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**Universal Mobile Telecommunications System (UMTS);
LTE;
5G;
General Packet Radio System (GPRS)
Tunnelling Protocol User Plane (GTPv1-U)
(3GPP TS 29.281 version 16.0.0 Release 16)**



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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
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Foreword

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

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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, S11-U, S2a, S2b, X2, S4, S5, S8, S12, M1 and Sn interfaces of the Evolved Packet System (EPS);
- the F1-U, Xn, N3, N9 and N19 interfaces of the 5G System (5GS);

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 4291: "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".
- [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".
- [23] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".
- [24] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification".
- [25] 3GPP TS 36.425: "E-UTRAN X2 interface user plane protocol".
- [26] IETF RFC 2474, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers".
- [27] 3GPP TS 36.465: "Evolved Universal Terrestrial Radio Access (E-UTRAN) and Wireless LAN (WLAN) Xw interface user plane protocol".
- [28] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".
- [29] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".
- [30] 3GPP TS 38.425: "NG-RAN; NR user plane protocol".
- [31] 3GPP TS 38.415: "NG-RAN; PDU Session User Plane Protocol".
- [32] 3GPP TS 33.250: "Security assurance specification for the PGW network product class".
- [33] 3GPP TS 23.527: "5G System; Restoration Procedures".
- [34] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".
- [35] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".
- [36] IETF RFC 8200: "Internet Protocol, Version 6 (IPv6) Specification"
- [37] IETF RFC 6437: "IPv6 Flow Label Specification".

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].

Common Tunnel Endpoint Identifier (C-TEID): Unambiguously identifies a tunnel endpoint in the receiving GTP-U protocol entity for a given UDP/IP endpoint. The sending end side of a GTP tunnel locally assigns the C-TEID value used in the TEID field and signals it to the destination Tunnel Endpoint using a control plane message.

GTP-U Message: GTP-U (user plane) messages are either user plane messages or signalling messages. User plane messages are used to carry user data packets between GTP-U entities. Signalling messages are sent between network nodes for path management and tunnel management. **GTP-U peer:** node implementing at least one side of any of the GTP user plane based protocols. RNC, SGSN, GGSN, eNodeB, SGW, ePDG, gNB, N3IWF, UPF, PGW or TWAN or MME.

GTP-U Tunnel: A GTP-U tunnel is identified in each node with a TEID, an IP address and a UDP port number. A GTP-U tunnel is necessary to enable forwarding packets between GTP-U entities.

GTP-U Tunnel Endpoint: A GTP-U tunnel endpoint identifies a user plane context (e.g EPS bearer, PDU session or a RAB) for which a received GTP-U packet is intended. A given GTP-U tunnel endpoint may receive GTP-U packets from more than one source GTP-U peer (See clause 4.3.0). **UDP/IP Path:** Connection-less unidirectional or bidirectional path defined by two end-points. An IP address and a UDP port number define an end-point. A UDP/IP path carries GTP messages between network nodes related to one or more GTP tunnels.

GTP-PDU: GTP Protocol Data Unit (PDU) is a GTP-U message, which may be either a G-PDU or a signalling message.

G-PDU: User data packet (T-PDU) plus GTP-U header, sent between GTP network nodes.

Signalling Message: A GTP-U message (GTP-PDU that is not a G-PDU) sent between GTP network nodes. These may be Path Management messages or Tunnel Management messages.

T-PDU: A user data packet, for example an IP datagram, sent between a UE and a network entity in an external packet data network. A T-PDU is the payload that is tunnelled in the GTP-U tunnel.

Tunnel Endpoint Identifier (TEID): Unambiguously identifies a tunnel endpoint in the receiving GTP-U protocol entity for a given UDP/IP endpoint. The receiving end side of a GTP tunnel locally assigns the TEID value the transmitting side has to use. The TEID values are exchanged between tunnel endpoints using control plane message.

Trusted WLAN Access Network: see 3GPP TS 23.402 [23].

