.5] IEEE Std. 802.11-2012: "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications", March 2012.

[i.6] IEEE 1609.4-2010: "IEEE Standard for Wireless Access in Vehicular Environments (WAVE)--Multi-channel Operation".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in EN 302 636-4-1 [1], EN 302 663 [2], TS 102 687 [3], TS 102 792 [4], TS 102 724 [5] and the following apply:

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

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

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

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

3.2 Symbols

For the purposes of the present document, the symbols given in EN 302 636-4-1 [1], EN 302 663 [2], TS 102 687 [3], TS 102 792 [4], TS 102 724 [5] 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
PHY-S	ITS-S tuned on SCHs and operating in non-safety-related context
PHY-C	ITS-S tuned on CCH and operative in safety-related context
T_cbr	Lifetime of the channel busy ratio
T_trig	Trigger interval
T_duty	Multi-channel switching duty cycle
T_SCH1	Reference channel returning period
T_Safety	Phase, where an MCO-capable ITS-S is on PHY-C
T_Service	Phase, where an MCO-capable ITS-S is on PHY-S
T_mon	Minimum CBR monitoring interval as specified in [3]
t_offset	Offset time for the reference channel returning period

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 302 636-4-1 [1], EN 302 663 [2], TS 102 687 [3], TS 102 792 [4], TS 102 724 [5] and the following apply:

AC	Access Category
AC_BE	AC Best Effort
AC_BK	AC BacKground
AC_VI	AC VIdeo
AC_VO	AC VOice

AIFS	Arbitration InterFrame Space
BUSY	Busy Mode
CAM	Cooperative Awareness Message
CBR	Channel Busy Ratio
CCF	Channel Configuration Function
CCH	Control CHannel
CEN	Comité Européen de Normalisation
C-ITS	Cooperative ITS
CSF	Channel Switching Function
CW	Contention Window
DCC	Decentralized Congestion Control
DENM	Decentralized Environmental Notification Message
DSRC	Dedicated Short Range Communication
ETC	Electronic Toll Collection
GN	GeoNetworking
HST	Header Sub-Type
HT	Header Type
IN-SAP	interface between access layer and network & transport layer
ITS	Intelligent Transport Systems
ITS-S	ITS Station
LocTE	Location Table Entry
LocTEX	Location Table Entry Extension
MAC	Medium Access Control
MAP	road map message
MCO	Multi Channel Operations
MCS	Modulation and Coding Scheme
MHL	Maximum Hop Limit
MIB	Management Information Base
MN-SAP	Interface between management and network & transport layer
NDL	Network Design Limits (DCC management information base)
NF-SAP	Interface between networking & transport and facilities layer
NH	Next Header
OBU	On-Board Unit
PHY	PHYsical layer
PHY-C	ITS G5 transceiver tuned on CCH
PHY-S	ITS-G5 transceiver tuned on any channel
PL	Payload Length
POS	Position
PV	Position Vector
RSSI	Received Signal Strength Indicator
RSU	Road Side Unit
RX	Receiver
SAM	Service Announcement Message
SAP	Service Access Point
SCF	Store Carry Forward
SCH	Service CHannel
SHB	Single-Hop Broadcast
SO	Source
SW	Switching mode
TC	Traffic Class
TC ID	Traffic Class IDentity
TOPO	road topology message
TST	Time STamp
TX	Transmitter
TX/RX	transmit / receive

4 Overview

The present document specifies the media-dependent functionalities necessary to run the GeoNetworking protocol [1] over ITS-G5 media [2]. The functionalities are:

- information sharing for Decentralized Congestion Control (DCC) (clause 5);
- support for multi-channel operation (annex A);
- interference mitigation techniques for co-existence between CEN DSRC and cooperative ITS (annex B).

Additionally, the present document specifies extensions to the GeoNetworking location table (clause 6), to the GeoNetworking header (clause 7) and to the GeoNetworking MIB (clause 9). Clause 8 specifies the traffic classes (TC) used for ITS-G5.

