3GPP TS 29.281 V9.3.0 (2010-06)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Core Network and Terminals;
General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)
(Release 9)





The present document has been developed within the 3rd Generation Partnership Project (3GPP™) and may be further elaborated for the purposes of 3GPP.

The present document has not been subject to any approval process by the 3GPP Organizational Partners and shall not be implemented.
This Specification is provided for future development work within 3GPP only. The Organizational Partners accept no liability for any use of this Specification.
Specifications and reports for implementation of the 3GPP™ system should be obtained via the 3GPP Organizational Partners' Publications Offices.

Keywords
EPS, GSM, UMTS, packet mode, GPRS

3GPP

Postal address

3GPP support office address
650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet
http://www.3gpp.org

Copyright Notification

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© 2010, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TTA, TTC).
All rights reserved.

UMTS™ is a Trade Mark of ETSI registered for the benefit of its members
3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners
LTE™ is a Trade Mark of ETSI currently being registered for the benefit of its Members and of the 3GPP Organizational Partners
GSM® and the GSM logo are registered and owned by the GSM Association

Contents

Foreword 5
1 Scope 6
2 References 6
3 Definitions and abbreviations 7
3.1 Definitions 7
3.2 Abbreviations 7
4 General 8
4.1 GTP Path 8
4.2 GTP-U Tunnels 8
4.2.1 GTP-U Tunnel description 8
4.2.2 IP transport 8
4.2.3 GTP-U Tunnel IP transport 9
4.2.4 Ingress GTP tunnel (GTPv1-U sending endpoint) 9
4.2.5 Egress GTP tunnel (GTPv1-U receiving endpoint) 9
4.2.6 MBMS IP Multicast Distribution of the User Plane Data 9
4.3 GTP-U Protocol Entity 10
4.3.1 Handling of Sequence Numbers 10
4.4 Protocol stack 10
4.4.1 UDP/IP 10
4.4.2 UDP header and port numbers 11
4.4.2.1 Echo Request Message 11
4.4.2.2 Echo Response Message 11
4.4.2.3 Encapsulated T-PDUs 11
4.4.2.4 Error Indication 11
4.4.2.5 Supported Extension Headers Notification 11
4.4.3 IP header and IP addresses 11
4.4.3.1 Echo Request Message 11
4.4.3.2 Echo Response Message 11
4.4.3.3 Encapsulated T-PDUs 11
4.4.3.4 Error Indication 12
4.4.3.5 Supported Extension Headers Notification 12
4.5 Transmission Order and Bit Definitions 12
4.6 New Functionality 12
5 GTP-U header 12
5.1 General format 12
5.2 GTP-U Extension Header 14
5.2.1 General format of the GTP-U Extension Header 14
5.2.2 Extension Header types 15
5.2.2.1 UDP Port 15
5.2.2.2 PDCP PDU Number 15
6 GTP-U Message Formats 16
6.1 General 16
6.2 Presence requirements of Information Elements 16
7 GTP-U Messages 17
7.1 General 17
7.2 Path Management Messages 17
7.2.1 Echo Request 17
7.2.2 Echo Response 17
7.2.3 Supported Extension Headers Notification 18
7.3 Tunnel Management Messages 18
7.3.1 Error Indication 18
7.3.2 End Marker 18

8 Information Elements 19
8.1 Information Element Types 19
8.2 Recovery 20
8.3 Tunnel Endpoint Identifier Data I 20
8.4 GTP-U Peer Address 20
8.5 Extension Header Type List 21
8.6 Private Extension 21
9 Error Handling 21
9.1 Protocol Errors 21
9.2 Path Failure 21
10 Security 22
11 Reliable Delivery of Signalling Messages 22
12 GTP Parameters 22
12.1 General 22
12.2 Timers 22
12.3 Others 22
13 Tunnelling Scenarios 22
13.1 General 22
13.2 Tunnelling between Serving GWs 22
13.3 Transfer of the user plane data between PDN GWs 23
13.4 Tunnelling between SGSNs 23
13.5 Tunnelling between Source RNC and Target RNC 23
13.6 Transfer of the user plane data between GGSNs 23
Annex A (informative): Change history 24

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document defines the user plane of GTP used on:

- the Gn and Gp interfaces of the General Packet Radio Service (GPRS);
- the Iu, Gn and Gp interfaces of the UMTS system;
- the S1-U, X2, S4, S5, S8 and S12 interfaces of the Evolved Packet System (EPS);

This definition ensures full backwards compatibility with RNC, SGSN and GGSN implementations according to release 7 of 3GPP TS 29.060 [6].

NOTE: Releases previous to Release-8 have used 3GPP TS 29.060 [6] as normative definition of the user plane of GTP. This shall be considered when essential corrections are included in the present document or in pre-release-8 version of 3GPP TS 29.060 [6].

Fallback from GTPv1-U to GTPv0-U shall not be supported. Therefore, 3GPP Rel-8 and onwards GTPv1-U entity should not listen to the well-known GTPv0 port 3386. If GTPv1 entity listens to the GTPv0 port, the entity shall silently discard any received GTPv0-U message.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.003: "Numbering, addressing and identification".

[3] 3GPP TS 23.007: "Restoration procedures".

[4] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".

[5] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[6] 3GPP TS 29.060: "General Packet Radio Service (GPRS); GPRS Tunnelling Protocol (GTP) across the Gn and Gp interface".

[7] 3GPP TS 29.274: "3GPP Evolved Packet System; Evolved GPRS Tunnelling Protocol for EPS (GTPv2)".

[8] 3GPP TS 32.295: "Telecommunication management; Charging management; Charging Data Record (CDR) transfer".

[9] IETF RFC 768 (STD 0006): "User Datagram Protocol", J. Postel.

[10] IETF RFC 791 (STD 0005): "Internet Protocol", J. Postel.

[11] IETF RFC 2373: "IP Version 6 Addressing Architecture".

[12] 3GPP TS 33.210: "3G security; Network Domain Security (NDS); IP network layer security".

[13] 3GPP TS 23.121: "Architectural requirements for Release 1999".

[14] 3GPP TS 43.129: "Packet-switched handover for GERAN A/Gb mode; Stage 2".

[15] IETF RFC 2460: "Internet Protocol, Version 6 (IPv6) Specification", Standards Track

[16] 3GPP TS 25.413: "UTRAN Iu interface RANAP signalling".

