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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 1: Media-Independent Functionality**

ETSI

Reference

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

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 stations 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 and infrared. The ITS access technologies for short-range wireless technologies have many technical commonalities, but also differences. 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 functionalities are those which are common to all ITS access technologies for short-range wireless communication to be used for GeoNetworking. These media-dependent functionalities extend the media-independent functionality for a specific ITS access technology. Therefore, the GeoNetworking protocol specification consists of the standard for media-independent functionality and at least one standard for media-dependent functionality. However, it should be noted that the media-dependent extensions do not represent distinct protocol entities.

1 Scope

The present document specifies the media-independent functionality of the GeoNetworking protocol.

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 102 636-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 1: 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] ETSI TS 102 636-5-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol".

[6] ETSI TS 102 636-6-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 6: Internet Integration; Sub-part 1: Transmission of IPv6 Packets over GeoNetworking Protocols".

[7] ETSI EN 302 931: "Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition".

[8] ITU-T Recommendation X.691 (2002): "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".

[9] Annex to ITU Operational Bulletin No. 741 - 1.VI.200: "Complement To ITUT Recommendation E.212 (11/98)".

NOTE: Available at: http://www.itu.int/ITUT/.

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 ES 202 663: "Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.2]   ETSI TS 102 636-4-2: "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-G5A media".

[i.3]   IEEE 802.3: "Ethernet Working Group".

[i.4]   IEEE 802.11p: "IEEE Standard for Local and Metropolitan Area Networks - Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments".

3   Definitions, symbols and abbreviations

3.1   Definitions

For the purposes of the present document, the terms and definitions given in EN 302 665 [1], TS 102 636-3 [4], TS 102 636-6-1 [6] and the following apply:

destination: receiver that processes a GeoUnicast packet and delivers it to upper protocol entities, but does not relay the packet to other GeoAdHoc routers

forwarder: GeoAdhoc router that processes a packet and relays it to other GeoAdhoc routers

GeoAdhoc router: Ad hoc router that implements the GeoNetworking protocol

local position vector: position vector for the local GeoAdhoc router

neighbour: GeoAdhoc router in direct (single-hop) communication range

packet: GeoNetworking PDU

position vector: position information of a GeoAdhoc router represented by a tuple of address, timestamp, geographical position, speed, heading and corresponding accuracy information

receiver: GeoAdhoc router that processes a packet, delivers it's data to upper protocol entities and relays the packet to other GeoAdhoc routers

sender: GeoAdhoc router that has sent the GeoNetworking packet

source: GeoAdhoc router that originates a GeoNetworking packet

3.2   Symbols

For the purposes of the present document, the following symbols apply:

ALT	Altitude
ACC(POS, GN_ADDR)	Accuracy of the position for the GeoAdhoc router GN_ADDR
ACC(S, GN_ADDR)	Accuracy of the speed for the GeoAdhoc router GN_ADDR
ACC(H, GN_ADDR)	Accuracy of the heading for the GeoAdhoc router GN_ADDR
GEO_MAX	Maximum size of the GeoNetworking packet header
GEOSEC_MAX	Maximum size of the optional GeoNetworking Security header
H(GN_ADDR)	Heading of the ITS station GN_ADDR
LAT	Latitude
LL_ADDR	Link layer address that identifies the ITS station at the link layer protocol entity in the ITS Access Layer
LL_ADDR_NH	Link layer address of the next hop
LONG	Longitude
LS_PENDING	Location Service pending flag
LSB(LONG)	LSB of the Longitude
LSB(ALT)	LSB of the Altitude
LSB(TST)	LSB of the Timestamp
LSB(S)	LSB of the Speed

LSB(H)	LSB of the Heading
M	Manual
MRC	Maximum Retransmit Counter
MTU_AL	MTU of the ITS Access Layer
POS(GN_ADDR)	Geographical position of the ITS station GN_ADDR
RAND[x,y]	Function that returns a random (integer) number in the given interval [x,y]
S(GN_ADDR)	Speed of the ITS station GN_ADDR
SN(GN_ADDR)	Last maximum sequence number received from the GeoAdhoc router
SN_MAX	Largest possible value of the sequence number
SN(P)	Value of the sequence number field carried in a GeoNetworking packet
T(LocTE)	Lifetime of an entry in the location table
TO_CBF_MIN	Timeout; minimum duration a packet is buffered in the CBF cache
TO_CBF_MAX	Timeout; maximum duration a packet is buffered in the CBF cache
TST(UET)	Number of milliseconds since the Unix Epoch midnight (0 hour), January 1, 1970

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 302 665 [1], TS 102 636-3 [4],
TS 102 636-6-1 [6] and the following apply:

Acc	Accuracy
BC	Broadcast
BTP	Basic Transport Protocol
BTP	Basic Transport Protocol
CBF	Contention-Based Forwarding
DE	Destination
FCS	Frame Check Sequence
FIFO	First In First Out
GAC	Geographically-Scoped Anycast
GBC	Geographically-Scoped broadcast
GF	Greedy Forwarding
GN	GeoNetworking
GN_ADDR	GeoNetworking Address
GN6ASL	GeoNetworking to IPv6 Adaptation Sub-Layer
GN6ASL	GeoNetworking to IPv6 Adaptation Sub-Layer
GN6-SDUGN6	Service Data Unot
HL	Hop Limit
HST	Header Sub-Type
HT	Header Type
LL	Link Layer
LocT	Location Table
LocTE	Location Table Entry
LPV	Local Position Vector
LS	Location Service
LSB	Least Significant Bit
LT	Lifetime
MAC	Medium Access Control
MFR	Most Forward within Radius
MHVB	Multi-Hop Vehicular Broadcast
MID	MAC ID
MTU	Maximum Transmit Unit
NH	Next Header
PCI	Protcol Control Information
PCI	Protocol Control Information
PDU	Protocol Data Unit
PL	Payload Length
POS	Position
PV	Position Vector
PV	Position Vector
RTC	Retransmit Counter
SCC	Station Country Code

SE	Sender
SHB	Single Hop Broadcast
SN	Sequence Number
SO	Source
SPV	Short Position Vector
SST	Station Subtype
ST	Station Type
TSB	Topologically Scoped Broadcast
T-SDU	Transport Service Data Unit
TST	Timestamp
UC	Unicast
UET	UNIX Epoch Time

4   Services provided by the GeoNetworking protocol

The GeoNetworking protocol is a network protocol that resides in the ITS network and transport layer [1] and is executed in the ad hoc router [4], specifically in the GeoAdhoc router. It provides the transport of packets in the ITS ad hoc network [4]. It shall support the requirements specified in [2] and the scenarios specified in [3].

The GeoNetworking protocol provides services to upper protocol entities, i.e. the ITS Transport Protocol, such as the Basic Transport Protocol (BTP) [5], and the GeoNetworking to IPv6 Adaptation Sub-Layer (GN6ASL) [6]. The services are provided via the GN_SAP using service primitives of different types that carry parameters and the PDU of the upper protocol entity, i.e. T/GN6 PDU (see figure 1). A PDU of the transport protocols are considered as SDU in the GeoNetworking protocol. The SDU is complemented with Protocol Control Information (PCI) and transmitted as GN PDU to the peer entity.

In order to provide its packet transport services, the GeoNetworking protocol uses the services of the ITS Access Layer.
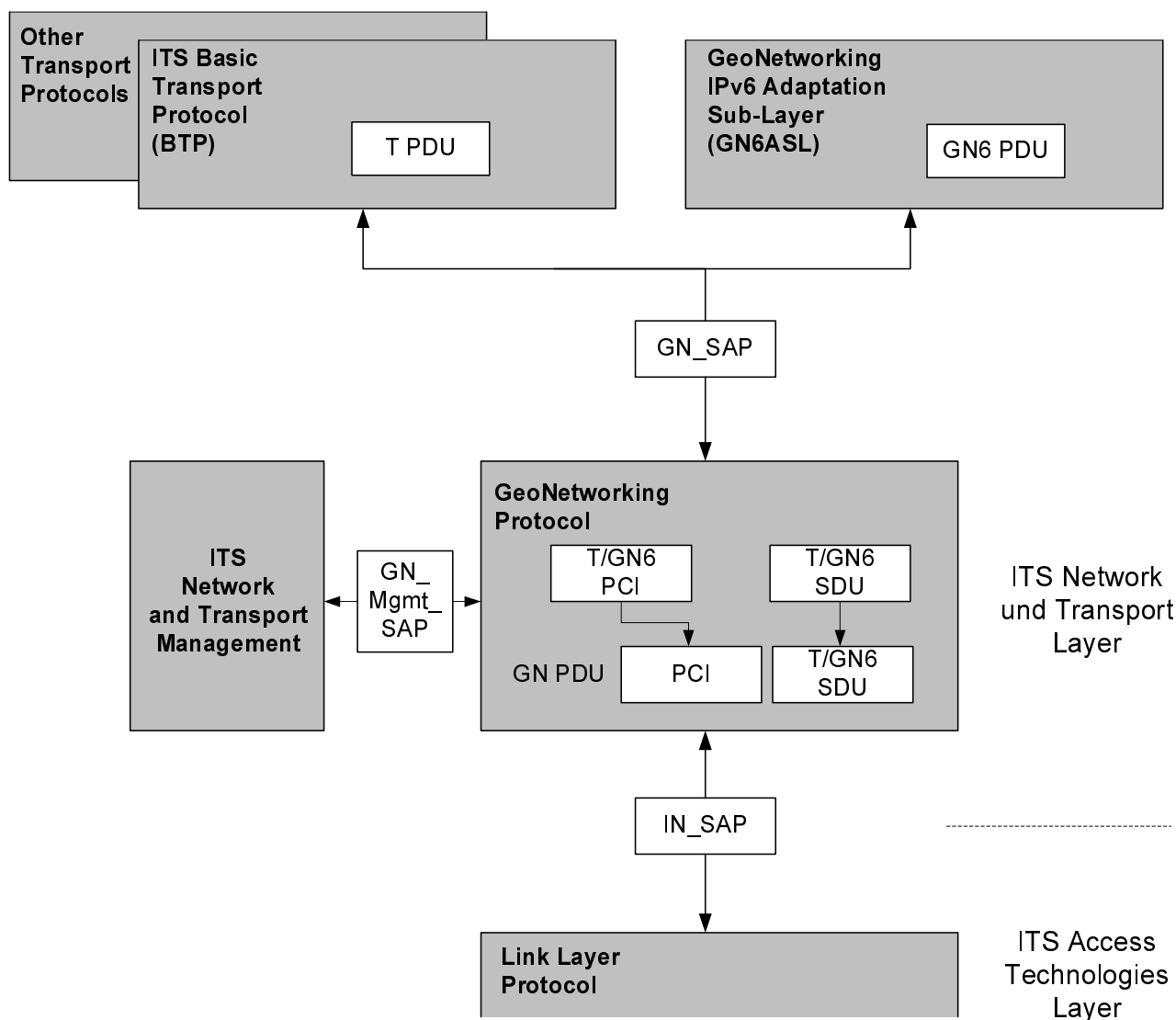
Figure 1: Service primitives, SDUs and PDUs relevant for the GeoNetworking protocol

The present document specifies the internal GN_SAP between the GeoNetworking protocol and the ITS transport protocol, such as the Basic Transport Protocol (BTP) [5]), the GeoNetworking IPv6 Adaptation Sub-Layer (GN6ASL) as defined in [6] and other transport protocols as well as the GN_Mgmt_SAP between the GeoNetworking protocol and the ITS Network and Transport Management.

5   Format convention

The basic convention for the specification of packet formats is illustrated in figure 2. The bits are grouped into bytes. The bits of an octet are always shown horizontally and are numbered from 0 to 7. Up to 4 octets are shown horizontally; multiple sets of 4 octets are grouped vertically. Octets are numbered from 1 to N.

The octets are transmitted in ascending numerical order; inside an octet the bit 0 is transmitted first.

When a field is contained within a single octet, the highest bit number of the field represents the lowest order value, i.e. the Least Significant Bit (LSB).

When a field spans more than one octet, the order of bit values within each octet progressively increases as the octet number increases, i.e. the highest bit number of the multi-octet field represents the LSB.

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
Octet 0								Octet 1								Octet 2								Octet 3							
Octets 4 to 7																															
…																								Octet N-1							
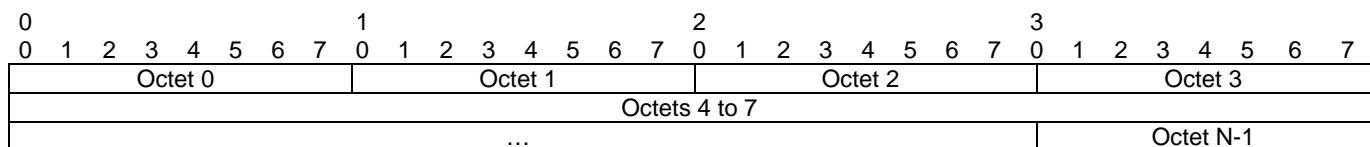
Figure 2: Format convention

6 GeoNetworking address

6.1 General

Every GeoAdhoc router shall have a unique GeoNetworking address. This address shall be used in the header of a GeoNetworking packet and identify the communicating GeoNetworking entities.

6.2 GeoNetworking address format

The format of the GeoNetworking address is described in figure 3.

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				SST		SCC									MID															
MID																															
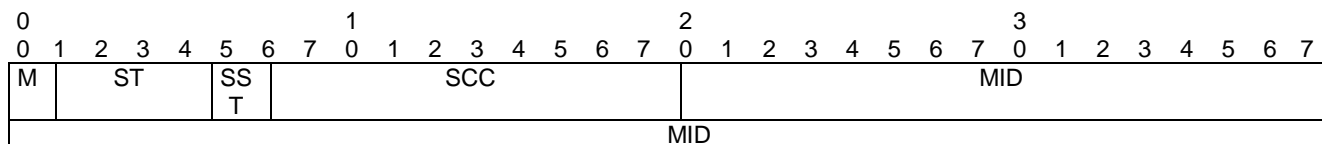
Figure 3: GeoNetworking address format

6.3 Fields of the GeoNetworking address

The GeoNetworking address shall be comprised of the fields specified in table 1.

Table 1: Fields of the GeoNetworking address

Field #	Field name	Octet/bit position		Type	Description
		First	Last		
1	M	Octet 0 Bit 0	Octet 0 Bit 0	1 bit unsigned integer	This bit allows distinguishing between manually configured network address and the initial GeoNetworking address. M is set to 1 if the address is manually configured otherwise it equals 0.
2	ST	Octet 0 Bit 1	Octet 0 Bit 4	4 bit unsigned integer	ITS Station Type. To identify the ITS Station type. Bit 1: 0 - Vehicle ITS station. 1 - Roadside ITS station. Bit 2 to Bit 4: **For Roadside ITS station:** 0 - Traffic light. 1 - Ordinary Roadside ITS station. **For Vehicle ITS station:** 0 - Bike. 1 - Motorbike. 2 - Car. 3 - Truck. 4 - Bus.
3	SST	Octet 0 Bit 5	Octet 0 Bit 5	1 bit unsigned integer	ITS Station sub-type. To distinguish between public transport and private ITS stations. 0 - Public (e.g. school bus, public safety vehicle). 1 - Private (e.g. non-public transport vehicle).
4	SCC	Octet 0 Bit 6	Octet 1 Bit 7	10 bit unsigned integer	ITS Station Country Code.
5	MID	Octet 2	Octet 7	48 bit address	This field represents the LL_ADDR.

The first bit is reserved for the recognition of manual configured GeoNetworking addresses. The allocation of ITS Station Country Codes (SCC) is administered by the ITU-T [9].

The MID field corresponds to the access layer address. In case of IEEE 802.11p [i.4] MAC layer, the 48-bit MAC layer address shall be used.

In order to allow for the resolution of a GeoUnicast destination GN_ADDR from an IPv6 destination address using virtual interfaces of type Ethernet V2.0/IEEE 802.3 LAN, the GeoNetworking address space shall remain 48-bit wide (size of the MID field in the GeoNetworking address). In particular, as described in TS 102 636-6-1 [6], table 1, note 1, the GN6ASL resolves an MID from a unicast destination IPv6 address and passes it to GeoNetworking via the GN-DATA.request primitive (clause H.2). Then, the GeoNetworking protocol entity is responsible for deriving a full GN_ADDR from the MID. This full GN_ADDR shall be derived from a LocTE (if it exists) or by executing the Location Service with Request GN_ADDR field containing only the MID part and the other bits set to 0.

To be compliant with the IPv6 over GeoNetworking architecture, the GeoNetworking address space shall remain 48-bit wide (size of the MID field in the GeoNetworking address) in order to provide a virtual interface of Ethernet type to IPv6 layer and to perform the forwarding via GeoNetworking in a transparent way (see TS 102 636-6-1 [6]).

If the address is updated for privacy reasons, i.e. by assignment of a short-term identity, only the last field of the address shall be updated and derived from the short-term identity (pseudonym).

7   Data structures

7.1   Location table

7.1.1   General

A GeoAdhoc router shall maintain a local data structure, referred to as location table (LocT). This data structure holds information about other ITS stations that execute the GeoNetworking protocol. The data elements of a location table entry is specified in clause 7.1.2 and the maintenance of the location table in clause 7.1.3.

7.1.2   Minimum data elements of a Location Table Entry

A Location Table Entry (LocTE) shall contain at least the following data elements:

- GeoNetwork address of the ITS station *GN_ADDR*.

- LL address of the ITS station *LL_ADDR*.

- Type of the ITS station (vehicle ITS station, roadside ITS station).

- Position vector, i.e. Long Position Vector (clause 8.4.2), of the ITS station, comprised of:

  - Geographical position *POS(GN_ADDR)*.

  - Speed *S(GN_ADDR)*.

  - Heading *H(GN_ADDR)*.

  - Timestamp of the geographical position *TST(POS, GN_ADDR)*.

  - Accuracy of the geographical position *Acc(POS, GN_ADDR)*.

  - Accuracy of the speed *Acc(S, GN_ADDR)*.

  - Accuracy of the heading *Acc(H, GN_ADDR)*.

- Flag *LS_PENDING(GN_ADDR)*: Flag indicating that a Location Service (LS) (clause 9.2.4) is in progress.

- Flag *IS_NEIGHBOUR(GN_ADDR)*: Flag indicating that the GeoAdhoc router is in direct communication range, i.e. is a neighbour.

- Sequence number *SN(GN_ADDR)*: The sequence number of the last packet from the source *GN_ADDR* that was identified as 'not duplicated'.

  NOTE 1:   The LocTE can contain more data elements defined in media-dependent functionalities of GeoNetworking.

  NOTE 2:   The format of the data in the LocT is implementation-specific and, therefore, not further specified.

  NOTE 3:   *LS_PENDING(GN_ADDR)* equals TRUE indicates that for the *GN_ADDR* a location service has been invoked and is in process.

7.1.3   Maintenance of the Location Table

The entries in the location table shall be soft-state, i.e. entries are added with a lifetime *T(LocTE)* set to the value of the MIB attribute itsGnLifetimeLocTE and shall be removed when the lifetimes expires.

7.2   Local Position Vector

7.2.1   General

A GeoAdhoc router shall maintain a local data structure that holds position-related information for the local GeoAdhoc router, i.e. the local position vector LPV. The data elements of a location table entry is specified in clause 7.2.2 and the maintenance of the location table in clause 7.2.3.

7.2.2   Minimum data elements

The LPV shall contain at least the following data elements:

- Geographical position *POS_LPV*.

- Speed *S_LPV*.

- Heading *H_LPV*.

- Timestamp *TST_LPV* indicating when the geographical position POS_LPV was generated.

- Accuracy of the geographical position *Acc(POS, LPV)*.

- Accuracy of the speed *ACC (S, LPV)*.

- Accuracy of the heading *ACC(H, LPV)*.

7.2.3   Maintenance

At start-up, all data elements of the LPV shall be initialized with 0 to indicate an unknown value.