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].

C-TEID	Common Tunnel Endpoint Identifier
EN-DC	E-UTRA-NR Dual Connectivity
ePDG	Evolved Packet Data Gateway
GSN	GPRS Support Node
GGSN	Gateway GPRS Support Node
G-PDU	GTP encapsulated user Plane Data Unit
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
MME	Mobility Management Entity
PDU	Packet Data Unit
PGW	PDN Gateway
QoS	Quality of Service
RANAP	Radio Access Network Application Part

RNC	Radio Network Controller
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
TEID	Tunnel Endpoint Identifier
T-PDU	Transport PDU
TWAN	Trusted WLAN Access Network
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 signalled to the peer GTP-U entity 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.

Recommendations on how to set the default inner MTU size at the PDN GW and UE/MS to avoid IP fragmentation of both inner IP packets (in the PDN GW or UE/MS) and outer IP packets in the backbone are specified in clause 9.3 of 3GPP TS 23.060 [4].

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].

Functionality for IP transport and IP fragmentation at an NG-RAN on the N3 and Xn interface is defined in 3GPP TS 38.300 [34].

The outer GTPv1-U packet layer shall support IPv4 as defined by IETF RFC 791 [10] and should support IPv6 as defined by IETF RFC 8200 [36].

The following text as well as 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/UPF may change the hopcount/TTL as the IP datagram enters/leaves the Gi/SGi/N6 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 8200 [36] 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 8200 [36] 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 8200 [36] 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 clause 7.1.

4.3 GTP-U Protocol Entity

4.3.0 General

The GTP-U protocol entity provides packet transmission and reception services to user plane entities in the RNC, SGSN, GGSN, eNodeB, SGW, ePDG, PGW, TWAN, MME, gNB, N3IWF, and UPF. 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. The GTP-U protocol supports the possibility for one GTP-U tunnel endpoint to receive packets from multiple remote GTP-U endpoints. This may be used in the following scenarios:

- Tracking Area Update procedure with Serving GW change and data forwarding as specified in clause 5.3.3.1A of 3GPP TS 23.401 [5], if the above capability is supported by the receiving eNB;
- Dual connectivity in 5GC as specified in clause 5.11.1 of 3GPP TS 23.501 [28], where the master and secondary NG-RAN may be assigned the same uplink F-TEID of the UPF by the SMF for uplink traffic of the same PDU session; and
- IPv6 multihoming scenario as specified in clause 5.6.4.3 of 3GPP TS 23.501 [28], where the downlink traffic from multiple PDU Session Anchors of the same PDU session may be assigned the same N9 F-TEID of the branching point UPF by the SMF.

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, ePDG, eNodeB, TWAN, MME, gNB, N3IWF, and UPF, 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, ePDG, eNodeB, TWAN, MME, gNB, N3IWF and UPF 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 SNDPCP) 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 SNDPCP 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 clause Reliable delivery of signalling messages). The Sequence Number in a signalling response message shall be copied from the signalling request message that the GTP-U entity 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

4.4.0 GTP-PDU Stacks

The protocol stack for a GTP-PDU G-PDU is shown in Figure 4.4-1. The protocol stack for a GTP-PDU signaling message is shown in Figure 4.4-2.

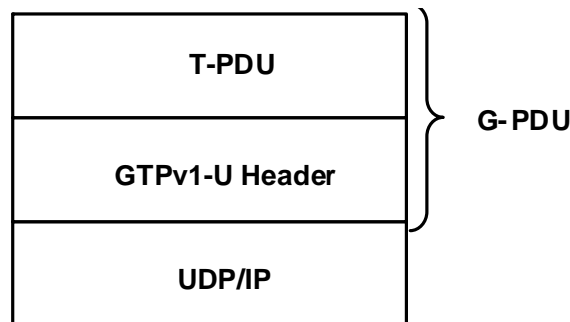


Figure: 4.4-1 G-PDU Protocol Stack

NOTE: T-PDU may contain an IP Datagram, Ethernet or unstructured PDU Data frames as specified in 3GPP TS 23.501 [28].