[17] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[18] 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description; Stage 2".

[19] IETF RFC 4604 (2006): "Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast".

[20] IETF RFC 4607 (2006): "Source-Specific Multicast for IP".

[21] 3GPP TS 33.102: "3G Security;Security architecture".

[22] 3GPP TS 33.401: "3GPP System Architecture Evolution (SAE): Security architecture ".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

GTP-U peer: node implementing at least one side of any of the GTP user plane based protocols. RNC, SGSN, GGSN, eNodeB, SGW or PGW.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

GTP	GPRS Tunnelling Protocol
GTP-C	GTP Control
GTP-U	GTP User
IE	Information Element
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
QoS	Quality of Service
RANAP	Radio Access Network Application Part
RNC	Radio Network Controller
TEID	Tunnel Endpoint IDentifier
UDP	User Datagram Protocol
UTRAN	UMTS Terrestrial Radio Access Network

4 General

4.1 GTP Path

For the definition of UDP/IP Path and GTP Endpoint, see 3GPP TS 29.060 [6].

4.2 GTP-U Tunnels

4.2.1 GTP-U Tunnel description

GTP-U Tunnels are used to carry encapsulated T-PDUs and signalling messages between a given pair of GTP-U Tunnel Endpoints. The Tunnel Endpoint ID (TEID) which is present in the GTP header shall indicate which tunnel a particular T-PDU belongs to. In this manner, packets are multiplexed and de-multiplexed by GTP-U between a given pair of Tunnel Endpoints. The TEID value to be used in the TEID field shall be negotiated using a control plane protocol like GTPv1-C, GTPv2-C, RANAP or S1-AP.

In what follows we refer to the outer GTPv1-U IP packet as the IP packet that carries a GTPv1-U packet. The inner IP packet in a GTPv1-U packet (T-PDU) is either

- An IP packet sent to the UE/MS in the downlink direction over one or more tunnels from the external network identified by the APN.
- An IP packet sent from a UE/MS in the uplink direction over one or more tunnels to the external network identified by the APN.

NOTE 1: Not all tunnels in 3GPP networks will necessarily be GTPv1-U,

NOTE 2: The inner MTU size of the GTPv1-U tunnel is typically not the same as the outer MTU size of the IP path carrying the outer IP packets.

The maximum size of a T-PDU that may be transmitted without fragmentation by GGSN or the MS is defined in 3GPP TS 23.060 [4].

4.2.2 IP transport

According to IETF RFC 791 [10], any IPv4 router in the backbone may fragment the outer IPv4 GTPv1-U packet with a flag of DF=0.

Unnecessary fragmentation should be avoided when possible due to the following;

- Fragmentation is bandwidth inefficient, since the complete IP header is duplicated in each fragment.
- Fragmentation is CPU intensive since more fragments require more processing at both GTPv1-U endpoints and IP routers. It also requires additional memory at the receiver.
- If one fragment is lost, the complete packet has to be discarded. The reason is there is no selective retransmission of IP fragments provided in IPv4 or IPv6.

To avoid unnecessary fragmenting the outer IP packets backbone links between GTP peers should, when possible, have outer MTU values that exceed the sum of the maximum value of the inner MTU size plus the size of the tunnel headers (outer IP header, outer UDP header, and GTP header, including any possible GTP extension headers) in order to avoid unnecessary IP fragmentation in the backbone.

To avoid unnecessary fragmenting the inner IP packets the UE/MS, or a server in an external network, may find out the inner MTU by path MTU discovery and hence fragment correctly at the source.

4.2.3 GTP-U Tunnel IP transport

Functionality for IP transport and IP fragmentation at a RAN node on the Iu interface or S12 is defined in 3GPP TS 25.414 [16].

Functionality for IP transport and IP fragmentation at an eNodeB on the S1-U and X2 interface is defined in 3GPP TS 36.300 [17].

The outer GTPv1-U packet layer shall IPv4 as defined by IETF RFC 791 [10] and should support IPv6 as defined by IETF RFC 2460[15].

The following text as well as sub-clauses 4.2.4 and 4.2.5 apply only to core network GTPv1-U endpoints.

GTPv1-U tunnel endpoints do not need to change the hopcount/TTL or to perform any IP routing functions in respect to inner IP packet other than the functions explicitly stated here. However, other co-located functions may do so. For example, the GGSN/PGW may change the hopcount/TTL as the IP datagram enters/leaves the Gi/SGi interface from/to the GTPv1-U tunnel interface and IP packets may be discarded or rejected at any point by a co-located function due to local policy and/or QoS (the policy enforcement point).

4.2.4 Ingress GTP tunnel (GTPv1-U sending endpoint)

An inner IP packet shall be encapsulated at the GTPv1-U sender with a GTP header, UDP and IP header. If the resulting outer IP packet is larger than the MTU of the first link towards the destination GTPv1-U endpoint, fragmentation of the IP packet shall be performed by the sender as per IETF RFC 791 [10] for an outer layer of IPv4 and IETF RFC 2460 [15] for an outer layer of IPv6. The GTPv1-U sender should preferably fragment the IP packet to the smallest MTU of any link between GTPv1-U sender and GTPv1-U receiver.

Fragmentation policy of the inner datagram is implementation dependent but shall interwork with IETF RFC 791 [10] for inner IPv4 datagrams and IETF RFC 2460 [15] for inner IPv6 packets.

4.2.5 Egress GTP tunnel (GTPv1-U receiving endpoint)

The GTPv1-U receiving endpoint packets shall reassemble any IP fragments in datagrams received from the GTPv1-U sending endpoint as per IETF RFC 791 [10] for outer IPv4 datagrams and as per IETF RFC 2460 [15] for outer IPv6 datagrams. The IP reassembly buffer in the receiving endpoint shall be at least the inner MTU size plus the size of the tunnel headers (outer IP header, outer UDP header, and GTP header, including any GTP extension headers).

The completely reassembled IP packet shall then be passed to the IP/UDP/GTPv1-U layers to extract the inner IP packet which is then processed further according to the receiving node's functionality.