The LPV should be updated with a minimum frequency of the MIB attribute itsGnMinimumUpdateFrequencyLPV.

If the LPV is updated with a smaller frequency, the GeoAdhoc router shall not handle GeoNetworking packets.

NOTE: The MIB attribute itsGnMinimumUpdateFrequencyLPV should have different values for vehicle ITS station and roadside ITS station. This reflects the fact that roadside ITS stations are not mobile, but at most portable, and therefore require a smaller update frequency.

7.3   Sequence number

7.3.1   General

Each GeoAdhoc router shall maintain a local sequence number that determines the Sequence Number (SN) field of the next GeoNetworking packet to be transmitted.

7.3.2   Maintenance

SN shall be initialized to 0. For every GeoNetworking packet P, the sequence number SN(P) shall be incremented as follows:

$$SN(P) = (SN(P) + 1) \bmod SN\_MAX$$

with SN(P) being the sequence number of the GeoNetworking packet and SN_MAX the largest possible sequence number. The resulting sequence number shall be included in the GeoNetworking packet.

The SN is incremented for multi-hop GeoNetworking packets only. Single-hop GeoNetworking packets (BEACON, SHB) do not carry a *SN* field.

7.4 Location service packet buffer

7.4.1 General

Upon invocation of the LS (clause 9.2.4), a GeoAdhoc router shall queue a GeoNetworking packet in a *LS packet buffer* for the sought destination until the LS is completed. Subsequent GeoNetworking packets, which are processed while the LS is in progress, shall also be buffered (see clause 9.2.4).

7.4.2 Maintenance

The *LS packet buffer* shall have a minimum size of the value stored in the MIB attribute itsGnLocationServicePacketBufferSize.

The *LS packet buffer* shall work as follows:

- GeoNetworking packets arriving at the LS packet buffer for a destination (GN_ADDR of a certain ITS station) shall be queued at the tail of the queue.

- When a new GeoNetworking packet arrives at the *LS packet buffer* and exceeds the buffer capacity (buffer overflow), GeoNetworking packets from the head of the queue are removed and the new GeoNetworking packet queued at the tail (head drop).

- When the LS is completed, the *LS packet buffer* shall be flushed, i.e. all GeoNetworking packets stored in the buffer shall be sent in a First-In-First-Out (FIFO) manner.

- When the queuing time of the GeoNetworking packet in the *LS packet buffer* exceeds the packet lifetime carried in the GeoNetworking packet's *LT* field in the Extended Header, the GeoNetworking packet shall be discarded.

- When a stored GeoNetworking packet is sent, the *LT* field shall be reduced by the queuing time in the *LS packet buffer*.

- When the LS does not complete, all stored GeoNetworking packets shall be discarded triggered by the *LS*.

NOTE: The mechanism to detect that a LS does not complete is implementation dependent.

7.5 Forwarding packet buffer

7.5.1 General

A GeoAdhoc router shall use *forwarding packet buffers* to temporarily keep packets in a GeoAdhoc router during the forwarding process.

A GeoAdhoc router shall maintain the following *forwarding packet buffers*:

- *UC forwarding packet buffer* to buffer GeoUnicast packets per GN_ADDR.

- *BC forwarding packet buffer* to buffer TSB, GeoBroadcast and GeoAnycast packets.

If Contention-Based Forwarding (CBF) is enabled, i.e. MIB attribute itsGnGeoUnicastForwardingAlgorithm set to 2 (CBF), the GeoAdhoc router shall maintain a *CBF packet buffer* per packet.

7.5.2 Buffer size

The *UC forwarding packet buffer* shall have a minimum size given by the value of the MIB attribute itsGnUcForwardingPacketBufferSize.

The *BC forwarding packet buffer* shall have a minimum size given by the value of the MIB attribute itsGnBcForwardingPacketBufferSize.

The *CBF packet buffer* shall have a minimum size given by the value of the MIB attribute itsGnCbfPacketBufferSize.

7.5.3   Maintenance

The *UC forwarding packet buffer* and the *BC forwarding packet buffer* shall work as follows:

- GeoNetworking packets arriving at the *forwarding packet buffer* shall be queued at the tail of the queue.

- When a new GeoNetworking packet arrives at the *forwarding packet buffer* and exceeds the buffer capacity, GeoNetworking packets from the head of the queue are removed and the new GeoNetworking packet queued at the tail (head drop).

- When the *forwarding packet buffer* is flushed, the GeoNetworking packets stored in the buffer shall be forwarded in a FIFO manner.

- When the queuing time of the GeoNetworking packet in the *forwarding packet buffer* exceeds the packet lifetime carried in the packet's *LT* field in the Extended Header, the GeoNetworking packet shall be discarded.

- When a stored GeoNetworking packet is sent, the value of the *LT* field shall be reduced by the queuing time in the forwarding packet buffer.

The *CBF packet buffer* shall work as follows:

- Packets arriving at the *CBF packet buffer* shall be queued at the tail of the queue.

- When a new GeoNetworking packet arrives at the *CBF packet buffer* and exceeds the buffer capacity, GeoNetworking packets from the head of the queue are removed and the new GeoNetworking packet queued at the tail (head drop).

- Every GeoNetworking packet in the buffer is associated with a timer. When the timer expires the GeoNetworking packet is removed from the queue.

  NOTE: The value of the timer is set by the CBF forwarding algorithm specified in clause C.3.

8   GeoNetworking packet structure and formats

8.1   Overview

This clause specifies the structure and the format of the GeoNetworking packet.

8.2   Packet structure

8.2.1   General

As specified in TS 102 636-3 [4], the GeoNetworking protocol shall either be used in the GeoNetworking protocol stack (TS 102 636-3 [4], clause 7.3.2) or in the protocol stack that combines the GeoNetworking protocol and IPv6 (TS 102 636-3 [4], clause 7.3.4).

8.2.2   Overall structure

A GeoNetworking packet is part of the overall frame/packet structure depicted in figure 4:

- The *MAC header* is the header of the MAC protocol of the ITS access technology. The MAC protocol can add additional protocol elements, such as a trailer for the MAC FCS as in ITS-G5 [i.1].

  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.

- The *GeoNetworking header* is the header of the GeoNetworking packet as defined in the present document and extended for media-dependent GeoNetworking functionality, such as for ITS-G5A specified in TS 102 636-4-2 [i.2].

- The optional *GeoNetworking security header*.

NOTE 2: The specification of the *GeoNetworking security header* is outside the scope of the present document.

- 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 entity for transmission.

NOTE 3: The general packet structure is shown as seen by the MAC protocol of the ITS Access Layer.

NOTE 4: Some GeoNetworking packet do not carry a payload, such as Beacon.

MAC Header	LLC Header	GeoNetworking Header	GeoNetworking Security Header (optional)	Payload (optional)

Figure 4: GeoNetworking packet structure

8.2.3   Maximum Transmit Unit

The Maximum Transmit Unit (MTU), which the GeoNetworking protocol supports via the GN_SAP, i.e. the MTU_GN depends on the MTU of the access layer technology (MTU_AL) over which the GeoNetworking packet is transported. In particular, MTU_GN shall be less or equal to MTU_AL reduced by the size of the largest GeoNetworking protocol header (GEO_MAX) and by the size of the largest GeoNetworking Security header (GEOSEC_MAX):

$$MTU\_GN \le MTU\_AL - GEO\_MAX - GEOSEC\_MAX$$

GEO_MAX is set by the MIB attribute itsGnMaxGeoNetworkingHeaderSize.

The value of GEOSEC_MAX is beyond the scope of the present document.

8.3   GeoNetworking header structure

The GeoNetworking header shall be comprised of a *Common Header* and an *Extended Header* (figure 5).

Common Header	Extended Header
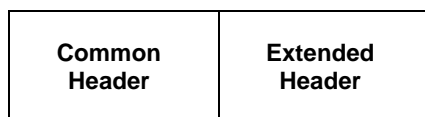
Figure 5: GeoNetworking header structure

Common Header and *Extended Header* are specified in clauses 8.5 and 8.6, respectively.

8.4   Position vector

8.4.1   Overview

For simplicity, a set of position-related fields of the GeoNetworking header are subsumed to a position vector (PV). Two types of PV are defined:

- *Long position vector.*

- *Short position vector.*

8.4.2   Long Position Vector

8.4.2.1   Structure

The *Long Position Vector* shall consist of the fields specified in figure 6.

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
GN_ADDR																															
TST																															
Lat																															
Long																															
S																H															
Alt																TAcc				PosAcc				SAcc		HAcc		AltAcc			

Figure 6: *Long Position Vector*

8.4.2.2   Fields

The *Long Position Vector* shall consist of the fields as specified in table 2.

Table 2: Fields of *Long Position Vector*

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	**Last**			
1	GN_ADDR	Octet 0	Octet 7	64 bit address	n/a	The network address for the GeoAdhoc router entity in the ITS station.
2	TST	Octet 8	Octet 11	32 bit unsigned integer	[ms]	Expresses the time in milliseconds at which the latitude and longitude of the ITS station were acquired by the GeoAdhoc router. The time is encoded as: $$TST = TST(UET)\,\mathrm{mod}\,2^{32}$$ where *TST(UET)* is the number of milliseconds since the Unix Epoch 1970-01-01T00:00.
3	Lat	Octet 12	Octet 15	32 bit signed integer	[1/10 micro-degree]	WGS-84 latitude of the GeoAdhoc router expressed in 1/10 micro degree.
4	Long	Octet 16	Octet 19	32 bit signed integer	[1/10 micro-degree]	WGS84 longitude of the GeoAdhoc router expressed in 1/10 micro degree.
5	S	Octet 20	Octet 21	16 bit signed integer	[1/100 m/s]	Speed of the GeoAdhoc router expressed in signed units of 0,01 meters per second.
6	H	Octet 22	Octet 23	16 bit unsigned integer	[1/10 degrees]	Heading of the GeoAdhoc router from which the Network Header originates, expressed in unsigned units of 0,1 degrees from North
7	Alt	Octet 24	Octet 25	16 bit signed integer	[m]	Altitude of the GeoAdhoc router expressed in signed units of 1 meter.
8	TAcc	Octet 26 Bit 0	Octet 26 Bit 3	4 bit unsigned integer	n/a	Accuracy indicator for the value expressed in the field TST. The accuracy interval of the 95 % accuracy level for the value of the TST field defined as: $Accuracy_{95\%} = Value of\,(LSbit\,(TST)\cdot 2^{TAcc} = 1ms\cdot 2^{TAcc}$ The minimum and maximum value of the time accuracy interval is then: $$1\,ms\times 2^{0...15} = 1...32\,768\,ms\,.$$

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
9	*PosAcc*	Octet 26 Bit 4	Octet 26 Bit 7	4 bit unsigned integer	n/a	Encoded accuracy indicator for the value of the position *POS*. The accuracy interval of the 95 % accuracy level for POS is defined as: $$Accuracy_{95\%} = Area(POS, R)$$ with $$POS = Lat, Long$$ and $$R = LSbit(Long) \cdot 2^{PosAcc}$$ *PosAcc* = 0000 is reserved to indicate that no specific accuracy interval is specified. The maximum error the 95 % accuracy interval can cover, represented by *PosAc*c = 1111, is 1/10 micro degree * 2^{15} equivalent to about 365 m. (see notes 1 to 3)
10	*SAcc*	Octet 27 Bit 0	Octet 27 Bit 2	3 bit unsigned integer	n/a	Encoded accuracy indicator for the value expressed in the field Speed *S*. The accuracy interval of the 95 % accuracy level for the currently reported value is defined as: $$Accuracy_{95\%} = Valueof(LSbit(S)) \cdot 2^{SAcc} = 0.01 m/s \cdot 2^{SAcc}$$ SAcc = 00 is reserved to indicate that the accuracy interval is not specified. The maximum error the 95 % accuracy interval can cover, represented by *SAcc* = 111, is 0,01 m/s * 2^7 equivalent to 0,01 m/s * 128 = 1,28 m/s.
11	*HAcc*	Octet 27 Bit 3	Octet 27 Bit 5	3 bit unsigned integer	n/a	Encoded accuracy indicator for the value of the field Heading *H*. The interval of the 95 % accuracy level for the currently Heading value H is defined as: $$Accuracy_{95\%} = Valueof(LSbit(H)) \cdot 2^{HAcc} = 0.005493247 \deg \cdot 2^{HAcc}$$ *HAcc* = 000 is reserved to indicate that no specific accuracy interval is specified. The maximum error the 95 % accuracy interval can cover, represented by the *HAcc* = 111, is 0,005493247 deg * 2^7 equivalent to about 0,005493247 deg * 128 ≈ 0,7 deg.
12	*AltAcc*	Octet 27 Bit 6	Octet 27 Bit 7	2 bit unsigned integer	n/a	Encoded accuracy indicator for the value in the field Altitude (*Alt*). The accuracy interval of the 95 % accuracy level is defined as: $$Accuracy_{95\%} =$$ $$Valueof(LSbit(Alt)) \cdot 2^{AAcc} =$$ $$1m \cdot 2^{AAcc}$$ *AltAcc* = 00 is reserved to indicate that no specific accuracy interval is specified. The maximum error the 95 % accuracy interval can cover, represented by *AltAcc*=11, is 1 m ˙ 2^3 equivalent to about 1 m * 8 = 8 m.

NOTE 1: The least significant bit (LSB) of the Longitude *LSbit(Long)* represents the smallest encoded unit of the Longitude.

NOTE 2: Packets with Latitude and Longitude information and a *PosAcc* = 1111 shall receive special treatment whenever used.

NOTE 3: The geographic extend of the area defined by (POS, R) is invariant with respect to the location of the center of the area on the Earth.

8.4.3   Short Position Vector

8.4.3.1   Structure

The *Short Position Vector* shall consist of the fields specified in 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
+-------------------------------------------------------------------+
|                             GN_ADDR                               |
+-------------------------------------------------------------------+
|                               TST                                 |
+-------------------------------------------------------------------+
|                               Lat                                 |
+-------------------------------------------------------------------+
|                               Long                                |
+-------------------------------------------------------------------+
```

Figure 7: *Short Position Vector*

8.4.3.2   Fields

The *Short Position Vector* shall consist of the fields as specified in table 3.

Table 3: Fields of *Short Position Vector*

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*GN_ADDR*	Octet 0	Octet 7	64 bit address	n/a	The *GN_ADDR* field as specified in table 2.
2	*TST*	Octet 8	Octet 11	32 bit unsigned integer	[ms]	The Timestamp TST field as specified in table 2.
3	*Lat*	Octet 12	Octet 15	32 bit signed integer	[1/10 micro-degree]	The Latitude (*Lat*) field as specified in table 2.
4	*Long*	Octet 16	Octet 19	32 bit signed integer	[1/10 micro-degree]	The Longitude (*Long*) field as specified in table 2.

NOTE 1: The short position vector does not have an altitude field.

NOTE 2: The timestamp TST field indicates the time when the position (LAT, LONG) of the SPV was acquired.

8.5   Common Header

8.5.1   Composition of the *Common Header*

The common header shall be present in every GeoNetworking packet and consists of the fields as depicted in figure 8.

```
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
+-------------------------------------------------------------------+
| Version |  NH   |   HT   |  HST   |     Reserved    |   Flags     |
+-------------------------------------------------------------------+
|            PL           |         TC        |        HL           |
+-------------------------------------------------------------------+
|                             SE PV                                 |
|                                                                   |
+-------------------------------------------------------------------+
```

Figure 8: *Common Header* format

8.5.2   Fields of the *Common Header*

The *Common Header* shall carry the fields as specified in table 4.

Bit 0 to 5: 0 Bit 6: itsGnStationType (MIB attribute) Bit 7: 0	Only Bit 6 used. Other fields reserved for future use.

Table 4: Fields of the *Common* Header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Version*	Octet 0 Bit 0	Octet 0 Bit 3	4 bit unsigned integer	n/a	Identifies the version of the GeoNetworking protocol.
2	*NH*	Octet 0 Bit 4	Octet 0 Bit 7	4 bit unsigned integer	n/a	Identifies the type of header immediately following the GeoNetworking header as specified in table 5.
3	*HT*	Octet 1 Bit 0	Octet 1 Bit 3	4 bit unsigned integer	n/a	Identifies the type of the GeoAdhoc header type as specified in table 6.
4	*HST*	Octet 1 Bit 4	Octet 1 Bit 7	4 bit unsigned integer	n/a	Identifies the sub-type of the GeoAdhoc header type as specified in table 6.
5	*Reserved*	Octet 2	Octet 2		n/a	Reserved for media-dependent functionality.
6	*Flags*	Octet 3	Octet 3	Bit field	n/a	Bit 0 to 5: Reserved. Set to 0. Bit 6: Type if ITS station. Bit 7: Reserved. Set to 0.
7	*PL*	Octet 4	Octet 5	16 bit unsigned integer	[bytes]	Length of the Network Header payload, i.e. the rest of the packet following the whole GeoNetworking header in octets.
8	*TC*	Octet 6	Octet 6	Four sub-fields: 1bit unsigned integer, 3 bit unsigned integer, 2 bit selector, 2 bit selector	n/a	Traffic class that represents Facility-layer requirements on packet transport. Composed of four sub-fields (figure 9): Bit 0: Reserved. Set to 0. Bit 1 to 3: **Relevance** Relevance expresses the relevance or importance of a message given by the upper protocol entity. The relevance of a message shall be encoded as defined in clause 8.5.6.1. Bit 4 to 5: **Reliability** Reliability means the relative probability of correctly receiving a packet in a geographical area encoded by a 2 bit selector as detailed in table 7. Bit 6 to 7: **Latency** Latency expresses the relative packet delivery latency in a geographical area encoded by a 2 bit selector as detailed in table 8.
9	*HL*	Octet 7	Octet 7	8 bit unsigned integer	[hops]	Decremented by 1 by each GeoAdhoc router that forwards the packet. The packet must not be forwarded if Hop Limit is decremented to zero.
10	*SE PV*	Octet 8	Octet 35	Long Position Vector	n/a	Long position vector of the sender. It shall carry the fields as specified in clause 8.4.2 (Long Position Vector). Length: 28 octets.

8.5.3   Encoding of the NH field

For the *Next Header (NH)* field in the *Common Header* the values as specified in table 5 shall be used.

Table 5: *Next Header* (*NH*) field in the GeoNetworking *Common Header*

Next Header (NH)	Encoding	Description
ANY	0	Unspecified
BTP-A	1	Transport protocol (BTP-A for interactive packet transport) as defined in TS 102 636-5-1 [5]
BTP-B	2	Transport protocol (BTP-B for non-interactive packet transport) as defined in TS 102 636-5-1 [5]
IPv6	3	IPv6 header as defined in TS 102 636-6-1 [6]

8.5.4   Encoding of the HT and HST fields

For the *Header Type* (*HT)* and the *Header Sub-Type* (*HST)* fields in the *Common Header* the values as specified in table 6 shall be used.

Table 6: GeoNetworking *Header Types* and *Header Sub-Types*

Header Type (HT)	Header Sub-type (HST)	Encoding	Description
ANY		0	Unspecified
	UNSPECIFIED	0	Unspecified
BEACON		1	Beacon
	UNSPECIFIED	0	Unspecified
GEOUNICAST		2	GeoUnicast
	UNSPECIFIED	0	Unspecified
GEOANYCAST		3	Geographically-Scoped Anycast (GAC)
	GEOANYCAST_CIRCLE	0	Circular area
	GEOANYCAST_RECT	1	Rectangular area
	GEOANYCAST_ELIP	2	Ellipsoidal area
GEOBROADCAST		4	Geographically-Scoped broadcast (GBC)
	GEOBROADCAST_CIRCLE	0	Circular area
	GEOBROADCAST_RECT	1	Rectangular area
	GEOBROADCAST_ELIP	2	Ellipsoidal area
TSB		5	Topologically-scoped broadcast (TSB)
	SINGLE_HOP	0	Single-hop broadcast (SHB)
	MULTI_HOP	1	Multi-hop TSB
LS		6	Location service (LS)
	LS_REQUEST	0	Location service request
	LS_REPLY	1	Location service reply

8.5.5   Composition of the TC field

The TC field shall consist of the fields as depicted in figure 9.

