ETSI EN 302 636-1 V1.2.1 (2014-04)

European Standard

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

Reference

REN/ITS-0030032

Keywords

autonomic networking, ITS, network, safety

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Foreword

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

National transposition dates	
Date of adoption of this EN:	28 April 2014
Date of latest announcement of this EN (doa):	31 July 2014
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 January 2015
Date of withdrawal of any conflicting National Standard (dow):	31 January 2016

Introduction

Wireless communication is a cornerstone of future Intelligent Transport Systems (ITS). Many ITS applications require the dissemination of information with a rapid and direct communication, which can be achieved by ad hoc networking. GeoNetworking is a network-layer protocol for mobile 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 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.
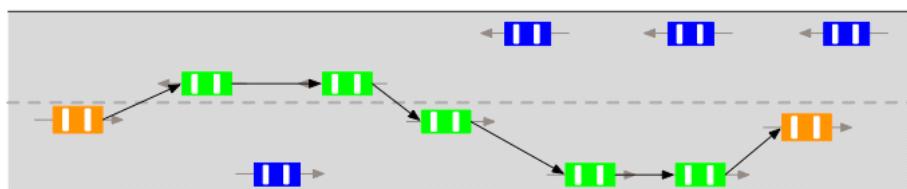
Figure 1: GeoUnicast

- GeoBroadcast: figure 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.
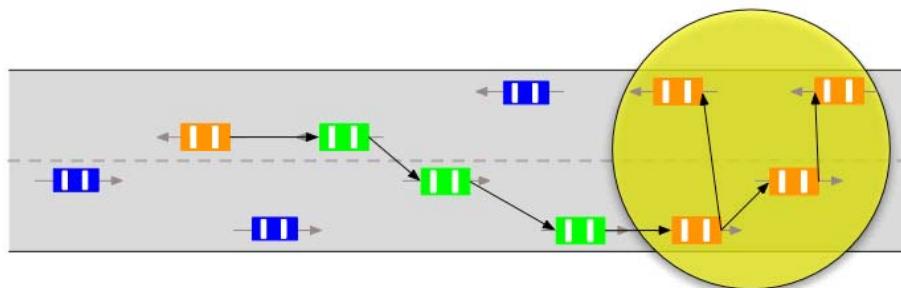
Figure 2: GeoBroadcast

- Topologically-scoped broadcast: figure 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.
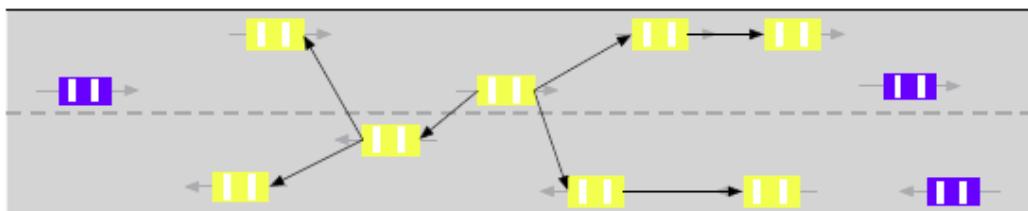
Figure 3: Topologically-scoped broadcast

1   Scope

The present document specifies, at an abstract level, the general, functional and performance requirements that apply to the GeoNetworking protocols (EN 302 636-4 [i.1], EN 302 636-5 [i.2] and EN 302 636-6 [i.3]) for use in ETSI ITS G5 access technology (EN 302 663 [i.4]).

The present document is applicable to ITS stations implementing ETSI ITS G5 access technology (EN 302 663 [i.4]) and the GeoNetworking protocols (EN 302 636-4 [i.1], EN 302 636-5 [i.2] and EN 302 636-6 [i.3]) for both single hop and multi-hop communications.

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 reference 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 302 665: "Intelligent Transport Systems (ITS); Communications Architecture".

[2]   ETSI TS 101 539-1: "Intelligent Transport Systems (ITS); V2X Applications; Part 1: Road Hazard Signalling (RHS) application requirements specification".

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

[4]   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".

[5]   ETSI EN 302 636-2: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 2: Scenarios".

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

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

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

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

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

[11]   IETF RFC 5648: "Multiple Care-of Addresses Registration".

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 302 636-4 (all parts): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications".

[i.2]   ETSI EN 302 636-5 (all parts): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols".

[i.3]   ETSI EN 302 636-6 (all parts): "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 6: Internet Integration".

[i.4]   ETSI EN 302 663: "Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band".

3   Definitions and abbreviations

3.1   Definitions

For the purposes of the present document, the terms and definitions given in TS 102 636-3 [6] and the following apply:

ad hoc communication: communication in an ad hoc network

Transmission Power Control (TPC): mechanisms to adjust transmission power on wireless channel

Transmission Rate Control (TRC): mechanisms to adjust the rate of sending messages via the wireless channel

3.2   Abbreviations

For the purposes of the present document, the abbreviations given in TS 102 636-3 [6], TS 102 687 [4] and the following apply:

MCoA   Multiple Care-of Addresses Registration
NEMO   NEtwork MObility
TPC   Transmission Power Control
TRC   Transmission Rate Control
VANET   Vehicular Ad hoc NETwork

4   Design guidelines

The GeoNetworking protocols as defined in this multi-part deliverable shall be designed to:

*   efficiently disseminate safety and traffic efficiency messages considering functional requirements on applications as specified in TS 102 637-1 [3];

*   support all communication scenarios specified in EN 302 636-2 [5];

*   transparently transport IPv6 packets with minimum changes to IPv6;

*   support privacy and security functions;

*   support different communication media and interfaces as specified in EN 302 665 [1].