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

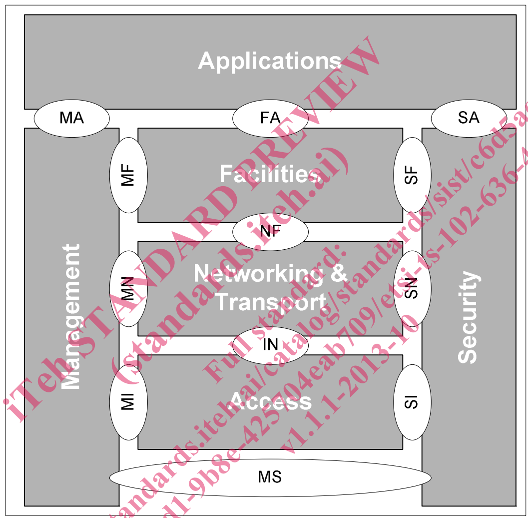

Figure 1: ITS-S reference architecture as specified in [i.2]

DCC is a necessity to control the load on a specific frequency channel and to avoid unstable behaviour. As specified in [i.3], several different frequency channels are available for Cooperative ITS (C-ITS) in Europe. Figure 2 illustrates the frequency channels together with their maximum allowed output power levels [i.3]. The spectrum comprises of four service channels (SCHx) and one control channel (CCH). The frequency band ITS-G5A contains frequency channels CCH, SCH1, and SCH2, which are intended for ITS road safety related applications. SCH3 and SCH4 are contained in the frequency band ITS-G5B and are intended for ITS non-safety applications. ITS-G5D is for future use and not yet allocated for C-ITS. The present document addresses information sharing to be used in the DCC algorithm for the access layer technology ITS-G5, which primarily uses the frequency bands ITS-G5A, ITS-G5B, and ITS-G5D.

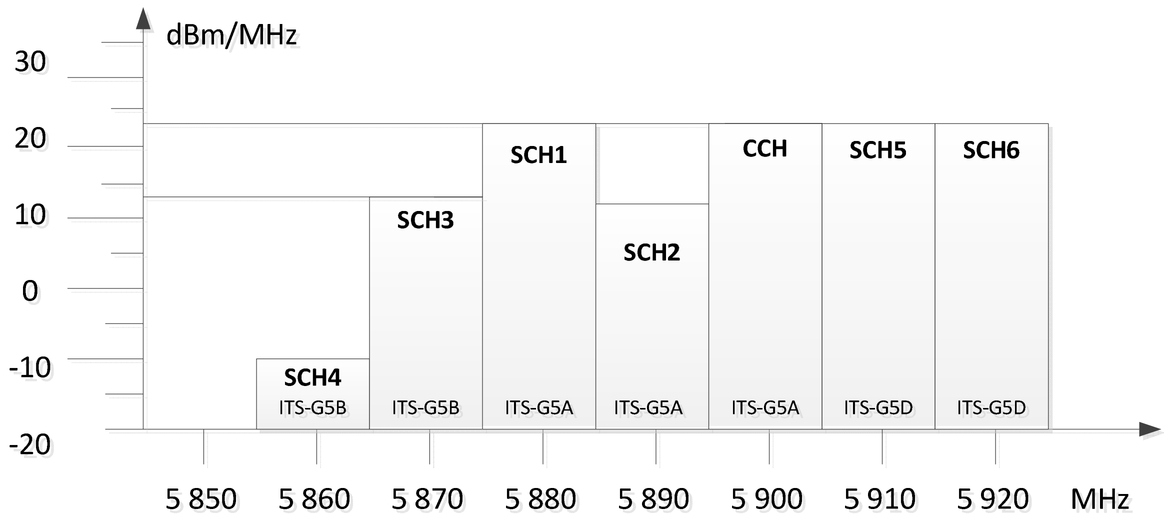

Figure 2: Maximum limit of mean spectral power density for each channel in ITS-G5A, ITS-G5B, and ITS-G5D as specified in [i.3]