4.2.6 MBMS IP Multicast Distribution of the User Plane Data

GTP-U Multicast Tunnels are used for unidirectional transfer of the encapsulated T-PDUs from one GTP-U Tunnel Endpoint acting as an IP multicast source to multiple GTP-U Tunnel Endpoints acting as IP multicast listeners, as specified in TS 23.246 [18]. The Common Tunnel Endpoint ID (C-TEID) which is present in the GTP header shall indicate which tunnel a particular T-PDU belongs to. The C-TEID value to be used in the TEID field is allocated at the source Tunnel Endpoint and signalled to the destination Tunnel Endpoint using a control plane protocol i.e. GTPv1-C, and RANAP, GTPv2-C and S1-AP. There is one C-TEID allocated per MBMS bearer service.

The destination IP address in the outer GTPv1-U IP header is an address in the multicast address range as specified in IETF RFC 4607 [20].

If the RNC decides to receive IP multicast packets, then the RNC shall join the IP multicast group as specified by IETF RFC 4604 [19] and IETF RFC 4607 [20].

If the eNodeB supports MBMS as specified in TS 23.246 [18], it shall join the IP multicast group as specified in IETF RFC 4604 [19] and IETF RFC 4607 [20].

The characteristics for point-to-multipoint GTP-U Multicast Tunnels used for MBMS are the same as for a point-to-point GTP-U Tunnels unless specified otherwise. The differences are specified in subclause 7.1.

4.3 GTP-U Protocol Entity

The GTP-U protocol entity provides packet transmission and reception services to user plane entities in the RNC, SGSN, GGSN, eNodeB, SGW and PDN-GW. The GTP-U protocol entity receives traffic from a number of GTP-U

tunnel endpoints and transmits traffic to a number of GTP-U tunnel endpoints. There is a GTP-U protocol entity per IP address.

The TEID in the GTP-U header is used to de-multiplex traffic incoming from remote tunnel endpoints so that it is delivered to the User plane entities in a way that allows multiplexing of different users, different packet protocols and different QoS levels. Therefore no two remote GTP-U endpoints shall send traffic to a GTP-U protocol entity using the same TEID value except for data forwarding as part of mobility procedures.

4.3.1 Handling of Sequence Numbers

This functionality is provided only when the S bit is set to 1 in the GTP-U header.

For PGW, SGW and eNodeB the usage of sequence numbers in G-PDUs is optional, but if GTP-U protocol entities in these nodes are relaying G-PDUs to other nodes, then they shall relay the sequence numbers as well For all other cases, the PGW, SGW and eNodeB should set the "S" flag to 0 in the GTPv1 header which then indicates that the sequence number is not used in the T-PDU.

An RNC, SGSN or GGSN shall reorder out of sequence T-PDUs when in sequence delivery is required. This is optional at the SGSN for UTRAN access. The GTP-U protocol entity shall deliver to the user plane entity only in sequence T-PDUs and notify the sequence number associated to each of them. The notification of the sequence number is not necessary at the GGSN, but it is mandatory at the SGSN and RNC. The user plane entity shall provide a sequence number to the GTP-U layer together with T-PDUs to be transmitted in sequence. GTP-U protocol entities at the GGSN may optionally generate autonomously the sequence number, but should be able to use sequence numbers provided by the user plane entity. The sequence number is handled on a per GTP-U Tunnel (that is TEID) basis. During relocations and handovers, if a buffered packet is forwarded from the source to the target GTP-U protocol entity along with PDCP T-PDU extension headers, the source of the T-PDU may be considered different and may not relay the sequence numbers.

When the sequence number is included in the GTP-U header, a user plane entity acting as a relay of T-PDUs between GTP-U protocol entities, or between PDCP (or SNDCP) protocol entities and GTP-U protocol entities, shall relay the sequence numbers between those entities as well. In this way it is possible to keep consistent values of sequence numbers from the GGSN to the UE (MS in GPRS) by relaying the sequence number across the CN GTP-U bearer, the Iu GTP-U bearer and the Radio bearer (via PDCP or SNDCP N-PDU numbers). This functionality is beneficial during SRNS relocation.

For GTP-U signalling messages having a response message defined for a request message, Sequence Number shall be a message number valid for a path. Within a given set of continuous Sequence Numbers from 0 to 65535, a given Sequence Number shall, if used, unambiguously define a GTP-U signalling request message sent on the path (see section Reliable delivery of signalling messages). The Sequence Number in a signalling response message shall be copied from the signalling request message that the GSN or RNC is replying to. For GTP-U messages not having a defined response message for a request message, i.e. for messages Supported Extension Headers Notification and Error Indication, the Sequence Number shall be ignored by the receiver.

4.4 Protocol stack

4.4.1 UDP/IP

UDP/IP is the only path protocol defined to transfer GTP messages in the version 1 of GTP.

A GTPv1-U peer shall support the User Datagram Protocol (UDP) as defined by IETF RFC 768 [9] shall be used.

A GTPv1-U peer shall support IPv4 as defined by IETF RFC 791 [10] and should support IPv6 as defined by IETF RFC 2460 [15].

4.4.2 UDP header and port numbers

4.4.2.1 Echo Request Message

The UDP Destination Port number for GTP-U request messages is 2152. It is the registered port number for GTP-U.

The UDP Source Port is a locally allocated port number at the sending GTP-U entity.

4.4.2.2 Echo Response Message

The UDP Destination Port value shall be the value of the UDP Source Port of the corresponding request message.

The UDP Source Port shall be the value from the UDP Destination Port of the corresponding request message.

4.4.2.3 Encapsulated T-PDUs

The UDP Destination Port number shall be 2152. It is the registered port number for GTP-U.

The UDP Source Port is a locally allocated port number at the sending GTP-U entity.

4.4.2.4 Error Indication

The UDP destination port for the Error Indication shall be the user plane UDP port (2152).

The UDP source port shall be locally assigned at the sending node.

NOTE: In network deployments including non-GTP-aware stateful firewalls, those firewalls must be configured to allow response messages coming from a different UDP port and IP address than the triggering message.

4.4.2.5 Supported Extension Headers Notification

The UDP destination port for the Supported Extension Headers Notification shall be the user plane UDP port (2152).

The UDP source port shall be locally assigned at the sending node.

4.4.3 IP header and IP addresses

4.4.3.1 Echo Request Message

The IP Source Address shall be an IP address of the source GTP-U entity from which the message is originating.

The IP Destination Address in a GTP request message shall be an IP address of the destination GTP-U entity.

4.4.3.2 Echo Response Message

The IP Source Address shall be copied from the IP destination address of the GTP request message to which this GTP-U entity is replying.