```
      0       1    2    3    4    5    6    7
  ┌──────────┬──────────────┬────────────┬──────────┐
  │ Reserved │  Relevance   │ Reliability │ Latency  │
  └──────────┴──────────────┴────────────┴──────────┘
```
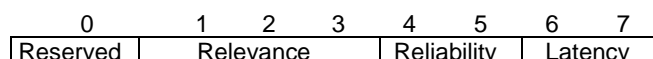
Figure 9: *Traffic Class (TC)* field composition

The TC subfields are defined as relative values; i.e. they are not based on quantities.

   NOTE: The usage of the TC field is further specified in the media-dependent functionality of GeoNetworking.

8.5.6   Encoding of the TC-sub-fields

8.5.6.1   Encoding of the TC-sub-field *Relevance*

The relevance of a message shall be encoded to a value in the range between 0 and 7. The most relevant messages have the relevance value 0 and the least relevant messages have the value 7.

The default value for the TC sub-field *Relevance* field is set by the MIB attribute itsGnTrafficClassRelevance.

8.5.6.2   Encoding of the TC-sub-field *Reliability*

The reliability of a message shall be encoded as specified in table 7.

The default value for the TC sub-field *Reliability* field is set by the MIB attribute itsGnTrafficClassReliability.

NOTE: So far, *Reliability* is only defined for dissemination of a packet in a geographical area. For other forwarding types (e.g. GeoUnicast), the field is ignored. Same holds for *Latency* in clause 8.5.6.3.

Table 7: Encoding of the *Traffic Class (TC)* sub-field *Reliability*

	00	**01**	**10**	**11**
Reliability	Very high	High	Medium	Low

8.5.6.3   Encoding of the TC-sub-field *Latency*

The *TC* sub-field *Latency* shall be encoded as specified in table 8.

The default value for the TC sub-field *Latency* field is set by the MIB attribute itsGnTrafficClassLatency.

Table 8: Encoding of the *TC* sub-field *Latency*

	00	**01**	**10**	**11**
Latency	Very low	Low	Medium	High

8.5.7   Encoding of the LT field in *Extended Headers*

The *Lifetime (LT)* field shall indicate the maximum tolerable time a packet can be buffered until it reaches its destination.

NOTE: This parameter is relevant for safety and traffic efficiency information that do not have strict real-time requirements. In sparse network scenarios, this lifetime can also be used to avoid re-transmission and forwarding of outdated information.

The following method for encoding of the *LT* field uses a non-linear encoding, which provides a high resolution for low numbers and progressively lower resolution for higher numbers.

The *LT* field shall be comprised of two sub-fields: a $LT_{Multiplier}$ sub-field (*Multiplier*) and a LT_{Base} sub-field (*Base*) (figure 10) and shall be encoded as follows:

$$Lifetime_{decoded} = LT_{Multiplier} \cdot LT_{Base}$$

The LT_{Base} sub-field represents a two bit unsigned selector that chooses one out of four predefined values as specified in table 9.

Table 9: Encoding of *LT* sub-field *LT Base*

Value	LT_base
0	50 ms
1	1 s
2	10 s
3	100 s

The $LT_{Multiplier}$ is a 6 bit unsigned integer, which represents a multiplier range from 1 to 2^6 - 1 = 63. The default value is 0, indicating no special requirement on the lifetime of the packet. The maximum lifetime is 6 300 s.

0	1	2	3	4	5	6	7
Multiplier [1.. 64]						Base: 50 ms, 1 s, 10 s, 100 s	
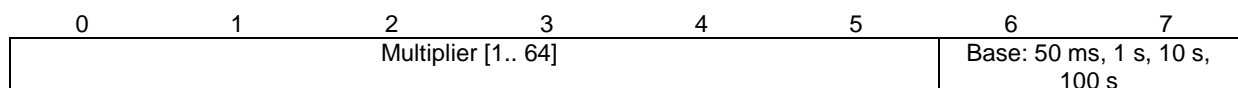
Figure 10: Composition of the *LT field*

8.6 GeoNetworking packet headers

8.6.1 Overview

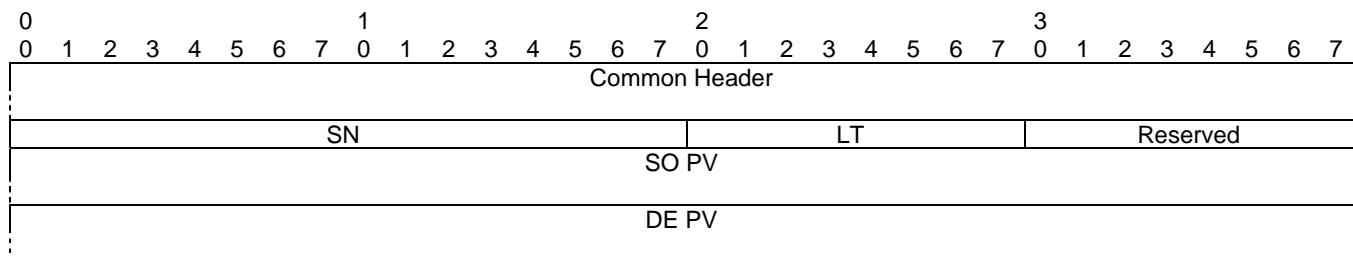The GeoNetworking packet header shall be present in the every GeoNetworking packet:

- GeoUnicast (clause 8.6.2).

- TSB (clause 8.6.3).

- SHB (clause 8.6.4).

- GeoBroadcast and GeoAnycast (clause 8.6.5).

- BEACON (clause 8.6.6).

- LS Request and LS Reply (clauses 8.6.7 and 8.6.8).

8.6.2 GeoUnicast packet header

8.6.2.1 Composition of the GeoUnicast packet header

The GeoUnicast header shall be comprised of the *Common Header* and the *Extended Header* as shown in figure 11.

NOTE: The *Extended Header* comprises all fields except the *Common Header*.

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
Common Header																															
SN																LT								Reserved							
SO PV																															
DE PV																															

Figure 11: Packer header format: GeoUnicast

8.6.2.2   Fields of the GeoUnicast packet header

The GeoUnicast packet header shall consist the fields as specified in table 10.

Table 10: Fields of the GeoUnicast packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	Octet 0	Octet 35	Common Header	n/a	Common header as specified in clause 8.5.
2	*SN*	Octet 36	Octet 37	16-bit unsigned integer	n/a	Sequence number field. Indicates the index of the sent GeoUnicast packet (clause 7.3) and used to detect duplicate GeoNetworking packets (annex A).
3	*LT*	Octet 38	Octet 38	8-bit unsigned integer	n/a	Lifetime field. Indicates the maximum tolerable time a packet can be buffered until it reaches its destination. Bit 0 to 5: LT sub-field Multiplier. Bit 6 to 7: LT sub-field Base. Encoded as shown in clause 8.5.7.
4	*Reserved*	Octet 39	Octet 39	8-bit unsigned integer	n/a	Reserved for media-dependent functionality.
5	*SO PV*	Octet 40	Octet 67	Long position vector	n/a	Long position vector of the source as specified in clause 8.4.2 (Long Position Vector). Length: 28 octets.
6	*DE PV*	Octet 68	Octet 87	Short position vector	n/a	Short position vector of the destination. It shall consist of the fields as specified in clause 8.4.3 (Short Position Vector). Length: 20 octets.

8.6.3   TSB packet header

8.6.3.1   Composition of the TSB packet header

The TSB header shall be comprised of the *Common Header* and the *Extended Header* as shown in figure 12.

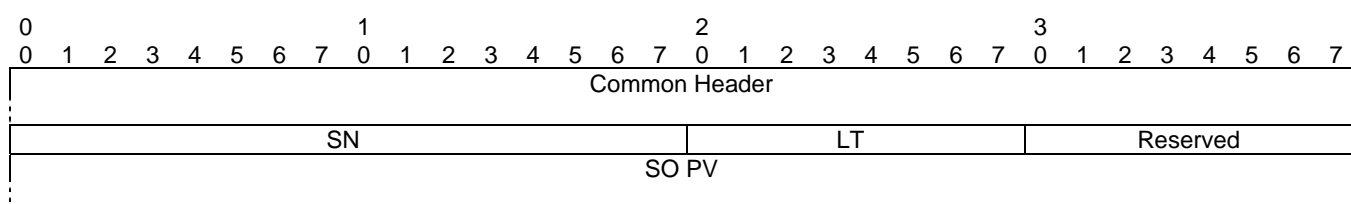NOTE: The *Extended Header* comprises all fields except the *Common Header*.

Figure 12: Packer header format: TSB

8.6.3.2 Fields of the TSB packet header

The TSB packet header shall consist of the fields as specified in table 11.

Table 11: Fields of the TSB packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	Octet 0	Octet 35	Common Header	n/a	Common header as specified in clause 8.5.
2	*SN*	Octet 36	Octet 37	16-bit unsigned integer	n/a	Sequence number field. Indicates the index of the sent GeoUnicast packet (clause 7.3) and used to detect duplicate GeoNetworking packets (annex A).
3	*LT*	Octet 38	Octet 38	8-bit unsigned integer	[s]	Lifetime field. Indicates the maximum tolerable time a packet can be buffered until it reaches its destination. Encoded as shown in clause 8.5.7.
4	*Reserved*	Octet 39	Octet 39	8-bit unsigned integer	n/a	Reserved for media-dependent functionality.
5	*SO PV*	Octet 40	Octet 67	Long Position Vector	n/a	Long position vector of the source as specified in clause 8.4.2 (Long Position Vector). Length: 28 octets.

8.6.4 SHB packet header

8.6.4.1 Composition of the SHB packet header

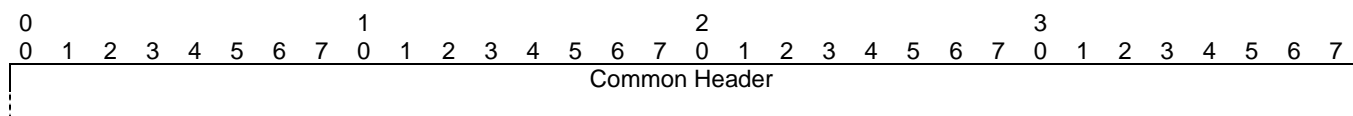The SHB header shall consist of a *Common Header* only. It has no *Extended Header* (see figure 13).

