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Technical Specification

Intelligent Transport Systems (ITS);
Vehicular Communications;
GeoNetworking;
Part 1: Requirements

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

Contents

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Foreword

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

The present document is part 1 of a multi-part deliverable covering Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking, as identified below:

Part 1: " Requirements";

Part 2: "Scenarios";

Part 3: "Network architecture";

Part 4: "Geographical addressing and forwarding for point-to-point and point-to-multipoint communications;

Part 5: "Transport protocols";

Part 6: "Internet integration".

1 Scope

The present document specifies the general, functional and performance requirements for ITS network and transport layer at a high level.

The present document is applicable to different types of ITS access technologies.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] ETSI EN 302 665: "Intelligent Transport Systems (ITS); Communications Architecture".

[2] ETSI TS 102 637-1: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 1: Functional Requirements".

[3] ETSI TS 102 636-2 "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 2: Scenarios".

[4] ETSI TS 102 636-3 "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 3: Network architecture".

[5] IETF RFC 4861: "Neighbor Discovery for IP version 6 (IPv6)".

[6] IETF RFC 4862: "IPv6 Stateless Address Autoconfiguration".

[7] IETF RFC 3775: "Mobility Support in IPv6".

[8] IETF RFC 3963: "Network Mobility (NEMO) Basic Support Protocol".

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Not applicable.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [4] and the following apply:

ad hoc communication: communication in an ad hoc network

transmission interval control: mechanisms to adjust the rate of sending messages via wireless channel

transmission power control: mechanisms to adjust transmission power on wireless channel

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in [4] and the following apply:

TIC	Transmission Interval Control
TPC	Transmission Power Control
VANET	Vehicular Ad hoc Network

4 Design guidelines

The ITS network and transport layer shall be designed to:

- efficiently disseminate safety and traffic efficiency messages as specified in [2];
- support all communication scenarios specified in [3];
- transparently transport IPv6 packets with minimum changes to IPv6;
- support privacy and security functions;
- support different communication media and interfaces as specified in [1].

5 Functional requirements

5.1 Communication mode

The ITS network and transport layer shall support self-organized communication between ITS vehicle stations without any assistance from the ITS access network, and also allow communication with assistance from the ITS access network. The ITS network and transport layer shall also support self-organized communication ITS vehicle stations and ITS roadside stations.

For safety applications that have stringent requirement on the latency of message delivery, the ITS network and transport layer shall support communication without the need to exchange any signalling messages beforehand.

5.2 GeoNetworking addressing

Each ITS station must have at least one unique address at the ITS network and transport layer in its communication environment. The address may be based on each individual node's identity or geographical position.

The ITS network and transport layer shall support at least circular geographical target areas and may support other types of geographical target areas needed by applications.

The ITS network and transport layer shall support automatic address configuration, which does not require any manual configuration from human beings. The ITS network and transport layer shall also allow manual address configuration.

5.3 Geographical routing

Routing functions must efficiently support all communication scenarios specified in [3].

5.4 Status information signalling

The status information of ITS stations shall include each node's address at the ITS network and transport layer, position, speed, heading, time stamp and their accuracy, and may also include other information such as altitude, etc. Status information shall be maintained in a database and the ITS network and transport layer shall have access to this data.

Exchange of status information shall be carried out by at least one of the following means:

- explicit status information exchange protocol, e.g. location resolution of an ITS station by means of location service;
- implicit status information signalling by sending periodical packets including status information.

The status information signalling shall to be carried out in an efficient way that will not cause congestion in the network.

5.5 Priority and buffering

The ITS network and transport layer shall support packets with different priorities with the highest priority for critical safety packets. The ITS network and transport layer shall treat packets with different priorities differently in that high priority packets have easier access to communication channel.

The ITS network and transport layer shall be able to temporarily buffer packets and either drop them or send them to the lower layer at a later time. Such buffering functions are necessary in certain conditions, such as in case the location of the destination is unknown or there is no direct neighbour to forward packets to the destination.

5.6 Data congestion control

The ITS network and transport layer shall support data congestion control functions in order to keep network load at an acceptable level, for example, by means of Transmission Interval Control (TIC), Transmission Power Control (TPC), reducing packet size, efficient routing and forwarding protocol, etc.