The IP Destination Address shall be copied from the IP Source Address of the GTP request message to which this GTP-U entity is replying.

4.4.3.3 Encapsulated T-PDUs

The IP Source Address shall be an IP address of the source GTP-U entity from which the message is originating.

The IP Destination Address shall be an IP address of the destination GTP-U entity.

4.4.3.4 Error Indication

The IP source address shall be an address of the source GTP-U entity from which the message is originated

NOTE: In network deployments including non-GTP-aware stateful firewalls, those firewalls must be configured to allow response messages coming from a different UDP port and IP address than the triggering message.

The IP destination address for Error Indication shall be the source address of the GTP-PDU that is the cause for this GTP-U entity to send this message.

4.4.3.5 Supported Extension Headers Notification

The IP Source Address for the Supported Extension Headers Notification shall be copied from the IP destination address of the GTP message that triggered the GTP-U entity to send this message.

The IP Destination Address for the Supported Extension Headers Notification shall be copied from the IP source address of the GTP message that triggered the GTP-U entity to send this message.

4.5 Transmission Order and Bit Definitions

As specified in 3GPP TS 29.060 [6], clause 5.

4.6 New Functionality

With regard to the previous releases, the present specification may define some new functions. Such new functions shall ensure full backwards compatibility with Pre-Rel-8 nodes conforming to 3GPP TS 29.060 [6]. If the new functions are specified with the Extension Headers, bits 8 and 7 of the Extension Header Type shall be set to 0, 0 respectively or 0, 1 respectively. If the new functions are specified with Information Elements, such Information Elements shall be TLV-encoded and optional.

5 GTP-U header

5.1 General format

The GTP-U header is a variable length header whose minimum length is 8 bytes. There are three flags that are used to signal the presence of additional optional fields: the PN flag, the S flag and the E flag. The PN flag is used to signal the presence of N-PDU Numbers. The S flag is used to signal the presence of the GTP Sequence Number field. The E flag is used to signal the presence of the Extension Header field, used to enable future extensions of the GTP header defined in this document, without the need to use another version number. If and only if one or more of these three flags are set, the fields Sequence Number, N-PDU and Extension Header shall be present. The sender shall set all the bits of the unused fields to zero. The receiver shall not evaluate the unused fields.

Always present fields:

- Version field: This field is used to determine the version of the GTP-U protocol. The version number shall be set to '1'.

- Protocol Type (PT): This bit is used as a protocol discriminator between GTP (when PT is '1') and GTP' (when PT is '0'). GTP is described in this document and the GTP' protocol in 3GPP TS 32.295 [8]. Note that the interpretation of the header fields may be different in GTP' than in GTP.

- Extension Header flag (E): This flag indicates the presence of a meaningful value of the Next Extension Header field. When it is set to '0', the Next Extension Header field either is not present or, if present, shall not be interpreted. When it is set to '1', the Next Extension Header field is present, and shall be interpreted, as described below in this section.

- Sequence number flag (S): This flag indicates the presence of a meaningful value of the Sequence Number field. When it is set to '0', the Sequence Number field either is not present or, if present, shall not be interpreted. When it is set to '1', the Sequence Number field is present, and shall be interpreted, as described below in this section. For the Echo Request, Echo Response, Error Indication and Supported Extension Headers Notification messages, the S flag shall be set to '1'. Since the use of Sequence Numbers is optional for G-PDUs, the PGW, SGW and eNodeB should set the flag to '0'. However, when a G-PDU (T-PDU+header) is being relayed by the Indirect Data Forwarding for Inter RAT HO procedure, then if the received G-PDU has the S flag set to '1', then the relaying entity shall set S flag to '1' and forward the G-PDU (T-PDU+header).

- N-PDU Number flag (PN): This flag indicates the presence of a meaningful value of the N-PDU Number field. When it is set to '0', the N-PDU Number field either is not present, or, if present, shall not be interpreted. When it is set to '1', the N-PDU Number field is present, and shall be interpreted, as described below in this section.

- Message Type: This field indicates the type of GTP-U message.

- Length: This field indicates the length in octets of the payload, i.e. the rest of the packet following the mandatory part of the GTP header (that is the first 8 octets). The Sequence Number, the N-PDU Number or any Extension headers shall be considered to be part of the payload, i.e. included in the length count.

- Tunnel Endpoint Identifier (TEID): This field unambiguously identifies a tunnel endpoint in the receiving GTP-U protocol entity. The receiving end side of a GTP tunnel locally assigns the TEID value the transmitting side has to use. The TEID shall be used by the receiving entity to find the PDP context, except for the following cases:

  - The Echo Request/Response and Supported Extension Headers notification messages, where the Tunnel Endpoint Identifier shall be set to all zeroes.

  - The Error Indication message where the Tunnel Endpoint Identifier shall be set to all zeros.

Optional fields:

- Sequence Number: If Sequence Number field is used for G-PDUs (T-PDUs+headers), an increasing sequence number for T-PDUs is transmitted via GTP-U tunnels, when transmission order must be preserved. For Supported Extension Headers Notification and Error Indication messages, the Sequence Number shall be ignored by the receiver, even though the S flag is set to '1'.

- N-PDU Number: This field is used at the Inter SGSN Routeing Area Update procedure and some inter-system handover procedures (e.g. between 2G and 3G radio access networks). This field is used to co-ordinate the data transmission for acknowledged mode of communication between the MS and the SGSN. The exact meaning of this field depends upon the scenario. (For example, for GSM/GPRS to GSM/GPRS, the SNDCP N-PDU number is present in this field).

- Next Extension Header Type: This field defines the type of Extension Header that follows this field in the GTP-PDU.

	Bits							
Octets	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
1	Version			PT	(*)	E	S	PN
2	Message Type							
3	Length (1st Octet)							
4	Length (2nd Octet)							
5	Tunnel Endpoint Identifier (1st Octet)							
6	Tunnel Endpoint Identifier (2nd Octet)							
7	Tunnel Endpoint Identifier (3rd Octet)							
8	Tunnel Endpoint Identifier (4th Octet)							
9	Sequence Number (1st Octet) 1) 4)							
10	Sequence Number (2nd Octet) 1) 4)							
11	N-PDU Number 2) 4)							
12	Next Extension Header Type 3) 4)							

NOTE 0: (*) This bit is a spare bit. It shall be sent as '0'. The receiver shall not evaluate this bit.
NOTE 1: 1) This field shall only be evaluated when indicated by the S flag set to 1.
NOTE 2: 2) This field shall only be evaluated when indicated by the PN flag set to 1.
NOTE 3: 3) This field shall only be evaluated when indicated by the E flag set to 1.
NOTE 4: 4) This field shall be present if and only if any one or more of the S, PN and E flags are set.