5   Functional requirements

5.1   Communication mode

The GeoNetworking protocols as defined in this multi-part deliverable shall support self-organized communication among vehicle ITS stations without assistance from an infrastructure network, and also allow communication with assistance from an infrastructure network. These GeoNetworking protocols shall also support self-organized communication between vehicle ITS stations and roadside ITS stations.

For safety applications that have stringent requirement on the latency of message delivery, these GeoNetworking protocols shall support communication without the need to exchange any signalling messages beforehand.

5.2   GeoNetworking addressing

An ITS station implementing the GeoNetworking protocol shall have at least one unique address at the ITS-S networking & transport layer. The address may be based on each individual ITS stations' identity or geographical position.

NOTE: Details of the address are out of scope of the present document and will be specified in other standards.

The GeoNetworking protocols as defined in this multi-part deliverable shall support at least circular, rectangular and ellipsoidal geographical target areas and may support other types of geographical target areas needed by applications.

The GeoNetworking protocols as defined in this multi-part deliverable shall support automatic address configuration, which does not require any manual configuration from human beings. These GeoNetworking protocols shall also allow manual address configuration.

5.3   Geographical routing

Routing functions of the GeoNetworking protocols as defined in this multi-part deliverable shall support all communication scenarios specified in EN 302 636-2 [5].

5.4   Status information signalling

The status information of ITS stations for the GeoNetworking protocols as defined in this multi-part deliverable shall include each ITS station's network address, position, speed, heading, time stamp and their accuracy, and may also include other information such as altitude. The GeoNetworking protocols as defined in this multi-part deliverable shall have access to these data.

Exchange of status information for the GeoNetworking protocols as defined in this multi-part deliverable 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 a location service;

- implicit status information signalling by periodically sending packets including status information.

The GeoNetworking protocols as defined in this multi-part deliverable shall support status information signalling that will not cause congestion in the network.

5.5   Priority and buffering

The GeoNetworking protocols as defined in this multi-part deliverable shall support packets with different priorities. These GeoNetworking protocols shall treat packets with different priorities such that that high priority packets have preferred access to communication channel(s).

The GeoNetworking protocols as defined in this multi-part deliverable 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, for example in case the location of the destination is unknown or there is no direct neighbour to forward packets to the destination.

5.6   Decentralized congestion control

The GeoNetworking protocol as defined in this multi-part deliverable shall support decentralized congestion control (DCC) functions in order to keep the network load at an acceptable level, for example by means of Transmit Rate Control (TRC), Transmit Power Control (TPC), reducing packet size, efficient routing and forwarding protocol, etc.

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

The decentralized congestion control of these GeoNetworking protocols shall be compliant to the DCC framework specified in TS 102 687 [4].

5.7   Security and privacy

The GeoNetworking protocols as defined in this multi-part deliverable shall support security objectives for both single-hop and multi-hop communication. Security objectives particularly include integrity, privacy and non-repudiation. The security measures shall protect the GeoNetworking protocol header. These GeoNetworking protocols shall also protect privacy, i.e. provide confidentiality to personal data such as ITS station's ID and location.

5.8   Cross-layer signalling

The GeoNetworking protocol as defined in this multi-part deliverable shall support information exchange between different layers, and entities at each layer may select the required information to be received. The information exchange shall be bi-directional, structured and efficient in terms of processing and data overhead.

5.9   GeoNetworking and IPv6

The GeoNetworking protocols as defined in this multi-part deliverable shall allow legacy IPv6 applications to run on top of the GeoNetworking protocols and support transparent routing of IPv6 packets. The following functions shall be supported by the ITS-S networking & transport layer implementing these GeoNetworking protocols:

- Efficient methods to support IPv6 Neighbor Discovery function (RFC 4861 [7]).

- IPv6 Stateless Address Autoconfiguration (RFC 4862 [8]).

- Interfaces and method to support IPv6 unicast.

- Interfaces and method to support IPv6 multicast.

- IPv6 mobility protocols (RFC 3775 [9]) if the ITS station represents a single IPv6 node.

- IPv6 Network Mobility (NEMO) Basic Support Protocol (RFC 3963 [10]) if the ITS station represents an IPv6 mobile network.

The following functions may be supported by the ITS-S networking & transport layer implementing the GeoNetworking protocols:

- Multiple Care-of Addresses Registration (MCoA) (RFC 5648 [11]).

5.10   Transport layer functions

The transport protocols as defined in this multi-part deliverable and used together with GeoNetworking shall support multiplexing and de-multiplexing of data from upper layers.

6   Performance requirements

In general, the GeoNetworking protocols as defined in this multi-part deliverable 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 ITS stations 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 ITS stations.

These GeoNetworking protocols shall meet the performance requirements specified in TS 101 539-1 [2].

Annex A (informative):
Bibliography

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ETSI EN 302 636-4-1: "Intelligent Transport System (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".

ETSI EN 302 636-5-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol".

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History

Document history		
V1.1.1	March 2010	Publication as TS 102 636-1
V1.2.0	August 2013	EN Approval Procedure AP 20131130: 2013-08-02 to 2013-12-02
V1.2.1	February 2014	Vote V 20140426: 2014-02-25 to 2014-04-28
V1.2.1	April 2014	Publication