```
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
                                        Common Header
```

Figure 13: Packer header format: SHB

8.6.4.2 Fields of the SHB packet header

The SHB packet header shall consist of the fields as specified in table 12.

Table 12: Fields of the SHB packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	1	36	Common Header	n/a	Common header as specified in clause 8.5.

8.6.5 GeoBroadcast/GeoAnycast packet header

8.6.5.1 Composition of the GeoBroadcast/GeoAnycast packet header

The GeoBroadcast and GeoAnycast packets shall have the same header structure. They are distinguished by the *HT* field in the *Common Header*.

The header shall be comprised of the *Common Header* and the *Extended Header* as shown in figure 14.

NOTE: The *Extended Header* comprises all fields except the *Common Header*.
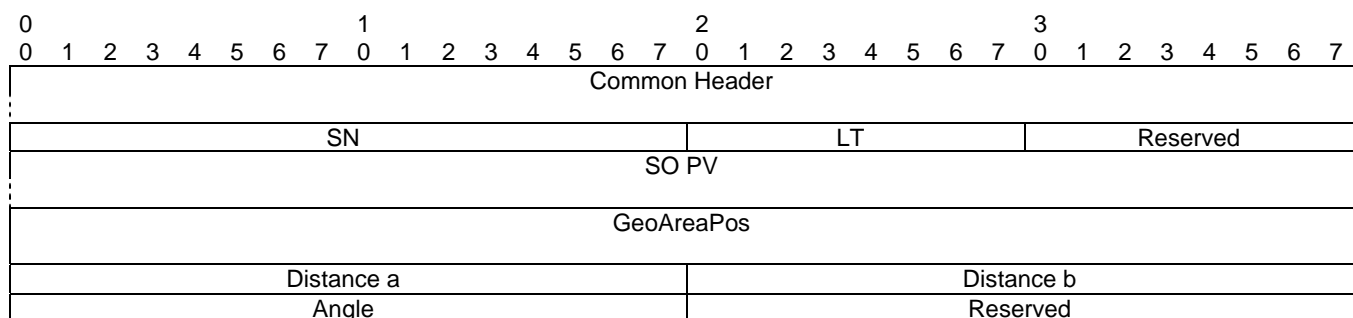
```
 0                    1                    2                    3
 0 1 2 3 4 5 6 7  0 1 2 3 4 5 6 7  0 1 2 3 4 5 6 7  0 1 2 3 4 5 6 7
┌─────────────────────────────────────────────────────────────────┐
│                          Common Header                            ┆
├─────────────────────────────────┬───────────────┬───────────────┤
│               SN                │      LT       │   Reserved    │
├─────────────────────────────────┴───────────────┴───────────────┤
│                              SO PV                               ┆
├──────────────────────────────────────────────────────────────────┤
│                           GeoAreaPos                             │
├─────────────────────────────────┬────────────────────────────────┤
│           Distance a            │           Distance b           │
├─────────────────────────────────┼────────────────────────────────┤
│             Angle               │            Reserved            │
└─────────────────────────────────┴────────────────────────────────┘
```

Figure 14: Packer header format: GeoBroadcast/GeoAnycast

8.6.5.2 Fields of the GeoBroadcast/GeoAnycast packet header

The GeoBroadcast/GeoAnycast packet header shall consist of the fields as specified in table 13.

Table 13: Fields of the GeoBroadcast/GeoAnycast packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	Octet 0	Octet 35	Common Header	n/a	Common header as specified in clause 8.5.
2	*SN*	Octet 36	Octet 37	16-bit unsigned integer	n/a	Sequence number field. Indicates the index of the sent GeoUnicast packet (clause 7.3) and used to detect duplicate GeoNetworking packets (annex A).
3	*LT*	Octet 38	Octet 38	8-bit unsigned integer	n/a	Lifetime field. Indicates the maximum tolerable time a packet can be buffered until it reaches its destination. Encoded as shown in clause 8.5.7.
4	*Reserved*	Octet 39	Octet 39	8-bit unsigned integer	n/a	Reserved for media-dependent functionality.
5	*SO PV*	Octet 40	Octet 67	Long position vector	n/a	Long position vector of the source as specified in clause 8.4.2 (Long Position Vector). Length: 28 octets.
6	*GeoAreaPos Latitude*	Octet 68	Octet 71	32-bit signed integer	[1/10 micro-degree]	WGS-84 latitude for the center position of the geometric shape as defined in [7] in 1/10 micro degree.
7	*GeoAreaPos Longitude*	Octet 72	Octet 75	32-bit signed integer	[1/10 micro-degree]	WGS-84 longitude for the center position of the geometric shape as defined in [7] in 1/10 micro degree.
8	*Distance a*	Octet 76	Octet 77	16-bit unsigned integer	[m]	Distance a of the geometric shape as defined in [7] in meters.
9	*Distance b*	Octet 78	Octet 79	16-bit unsigned integer	[m]	Distance b of the geometric shape as defined in [7] in meters.
10	*Angle*	Octet 80	Octet 81	16-bit unsigned integer	[°]	Angle of the geometric shape as defined in [7] in degrees from North.
11	*Reserved*	Octet 82	Octet 83	16-bit unsigned integer	n/a	Unused.

In case of a circular area (GeoNetworking packet sub-type *HST* = 0), the fields shall be set to the following values:

- *Distance a* is set to the radius r.

- *Distance b* is set to 0.

- *Angle* is set to 0.

8.6.6   BEACON packet header

8.6.6.1   Composition of the BEACON packet header

A BEACON packet shall consist of a *Common Header* only. It has no *Extended Header* (see figure 15).
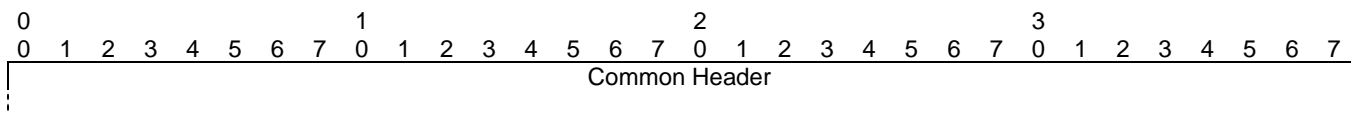
0								1								2								3							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Common Header																															

Figure 15: Packer header format: BEACON

8.6.6.2   Fields of the BEACON packet header

The BEACON shall consist of the fields of a *Common Header* only as specified in table 14.

Table 14: Fields of the BEACON packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	Octet 0	Octet 35	Common Header	n/a	Common header as specified in clause 8.5.

8.6.7   LS Request header

8.6.7.1   Composition of the LS Request header

The LS Request packet header shall be comprised of the *Common Header* and the *Extended Header* as shown in figure 16.

> NOTE: The *Extended Header* comprises all fields except the *Common Header*.
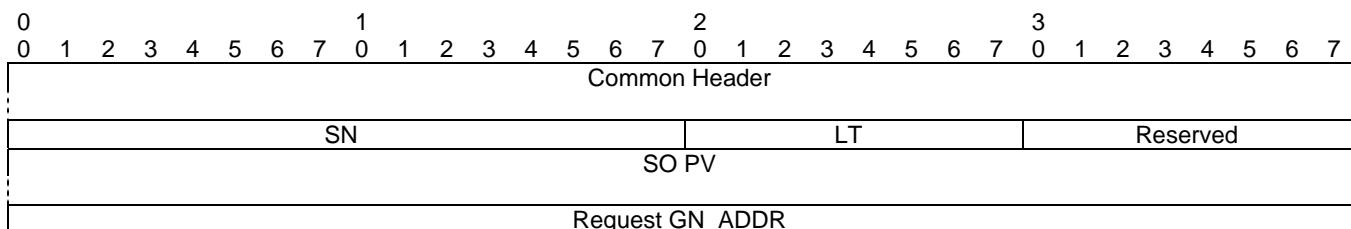
0								1								2								3							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Common Header																															
SN																LT								Reserved							
SO PV																															
Request GN_ADDR																															

Figure 16: Packer header format: LS Request

8.6.7.2 Fields of the LS Request packet header

The LS Request packet header shall carry the fields as specified in table 15.

Table 15: Fields of the LS Request packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	Octet 0	Octet 35	Common Header	n/a	Common header as specified in clause 8.5.
2	*SN*	Octet 36	Octet 37	16-bit unsigned integer	n/a	Sequence number field. Indicates the index of the sent GeoUnicast packet (clause 7.3) and used to detect duplicate GeoNetworking packets (annex A).
3	*LT*	Octet 38	Octet 38	8-bit unsigned integer	n/a	Lifetime field. Indicates the maximum tolerable time a packet can be buffered until it reaches its destination. Encoded as shown in clause 8.5.7.
4	*Reserved*	Octet 39	Octet 39	8-bit unsigned integer	n/a	Reserved for media-dependent functionality.
5	*SO PV*	Octet 40	Octet 67	Long position vector	n/a	Long position vector of the source as specified in clause 8.4.2 (Long Position Vector). Length: 28 octets.
6	*Request GN_ADDR*	Octet 68	Octet 75	64-bit address	n/a	The GN_ADDR address for the GeoAdhoc router entity for which the location is being requested.

8.6.8 LS Reply packet header

8.6.8.1 Composition of the LS Reply packet header

The LS Reply packet header shall be comprised of the *Common Header* and the *Extended Header* as shown in figure 17.

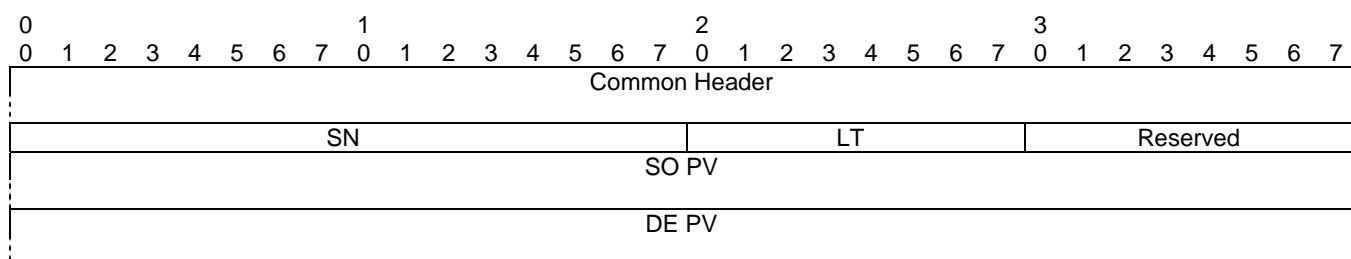NOTE: The *Extended Header* comprises all fields except the *Common Header*.

Figure 17: Packer header format: LS Reply

8.6.8.2   Fields of the LS Reply packet header

The LS Reply packet header shall carry the fields as specified in table 16.

Table 16: Fields of the LS Reply packet header

Field #	Field name	Octet/bit position		Type	Unit	Description
		First	Last			
1	*Common Header*	Octet 0	Octet 35	Common Header	n/a	Common header as specified in clause 8.5.
2	*SN*	Octet 36	Octet 37	16-bit unsigned integer	n/a	Sequence number field. Indicates the index of the sent GeoUnicast packet (clause 7.3) and used to detect duplicate GeoNetworking packets (annex A).
3	*LT*	Octet 38	Octet 38	8-bit unsigned integer	n/a	Lifetime field. Indicates the maximum tolerable time a packet can be buffered until it reaches its destination. Encoded as shown in clause 8.5.7.
4	*Reserved*	Octet 39	Octet 39	8-bit unsigned integer	n/a	Reserved for media-dependent functionality.
5	*SO PV*	Octet 40	Octet 67	Long position vector	n/a	Long position vector of the source, which represents the Request GN_ADDR in the corresponding LS Request, as specified in clause 8.4.2. (Long Position Vector). Length: 28 octets.
6	*DE PV*	Octet 68	Octet 87	Short position vector	n/a	Short position vector of the destination. It shall carry the fields as specified in clause 8.4.3 (Short Position Vector). Length: 20 octets.

9   Protocol operation

9.1   General

This clause specifies the media-independent operations of the GeoNetworking protocol.

The operations include:

- Network management:

    - Address configuration (clause 9.2.1).

    - Local position vector and time update (clause 9.2.2).

    - Beaconing (clause 9.2.3).

    - Location service (clause 9.2.4).

- Packet handling:

    - GeoUnicast (clause 9.3.4).

    - TSB (clause 9.3.5).

    - SHB (clause 9.3.6).

    - GeoBroadcast (clause 9.3.7).

    - GeoAnycast (clause 9.3.8).

9.2   Network management

9.2.1   Address configuration

9.2.1.1   General

At start-up, a GeoAdhoc router shall have a self-assigned initial GeoNetworking address with the format specified in clause 6. GeoNetworking defines two methods for the configuration of the local GN_ADDR

- Auto-address configuration (clause 9.2.1.2).

- Managed address configuration(clause 9.2.1.3).

The method is defined in the MIB attribute itsGnLocalAddrConfMethod.

In the managed address configuration, the initial GeoNetworking address (clause 9.2.1.3.1) of the GeoAdhoc router can be updated (clause 9.2.1.3.2).

Operations for duplicate address detection are specified in clause 9.2.1.4.

9.2.1.2   Auto-address configuration

The auto-address configuration method shall be used if the MIB attribute itsGnLocalAddrConfMethod is set to AUTO (0).

At start-up, the GeoAdhoc router shall assign its local GN_ADDR from the MIB attribute itsGnLocalGnAddr.

   NOTE: The setting of the MIB attribute itsGnLocalGnAddr is implementation dependent. One example
              implementation is the usage of randomly-generated addresses.

The local GN_ADDR shall not be changed unless the MIB attribute itsGnLocalAddrConfMethod is set to MANAGED (1).

9.2.1.3   Managed address configuration

The managed address configuration method shall be used if the MIB attribute itsGnLocalAddrConfMethod is set to MANAGED (1).

With managed address configuration, the *ITS Network and Transport Layer Management* layer is responsible for providing the GeoAdhoc router a GN_ADDR.

9.2.1.3.1   Initial address configuration

At startup, the GeoAdhoc router shall request a GN_ADDR from the *ITS Network and Transport Layer Management* entity using the *GN-MGMT.request* primitive (clause I.2). The *ITS Network and Transport Layer Management* entity is responsible for generating the appropriate GeoNetworking address using the *GN-MGMT.response* primitive (clause I.3).

9.2.1.3.2   Address update

The update of the local GN_ADDR can be triggered by the GeoAdhoc router or the *ITS Network and Transport Layer Management* entity.

If the update is triggered by the GeoAdhoc router, the GeoAdhoc router shall use the *GN-MGMT.request* primitive (clause I.2). The *ITS Network and Transport Layer Management* entity is responsible for generating the appropriate GeoNetworking address using the *GN-MGMT.response* primitive (clause I.3).

If the update is triggered by the *ITS Network and Transport Layer Management* entity, the *ITS Network and Transport Layer Management* entity sends an unsolicited *GN-MGMT.response* to the GeoAdhoc router. Upon reception of the *GN-MGMT.response*, the GeoAdhoc router shall update its local GN_ADDR.

NOTE 1:   For privacy reasons, the GN_ADDR can be derived from the station's short-term identity or pseudonym. The frequency of update and the algorithm of generating pseudonyms are beyond the scope of the present document.

NOTE 2:   From communication point of view, a frequent update of the GN_ADDR can impair the performance of the GeoNetworking protocol.

9.2.1.4   Duplicate address detection

The configuration of the GeoNetworking address does not guarantee its uniqueness. In order to achieve uniqueness, a GeoAdhoc router shall execute the following operations for duplicate address detection:

- Upon reception of a GeoNetworking packet, the GeoAdhoc router compares its local GN_ADDR and the GN_ADDR of the SE and SO carried in the GeoNetworking packet header. The comparison is done based on the last field of the GN_ADDR (MID) which corresponds to the 48-bit MAC address.

- If a conflict is detected, the GeoNetworking protocol entity shall request a new GeoNetworking address from the *ITS Network and Transport Layer Management* entity using a *GN-MGMT.request* primitive (clause I.2) indicating *Duplicate address* as the *Request cause*.

9.2.2   Local position vector and time update

9.2.2.1   Overview

Local position and time are set by the *Network and Transport Layer Management* entity via the GN_MGT interface (clause I.3).

9.2.2.2   Local Position Vector update

For position update, the *ITS Network and Transport Layer Management* entity shall send an unsolicited *GN-MGMT.response* with the *Local position vector* parameter (clause I.3) to the GeoAdhoc router. Upon reception of the *GN-MGMT.response* with the *Local position vector* parameter, the GeoAdhoc router shall update its Local Position Vector (LPV) (clause 7.2).

As specified in clause 7.2.3, the LPV shall be updated with a minimum frequency of the MIB attribute itsGnMinimumUpdateFrequencyLPV.

9.2.2.3   Time update

For time update, the *ITS Network and Transport Layer Management* entity shall send an unsolicited *GN-MGMT.response* with the *Time* parameter (clause I.3) to the GeoAdhoc router. Upon reception of the *GN-MGMT.response* with the *Time* parameter, the GeoAdhoc router shall set its local system time.

NOTE: Details of the system time management and usage are implementation specific.

9.2.3   Beaconing

9.2.3.1   Overview

Beaconing is used to periodically advertise a GeoAdhoc router's position vector to its neighbours.

A BEACON packet shall be sent periodically unless the GeoAdhoc router sends another GeoNetworking packet that carries the GeoAdhoc router's LPV.

NOTE: Typically, this is implemented by a timer that is reset upon transmission of any GeoNetworking packet.

9.2.3.2   Source operations

At start-up, a GeoAdhoc router shall execute the following operations:

1)   create a GN-PDU with a BEACON packet header (clause 8.6.6) and the field settings as specified in table 17;

2)   execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request
      primitive is set to:

      a)   UNSPECIFIED then omit this operation;

      b)   is set to ITS-G5A then execute the operations as specified in [i.2];

3)   pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the Broadcast
      address of the LL entity;

Table 17: Field settings for the *Common Header* in BEACON packets

Field name	Field setting	Description
Version	MIB attribute itsGnProtocolVersion	Version of the GeoNetworking protocol.
NH	0 (ANY)	Next header (table 5 in clause 8.5.3).
HT	1 (BEACON)	Header type (table 6 in clause 8.5.4).
HST	0 (UNSPECIFIED)	Header sub-type (specified in table 6 in clause 8.5.4).
Reserved	0	Unused fields.
Flags	Bit 0 to 5: 0 Bit 6: itsGnStationType (MIB attribute) Bit 7: 0	Only Bit 6 used. Other fields reserved for future use.
PL	0	Payload length (packet does not carry payload).
TC	Bit 0: 0 (Reserved) Bit 1 to 3: MIB attribute itsGnTrafficClassRelevance (Relevance) Bit 4 to 5: MIB attribute itsGnTrafficClassReliability (Reliability) Bit 6 to 7: MIB attribute itsGnTrafficClassLatency (Latency)	Traffic class as specified in clauses 8.5.5 and 8.5.6.
HL	Set to 1	Hop limit.
SE PV	Actual values of the LPV (clause 7.2).	PV of the local GeoAdhoc router (sender of the BEACON packet).

4)   initialize the timer for the periodic transmission of beacons T_{Beacon} with a timeout set to
      (itsGnBeaconServiceRetransmitTimer + RAND[0,itsGnBeaconServiceMaxJitter]), whereas
      itsGnBeaconServiceRetransmitTimer and itsGnBeaconServiceMaxJitter represent MIB attribute values.

NOTE: The RAND function introduces a random component for the timer to avoid synchronization issues among
           GeoAdhoc routers.

If the timer T_{Beacon} expires, the source shall execute the following operations:

1)   create a GN-PDU with a BEACON packet header (clause 8.6.6) and the field settings as specified in table 17;

2)   execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request
      primitive is set to:

      a)   UNSPECIFIED then omit this operation;

      b)   is set to ITS-G5A then execute the operations as specified in [i.2];

3)   pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the Broadcast
      address of the LL entity;

4)   set the timer T_{Beacon} to a timeout set to (itsGnBeaconServiceRetransmitTimer +
      RAND[0,itsGnBeaconServiceMaxJitter))

The GeoAdhoc router shall reset the timer T_{Beacon} for every sent GeoNetworking packet.

9.2.3.3   Receiver operations

If a GeoAdhoc router receives a BEACON packet, it shall execute the following operation:

1)   *Common Header* processing (clause 9.3.3).

9.2.4   Location service

9.2.4.1   General

The location service is used if a GeoAdhoc router needs to determine the position of another GeoAdhoc router. This is the case if a GeoAdhoc router is in the process to send a T/GN6-SDU as a GeoUnicast packet to another GeoAdhoc router, i.e. from the source to the destination, and does not have the position information for the destination in its LocT.

The execution of a location service is fully transparent to protocol entities of higher layers.

The location service function resides on top of the forwarding functions and can therefore use any forwarding type.

The location service is based on the exchange of control packets between GeoAdhoc routers (figure 18). The querying GeoAdhoc router (source) issues a LS Request packet with the GN_ADDR of the sought GeoAdhoc router (destination). The LS Request packet is forwarded by intermediate GeoAdhoc routers (forwarders) until it reaches the destination. The destination replies with a LS Reply packet.
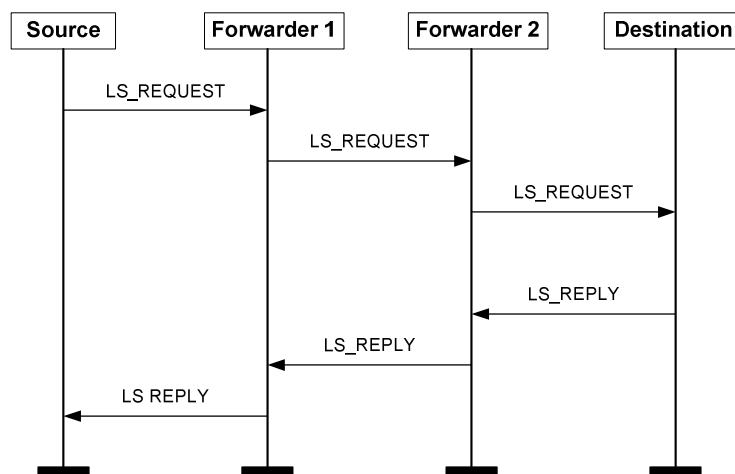
Figure 18: Message sequence chart for the location service (example scenario with two forwarders)

Table 18: Field settings for the *Common Header* in LS Request and LS Reply packets

Field name	Field setting	Description
Version	MIB attribute itsGnProtocolVersion	Version of the GeoNetworking protocol.
NH	0	Next header (table 5 in clause 8.5.3).
HT	6 (LS)	Header type (table 6 in clause 8.5.4).
HST	0 (LS_REQUEST) 1 (LS_REPLY)	Header sub-type (specified in table 6 in clause 8.5.4).
Reserved	0	Unused fields.
Flags	Bit 0 to 5: 0 Bit 6: itsGnStationType (MIB attribute) Bit 7: 0	Only Bit 6 used. Other fields reserved for future use.
PL	0	Payload length (packet does not carry payload).
TC	Bit 0: 0 (Reserved) Bit 1 to 3: MIB attribute itsGnTrafficClassRelevance (Relevance) Bit 4 to 5: MIB attribute itsGnTrafficClassReliability (Reliability) Bit 6 to 7: MIB attribute itsGnTrafficClassLatency (Latency)	Traffic class as specified in clauses 8.5.5 and 8.5.6.
HL	MIB attribute itsGnDefaultHopLimit	Hop limit.
SE PV	Actual values of the LPV (clause 7.2).	PV of the local GeoAdhoc router (sender of the LS Request and LS Reply packet).

9.2.4.2   Source operations

9.2.4.2.1   Overview

Three cases are distinguished for the source operations:

- Source operation for initial LS Request (clause 9.2.4.2.2).

- Source operation for LS Request re-transmission (clause 9.2.4.2.3).

- Source operation for LS Reply (clause 9.2.4.2.4).

9.2.4.2.2   Source operation for initial LS Request

When a source has a T/GN6-SDU to send and has no position vector information for the destination address, the source shall invoke the location service and shall execute the following operations:

1)   check whether a LS for the sought *GN_ADDR* is in progress, i.e. the flag *LS_pending* is set TRUE:

   a)   if *LS_pending* is TRUE for the sought *GN_ADDR*, the packet shall be buffered in the *LS packet buffer* (clause 7.4) and the execution of the next steps shall be omitted;

2)   issue a LS Request packet with a format as specified in clause 8.6.7 as a TSB packet:

   a)   set the fields of the *Common Header* to the values specified in table 18;

   b)   set the fields of the LS Request *Extended Header* to the values specified in table 19.

Table 19: Field settings for the LS Request *Extended Header*

Field name	Field setting	Description
SN	Actual value of the local sequence number as specified in clause 7.3.	Sequence number of the packet.
LT	Value of *Maximum lifetime* parameter from *GN-DATA.request* primitive.	Lifetime.
SO PV	Actual values of the LPV as specified in clause 7.2.	Position vector of the local GeoAdhoc router (source of the GeoNetworking packet).
Request GN_ADDR	GN_ADDR from *GN-DATA.request* parameter *Destination (annex* H*).*	GeoNetworking address of the sought GeoAdhoc router.

3)   start a timer T_{LS, GN_ADDR} with a timeout set to the value of the MIB attribute itsGnLocationServiceRetransmitTimer;

4)   initialize the LS retransmit counter for the GeoAdhoc router GN_ADDR RTC_{LS, GN_ADDR} to 0;

5)   add a LocTE for the sought GN_ADDR in its LocT and sets the flag *LS_pending* to TRUE.

9.2.4.2.3   Source operation for LS Request re-transmission

If the timer T_{LS, GN_ADDR} for the GN_ADDR expires, the source shall execute the following operation:

1)   check the retransmit counter RTC_{LS, GN_ADDR};

2)   if the retransmit counter is less than the maximum number of LS retransmissions set by the MIB attribute itsGnLocationServiceMaxRetrans, i.e. RTC_{LS, GN_ADDR} < itsGnLocationServiceMaxRetrans the GeoAdhoc router shall:

   a)   re- issue a LS Request packet with the format as specified in clause 8.6.7 as a TSB packet;

   b)   restart the timer T_{LS, GN_ADDR} with a timeout set to of itsGnLocationServiceRetransmitTimer; and

   c)   increment the retransmit counter RTC_{LS, GN_ADDR};

3)   if the retransmit counter is greater equal than the maximum number of LS retransmissions set by the MIB attribute itsGnLocationServiceMaxRetrans, i.e. RTC_{LS, GN_ADDR} ≥ itsGnLocationServiceMaxRetrans the GeoAdhoc router shall:

   a)   flush the LS packet buffer (clause 7.4) for the sought GN_ADDR and discard the stored packets;

   b)   remove the LocTE for the sought GN_ADDR.

9.2.4.2.4   Source operation for LS Reply

If the source receives a LS Reply packet for the sought GN_ADDR, the source shall execute the following operations:

1)   *Common Header* processing (clause 9.3.3);

2)   execute duplicate packet detection (annex A); if the LS Reply packet is a duplicate, discard the packet and omit the execution of further steps;

3)   update the SO PV$_{LocT}$ with the *SO PV* of the received LS Reply *Extended Header* using the algorithm specified in clause B.2;

4)   set the *SO IS_NEIGHBOUR* flag to FALSE, if the *SO GN_ADDR* does not equal the *SE GN_ADDR*;

5)   flush packet buffers (*SO LS packet buffer*, *SO UC forwarding packet buffer*):

   a)   if *SO LS_pending* is TRUE:

      i.   flush the *SO LS packet buffer* (clause 7.4);

     ii.   forward the stored packets;

     iii.   set *SO LS_pending* to false;

  b)   if the *UC forwarding packet buffer* (clause 7.5) for *SO* is not empty, flush the *UC forwarding buffer* and forward the stored packets;

6)   flush the *LS packet buffer* (clause 7.4) for the sought GN_ADDR and forward the stored packets;

7)   set the flag *LS_pending* for the sought *GN_ADDR* to false;

8)   stop the timer T_{LS, GN_ADDR};

9)   reset the re-transmit counter RTC_{LS, GN_ADDR}.

9.2.4.3 Forwarder operations

If a GeoAdhoc router receives a LS Request packet and the *Request GN_ADDR* field in the LS Request header does not match its *GN_ADDR*, the GeoAdhoc router shall handle the packet according to the packet handling procedure for TSB (clause 9.3.5.3), except step 7 for passing the payload of the GN-PDU to the upper protocol entity.

If a GeoAdhoc router receives a LS Reply packet and the *GN_ADDR* in the *DE PV* of the LS Reply packet does not match its *GN_ADDR*, the GeoAdhoc router shall handle the packet according to the packet handling operations for GeoUnicast (clause 9.3.4).

   NOTE: The *Common Header* processing and duplicate packet detection is part of the GeoUnicast and TSB packet handling procedure, respectively.

9.2.4.4 Destination operations

On reception of a LS Request packet, the GeoAdhoc router shall check the *Request GN_ADDR* field. If this MID field matches the MID field of its GN_ADDR, the GeoAdhoc router shall execute the following operations:

1)   *Common Header* processing (clause 9.3.3);

2)   execute duplicate packet detection (annex A); if the LS Request packet is a duplicate, discard the packet and omit the execution of further steps;

3)   update the *SO PV$_{LocT}$* with the *SO PV* fields of the LS Request *Extended Header* using the algorithm specified in clause B.2;

4)   set the *SO IS_NEIGHBOUR* flag to FALSE if *SO GN_ADDR* does not equal the *SE GN_ADDR*;

5)   issue a LS Reply packet as a GeoUnicast packet (clause 8.6.2) and forward the packet according to the forwarding procedure for GeoUnicast (clause 9.3.4).

9.3 Packet handling

9.3.1 Overview

This clause defines the behaviour of the protocol in the source, forwarder and destination. Packet handling includes the procedures to determine the destination (GeoAdhoc router, geographical area) of the T/GN6-SDU, execute functions that are specific to the packet type, and pass the GN-PDU to the LL protocol entity via the IN interface.

The following packet handling types are defined:

- GeoUnicast packet handling (clause 9.3.4);

- TSB packet handling (clause 9.3.5);

- SHB packet handling (clause 9.3.6);

- GeoBroadcast packet handling (clause 9.3.7); and

- GeoAnycast packet handling (clause 9.3.8).

The packet handling is further specified in the following clauses.

NOTE: The current version of the present document does not make use of all fields carried in the GeoNetworking packet header. In particular, the altitude, speed, heading and accuracy fields are not used.

9.3.2   *Common Header* field settings

For all GeoNetworking packets of type GeoUnicast, SHB, TSB, GeoBroadcast and GeoAnycast, the fields of the *Common Header* shall be set as specified in table 20.

Table 20: Field settings for the *Common Header*

Field name	Field setting	Description
Version	MIB attribute itsGnProtocolVersion	Version of the GeoNetworking protocol.
NH	1 (BTP) if *GN-DATA.request* parameter *Upper protocol* entity is BTP 2 (IPv6) if *GN-DATA.request* parameter *Upper protocol* entity is IPv6	Next header (table 5 in clause 8.5.3)
HT	2 (GEOUNICAST) if *GN-DATA.request* parameter *Packet transport type* is GeoUnicast 3 (GEOANYCAST) if *GN-DATA.request* parameter *Packet transport type* is GeoAnycast 4 (GEOBROADCAST) if *GN-DATA.request* parameter *Packet transport type* is GeoBroadcast 5 (TSB) if *GN-DATA.request* parameter *Packet transport type* is TSB 5 (TSB) if *GN-DATA.request* parameter *Packet transport type* is SHB	Header type (table 6 in clause 8.5.4)
HST	As specified in table 6 in clause 8.5.4	Header sub-type
Reserved	0	Unused fields.
Flags	Bit 0 to 5: 0 Bit 6: MIB attribute itsGnStationType Bit 7: 0	Only bit 6 used. Other fields reserved for future use.
PL	Size of T/GN6-SDU defined in *GN-DATA.request*	Payload length in bytes
TC	*Traffic class* defined in *GN-DATA.request* primitive parameter *Traffic class*	Traffic class, encoded as specified in clause 8.5.5
HL	Source: • 1 if *GN-DATA.request* parameter *Packet transport type* is SHB • MIB attribute `itsGnDefaultHopLimit` if *GN-DATA.request* parameter *Packet transport type* is GeoUnicast, GeoAnycast, GeoBroadcast or TSB Forwarder: Decrement HL by one	Hop limit
SE PV	Actual values of the LPV as specified in clause 7.2	PV of the local GeoAdhoc router (sender of the GeoNetworking packet)

NOTE: TSB and SHB carry the same value in the HT field (equals 5), but have a different value in the HST field, i.e. HST = 0 for SHB and HST = 1 for TSB (table 6 in clause 8.5.4).

9.3.3 *Common Header* processing

When a GeoAdhoc router (forwarder, receiver, destination) processes a *Common Header* upon reception of a GeoNetworking packet, the GeoAdhoc router shall execute the following operations:

1) update the *PV* in the *SE* LocTE with the *SE PV* fields of the *Common Header* (clause B.2);

2) set the *IS_NEIGHBOUR* flag of the *SE* LocTE to TRUE;

3) flush packet buffers (*SE LS packet buffer*, *SE UC forwarding packet buffer*, *BC forwarding packet buffer*):

   a) if *SE LS_pending* is TRUE:

      i. flush the *SE LS packet buffer* (clause 7.4);

      ii. forward the stored packets;

      iii. set *SE LS_pending* to false;

   b) if the *UC forwarding packet buffer* (clause 7.5) for SE is not empty, flush the *UC forwarding buffer* and forward the stored packets;

   c) if the *BC forwarding packet buffer* (clause 7.5) is not empty, flush the *BC forwarding buffer* and forward packets;

4) check the *NH* field of the *Common Header:*

   a) if *NH* = 0 (ANY) discard the packet and omit the execution of further steps;

NOTE: *NH* = 0 (ANY) is used by network management packets, i.e. beaconing (clause 9.2.3) and location service (clause 9.2.4).

5) check the *HT* field of the *Common Header:*

   a) if HT = 0 (ANY) discard the packet and omit the execution of further steps.

9.3.4 GeoUnicast packet handling

9.3.4.1 General

This clause specifies the operations of a GeoAdhoc router to handle a GeoUnicast packet. The following clauses define the operations of the source, forwarder and destination.

GeoUnicast forwarding applies the algorithm selected by the setting of the value in the MIB attribute itsGnGeoUnicastForwardingAlgorithm and specified in annex C.

9.3.4.2 Source operations

On reception of a *GN-DATA.request* primitive with a *Packet transport type* parameter set to *GeoUnicast*, the source shall execute the following operations:

1) check whether it has a valid position vector for DE in its LocT:

   a) If no valid position vector information is available, the source shall invoke the location service as specified in clause 9.2.4 and omit the execution of further steps. Otherwise, the source shall proceed with step 2;

2) determine the link-layer address *LL_ADDR_NH* of the next hop (annex C):

   a) if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 0 (UNSPECIFIED), execute the GF algorithm as specified in clause C.2;

   b) if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 1 (GREEDY), execute the GF algorithm as specified in clause C.2;

    c)   if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 2 (CBF), execute the CBF algorithm as specified in clause C.3;

NOTE: The CBF algorithm returns the broadcast LL or, in case of no neighbours, 0 (see clause C.3).

3)   create a GN-PDU with the T/GN6-SDU as payload and a GeoUnicast packet header (clause 8.6.2):

    a)   set the fields of the *Common Header* (clause 9.3.2);

    b)   set the fields of the GeoUnicast *Extended Header* (table 21).

Table 21: Field settings for the GeoUnicast *Extended Header*

Field name	Field setting	Description
SN	Actual value of the local sequence number (clause 7.3).	Sequence number of the packet
LT	Value of *Maximum lifetime* parameter from the *GN-DATA.request* primitive.	Lifetime
SO PV	Actual values of the LPV (clause 7.2).	Position vector of the local GeoAdhoc router (source of the GeoNetworking packet)
DE PV	Actual values of the LocTE for the destination.	Position vector of the destination

4)   if *LL_ADDR_NH* = 0, then buffer the GeoUnicast packet in the *UC forwarding packet buffer* and omit the execution of further steps;

5)   if the optional Repetition interval parameter in the GN-DATA.request parameter is set:

    a)   save the GeoUnicast packet;

    b)   retransmit the packet with period as specified in *Repetition interval* until the maximum lifetime of the packet is expired;

NOTE 2:   The lifetime of the packet is specified in the *Maximum lifetime* parameter of the *GN-DATA.request* primitive.

NOTE 3:   For every retransmission, the operations need to be re-executed.

6)   execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request primitive is set to:

    a)   UNSPECIFIED then omit this operation;

    b)   ITS-G5A then execute the operations as specified in [i.2];

7)   pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the LL address of the next hop *LL_ADDR_NH*.

9.3.4.3   Forwarder operations

On reception of a GeoUnicast packet, the GeoAdhoc router shall check the *GN_ADDR* field in the *DE PV* of the GeoUnicast packet header. If this address does not match its *GN_ADDR*, the GeoAdhoc router shall execute the following operations:

1)   *Common Header* processing (clause 9.3.3);

2)   execute duplicate packet detection (annex A); if the GeoUnicast packet is a duplicate, discard the packet and omit the execution of further steps;

3)   update the *PV(SO)* in the LocT with the *SO PV* fields of the GeoUnicast *Extended Header* (clause B.2);

4)   set the *IS_NEIGHBOUR(SO)* flag to FALSE if *SO GN_ADDR* does not equal *SE GN_ADDR*;

5) flush packet buffers (*SO LS packet buffer*, *SO UC forwarding packet buffer*):

    a) if *LS_pending(SO)* is TRUE:

        i. flush the *SO LS packet buffer* (clause 7.4);

        ii. forward the stored packets;

        iii. set *LS_pending(SO)* to false;

    b) if the *UC forwarding packet buffer* (clause 7.5) for *SO* is not empty, flush the *UC forwarding buffer* and forward the stored packets;

6) update the *DE PV(DE)* in the LocT with *DE PV* fields in the GeoUnicast *Extended Header* (clause B.2);

7) update the fields of the *Common Header*, i.e.:

    - the *HL* field with the decremented *HL* value;

    - the *SE PV* fields with the *LPV* (clause 7.2);

8) update the *DE PV* fields with the PV(DE) in the LocT (clause B.3);

9) decrement the value of the *HL* field by one; if *HL* is decremented to zero, discard the GN-PDU and omit the execution of further steps;

10) determine the link-layer address *LL_ADDR_NH* of the next hop (annex C):

    a) if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 0 (UNSPECIFIED), execute the GF algorithm as specified in clause C.2;

    b) if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 1 (GREEDY), execute the GF algorithm as specified in clause C.2;

    c) if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 2 (CBF), execute the CBF algorithm as specified in clause C.3;

11) if *LL_ADDR_NH* = 0, then buffer the GeoUnicast packet in the *UC forwarding packet buffer* and omit the execution of further steps;

12) execute media-dependent procedures: if the *Communication profile* parameter of the *GN-DATA.request* primitive is set to:

    a) UNSPECIFIED then omit this operation;

    b) ITS-G5A then execute the operations as specified in [i.2];

13) pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the LL address of the next hop *LL_ADDR_NH*.

9.3.4.4 Destination operations

On reception of a GeoUnicast packet, the GeoAdhoc router shall check the *GN_ADDR* field in the *DE PV* of the GeoUnicast packet header. If this address matches its *GN_ADDR*, the GeoAdhoc router shall execute the following operations:

1) *Common Header* processing (clause 9.3.3);

2) execute duplicate packet detection (annex A); if the GeoUnicast packet is a duplicate, discard the packet and omit the execution of further steps;

3) update the *PV(SO)* in the LocT with the *SO PV* fields of the GeoUnicast *Extended Header* (clause B.2);

4) set the *IS_NEIGHBOUR(SO)* flag to FALSE if *SO GN_ADDR* does not equal the *SE GN_ADDR*;

5) flush packet buffers (*SO LS packet buffer*, *SO UC forwarding packet buffer*):

    a) if *LS_pending(SO)* is TRUE:

        i. flush the *SO LS packet buffer* (clause 7.4);

        ii. forward the stored packets;

        iii. set *LS_pending(SO)* to false;

    b) if the *UC forwarding packet buffer* (clause 7.5) for *SO* is not empty, flush the *UC forwarding buffer* and forward the stored packets;

6) pass the payload of the GN-PDU to the upper protocol entity by means of a *GN-DATA.indication* primitive with the parameter settings in table 22.

Table 22: Parameter settings in the *GN-DATA.indication* primitive
to indicate a received GeoUnicast packet

Parameter name	Parameter setting
Upper protocol entity	BTP if NH = 1 (BTP-A) BTP if NH = 2 (BTP-B) IPv6 if NH = 3 (IPv6) (NH encoding see table 5 in clause 8.5.3)
Packet transport type	GeoUnicast
Destination	*DE GN_ADDR*
Source position vector	Values of *SO PV* from *Extended Header*
Traffic class	Value of *TC* field from GeoUnicast *Common Header*
Remaining packet lifetime	Value of *LT* from GeoUnicast *Common Header*
Length	Length of the GN-PDU payload
Data	GN-PDU payload

9.3.5   TSB packet handling

9.3.5.1   General

This clause specifies the operations of a GeoAdhoc router to handle a TSB packet. The following clauses define the operations of the source and forwarder/receiver.

NOTE: In TSB, a forwarder is also always a receiver. Therefore, the roles are not distinguished.

9.3.5.2   Source operations

On reception of a *GN-DATA.request* primitive with a *Packet transport type* parameter set to *TSB,* the source shall execute the following operations:

1) create a GN-PDU with the T/GN6-SDU as payload and a TSB packet header (clause 8.6.3):

    a) set the fields of the *Common Header* (clause 9.3.2);

    b) set the fields of the TSB *Extended Header* (table 23);

Table 23: Field settings for the TSB *Extended Header*

Field name	Field setting	Description
SN	Actual value of the local sequence number (clause 7.3)	Sequence number of the packet
LT	Value of *Maximum lifetime* parameter from the *GN-DATA.request* primitive	Lifetime
SO PV	Actual values of the LPV (clause 7.2)	Position vector of the local GeoAdhoc router (source of the GeoNetworking packet)

2) if no neighbour exists, i.e. the LocT does not contain a LocTE with the *IS_NEIGHBOUR* flag set to TRUE, then buffer the TSB packet in the *BC forwarding packet buffer* and omit the execution of further steps;

3) if the optional *Repetition interval* parameter in the *GN-DATA.request* parameter is set:

   a) save the TSB packet;

   b) retransmit the packet with period as specified in *Repetition interval* until the maximum lifetime of the packet is expired;

NOTE 1: The lifetime of the packet is specified in the *Maximum lifetime* parameter of the *GN-DATA.request* primitive.

NOTE 2: For every retransmission, the operations need to be re-executed.

4) execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request primitive is set to:

   a) UNSPECIFIED then omit this operation;

   b) is set to ITS-G5A then execute the operations as specified in [i.2];

5) pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the Broadcast address of the LL entity.

9.3.5.3 Forwarder and receiver operations

On reception of a TSB packet, GeoAdhoc router shall execute the following operations:

1) *Common Header* processing (clause 9.3.3);

2) execute duplicate packet detection (annex A); if the TSB packet is a duplicate, discard the packet and omit the execution of further steps;

3) update the *PV(SO)* in the LocT with the *SO PV* fields of the TSB *Extended Header* (clause B.2);

4) set the *IS_NEIGHBOUR(SO)* flag to FALSE if *SO GN_ADDR* does not equal *SE GN_ADDR*;

5) pass the payload of the GN-PDU to the upper protocol entity by means of a *GN-DATA.indication* primitive with the parameter settings in table 24.

**Table 24: Parameter settings in the *GN-DATA.indication* primitive
to indicate a received TSB packet**

Parameter name	Parameter setting
Upper protocol entity	BTP if NH = 1 (BTP-A) BTP if NH = 2 (BTP-B) IPv6 if NH = 3 (IPv6) (NH encoding see table 5 in clause 8.5.3)
Packet transport type	TSB
Source position vector	Values of *SO PV* from *Extended Header*
Traffic class	Value of *TC* field from TSB *Common Header*
Remaining packet lifetime	Value of *LT* from TSB *Common Header*
Length	Length of the GN-PDU payload
Data	GN-PDU payload

6) decrement the value of the *HL* field by one; if *HL* is decremented to zero, discard the GN-PDU and omit the execution of following operations;

7) update the fields of the *Common Header*, i.e.:

   a) the *HL* field with the decremented *HL* value;

   b) the *SE PV* fields with the *LPV* (clause 7.2);

8) execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request primitive is set to:

    a) UNSPECIFIED then omit this operation;

    b) ITS-G5A then execute the operations as specified in [i.2];

9) pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the Broadcast address of the LL entity.

9.3.6 SHB packet handling

9.3.6.1 General

This clause specifies the operations of a GeoAdhoc router to handle a SHB packet. The following clauses define the operations of the source and receiver.

NOTE: SHB packets are not forwarded. Therefore, no forwarder operations are specified.

9.3.6.2 Source operations

On reception of a *GN-DATA.request* primitive with a *Packet transport type* parameter set to *SHB,* the source shall execute the following operations:

1) create a GN-PDU with the T/GN6-SDU as payload and a SHB packet header (clause 8.6.4):

    a) set the fields of the *Common Header* (clause 9.3.2);

2) if no neighbour exists, i.e. the LocT does not contain a LocTE with the *IS_NEIGHBOUR* flag set to TRUE, then buffer the SHB packet in the *BC forwarding packet buffer* and omit the execution of further steps;

3) if the optional Repetition interval parameter in the GN-DATA.request parameter is set:

    a) save the SHB packet;

    b) retransmit the packet with period as specified in *Repetition interval* until the maximum lifetime of the packet is expired;

NOTE 1: The lifetime of the packet is specified in the *Maximum lifetime* parameter of the *GN-DATA.request* primitive.

NOTE 2: For every retransmission, the operations need to be re-executed.

4) execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request primitive is set to:

    a) UNSPECIFIED then omit this operation;

    b) is set to ITS-G5A then execute the operations as specified in [i.2];

5) pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the Broadcast address of the LL entity.

9.3.6.3 Receiver operations

On reception of a SHB packet, the GeoAdhoc router shall execute the following operations:

1) *Common Header* processing (clause 9.3.3);

2) pass the payload of the GN-PDU to the upper protocol entity by means of a *GN-DATA.indication* primitive with the parameter settings in table 25.

**Table 25: Parameter settings in the *GN-DATA.indication* primitive
to indicate a received SHB packet**

Parameter name	Parameter setting
Upper protocol entity	BTP if NH = 1 (BTP-A) BTP if NH = 2 (BTP-B) IPv6 if NH = 3 (IPv6) (NH encoding see table 5 in clause 8.5.3)
Packet transport type,	SHB
Source position vector	Values of *SE PV* from SHB *Common Header*
Traffic class	Value of *TC* field from SHB *Common Header*
Maximum lifetime	Value of *LT* from SHB *Common Header*
Length	Length of the GN-PDU payload
Data	GN-PDU payload

9.3.7 GeoBroadcast packet handling

9.3.7.1 General

This clause specifies the operations of a GeoAdhoc router to handle a GeoBroadcast packet. The following clauses define the operations of the source and forwarder/receiver.

NOTE: In GeoBroadcast, a forwarder acts also always as a receiver. Therefore, the roles are not distinguished.

9.3.7.2 Source operations

On reception of a *GN-DATA.request* primitive with a *Packet transport type* parameter set to *GeoBroadcast*, the source shall execute the following operations:

1)   create a GN-PDU with the T/GN6-SDU as payload and a GeoBroadcast packet header (clause 8.6.5):

   a)   set the fields of the *Common Header* (clause 9.3.2);

   b)   set the fields of the GeoBroadcast *Extended Header* (table 26);

Table 26: Field settings for the GeoBroadcast *Extended Header*

Field name	Field setting	Description
SN	Actual value of the local sequence number (clause 7.3)	Sequence number of the packet
LT	Value of *Maximum lifetime* parameter from the *GN-DATA.request* primitive	Lifetime
SO PV	Actual values of the LPV (clause 7.2)	Position vector of the local GeoAdhoc router (source of the GeoNetworking packet)
GeoAreaPos Latitude	GeoAreaPos Latitude from *GN-DATA.request* primitive	GeoArea Area specification according to EN 302 931 [7]
GeoAreaPos Longitude	GeoAreaPos Longitude from *GN-DATA.request* primitive	GeoArea Area specification according to EN 302 931 [7]
Distance a	Distance a from *GN-DATA.request* primitive	GeoArea Area specification according to EN 302 931 [7]
Distance b	Distance a from *GN-DATA.request* primitive	GeoArea Area specification according to EN 302 931 [7]
Angle	Angle from *GN-DATA.request* primitive	GeoArea Area specification according to EN 302 931 [7]
Reserved	Reserved. Set to 0	

2)   if no neighbour exists, i.e. the LocT does not contain a LocTE with the *IS_NEIGHBOUR* flag set to TRUE, then buffer the GeoBroadcast packet in the *BC forwarding packet buffer* and omit the execution of further steps;

3)   if the optional *Repetition interval* parameter in the *GN-DATA.request* parameter is set:

   a)   save the GeoBroadcast packet;

   b)   retransmit the packet with period as specified in *Repetition interval* until the maximum lifetime of the packet is expired;

NOTE 1:   The lifetime of the packet is specified in the *Maximum lifetime* parameter of the *GN-DATA.request* primitive.

NOTE 2:   For every retransmission, the operations need to be re-executed.

4)   determine the link-layer address *LL_ADDR_NH* of the next hop (annex D):

   a)   if the MIB attribute itsGnGeoBroadcastForwardingAlgorithm is set to 0 (UNSPECIFIED), execute the Simple GeoBroadcast with line forwarding algorithm as specified in clause D.2;

   b)   if the MIB attribute itsGnGeoBroadcastForwardingAlgorithm is set to 1 (SIMPLE), execute the Simple GeoBroadcast with line forwarding algorithm as specified in clause D.2;

5)   if *LL_ADDR_NH* = 0, then buffer the GeoBroadcast packet in the *BC forwarding packet buffer* and omit the execution of further steps;

6)   execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request primitive is set to:

   a)   UNSPECIFIED then omit this operation;

   b)   is set to ITS-G5A then execute the operations as specified in [i.2];

7)   pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the LL address of the next hop *LL_ADDR_NH*.

9.3.7.3   Forwarder and receiver operations

On reception of a GeoBroadcast packet, the GeoAdhoc router shall execute the following operations:

1)   *Common Header* processing (clause 9.3.3);

2)   execute duplicate packet detection (annex A); if the GeoBroadcast packet is a duplicate, discard the packet and omit the execution of further steps;

3)   update the *PV(SO)* in the LocT with the *SO PV* fields of the GeoBroadcast *Extended Header* (clause B.2);

4)   set the *IS_NEIGHBOUR(SO)* flag to FALSE if *SO GN_ADDR* does not equal *SE GN_ADDR*;

5)   determine the link-layer address *LL_ADDR_NH* of the next hop (annex E):

   a)   if the MIB attribute itsGnGeoBroadcastForwardingAlgorithm is set to 0 (UNSPECIFIED), execute the Simple GeoBroadcast with line forwarding algorithm as specified in clause D.2;

   b)   if the MIB attribute itsGnGeoBroadcastForwardingAlgorithm is set to 1 (SIMPLE), execute the Simple GeoBroadcast with line forwarding algorithm as specified in clause D.2;

6)   if *LL_ADDR_NH* = 0, then buffer the GeoBroadcast packet in the *BC forwarding packet buffer* and omit the execution of further steps;

7)   if $F(x, y) \geq 0$ (GeoAdhoc router is inside or at the border of the geographical area) pass the payload of the GN-PDU to the upper protocol entity by means of a *GN-DATA.indication* primitive with the parameter settings in table 27;

NOTE: If the GeoAdhoc router is outside the geographical area, the GN-PDU will not be passed to the ITS Facilities layer.

**Table 27: Parameter settings in the *GN-DATA.indication* primitive
to indicate a received GeoBroadcast packet**

Parameter name	Parameter setting
Upper protocol entity	BTP if NH = 1 (BTP-A)
	BTP if NH = 2 (BTP-B)
	IPv6 if NH = 3 (IPv6)
	(NH encoding see table 5 in clause 8.5.3)
Packet transport type,	GeoBroadcast
Destination	GeoArea (GeoPos, distance a, distance b, angle)
Source position vector	Values of *SO PV* from *Extended Header*
Traffic class	Value of *TC* field from GeoBroadcast *Common Header*
Remaining packet lifetime	Value of *LT* from GeoBroadcast *Common Header*
Length	Length of the GN-PDU payload
Data	GN-PDU payload

8)   decrement the value of the *HL* field by one; if *HL* is decremented to zero, discard the GN-PDU and omit the execution of following operations;

9)   update the fields of the *Common Header*, i.e.:

   a)   the *HL* field with the decremented *HL* value;

   b)   the *SE PV* fields with the *LPV* (clause 7.2);

10)   execute media-dependent procedures: if the Communication profile parameter of the GN-DATA.request primitive is set to:

   a)   UNSPECIFIED then omit this operation;

   b)   ITS-G5A then execute the operations as specified in [i.2];

11)   pass the GN-PDU to the LL protocol entity via the IN interface and set the destination address to the LL address of the next hop LL_ADDR_NH.

9.3.8   GeoAnycast packet handling

9.3.8.1   General

This clause specifies the operations of a GeoAdhoc router to handle a GeoAnycast packet. The following clauses define the operations of the source and forwarder/receiver.

The operations for GeoAnycast packet handling are similar to those for GeoBroadcast packet.

9.3.8.2   Source operations

The operations of the source of a GeoAnycast packet are identical with the source of a GeoBroadcast packet as specified in clause 9.3.7.2, except the operation in step 5. Instead, the source shall execute the following operation:

1)   determine function F(x,y) as specified in [7] clause 5:

   a)   if $F(x, y) < 0$ (GeoAdhoc router is outside the geographical area) and the MIB attribute itsGnGeoAreaLineForwarding is set to TRUE, execute the GeoUnicast forwarding algorithm and determine the link-layer address *LL_ADDR_NH* of the next hop (annex C);

   b)   if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 0 (UNSPECIFIED), execute the GF algorithm as specified in clause C.2;

   c)   if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 1 (GREEDY), execute the GF algorithm as specified in clause C.2;

   d)   if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 2 (CBF), execute the CBF algorithm as specified in clause C.3.

9.3.8.3   Forwarder and receiver operations

On reception of a GeoAnycast packet, the GeoAdhoc router shall execute the following operations:

1)   *Common Header* processing (clause 9.3.3);

2)   execute duplicate packet detection (annex A); if the GeoAnycast packet is a duplicate, discard the packet and omit the execution of further steps;

3)   update the *PV(SO)* in the LocT with the *SO PV* fields of the GeoAnycast *Extended Header* (clause B.2);

4)   set the *IS_NEIGHBOUR(SO)* flag to FALSE if *SO GN_ADDR* does not equal *SE GN_ADDR*;

5)   determine function F(x,y) as specified in [7] clause 5:

    a)   if $F(x, y) < 0$ (GeoAdhoc router is outside the geographical area) and the MIB attribute itsGnGeoAreaLineForwarding is set to TRUE, execute the GeoUnicast forwarding algorithm and determine the link-layer address *LL_ADDR_NH* of the next hop (annex C):

        i.   if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 0 (UNSPECIFIED), execute the GF algorithm as specified in clause C.2;

        ii.   if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 1 (GREEDY), execute the GF algorithm as specified in clause C.2;

        iii. if the MIB attribute itsGnGeoUnicastForwardingAlgorithm is set to 2 (CBF), execute the CBF algorithm as specified in clause C.3;

    b)   if $F(x, y) \geq 0$ (GeoAdhoc router is inside or at the border of the geographical area) pass the payload of the GN-PDU to the upper protocol entity by means of a *GN-DATA.indication* primitive with the parameter settings in table 27.

NOTE: If the GeoAdhoc router is outside the geographical area, the GN-PDU will **not** passed to the ITS Facilities layer.

**Table 28: Parameter settings in the *GN-DATA.indication* primitive
to indicate a received GeoAnycast packet**

Parameter name	Parameter setting
Upper protocol entity	BTP if NH = 1 (BTP-A) BTP if NH = 2 (BTP-B) IPv6 if NH = 3 (IPv6) (NH encoding see table 5 in clause 8.5.3)
Packet transport type,	GeoAnycast
Destination	GeoArea (GeoPos, distance a, distance b, angle)
Source position vector	Values of SO PV from *Extended Header*
Traffic class	Value of TC field from GeoAnycast *Common Header*
MaximumRemaining packet lifetime	Value of LT from GeoAnycast *Common Header*
Length	Length of the GN-PDU payload
Data	GN-PDU payload

10   Conformance and test methods

Conformance and test methods for GeoNetworking are not specified in the present document.

Annex A (normative):
Duplicate packet detection

With multi-hop communication in an ad-hoc network, a GeoAdhoc router can receive multiple copies of the same packet. Reasons for packet duplications are the forwarding of the packet from multiple GeoAdhoc routers or routing loops. In order to control (e.g. prevent) the forwarding of duplicate packets, the GeoNetworking protocol uses a mechanism for duplicate packet detection.

The GeoNetworking protocol applies duplicate packet detection to multi-hop packets (GeoUnicast, TSB, GeoBroadcast, GeoAnycast, LS Request, LS Reply). The mechanism is based on sequence numbers and implies that every GeoNetworking packet carries a sequence number in its header.

> NOTE 1: For single-hop packets (BEACON and SHB) duplicate packet detection will not be applied and those packets do not carry SN fields.

For duplicate packet detection, a GeoAdhoc router maintains the sequence number of the last packet from the source that was identified as 'not duplicated' in its LocT, i.e. SN_{GN_ADDR} as defined in clause 7.1.2. When the GeoAdhoc router processes a GeoNetworking packet, it compares the value of the SN field carried in the GeoNetworking packet $SN(P)$ and $SN_{SO,SAV}$. If $SN(P)$ is greater than SN_{GN_ADDR} the received packet is regarded as 'not duplicated' and $SN_{SO,SAV}$ is updated.

> NOTE 2: The GeoNetworking protocol does not provide packet re-ordering. Due to the simple duplicate packet detection, out-of-sequence packets will be discarded.

The sequence numbers in the GeoNetworking protocol are limited in the number of bits that represent the sequence number. In order to handle the wrap around of sequence numbers (that the sequence number is incremented from the maximum possible value to zero), the following algorithm shall be used:

```
-- P is the received GeoNetworking packet
-- SN(P) is the sequence number in the received GeoNetworking packet
-- SN_SO,SAV is the last received sequence number from source SO saved by
--       the local GeoAdhoc router
-- SN_MAX is the maximum sequence number = 2^16-1
IF (((SN(P) > SN_SO,SAV) AND ((SN(P) - SN_SO,SAV) <= SN_MAX/2)) OR
    ((SN_SO,SAV > SN(P)) AND ((SN_SO,SAV - SN(P)) > SN_MAX/2))) THEN
    SN(P) is greater than SN_SO,SAV
    P is not a duplicate packet
    SN_SO,SAV ← SN(P)
ELSE
    SN(P) is not greater than SN_SO,SAV
    P is a duplicate
ENDIF
```

Annex B (normative):
Position vector update

B.1   Overview

The position vector update is executed in the GeoNetworking forwarding process (clause 9.3) when a PV in a LocTE is updated by PV carried in a GeoNetworking packet header. The algorithm ensures that always the newer PV is used indicated by the timestamp that is contained in the PV.

The algorithm is utilized in two cases:

1)   When a GeoNetworking packet is received, the forwarding procedure updates the PV in the LocT by the PV carried in the GeoNetworking packet.

2)   When a GeoNetworking packet is forwarded, the forwarding procedure updates the PV in the packet to be forwarded by the PV in the LocT.

The algorithm makes use of the timestamp that is associated with the position information and is part of the position vector fields. It handles the wrap around of the timestamp values that occur due to the limited number of bits that represent a timestamp.

NOTE: With a 32 bit timestamp in [ms], a wrap around occurs after 50 days:
$((((2^{32}) - 1) / 1\,000) / 60) / 60) / 24 = 49,7102696$

B.2   Update of LocT position vector

The following algorithm shall be applied to update a PV in the LocT. The algorithm shall also reset the lifetime of the location table entry *T(LocTE)* (clause 7.1.3).