5 Information sharing for decentralized congestion control

5.1 Introduction

This clause specifies an information sharing concept for the DCC algorithm situated in the ITS access layer [3]. The DCC algorithm controls the network load and thereby avoids unstable behaviour of the system due to its *ad hoc* topology [3]. The information sharing is based on dissemination of channel busy ratio (CBR) values among the ITS-Ss. This dissemination of CBR values makes the ITS-S aware of a possible channel congestion at neighbouring ITS-Ss that the ego ITS-S can contribute to (even though the ego ITS-Ss does not perceive a local congested channel status). More information about the CBR information dissemination and motivation of thereof is found in [i.4]. The obvious place for CBR dissemination is at the network & transport layer due to its network wide view. The dissemination of CBR values are conducted in every transmitted Single Hop Broadcast (SHB) packet assembled at the networking & transport layer, see clause 7. For every entry of an ITS-S in the location table [1], there will also be information about its transmitted CBR values.

Additionally, the algorithm to ensure coexistence between CEN DSRC equipment used for Electronic Toll Collection (ETC) and ITS described in TS 102 792 [4] belongs to the networking & transport layer (due to the network wide view and the placement of the location table). Depending on whether the placement of the CEN DSRC equipment on the roadside is known or unknown, the combination of the DCC concept and the coexistence algorithm looks different. Proposed implementation details for coexistence methods are given in informative annex B.

The information sharing shall provide a parameter called *CBR_G* to the management entity. This parameter is used by the DCC algorithm in the ITS access layer when calculating the current allowed time between packets [3]. The information sharing shall read the local CBR from the management via a parameter called *CBR_L_0_Hop*. The value of *CBR_L_0_Hop* is disseminated in SHB packets. More information about the inclusion of CBR values at the networking & transport layer can be found in clause 5.2.3. A schematic overview of the information sharing together with DCC in the protocol stack is depicted in figure 3. The exchange of *CBR_G* and *CBR_L_0_Hop* could also be performed via the service access point (SAP) between the access and networking & transport layers.

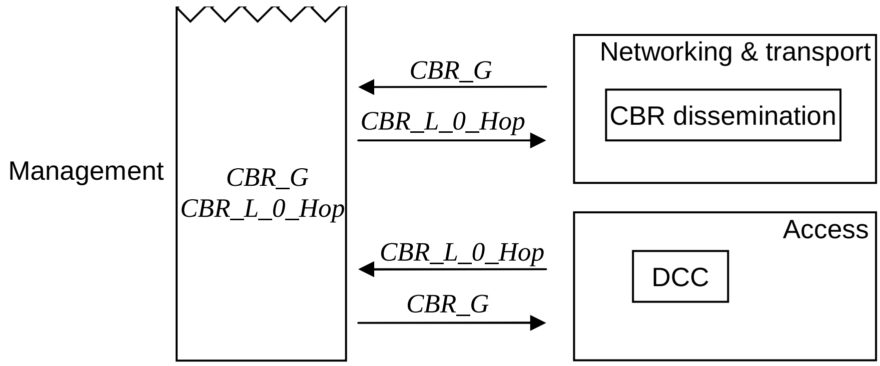

Figure 3: Overview of the information sharing together with the placement of DCC in the protocol stack

5.2 Information sharing

5.2.1 General rules

The information sharing is subject to the following general rules:

- The inclusion of CBR values shall be performed in each GN SHB packet.
- The calculation of *CBR_G* shall be activated at every trigger interval, *T_trig*.

5.2.2 CBR aggregation

The CBR dissemination and aggregation are central in DCC since this is regarded as the best feedback that can be used in C-ITS, where broadcast is the prevalent transmission mode (see also [i.4]).

The CBR aggregation is dependent upon the following CBR parameters:

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

The CBR parameters are described in detail in table 1.