NOTE: Data congestion control at the ITS network and transport layer is different from traditional data congestion control mechanisms in TCP in many aspects, e.g. communication type, data traffic characteristics, usage of the end-to-end approach, types of algorithms. Data congestion control at the ITS network and transport layer may take a totally different approach than TCP does.

Depending on the type of packet, one or a combination of several mechanisms shall be applied for data congestion control.

5.7 Security and privacy

The ITS network and transport layer shall support security objectives for both single-hop and multi-hop communication. Security objectives particularly include integrity, privacy and non-repudiation and shall protect the ITS network and transport layer protocol header. The ITS network and transport layer shall also protect privacy, i.e. provide confidentiality to personal data such as node ID and location.

5.8 Cross-layer signalling

The ITS network and transport layer shall support information exchange between different layers, and entities at each layer may select the required information to be received. Information exchange shall be bi-directional, structured and efficient.

5.9 GeoNetworking and IPv6

The ITS network and transport layer shall allow legacy IPv6 applications run on top of the ITS network and transport layer and support transparently routing of IPv6 packets. The following functions shall be supported by the ITS network and transport layer:

- Efficient methods to support IPv6 Neighbor Discovery function [5];
- IPv6 Stateless Address Autoconfiguration [6];
- Interfaces and method to support IPv6 unicast;
- Interfaces and method to support IPv6 multicast;
- IPv6 mobility protocols [7];
- IPv6 Network Mobility (NEMO) Basic Support Protocol [8].

5.10 Transport layer functions

The transport protocol used together with GeoNetworking shall support multiplexing and de-multiplexing of application data.

6 Performance requirements

In general, the ITS network and transport layer shall

- provide low-latency communications;
- provide reliable communications with the highest reliability for safety messages;
- keep signalling, routing and packet forwarding overhead low;
- be fair among different nodes with respect to bandwidth usage considering the type of messages;
- be robust against security attack, mal-function in ITS stations;
- be able to work in scenarios with low and high density of GeoNetworking-enabled nodes.

NOTE: The dissemination of safety messages in VANETs typically have requirements on latency, reliability and dissemination area. The metrics for latency and reliability should be studied and their relationship with message size, ITS stationdensity, and message dissemination range is to be studied with respect to different communication scenarios. Tradeoffs between efficiency and reliability should be studied. A set of rules should be defined to treat packets differently according to their priorities or other criteria.

Annex A (informative): Other requirements

The ITS network and transport layer should have low complexity.

It should also enable have interoperability among:

- different ITS stations;
- different applications;
- different hardware platforms;
- different hardware vendors;
- different software manufacturer.

Annex B (informative): Introduction to GeoNetworking

Wireless communication is a cornerstone of future Intelligent Transport Systems (ITS). Many ITS applications require a rapid and direct communication, which can be achieved by ad hoc network. GeoNetworking is a network-layer protocol for ad hoc communication based on wireless technology such as ITS-G5. It provides communication in mobile environments without the need for a coordinating infrastructure. GeoNetworking utilizes geographical positions for dissemination of information and transport of data packets. It offers communication over multiple wireless hops, where nodes in the network forward data packets on behalf of each other to extend the communication range. Originally proposed for general mobile ad hoc networks, variants of GeoNetworking have been proposed for other network types, such as vehicular ad hoc networks (VANETs), mesh networks and wireless sensor networks. Therefore, GeoNetworking can also be regarded as a family of network protocols based on the usage of geographical positions for addressing and transport of data packets in different types of networks.

In VANETs, GeoNetworking provides wireless communication among vehicles and among vehicles and fixed stations along the roads. GeoNetworking works connectionless and fully distributed based on ad hoc network concepts, with intermittent or even without infrastructure access. The principles of GeoNetworking meet the specific requirements of vehicular environments: It is well suited for highly mobile network nodes and frequent changes in the network topology. Moreover, GeoNetworking flexibly supports heterogeneous application requirements, including applications for road safety, traffic efficiency and infotainment. More specifically, it enables periodic transmission of safety status messages at high rate, rapid multi-hop dissemination of packets in geographical regions for emergency warnings, and unicast packet transport for Internet applications.