Figure 5.1-1: Outline of the GTP-U Header

5.2 GTP-U Extension Header

5.2.1 General format of the GTP-U Extension Header

The format of GTP-U Extension Headers is depicted in figure 5.2.1-1. The Extension Header Length field specifies the length of the particular Extension header in 4 octets units. The Next Extension Header Type field specifies the type of any Extension Header that may follow a particular Extension Header. If no such Header follows, then the value of the Next Extension Header Type shall be 0.

Octets		
1	Extension Header Length	
2 - m	Extension Header Content	
m+1	Next Extension Header Type	

Figure 5.2.1-1: Outline of the Extension Header Format

The length of the Extension header shall be defined in a variable length of 4 octets, i.e. m+1 = n*4 octets, where n is a positive integer.

Bits 7 and 8 of the Next Extension Header Type define how the recipient shall handle unknown Extension Types. The recipient of an extension header of unknown type but marked as 'comprehension not required' for that recipient shall read the 'Next Extension Header Type' field (using the Extension Header Length field to identify its location in the GTP-PDU).

The recipient of an extension header of unknown type but marked as 'comprehension required' for that recipient shall:

- If the message with the unknown extension header was a request, send a response message back with CAUSE set to "unknown mandatory extension header".
- Send a Supported Extension Headers Notification to the originator of the GTP PDU.
- Log an error.

Bits 7 and 8 of the Next Extension Header Type have the following meaning:

Bits 8	7	Meaning
0	0	Comprehension of this extension header is not required. An Intermediate Node shall forward it to any Receiver Endpoint
0	1	Comprehension of this extension header is not required. An Intermediate Node shall discard the Extension Header Content and not forward it to any Receiver Endpoint. Other extension headers shall be treated independently of this extension header.
1	0	Comprehension of this extension header is required by the Endpoint Receiver but not by an Intermediate Node. An Intermediate Node shall forward the whole field to the Endpoint Receiver.
1	1	Comprehension of this header type is required by recipient (either Endpoint Receiver or Intermediate Node)

Figure 5.2.1-2: Definition of bits 7 and 8 of the Extension Header Type

An Endpoint Receiver is the ultimate receiver of the GTP-PDU (e.g. an RNC or the GGSN for the GTP-U plane). An Intermediate Node is a node that handles GTP but is not the ultimate endpoint (e.g. an SGSN for the GTP-U plane traffic between GGSN and RNC).

Next Extension Header Field Value	Type of Extension Header
0000 0000	No more extension headers
0000 0001	Reserved - Control Plane only.
0000 0010	Reserved - Control Plane only.
0100 0000	UDP Port. Provides the UDP Source Port of the triggering message.
1100 0000	PDCP PDU Number [4]-[5].
1100 0001	Reserved - Control Plane only.
1100 0010	Reserved - Control Plane only.

Figure 5.2.1-3: Definition of Extension Header Type

5.2.2 Extension Header types

Extension header types marked as "Reserved – Control Plane only" in figure 5.2.1-3 are not used in the GTP user plane. These extension header types are defined in 3GPP TS 29.060 [6].

The following subclauses define the format of the extension header types applicable to the GTP user plane.

5.2.2.1 UDP Port

This extension header may be transmitted in Error Indication messages to provide the UDP Source Port of the G-PDU that triggered the Error Indication. It is 4 octets long, and therefore the Length field has value 1.

Octets	Bits 8	7	6	5	4	3	2	1
1	0x01							
2-3	UDP Port number							
4	Next Extension Header Type (note)							

NOTE: The value of this field is 0 if no other Extension header follows.

Figure 5.2.2.1-1: UDP Port Extension Header

5.2.2.2 PDCP PDU Number

This extension header is transmitted, for example in UTRAN, at SRNS relocation time, to provide the PDCP sequence number of not yet acknowledged N-PDUs. It is 4 octets long, and therefore the Length field has value 1.

When used between two eNBs at the X2 interface in E-UTRAN, bits 5-8 of octet 2 are spare. The meaning of the spare bits shall be set to zero.

Octets	Bits 8	7	6	5	4	3	2	1
1	0x01							
2	PDCP PDU number							
3	PDCP PDU number.							
4	Next Extension Header Type (note)							

NOTE: The value of this field is 0 if no other Extension header follows.

Figure 5.2.2.2-1: PDCP PDU Number Extension Header

6 GTP-U Message Formats

6.1 General

GTP-U defines a set of messages between the two ends of the user plane of the interfaces Iu-U, Gn, Gp, S1-U, S4, S5, S8, S12 and X2-U.

GTP-U messages are sent across a GTP user plane tunnel. A GTP-U message may be either a signalling message across the user plane tunnel, or a G-PDU message.

- GTP-U signalling messages are used for user plane path management, or for user plane tunnel management.
- G-PDU is a vanilla user plane message, which carries the original packet (T-PDU). In G-PDU message, GTP-U header is followed by a T-PDU.

A T-PDU is an original packet, for example an IP datagram, from an UE, or from a network node in an external packet data network.

The complete range of message types defined for GTPv1 is defined in 3GPP TS 29.060 [6]. The table below includes those applicable to GTP user plane. The three columns to the right define which of the three protocols sharing the common header of GTPv1 (GTP-C, GTP-U or GTP') might implement the specific message type.

Table 6.1-1: Messages in GTP-U

Message Type value (Decimal)	Message	Reference	GTP-C	GTP-U	GTP'
1	Echo Request		X	X	x
2	Echo Response		X	X	x
3-25	Reserved in 3GPP TS 32.295 [8] and 3GPP TS 29.060 [6]				
26	Error Indication			X	
27-30	Reserved in 3GPP TS 29.060 [6]				
31	Supported Extension Headers Notification		X	X	
32-253	Reserved in 3GPP TS 29.060 [6]				
254	End Marker			X	
255	G-PDU			X	

6.2 Presence requirements of Information Elements

As specified in 3GPP TS 29.060 [6], subclause 7.1.1.