```
-- RP is the received GeoNetworking packet
-- PV_RP is the position vector in the received GeoNetworking packet
-- PV_LocT is the position vector in the LocT to be updated
-- TST_PV,RP is the timestamp for the position vector in the received
--     GeoNetworking packet
-- TST_PV,LocT is the timestamp for the position vector in the location table
--     to be updated
-- TS_Max is the maximum value of the timestamp = 2^32-1
-- T(LocTE) is the lifetime of the location table entry
-- itsGnLifetimeLocTE is the value of the MIB attribute itsGnLifetimeLocTE
IF (((TST_PV,RP > TST_PV,LocT) AND ((TST_PV,RP - TST_PV,LocT) <= TST_Max/2)) OR
    ((TST_PV,LocT > TST_PV,RP) AND ((TST_PV,LocT - TST_PV,RP) > TST_Max/2))) THEN
    TST_PV,RP is greater than TST_PV,LocT
    PV_LocT ← PV_RP
    T(LocTE) ← value(itsGnLifetimeLocTE)
ELSE
    TST_PV,RP is not greater than TST_PV,LocT
ENDIF
```

B.3 Update of GeoNetworking packet position vector

The following algorithm shall be applied to update a PV in a packet to be forwarded:

```
-- FP is the GeoNetworking packet to be forwarded
-- PV_FP is the position vector in the GeoNetworking packet to be forwarded
-- PV_LocT is the position vector in the LocT
-- TST_PV,FP is the timestamp for the position vector in the GeoNetworking
--      packet to be forwarded
-- TST_PV,LocT is the timestamp for the position vector in the location table
-- TS_Max is the maximum value of the timestamp = 2^32-1
IF (((TST_PV,LocT > TST_PV,FP) AND ((TST_PV,LocT - TST_PV,FP) <= TST_Max/2)) OR
    ((TST_PV,FP > TST_PV,LocT) AND ((TST_PV,FP - TST_PV,LocT) > TST_Max/2))) THEN
    TST_PV,LocT is greater than TST_PV,FP
    PV_FP ← PV_LocT
ELSE
    TST_PV,FP is not greater than TST_PV,LocT
ENDIF
```

Annex C (normative):
GeoUnicast forwarding algorithms

C.1   Overview

The GeoUnicast forwarding algorithm is executed by a GeoAdhoc router to relay a packet to the next hop.

The present document defines two GeoUnicast forwarding algorithms:

- Greedy Forwarding (GF) algorithm (clause C.2);

- Contention-based forwarding (CBF) algorithm (clause C.3).

C.2   Greedy Forwarding algorithm

With the Greedy Forwarding (GF) algorithm, the GeoAdhoc router uses the location information of the destination carried in the GeoUnicast packet header and selects one of the neighbours as the next hop.

The algorithm applies the *most forward within radius (MFR)* policy, which selects the neighbour with the smallest geographical distance to the destination, thus providing the greatest progress when the GeoUnicast packet is forwarded.

```
-- P is the GeoUnicast packet to be forwarded
-- i is the i-th LocTE
-- NH is the LocTE idenfified as next hop
-- NH_LL_ADDR is the link layer address of the next hop
-- LPV is the local position vector
-- PVP is the destination position vector in the GeoNetworking packet to be forwarded
-- PVi is the position vector of the i-th LocTE
MFR = DIST(PVP, LPV)
FOR (i∈ LocT)
    IF (i.IS_NEIGHBOUR) THEN
        IF (DIST(PVP, PVi) < MFR) THEN
            NH ← i
            MFR ← DIST(PVP, PVi)
            ENDIF
    ENDIF
ENDFOR
IF (MFR < DIST(PVP, PVLPV)) THEN
    SET NH_LL_ADDR = NH.LL_ADDR
ELSEIF
    LOCAL OPTIMUM
    SET NH_LL_ADDR = 0
ENDIF
```

If no neighbour with greater progress than the local GeoAdhoc router exists, the packet has reached a local optimum.

C.3   Contention-based forwarding algorithm

With the Contention-based forwarding (CBF) algorithm, a receiver decides to be a forwarder of a GeoUnicast packet. This is in contrary to the sender-based forwarding scheme specified in clause C.2, where the sender determines the next hop. The CBF algorithm utilizes timer-based re-broadcasting with overhearing of duplicates in order to enable an implicit forwarding of a packet by the optimal node.

With CBF, the GeoAdhoc router broadcasts the GeoUnicast packet. All neighbours, which receive the packet, process it: the GeoAdhoc router buffers the packet in its CBF packet buffer and starts a timer with a timeout that is inversely proportional to the distance between the GeoAdhoc router's local position and the destination's positions.

Equation 1: Calculation of timeout for buffering packets in the CBF packet buffer TO_CBF

$$TO\_CBF = \begin{cases} TO\_CBF\_MIN + \dfrac{TO\_CBF\_MAX - TO\_CBF\_MIN}{DIST\_MAX} \cdot DIST & \text{for } Dist < DIST\_MAX \\ TO\_CBF\_MIN & \text{for } DIST > Dist\_MAX \end{cases}$$

where:

TO_CBF_MIN   is the minimum duration the packet shall be buffered in the CBF packet buffer.

TO_CBF_MAX   is the maximum duration the packet shall be buffered in the CBF packet buffer.

DIST_MAX   is the theoretical maximum communication range of the wireless access technology.

TO_CBF_MIN and TO_CBF_MAX shall be set to the MIB attributes itsGnGeoUnicastCbfMinTime and itsGnGeoUnicastCbfMaxTime, respectively. If DIST_MAX is not defined in the specification of GeoNetworking media-dependent functionality for the specific ITS access technology (e.g. TS 102 636-4-2 [i.2]), it shall be set to the MIB attribute itsGnDefaultMaxCommunicationRange.

Upon expiration of the timer, the GeoAdhoc router re-broadcasts the GeoUnicast packet. Before the timer expires, the GeoAdhoc router may receive a duplicate of the packet from a GeoAdhoc router with a shorter timeout, i.e. with a smaller distance to the destination. In this case, the GeoAdhoc router inspects its CBF packet buffer, stops the timer and removes the GeoUnicast packet from the CBF packet buffer.

Compared to the GF algorithm (clause C.2), CBF has an implicit reliability mechanism at the cost of larger forwarding delay and additional processing. The reliability mechanism ensures that a packets is re-forwarded by an alternative forwarder if the theoretically optimal forwarder does not receive the packet, e.g. due to wireless link errors.

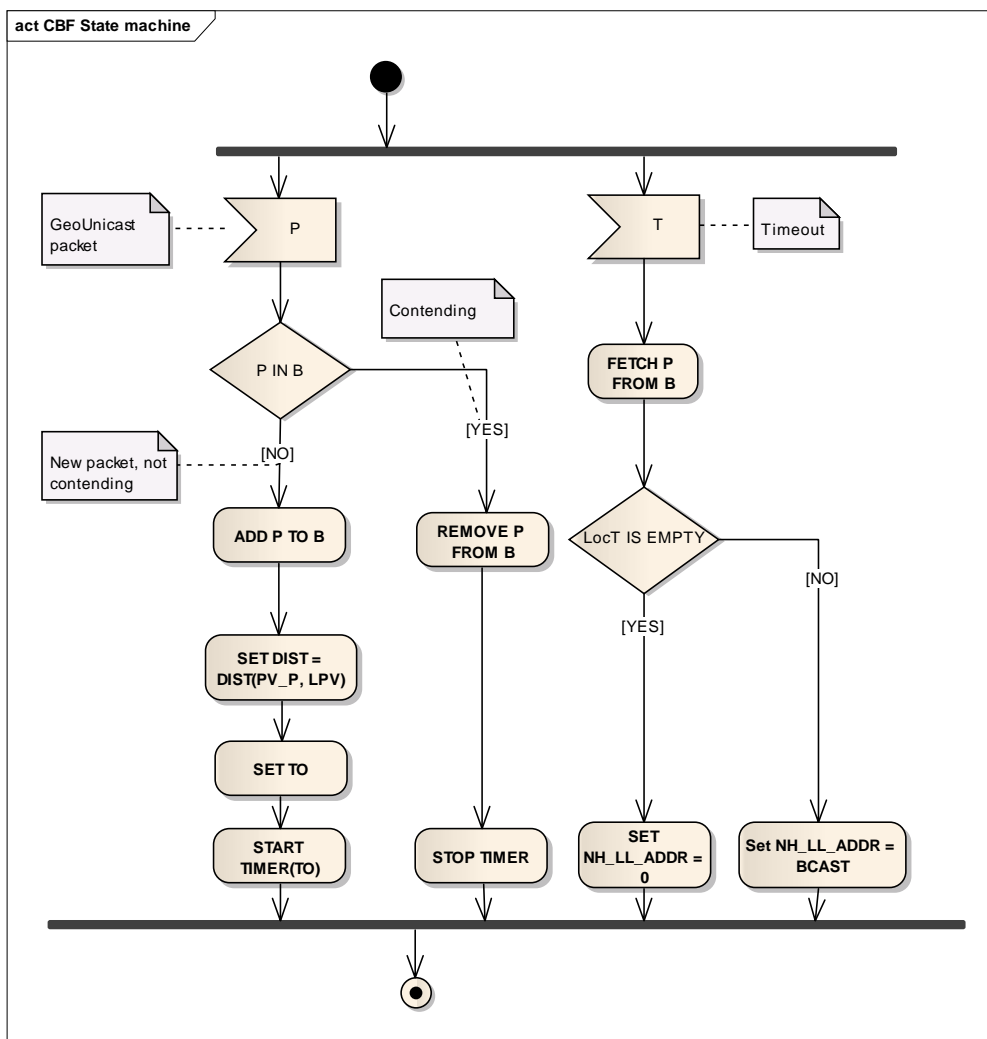The activity diagram of the CBF algorithm is depicted in figure C.1.

Figure C.1: CBF activity diagram

The pseudo-code of the algorithm is below:

```
-- P is the GeoUnicast packet to be forwarded
-- LPV is the local position vector
-- PV_P is the destination position vector in the GeoNetworking packet
--      to be forwarded
-- B is the CBF packet buffer
-- TO is the timeout that triggers the re-broadcast of the packet
-- NH_LL_ADDR is the LL address of the next hop
-- BCAST is the broadcast LL address

IF (P IN B) THEN                    # Contending
    REMOVE P FROM B
    STOP TIMER
ELSE                                # New packet
    ADD P TO B
    SET DIST = DIST(PV_P, LPV)
    SET TO                          # Equation 1
    START TIMER(TO)
ENDIF

IF (TIMER(TO) EXPIRES) THEN
    FETCH P FROM B
    IF (LocT IS EMPTY) THEN
        SET NH_LL_ADDR = 0          # No neighbors
    ELSE
        SET NH_LL_ADDR = BCAST
    ENDIF
ENDIF
```

Annex D (normative):
GeoBroadcast forwarding algorithms

D.1   Overview

The GeoBroadcast forwarding algorithm is executed by a GeoAdhoc router to relay a packet to the next hop.

The present document defines three forwarding algorithms:

- Simple GeoBroadcast forwarding algorithm (clause D.2);

- Advanced GeoBroadcast forwarding algorithm 1 (informative clause E.2);

- Advanced GeoBroadcast forwarding algorithm 2 (informative clause E.3).

The latter two algorithms are experimental and provided for informative purpose in the informative annex E.

D.2   Simple GeoBroadcast forwarding algorithm with line forwarding

The algorithm utilizes the function F(x,y) specified in [7] clause 5 in order to determine whether the GeoAdhoc router is located inside, at the border or outside the geographical target area carried in the GeoBroadcast packet header. If the GeoAdhoc router is inside or at the border of the area, the packet shall be re-broadcasted. If it is outside the area, the packet shall be forwarded by the GF algorithm specified in clause C.2.

NOTE 1:   Packet duplicate detection is not part of the forwarding algorithm but of the packet handling operations.

NOTE 2:   As defined in [7] clause 5,

$$F(x, y) \begin{cases} = 1 & \text{for } x = 0 \text{ and } y = 0 \text{ (at the centre point)} \\ > 0 & \text{inside the geographical area} \\ = 0 & \text{at the border of the geographical area} \\ < 0 & \text{outside the geographical area} \end{cases} .$$

```
-- P is the GeoNetworking packet to be forwarded
-- LAT and LONG are latitude and longitude of the LPV, respectively
-- DAP is the destination area in the GeoNetworking packet to be forwarded
-- A is the centre point of the destination area DAPP
-- LL_ADDR is the link layer address that identifies the next hop
--       of the GeoNetworking packet
-- BCAST is the broadcast LL address
-- GREEDY() is the GF algorithm

LL_ADDR = 0
Calculate F(LAT, LONG)
IF (F≥0) THEN
    RETURN LL_ADDR = BCAST
ELSE
    RETURN LL_ADDR = GREEDY(A) or 0
ENDIF
```

Annex E (informative):
Advanced GeoBroadcast forwarding algorithms

E.1 Overview

This clause specifies two advanced GeoBroadcast forwarding algorithms (clauses E.2 and E.3). These algorithms are experimental and provided for informative purpose.

E.2 Advanced GeoBroadcast forwarding algorithm 1

The Advanced GeoBroadcast forwarding algorithm1 relies on three main mechanisms:

1) CBF is used to deal with uncertainties in terms of reception failure caused by node mobility, fading phenomena and collisions on the wireless medium.

2) In order to minimize the forwarding delay, CBF is complemented with the selection of one specific forwarder at the sender, referred to as next hop. Upon reception of the packet, the next hop - in case of correct reception - forwards the message immediately.

3) the reliability of the dissemination process is increased by a controlled packet retransmission scheme within the geographical target area.

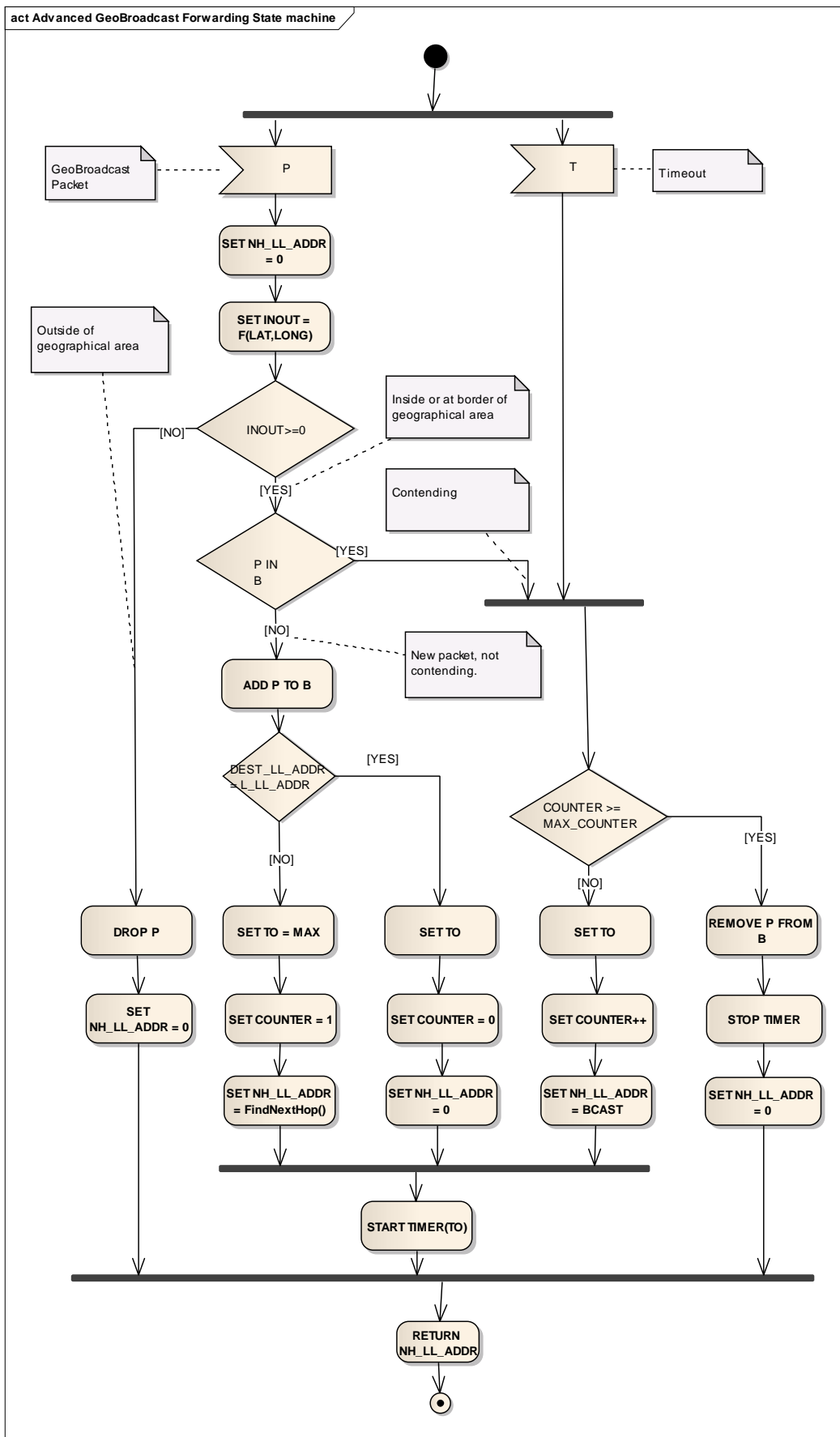The activity of the advanced GeoBroadcast forwarding algorithm is depicted in figure E.1.

Figure E.1: Activity diagram of Advanced GeoBroadcast algorithm 1

For the selection of the next hop, the GF algorithm (clause C.3) should be used, where the destination position is a point at the border of the geographical area farthest from the position of the source node.

The pseudo-code of the algorithm is below:

```
-- P is the GeoBroadcast packet to be forwarded
-- DEST_LL_ADDR is the LL destination address carried in P
-- B is the CBF packet buffer
-- LPV is the Local Position Vector
-- LAT and LONG are latitude and longitude of the LPV, respectively
-- L_LL_ADDR is the local LL address
-- NH is the LocTE idenfified as next hop
-- NH_LL_ADDR is the LL address of the next hop
-- BCAST is the broadcast LL address
-- i is the i-th LocTE
-- PVᵢ is the PV of the i-th LocTE
-- INOUT is determined by the area function specified in [7] clause 5

SET NH_LL_ADDR = 0
SET INOUT = F(LAT, LONG)                        # See [7] clause 5
IF (INOUT≥0) THEN                               # Inside or at border of the geogr. area
    IF (P NOT IN B) THEN                        # New packet, not contending
        ADD P TO B
        IF (DEST_LL_ADDR = L_LL_ADDR) THEN
            SET TO = MAX                        # TO_CBF_MAX (See equation 1)
            SET COUNTER = 1
            SET NH_LL_ADDR = FindNextHop()
        ELSE
            SET TO                              # See equation 1
            SET COUNTER = 0
            SET NH_LL_ADDR = 0
        ENDIF
        START TIMER(TO)
    ELSE                                        # Contending
        IF (COUNTER ≥ MAX_COUNTER) THEN    # Cancel contention
            REMOVE P FROM B
            STOP TIMER
            SET NH_LL_ADDR = 0
        ELSE
            SET TO                              # See equation 1
            SET COUNTER++
            SET NH_LL_ADDR = BCAST
            START TIMER(TO)
        ENDIF
    ENDIF
    RETURN NH_LL_ADDR
ELSE                                            # Outside of geographical area
    DROP P
    RETURN 0
ENDIF

IF (TIMER EXPIRES) THEN
    IF (COUNTER ≥ MAX_COUNTER) THEN         # Cancel contention
        REMOVE P FROM B
        STOP TIMER
        SET NH_LL_ADDR = 0
    ELSE
        SET TO                                  # See equation 1
        SET COUNTER++
        SET NH_LL_ADDR = BCAST
        START TIMER(TO)
    ENDIF
    RETURN NH_LL_ADDR
ENDIF

PROCEDURE: FindNextHop()
    MFR = 0
    LL_ADDR = 0
    FOR (i∈ LocT)
        IF (i.IS_NEIGHBOUR) THEN
            IF ((MFR != 0) AND (DIST(TARGET_POS, PVᵢ) < MFR)) THEN
                NH ← i
                MFR ← DIST(PVₚ, PVᵢ)
                LL_ADDR = i.LL_ADDR
            ENDIF
        ENDIF
    ENDFOR
    RETURN LL_ADDR
```

E.3 Advanced GeoBroadcast forwarding algorithm 2

The Advanced GeoBroadcast forwarding algorithm 2 is based on CBF to deal with uncertainties in terms of reception failure caused by node mobility, fading phenomena and collisions on the wireless medium. In addition to improve connectivity, a sectoral suppression algorithm is used. Details are available in the publication about MHVB in annex J.

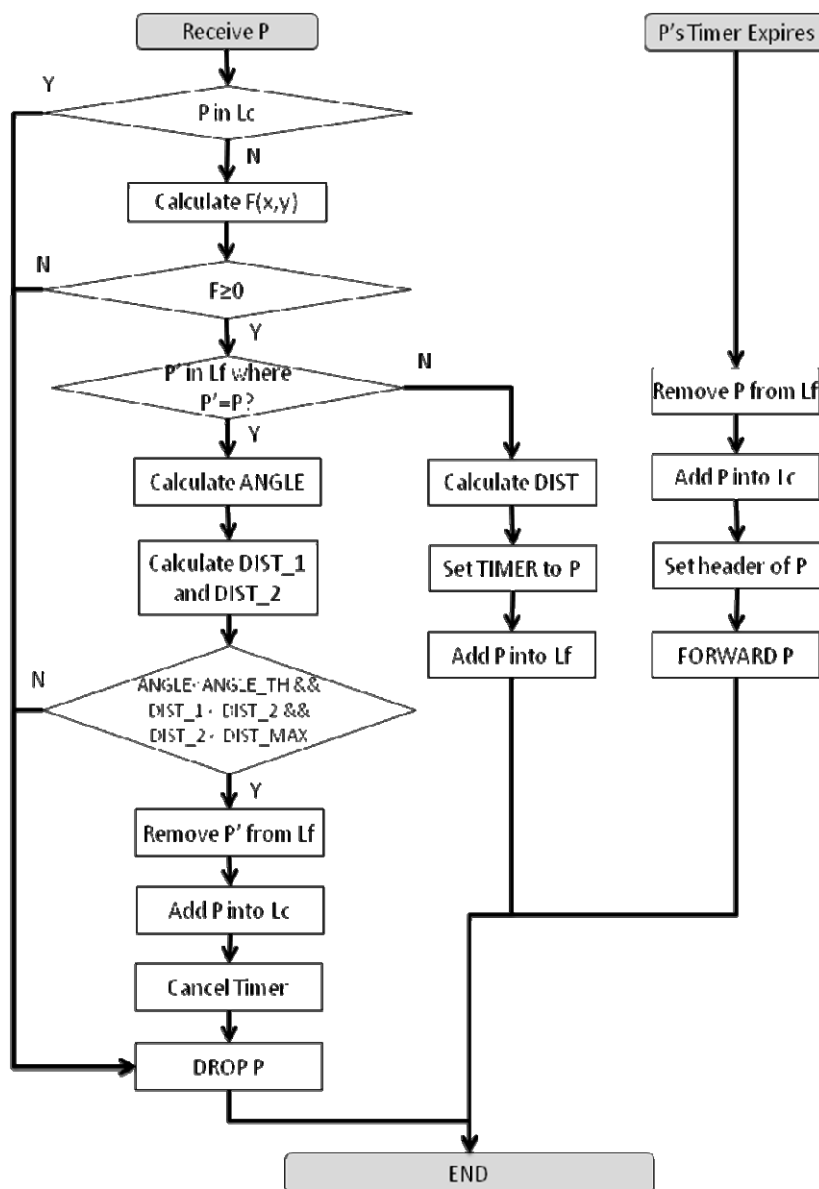The activity diagram of the advanced GeoBroadcast forwarding algorithm 2 is depicted in figure E.2.

Figure E.2: Activity diagram of Advanced GeoBroadcast algorithm 2

```
-- P is the GeoNetworking packet to be forwarded
-- Lf is the list of forwarding packet
-- P' is the GeoNetworking packet stored in Lf
-- Lc is the list of PID completed (e.g. already forwarded)
-- POS is {latitude, longitude} of this node's LPV
-- POS_s is {latitude, longitude} of the sender node's PV
-- GA is the geographical area to which this packet is supposed to be
forwarded
-- PID is the {GN_ADDR, SN} of the GeoNetworking packet
-- DIST_MAX is the theoretical maximum communication range
-- CalcDist (POS1, POS2) is the function to calculate the distance between POS1 and POS2
-- CalcAngle (POS_b, POS_1, POS_2) is the function to calculate the angle ∠(POS_1)-(POS_b)-(POS_2)
(or cosine value)
-- CalcTimer (DIST) corresponds to Equation 1 in C.3
-- ANGLE_TH is a certain threshold value (e.g. 30 [degree] or cosine value)

/*** Receive GeoBroadcast packet ***/
ReceivePacket (P):
    Extract {POS_s, PID, GA} from P
    IF (PID ∈ Lc) THEN
        DROP P
        RETURN
    ENDIF

    Calculate F (POS->longitude, POS->latitude) based on GA /* Refer D.2 */
    IF (F≥0) THEN

        IF (P' ∈ Lf where P'->PID = P->PID) THEN /* Already registered in the forwarding packet list
*/

            Set POS_s' to P'->POS_s
            ANGLE = CalcAngle (POS_s', POS, POS_s)
            DIST_1 = CalcDist (POS_s', POS) /* Distance with respect to the sender of P'*/
            DIST_2 = CalcDist (POS_s', POS_s) /* Distance between senders of P and P'*/
            IF (ANGLE < ANGLE_TH && DIST_1 < DIST_2 && DIST_2 < DIST_MAX) THEN
                Remove P' from Lf
                Cancel TIMER(P')
                Add PID into Lc
            ENDIF
            DROP P
        ELSE
            DIST = CalcDist (POS, POS_s)
            Set TO = CalcTimer(DIST)
            Set TIMER (P, TO)
            Add P into Lf
        ENDIF
    ELSE
        DROP P
    ENDIF