GeoNetworking basically provides two, strongly coupled functions: *geographical addressing* and *geographical forwarding*. Unlike addressing in conventional networks, in which a node has a communication name linked to its identity (e.g. a node's IP address), GeoNetworking can send data packets to a node by its position or to multiple nodes in a geographical region. For forwarding, GeoNetworking assumes that every node has a partial view of the network topology in its vicinity and that every packet carries a geographical address, such as the geographical position or geographical area as the destination. When a node receives a data packet, it compares the geo-address in the data packet and the node's view on the network topology, and makes an autonomous forwarding decision. As a results, packets are forwarded 'on the fly', without need for setup and maintenance of routing tables in the nodes.

The most innovative method for distribution of information enabled by geographical routing is to target messages to certain geographical areas. In practise, a vehicle can select and specify a well-delimited geographic area to which messages should be delivered. Intermediate vehicles serve as message relays and only the vehicles located within the target area process the message and further send it to corresponding applications. In this way, only vehicles that are actually affected by a dangerous situation or a traffic notification are notified, whereas vehicles unaffected by the event are not targeted.

Basically, geographical routing comprises the following forwarding schemes:

- GeoUnicast: figure B.1 shows a possible method of packet delivery between two nodes via multiple wireless hops. When a node wishes to send a unicast packet, it first determines the destination's position and then forwards the data packet to a node towards the destination, which in turn re-forwards the packet along the path until the packet reaches the destination.

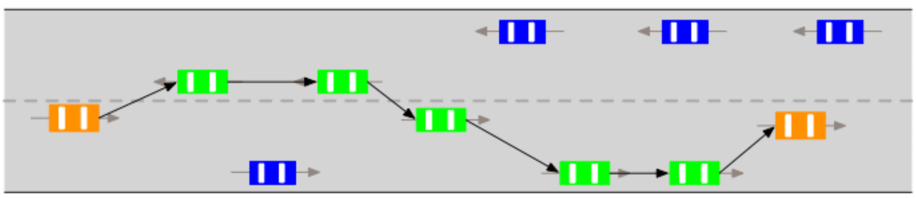

Figure B.1: GeoUnicast

- GeoBroadcast: figure B.2 shows a possible method of geographical broadcast. A packet is forwarded hop-by-hop until it reaches the destination area determined by the packet, and nodes rebroadcast the packet if they are located inside the destination area. GeoAnycast is different from geographical broadcast in that a node within the destination area will not re-broadcast any received packets.

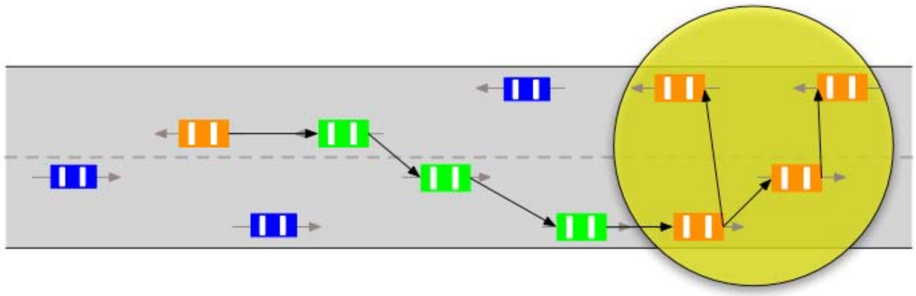

Figure B.2: GeoBroadcast

- Topologically-scoped broadcast: figure B.3 shows rebroadcasting of a data packet from a source to all nodes in the n-hop neighbourhood. Single-hop broadcast is a specific case of topologically-scoped broadcast, which is used to send packets only to one-hop neighbourhood.

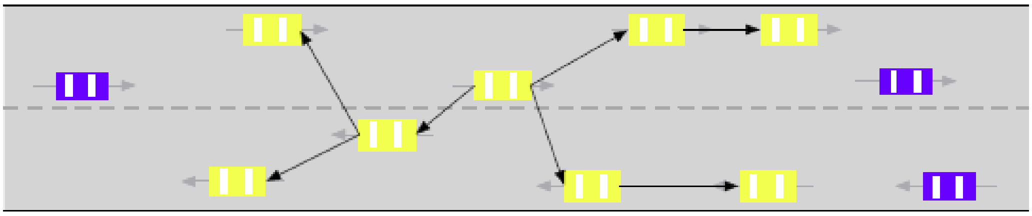

Figure B.3: Topologically-scoped broadcast

Annex C (informative): Bibliography

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History

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