7 GTP-U Messages

7.1 General

GTP-U Tunnels are used to carry encapsulated T-PDUs and signalling messages between a given pair of GTP-U Tunnel Endpoints. The Tunnel Endpoint ID (TEID) which is present in the GTP header shall indicate which tunnel a particular T-PDU belongs to. In this manner, packets are multiplexed and de-multiplexed by GTP-U between a given pair of Tunnel Endpoints. The TEID value to be used in the TEID field shall be negotiated for instance during the GTP-C Create PDP Context and the RAB assignment procedures that take place on the control plane.

For MBMS IP Multicast Distribution, the TEID value to be used in the TEID field shall be allocated at the source Tunnel Endpoint and signalled to the destination Tunnel Endpoint using for instance the GTP-C MBMS Session Start procedures that take place on the control plane. Because of the point-to-multipoint characteristics of MBMS IP Multicast Distribution, the path management messages Echo Request and Echo Response, the tunnel management message Error Indication, the message Supported Extension Headers Notification and the message End Marker shall not be used for MBMS IP Multicast Distribution.

User payload is transmitted in G-PDU packets. A G-PDU is a packet including a GTP-U header and a T-PDU. A G-PDU may include extension headers. A G-PDU shall not include any information element.

GTP-U signalling messages are classified into path management messages, defined in subclause 7.2 of the present document, and tunnel management messages, defined in subclause 7.3 of the present document.

7.2 Path Management Messages

7.2.1 Echo Request

A GTP-U peer may send an Echo Request on a path to the other GTP-U peer to find out if it is alive (see section Path Failure). Echo Request messages may be sent for each path in use. A path is considered to be in use if at least one PDP context, EPS Bearer, MBMS UE context, or MBMS bearer context uses the path to the other GTP-U peer. When and how often an Echo Request message may be sent is implementation specific but an Echo Request shall not be sent more often than every 60 s on each path. This doesn't prevent resending an Echo Request with the same sequence number according to the T3-RESPONSE timer.

A GTP-U peer shall be prepared to receive an Echo Request at any time and it shall reply with an Echo Response. The optional Private Extension contains vendor or operator specific information.

Table 7.2.1-1: Information Elements in an Echo Request

Information element	Presence requirement	Reference
Private Extension	Optional	8.6

For the GTP-U tunnel setup between two nodes for forwarding user traffic, e.g. between eNodeBs for direct forwarding over X2, Echo Request path maintenance message shall not be sent except if the forwarded data and the normal data are sent over the same path.

7.2.2 Echo Response

The message shall be sent as a response to a received Echo Request.

The Restart Counter value in the Recovery information element shall not be used, i.e. it shall be set to zero by the sender and shall be ignored by the receiver. The Recovery information element is mandatory due to backwards compatibility reasons.

The optional Private Extension contains vendor or operator specific information.

Table 7.2.2-1: Information Elements in an Echo Response

Information element	Presence requirement	Reference
Recovery	Mandatory	8.2
Private Extension	Optional	8.6

7.2.3 Supported Extension Headers Notification

This message indicates a list of supported Extension Headers that the GTP entity on the identified IP address can support. This message is sent only in case a GTP entity was required to interpret a mandatory Extension Header but the GTP entity was not yet upgraded to support that extension header. The GTP endpoint sending this message is marked as not enabled to support some extension headers (as derived from the supported extension header list). The peer GTP entity may retry to use all the extension headers with that node, in an attempt to verify it has been upgraded. Implementers should avoid repeated attempts to use unknown extension headers with an endpoint that has signalled its inability to interpret them.

Table 7.2.3-1: Information Elements in Supported Extension Headers Notification

Information element	Presence requirement	Reference
Extension Header Type List	Mandatory	8.5

7.3 Tunnel Management Messages

7.3.1 Error Indication

When a GTP-U node receives a GTP-U PDU for which no EPS Bearer context, PDP context, MBMS Bearer context, or RAB exists, the GTP-U node shall discard the GTP-U PDU and return a GTP error indication to the originating node. GTP entities may include the "UDP Port" extension header (Type 0x40), in order to simplify the implementation of mechanisms that can mitigate the risk of Denial-of-Service attacks in some scenarios.

Handling of the received Error Indication is specified in 3GPP TS 23.007 [3].

For the GTPv1-U tunnel setup between two nodes for direct or indirect forwarding of user traffic, e.g. between eNodeBs for direct forwarding over X2, when an Error Indication is received, it may result in the source node deleting the forwarding tunnel context locally, but EPS bearers shall not be deactivated.

The information element Tunnel Endpoint Identifier Data I shall be the TEID fetched from the G-PDU that triggered this procedure.

The information element GTP-U Peer Address shall be the destination address (e.g. destination IP address, MBMS Bearer Context) fetched from the original user data message that triggered this procedure. A GTP-U Peer Address can be a GGSN, SGSN, RNC, PGW, SGW or eNodeB address. The TEID and GTP-U peer Address together uniquely identify the related PDP context, RAB or EPS bearer in the receiving node.

The optional Private Extension contains vendor or operator specific information.

Table 7.3.1-1: Information Elements in an Error Indication

Information element	Presence requirement	Reference
Tunnel Endpoint Identifier Data I	Mandatory	8.3
GTP-U Peer Address	Mandatory	8.4
Private Extension	Optional	8.6

7.3.2 End Marker

End Marker message shall be as specified in 3GPP TS 23.401 [5]. The End Marker message shall be sent for each GTP-U tunnel (multiple messages). The End Marker message indicates the end of the payload stream on a given tunnel, i.e. a G-PDU that arrives after an End Marker message on this tunnel may be silently discarded. Table 7.3.2-1 specifies the information element included in the End Marker message.

The optional Private Extension contains vendor or operator specific information.

Table 7.3.2-1: Information Elements in End Marker message

Information element	Presence requirement	Reference
Private Extension	Optional	8.6

8 Information Elements

8.1 Information Element Types

A GTP-U Signalling message may contain several information elements. The TLV (Type, Length, Value) or TV (Type, Value) encoding format shall be used for the GTP information elements. The information elements shall be sorted, with the Type fields in ascending order, in the signalling messages. The Length field contains the length of the information element excluding the Type and Length field.

For all the length fields, bit 8 of the lowest numbered octet is the most significant bit and bit 1 of the highest numbered octet is the least significant bit.