/*** CBF timer expires ***/
TimerExpiration (P):
    Remove P from Lf
    Add PID into Lc
    Update P->POS
    FORWARD P
```

Annex F (normative): GeoNetworking protocol constants

Table F.1 specifies the GeoNetworking protocol constants that shall be supported by GeoAdhoc routers.

The protocol constants represent MIB attributes. The MIB is specified in annex G in ASN-1.

Table F.1: GeoNetworking MIB attribute types

MIB attribute type	Default/initial value	Comment
itsGnLocalGnAddr	1	GeoNetworking address of the GeoAdhoc router
itsGnLocalAddrConfMethod	AUTO (0) MANAGED (1)	AUTO: Local GN_ADDR is configured from MIB MANAGED: Local GN_ADDR is configured via the *GN-MGMTt* primitive (annex I)
itsGnProtocolVersion	TS 102 636-4-1 (V1.1.1) (0)	Version of the GeoNetworking protocol set in the GeoNetworking protocol headers
itsGnStationType	Vehicle ITS Station (0) Roadside ITS Station (1)	Type of ITS Station
itsGnMinimumUpdateFrequencyLPV	Vehicle ITS Station (1 000) Roadside ITS Station (0)	Minimum update frequency of local position vector (LPV) in ms
itsGnMaxSduSize	1 398	Maximum size of GN-SDU [bytes] 1 500- GN_MAX (88) - GNSEC_MAX (0)
itsGnMaxGeoNetworkingHeaderSize	88	GN_MAX: Maximum size of GeoNetworking header [bytes] Determined by the GeoUnicast header as defined in clause 8.6.2
itsGnLifetimeLocTE	20	Lifetime of location table entry [s]
itsGnLocationServiceMaxRetrans	10	Maximum number of retransmissions of LS Request packets
itsGnLocationServiceRetransmitTimer	1 000	Duration of Location service retransmit timer [ms]
itsGnLocationServicePacketBufferSize	1 024	Size of Location service packet buffer [Byte]
itsGnBeaconServiceRetransmitTimer	3 000	Duration of Beacon service retransmit timer [ms]
itsGnBeaconServiceMaxJitter	itsGnMaxPacketLifetime/4	Maximum beacon jitter [ms]
itsGnDefaultHopLimit	10	Default hop limit indicating the maximum number of hops a packet travels
itsGnMaxPacketLifetime	600	Upper limit of the maximum lifetime [s]
itsGnMinPacketRepetitionInterval	100	Lower limit of the packet repetition interval [ms]
itsGnGeoUnicastForwardingAlgorithm	UNSPECIFIED (0) GREEDY (1) CBF (2)	Default GeoUnicast forwarding algorithm
itsGnGeoBroadcastForwardingAlgorithm	UNSPECIFIED (0) SIMPLE (1)	Default GeoBroadcast forwarding algorithm
itsGnGeoUnicastCbfMinTime	1	Minimum duration a packet shall be buffered in the CBF packet buffer [ms]
itsGnGeoUnicastCbfMaxTime	100	Maximum duration a packet shall be buffered in the CBF packet buffer [ms]
itsGnDefaultMaxCommunicationRange	1 000	Default theoretical maximum communication range [m]
itsGnGeoAreaLineForwarding	DISABLED (0) ENABLED (1)	Forwarding of GeoBroadcast/GeoAnycast packet if GeoAdhoc router is located outside the GeoArea.
itsGnUcForwardingPacketBufferSize	256	Size of UC forwarding packet buffer [Kbytes].
itsGnBcForwardingPacketBufferSize	1 024	Size of BC forwarding packet buffer [Kbytes].

MIB attribute type	Default/initial value	Comment
itsGnCbfPacketBufferSize	256	Size of CBF packet buffer [Kbytes]
itsGnTrafficClassRelevance	3	Forwarding: Default traffic class Relevance
itsGnTrafficClassReliability	Medium (10)	Forwarding: Default traffic class Reliability
itsGnTrafficClassLatency	Medium (10)	Forwarding: Default traffic class Latency

Annex G (normative):
ASN.1 encoding of the GeoNetworking MIB

G.1   Use of modules

The ASN.1 module of the present document is **ITSGN { itu-t(0) identified-organization(4) etsi(0) itsgn(2636-4)}** as specified in the following clause. The encoding shall be packet encoding rules (PER) as specified in [8].

G.2   ASN.1 module

```
-- ****************************************************************************
-- * ETSI TC ITS TS 102 636-4 GeoNetworking MIB
-- ****************************************************************************

ITSGN-MIB DEFINITIONS::=BEGIN

   IMPORTS
      MODULE-IDENTITY, OBJECT-TYPE,
      Unsigned32, Integer32,
      enterprises                            FROM SNMPv2-SMI
      SnmpAdminString                          FROM SNMP-FRAMEWORK-MIB
      TEXTUAL-CONVENTION                 FROM SNMPv2-TC
      InterfaceIndex            FROM IF-MIB;

-- ****************************************************************************
-- * MODULE IDENTITY
-- ****************************************************************************

itsGn MODULE-IDENTITY
   LAST-UPDATED "201103310000Z"
   ORGANIZATION "ETSI Technical Committee ITS WG3"
   CONTACT-INFO
      "WG Email:    ITS_WG3@LIST.ETSI.ORG"
   DESCRIPTION
      "The MIB module for TS 102 636-4 (GeoNetworking) entities
       itu-t(0).identified-organization(4).etsi(0).itsgn(26364)
      "
   REVISION    "201103310000Z"
   DESCRIPTION "TS 102 636-4-1 V0.1.2"
   REVISION    "201011160000Z"
   DESCRIPTION "TS 102 636-4-1 V0.0.9"
   REVISION    "201007140000Z"
   DESCRIPTION "TS 102 636-4-1 V0.0.7"
   REVISION    "201006140000Z"
   DESCRIPTION "Initial version: TS 102 636-4-1 V0.0.6"
::= { enterprises 13019 26364}

-- ****************************************************************************
-- * PRIMARY GROUPS
-- ****************************************************************************

itsGnObjects    OBJECT IDENTIFIER ::= { itsGn 1 }
itsGnStatistics  OBJECT IDENTIFIER ::= { itsGn 2 }
itsGnConformance OBJECT IDENTIFIER ::= { itsGn 3 }

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

   itsGnMgmt    OBJECT IDENTIFIER ::= { itsGnObjects 1 }

-- ****************************************************************************
-- * 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 }


-- ****************************************************************************
-- * TEXTUAL CONVENTIONS
-- ****************************************************************************

   GnAddress ::= TEXTUAL-CONVENTION
       DISPLAY-HINT "2x:2x:2x:2x"
       STATUS       current
       DESCRIPTION
          "Represents a GeoNetworking address:

          Octets   Contents          Encoding
            1-8    GN address        network-byte order"
       SYNTAX       OCTET STRING (SIZE (8))


-- ****************************************************************************
-- * GN OBJECTS GROUP
-- ****************************************************************************

-- ****************************************************************************
-- * GN SYSTEM GROUP
-- ****************************************************************************

itsGnIfTable        OBJECT-TYPE
    SYNTAX      SEQUENCE OF ItsGnIfEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
    "A table representing the interfaces that will be used by the
    GeoAdhoc router for communication.  Each entry in this table
    represents a configured egress interface.
    "
    ::= { itsGnSystem 1 }


itsGnIfEntry OBJECT-TYPE
    SYNTAX      ItsGnIfEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
    "An entry in the interface table.  It
    represents a single interface entry.
    "
    INDEX  { itsGnIfIndex }
    ::= { itsGnIfTable 1 }

ItsGnIfEntry ::=
    SEQUENCE {
        itsGnIfIndex            InterfaceIndex,
    itsGnIfPriority       Unsigned32,
    itsGnIfDescription    SnmpAdminString
    }

itsGnIfIndex  OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
    "The index of the interface of the GeoAdhoc router.
    "
    ::= { itsGnIfEntry 1 }

itsGnIfPriority   OBJECT-TYPE
    SYNTAX      Unsigned32 (0..255)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
    "The priority configured to the interface.
    This value will be configured to a value between 0
    and 255.
    "
    ::= { itsGnIfEntry 2 }

itsGnIfDescription   OBJECT-TYPE
```

```
    SYNTAX      SnmpAdminString
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
    "A human-readable textual description of the
    interface on the GeoAdhoc router.
    "
    ::= { itsGnIfEntry 3 }

-- ****************************************************************************
-- * GN CONFIGURATION SUB GROUP
-- ****************************************************************************

itsGnLocalGnAddr OBJECT-TYPE
   SYNTAX      GnAddress
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       "GeoNetworking address of the GeoAdhoc router."
::= { itsGnConfig 1 }

itsGnLocalAddrConfMethod OBJECT-TYPE
    SYNTAX      INTEGER {
        auto(1),
        managed(2)
     }
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       "Local address configuration method
       AUTO: Local GN_ADDR is configured from MIB
       MANAGED: Local GN_ADDR is configured via the GN-MGMTt primitive (annex G)"
::= { itsGnConfig 2 }

itsGnProtocolVersion OBJECT-TYPE
   SYNTAX      Unsigned32
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       "GeoNetworking protocol version."
::= { itsGnConfig 3 }

itsGnStationType OBJECT-TYPE
   SYNTAX      INTEGER{
               vehicleItsStation (0),
               roadsideItsStation (1)
              }
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       "ITS Station type."
::= { itsGnConfig 4 }

itsGnMinUpdateFrequencyLPV OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "milliseconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       " Minimum update frequency of local position vector (LPV) in ms."
::= { itsGnConfig 5 }

itsGnMaxSduSize OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "Bytes"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       " Maximum size of GN-SDU in bytes."
::= { itsGnConfig 6 }

itsGnMaxGeoNetworkingHeaderSize OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "Bytes"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
       " Maximum size of GeoNetworking header in bytes."
```

```
::= { itsGnConfig 7 }

itsGnLifetimeLocTE OBJECT-TYPE
   SYNTAX      Integer32(0..65635)
   UNITS       "Seconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      " Location table maintenance: Lifetime of an entry in the location table
       in s."
::= { itsGnConfig 8 }

-- ****************************************************************************
-- * GN LOCATION SERVICE SUB GROUP
-- ****************************************************************************

itsGnLocationServiceMaxRetrans OBJECT-TYPE
   SYNTAX      Integer32(0..255)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Location service: Maximum number of retransmissions for a LS Request."
::= { itsGnLocationService 1 }

itsGnLocationServiceRetransmitTimer OBJECT-TYPE
   SYNTAX      Integer32(0..65535)
   UNITS       "milliseconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Location service: Duration of LS request retransmit timer in ms."
::= { itsGnLocationService 2 }

itsGnLocationServicePacketBufferSize OBJECT-TYPE
   SYNTAX      Integer32(0..65535)
   UNITS       "Bytes"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Location service: Size of LS packet buffer in bytes."
::= { itsGnLocationService 3 }

-- ****************************************************************************
-- * GN BEACON SERVICE SUB GROUP
-- ****************************************************************************

itsGnBeaconServiceRetransmitTimer OBJECT-TYPE
   SYNTAX      Integer32(0..65535)
   UNITS       "milliseconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Beacon service: Duration of Beacon retransmit timer in ms."
::= { itsGnBeaconService 1 }

itsGnBeaconServiceMaxJitter OBJECT-TYPE
   SYNTAX      Integer32(0..65535)
   UNITS       "milliseconds"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Beacon service: Maximum Beacon jitter in ms."
::= { itsGnBeaconService 2 }

-- ****************************************************************************
-- * GN PACKET FORWARDING SUB GROUP
-- ****************************************************************************

itsGnDefaultHopLimit OBJECT-TYPE
   SYNTAX      Integer32(0..255)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      " Default hop limit for forwarding."
::= { itsGnPacketForwarding 1 }

itsGnMaxLifetime OBJECT-TYPE
   SYNTAX      Integer32(0..6300)
```

```
   UNITS      "seconds"
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "Upper limit of the maximum lifetime of a packet in s."
::= { itsGnPacketForwarding 2 }

itsGnMinRepetitionInterval OBJECT-TYPE
   SYNTAX     Integer32(0..1000)
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "Lower limit of the packet repetition interval in ms."
::= { itsGnPacketForwarding 3 }

itsGnGeoUnicastForwardingAlgorithm OBJECT-TYPE
   SYNTAX      INTEGER {
                  unspecified  (0),
                  greedy       (1),
                  cbf          (2)
               }
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "GeoUnicast forwarding algorithm."
::= { itsGnPacketForwarding 4 }

itsGnGeoBroadcastForwardingAlgorithm OBJECT-TYPE
   SYNTAX      INTEGER {
                  unspecified  (0),
                  simple       (1),
                  advanced     (2)
               }
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "GeoBroadcast forwarding algorithm."
::= { itsGnPacketForwarding 5 }

itsGnGeoUnicastCbfMinTime OBJECT-TYPE
   SYNTAX     Integer32(0..65635)
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "Minimum duration a packet shall be buffered in the CBF packet buffer in ms."
::= { itsGnPacketForwarding 6 }

itsGnGeoUnicastCbfMaxTime OBJECT-TYPE
   SYNTAX     Integer32(0..65635)
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "Maximum duration a packet shall be buffered in the CBF packet buffer in ms."
::= { itsGnPacketForwarding 7 }

itsGnDefaultMaxCommunicationRange OBJECT-TYPE
   SYNTAX     Integer32(0..65635)
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "Default theoretical maximum communication range in m."
::= { itsGnPacketForwarding 8 }

itsGnGeoAreaLineForwarding OBJECT-TYPE
   SYNTAX      INTEGER {
                  disabled  (0),
                  enabled   (1)
               }
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION
      "Forwarding of GEOBROADCAST/GEOANYCAST packet if GeoAdhoc
       router is located outside the GeoArea."
::= { itsGnPacketForwarding 9 }

itsGnUcForwardingPacketBufferSize OBJECT-TYPE
   SYNTAX     Integer32(0..255)
   UNITS      "kByte"
```

```
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Forwarding: Size of UC forwarding packet buffer in kByte."
::= { itsGnPacketForwarding 10 }

itsGnBcForwardingPacketBufferSize OBJECT-TYPE
   SYNTAX      Integer32(0.. 65535)
   UNITS       "kByte"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Forwarding: Size of BC forwarding packet buffer in kByte."
::= { itsGnPacketForwarding 11 }

itsGnCbfPacketBufferSize OBJECT-TYPE
   SYNTAX      Integer32(0.. 65535)
   UNITS       "kByte"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Forwarding: Size of CBF packet buffer [Kbytes].."
::= { itsGnPacketForwarding 12 }

itsGnTrafficClassRelevance OBJECT-TYPE
   SYNTAX      Integer32(0..7)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Forwarding: Default traffic class Relevance."
::= { itsGnPacketForwarding 13 }

itsGnTrafficClassReliability OBJECT-TYPE
   SYNTAX      Integer32(0..3)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      " Forwarding: Default traffic class Reliability."
::= { itsGnPacketForwarding 14 }

itsGnTrafficClassLatency OBJECT-TYPE
   SYNTAX      Integer32(0..3)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Forwarding: Default traffic class Latency."
::= { itsGnPacketForwarding 15 }


END
```

Annex H (informative):
GeoNetworking data services

H.1   General

The GN data service primitives allow entities of ITS transport protocols to send and receive PDUs via the GN_SAP.

H.2   GN-DATA.request

The *GN-DATA.request* primitive is used by the ITS transport protocol entity to request sending a GeoNetworking packet. Upon reception of the *GN-DATA.request* primitive, the GeoNetworking protocol delivers the GeoNetworking packet to the LLC protocol entity via the IN_SAP.

The parameters of the *GN-DATA.request* are as follows:

```
GN-DATA.request (
            Upper protocol entity,
            Packet transport type,
            Destination,
            Communication profile,
            Maximum packet lifetime, (optional)
            Repetition interval, (optional)
            Traffic class,
            Length,
            Data
            )
```

The *Upper protocol entity* parameter specifies whether the primitive was triggered by an ITS Transport protocol (e.g. BTP) or by the GeoNetworking to IPv6 Adaptation Sub-Layer (GN6ASL).

The *Packet transport type* parameter specifies the packet transport type (GeoUnicast, SHB, TSB, GeoBroadcast, GeoAnycast).

The *Destination* parameter specifies the destination address for GeoUnicast or the geographical area for GeoBroadcast/GeoAnycast. The destination address for GeoUnicast can optionally contain the MID field only; with the other fields set to 0 (see figure 3 and table 1).

The *Communication profile* parameter determines the LL protocol entity (unspecified, ITS-G5A).

The *Maximum lifetime* parameter specifies the maximum tolerable time in [s] a GeoNetworking packet can be buffered until it reaches its destination. The parameter is optional. If it is not used, the MIB attribute *itsGnMaxPacketLifetime* is used.

The *Repetition interval* parameter specifies the duration between two consecutive transmissions of the same GeoNetworking packet during the lifetime of a packet in [ms]. The parameter is optional. If it is not used, the packet should not be repeated.

The *Traffic class* parameter specifies the traffic class for the message as a triple of Relevance, Reliability, and Latency.

The *Length* parameter indicates the length of the *Data* parameter.

The *Data* parameter represents the payload of the GeoNetworking packet to be sent, i.e. the T-SDU/GN6-SDU.

H.3   GN-DATA.confirm

The *GN-DATA.confirm* primitive is used to confirm that the GeoNetworking packet was successfully processed in response to a GN-DATA.request. For the reception of the primitive, no behaviour is specified.

The parameters of the primitive are as follows:

```
GN-DATA.confirm (
            ResultCode
            )
```

The *ResultCode* parameter specifies whether the GN-DATA.request primitive:

- has been accepted;

- rejected due to maximum length exceeded if the size of the T/GN6-PDU exceeds the MIB attribute itsGnMaxSduSize;

- reject due to maximum lifetime exceeded if the lifetime exceeds the maximum value of the MIB attribute itsGnMaxPacketLifetime;

- reject due to repetition interval too small, if the repetition interval is smaller than the MIB attribute itsGnMinPacketRepetitionInterval;

- rejected due to unsupported traffic class; or

- rejected for unspecified reasons if the *GN-DATA.request* primitive cannot accepted for any other reason.

H.4   GN-DATA.indication

The *GN-DATA.indication* primitive indicates to an upper protocol entity that a GeoNetworking packet has been received. The primitive is generated by the GeoNetworking protocol to deliver data contained in a received GeoNetworking packet to upper protocol entity. The data of the GeoNetworking packet are processed as determined by the receiving upper protocol entity.

The parameters of the GN-DATA.indication primitive are as follows:

```
GN-DATA.indication (
            Upper protocol entity,
            Packet transport type,
            Destination
            Source position vector,
            Traffic class,
            Remaining packet  lifetime (optional),
            Length,
            Data     -- T/GN6-PDU
            )
```

The *Upper protocol entity* parameter determines the protocol entity that processes the service primitive (BTP or GN6).

The *Packet transport type* parameter is the packet transport type (GeoUnicast, SHB, TSB, GeoBroadcast, GeoAnycast) of the received packet.

The *Destination* parameter is the destination address for GeoUnicast or the geographical area for GeoBroadcast/GeoAnycast, with which the GeoNetworking packet was generated by the source.

The *Source position vector* parameter is the geographical position for the source of the received GeoNetworking packet.

The *Remaining packet lifetime* parameter is the remaining lifetime of the packet.

The *Traffic Class* parameters is the traffic class, with which the GeoNetworking packet was generated by the source.

The *Length* parameter is the length of the *Data* parameter.

The *Data* parameter is the payload of the received GeoNetworking packet, i.e. the T-PDU/GN6-PDU.

Annex I (informative):
GeoNetworking management services

I.1 General

The GN management service primitives allow the *ITS Network and Transport Layer Management* entity to update position, time and GeoNetworking address of the GeoAdhoc router.

I.2 GN-MGMT.request

The *GN-MGMT.request* primitive is generated by the GeoNetworking protocol entity at the initialization phase in order to request management information, i.e. time, position vector, GeoNetworking address. After receiving the *GN-MGMT.request* primitive, the *ITS Network and Transport Layer Management* entity is in charge of providing the GeoNetworking entity with the requested management information.

The parameters of the *GN-MGMT.request* are as follows:

```
GN-MGMT.request (
            Request cause
            )
```

The *Request cause* parameter specifies the type of requested information, i.e. time, position vector, GeoNetworking address. In case the GeoNetworking address is requested, the parameter also indicates whether the address request is caused by duplicate address detection or is an initial request.

I.3 GN-MGMT.response

The *GN-MGMT.response* primitive is generated by the *ITS Network and Transport Layer Management* entity to indicate an update of management information, i.e. time, position vector and GeoNetworking address. The primitive can be triggered upon reception of a *GN-MGMT.request* primitive or can be generated unsolicited, i.e. without a *GN-MGMT.request* primitive.

The parameters of the *GN-MGMT.response* are as follows:

```
GN-MGMT.response (
            Time (optional)
            Local position vector (optional)
            GeoNetworking address (optional)
            )
```

The *Time* parameter specifies the timestamp that is used as a reference to determine the freshness of received information carried in packets.

The *Local position vector* parameter specifies the ITS station's most recent position vector (geographical position, speed, heading, timestamp when the position vector was generated, and corresponding accuracy information).

The *GeoNetworking address* parameter specifies the GeoNetworking address that shall be used by the GeoNetworking protocol entity.

All parameters are optional, whereas at least one parameter should be present.

Annex J (informative):
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History

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