Within information elements, certain fields may be described as spare. These bits shall be transmitted with the value defined for them. To allow for future features, the receiver shall not evaluate these bits.

The most significant bit in the Type field is set to 0 when the TV format is used and set to 1 for the TLV format.

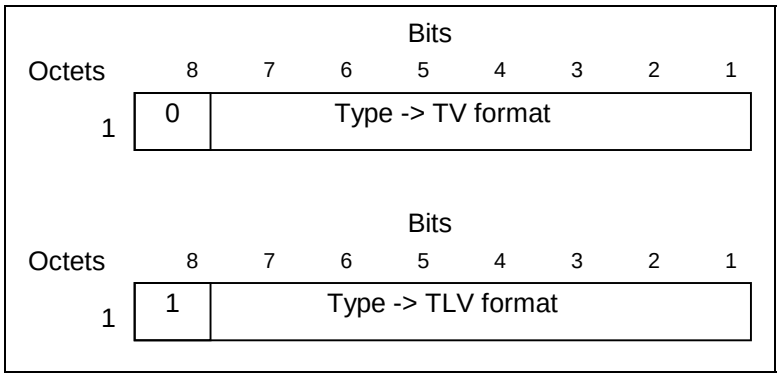


Figure 8.1-1: Type field for TV and TLV format

The complete range of information element types defined for GTPv1 is defined in 3GPP TS 29.060 [6]. The table below includes those applicable to GTP user plane.

Table 8.1-1: Information Elements

IE Type Value	Format	Information Element	Reference
0-13	TV	Reserved in 3GPP TS 29.060 [6]	
14	TV	Recovery	8.2
15	TV	Reserved in 3GPP TS 29.060 [6]	
16	TV	Tunnel Endpoint Identifier Data I	8.3
17-132	TV/TLV	Reserved in 3GPP TS 29.060 [6]	
133	TLV	GSN Address	8.4
134-140	TLV	Reserved in 3GPP TS 29.060 [6]	
141	TLV	Extension Header Type List	8.5
142-254	TLV	Reserved in 3GPP TS 29.060 [6]	
255	TLV	Private Extension	8.6

8.2 Recovery

The value of the restart counter shall be set to 0 by the sending entity and ignored by the receiving entity. This information element is used in GTP user plane due to backwards compatibility reasons.

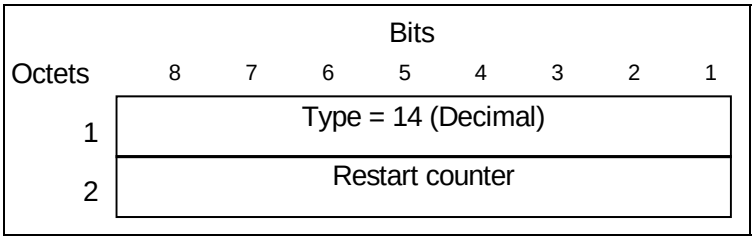


Figure 8.2-1: Restart Counter Information Element

8.3 Tunnel Endpoint Identifier Data I

The Tunnel Endpoint Identifier Data I information element contains the Tunnel Endpoint Identifier used by a GTP entity for the user plane.

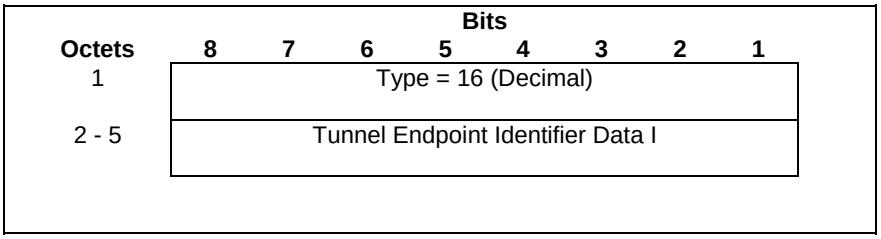


Figure 8.3-1: Tunnel Endpoint Identifier Data I Information Element

8.4 GTP-U Peer Address

The GTP-U peer Address information element contains the address of a GTP. The Length field may have only two values (4 or 16) that determine if the Value field contains IPv4 or IPv6 address.

The IPv4 address structure is defined in RFC 791 [10].

The IPv6 address structure is defined in RFC 2373 [11].

The encoded address might belong not only to a GSN, but also to an RNC, eNodeB, SGW or PGW.

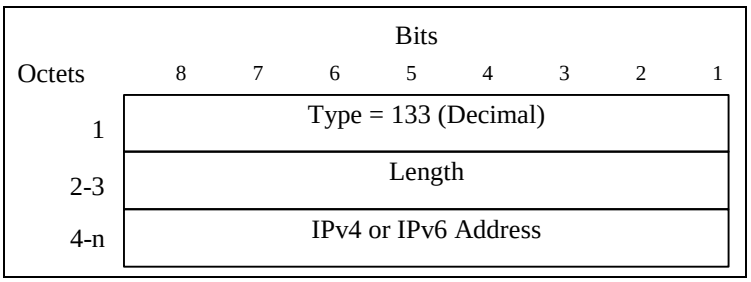


Figure 8.4-1: GTP-U Peer Address Information Element

8.5 Extension Header Type List

This information element contains a list of 'n' Extension Header Types. The length field is set to the number of extension header types included.

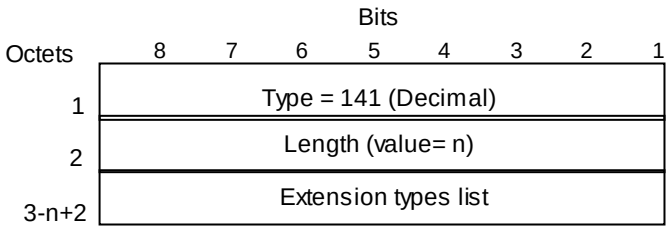


Figure 8.5-1: Extension Header Type List Information Element

8.6 Private Extension

The Private Extension information element contains vendor specific information. The Extension Identifier is a value defined in the Private Enterprise number list in the most recent "Assigned Numbers" RFC (RFC 1700 or later).

This is an optional information element that may be included in any GTP Signalling message. A signalling message may include more than one information element of the Private Extension type.

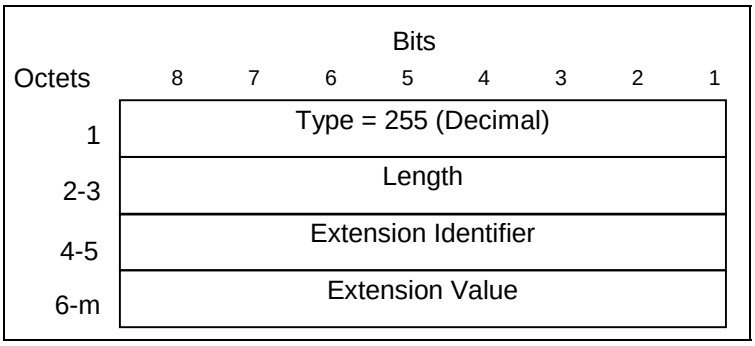


Figure 8.6-1: Private Extension Information Element

9 Error Handling

9.1 Protocol Errors

As specified in 3GPP TS 29.060 [6], subclauses 11.1.

9.2 Path Failure

A path counter shall be reset each time an Echo Response is received on the path and incremented when the T3-RESPONSE timer expires for any Echo Request message sent on the path. The path shall be considered to be down if the counter exceeds N3-REQUESTS. In this case, the GTP-U peer may notify the Operation and Maintenance network element. The GTP-U peer shall also notify the upper layer of the path failure, so that PDP or EPS contexts associated with the path may be deleted.

10 Security

Network domain security is specified in 3GPP TS 33.102 [21] and 3GPP TS 33.401 [22].

11 Reliable Delivery of Signalling Messages

Each path maintains a queue with signalling messages to be sent to the peer. The message at the front of the queue, if it is a request for which a response has been defined, shall be sent with a Sequence Number, and shall be held in a path list until a response is received. Each path has its own list. The Sequence Number shall be unique for each outstanding request message sourced from the same IP/UDP endpoint.

The T3-RESPONSE timer shall be started when a signalling request message (for which a response has been defined) is sent. A signalling message request or response has probably been lost if a response has not been received before the T3-RESPONSE timer expires. At the expiry of the timer the request is retransmitted if the total number of request attempts is less than N3-REQUESTS times.

All received request messages shall be responded to and all response messages associated with a certain request shall always include the same information. Duplicated response messages shall be discarded. A response message without a matching outstanding request should be considered as a duplicate.

If a GTP protocol entity is not successful with the transfer of a signalling message, it shall inform the upper layer of the unsuccessful transfer so that the controlling upper entity may take the necessary measures.

12 GTP Parameters

12.1 General

The GTP system parameters defined here and their recommended values shall not be fixed, but shall be possible to configure as described in section 'Reliable delivery of messages'.

12.2 Timers

The timer T3-RESPONSE holds the maximum wait time for a response of a request message.

12.3 Others

The counter N3-REQUESTS holds the maximum number of attempts made by GTP to send a request message. The recommended value is 5.

13 Tunnelling Scenarios

13.1 General

There are user packets sent between network nodes without a GTP-U reference point defined. The scenarios and applicability of GTP-U tunnelling are described in the following sections.

13.2 Tunnelling between Serving GWs

GTP T-PDU tunnelling is applicable from the old Serving GW to the new Serving GW only when indirect forwarding is applicable during a S1-based Handover procedure or inter-RAT handover procedure with SGW Relocation, as described in the 3GPP TS 23.401 [5].For the GTP-U tunnel setup between Serving GWs, path maintenance messages do not need to be sent.

13.3 Transfer of the user plane data between PDN GWs

GTP shall not specify tunnelling between PDN GWs. Transfer of UE-to-UE traffic between PDN GWs shall use the SGi interface.

13.4 Tunnelling between SGSNs

T-PDUs, stored in the old SGSN and not yet sent to the MS, shall be tunnelled to the new SGSN as a part of the Inter SGSN Routeing Update procedure described in 3GPP TS 23.060 [4]. Some T-PDUs may still be on their way from the GGSN to the old SGSN because they have been sent before the tunnel change. These T-PDUs shall also be tunnelled to the new SGSN.

For intersystem SRNS Relocation, the establishment of the GTP tunnel(s) for the forwarding of G-PDUs is as described in the 3GPP TS 23.121 [13] and in the 3GPP TS 23.060 [4] specifications.

For PS Handover, the establishment of the GTP tunnel(s) for the forwarding of G-PDUs is as described in the 3GPP TS 43.129 [14].

13.5 Tunnelling between Source RNC and Target RNC

For the 3G-3G SRNS Relocation, the establishment of the GTP tunnel for the forwarding of G-PDUs between source and target RNC, is as described in the 3GPP TS 23.121 [13] and in the 3GPP TS 23.060 [4] specifications.

13.6 Transfer of the user plane data between GGSNs

GTP shall not specify tunnelling between GGSNs. Transfer of MS-to-MS traffic between GGSNs shall use the Gi interface.

Annex A (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2008-12	CT#42	CP-080716			V2.0.0 approved in CT#42	2.0.0	8.0.0
2009-03	CT#43	CP-090048	0001	1	Correction on GTP-U path failure	8.0.0	8.1.0
			0002		UDP Port Extension Header		
			0003	1	Correction to IP support		
			0006		Handling of End Marker packet		
2009-06	CT#44	CP-090481	0007	3	GTP-U tunnelling over X2	8.1.0	8.2.0
			0008	2	GTP-U updates for MBMS HSPA Evolution		
2009-09	CT#45	CP-090539	0010	1	Forwarding Tunnel Error Indication handling	8.2.0	8.3.0
			0011	1	Clarification on the usage of Echo Request		
			0012	2	Clarification to the Sequence Number usage in EPC		
			0014	3	Updating the Error Indication subclause		
			0016		Eliminating Editor's Notes		
			0018	1	Path Failure text correction		
			0019	1	Support of NDS/IP for LTE		
2009-09	CT#45	CP-090559	0013	1	MBMS for EPS support in GTPv1-U	8.3.0	9.0.0
2009-12	CT#46	CP-090773	0023	2	End Marker in S1 based handover and Inter RAT handover procedures	9.0.0	9.1.0
			0025		GTP-U sequence number handling		
2010-03	CT#47	CP-100023	0027	1	Sequence Number corrections	9.1.0	9.2.0
2010-06	CT#48	CP-100287	0028	1	Message applicability of MBMS in GTP-U	9.2.0	9.3.0