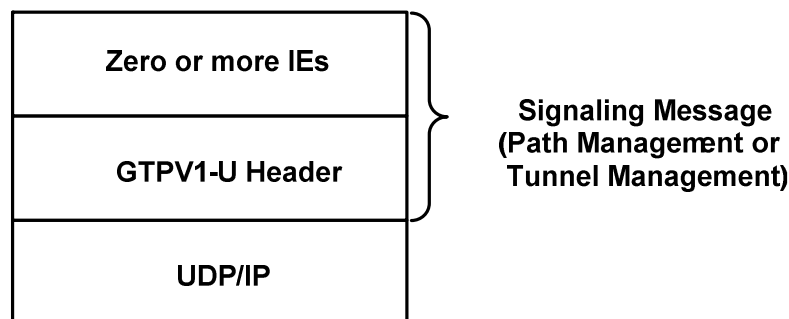


Figure: 4.4-2 Signalling Message Protocol Stack

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 8200 [36].

The DSCP marking as defined by IETF RFC 2474 [26] shall be set:

- based on the QCI, and optionally the ARP priority level, of the associated EPS bearer, as described in clause 4.7.3 of 3GPP TS 23.401 [5];
- based on the 5QI and ARP of the associated 5G QoS Flow, as described in clause 5.7.1.6 and clause 5.7.1.7 of 3GPP TS 23.501 [28].

4.4.2 UDP header and port numbers

4.4.2.0 General

For the GTP-U messages described below (other than the Echo Response message, see clause 4.4.2.2), the UDP Source Port or the Flow Label field (see IETF RFC 6437 [37]) should be set dynamically by the sending GTP-U entity to help balancing the load in the transport network.

When using GTP-U over IPv6 (see IETF RFC 8200 [36]), the UDP checksum shall not be set to zero by the sending GTP-U entity unless it is ensured that the peer GTP-U entity and the path in-between supports UDP zero checksum.

NOTE 1: GTP-U entities complying with an earlier version of the specification or on path IPv6 middleboxes can implement IPv6 as specified in IETF RFC 2460 [15] and discard UDP packets containing a zero checksum.

NOTE 2: How a sending GTP-U entity knows whether the peer GTP-U entity and the path in-between supports UDP zero checksum is out of scope of this specification.

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.

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.

4.4.2.4 Error Indication

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

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).

4.4.2.6 End Marker

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

The UDP Destination Port and UDP Source Port shall be the same as those of the corresponding GTP-U tunnel for which the End Marker message is sent.

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.

4.4.3.6 End Marker

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.

The IP Destination Address and IP Source Address shall be the same as those of the corresponding GTP-U tunnel for which the End Marker message is sent.

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. For example, if only the E flag is set to 1, then the N-PDU Number and Sequence Number fields shall also be present, but will not have meaningful values and shall not be evaluated.

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 clause.
- 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 clause. 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, ePDG, eNodeB and TWAN 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). In an End marker message the S flag shall be set to '0'.
- 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 clause.
- 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 value shall be assigned in a non-predictable manner for PGW S5/S8/S2a/S2b interfaces (see 3GPP TS 33.250 [32]). 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.
- When setting up a GTP-U tunnel, the GTP-U entity shall not assign the value 'all zeros' to its own TEID. However, for backward compatibility, if a GTP-U entity receives (via respective control plane message) a peer's

TEID that is set to the value 'all zeros', the GTP-U entity shall accept this value as valid and send the subsequent G-PDU with the TEID field in the header set to the value '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.

Octets	Bits							
	8	7	6	5	4	3	2	1
1	Version		PT	(*)	E	S	PN	
2	Message Type							
3	Length (1 st Octet)							
4	Length (2 nd Octet)							
5	Tunnel Endpoint Identifier (1 st Octet)							
6	Tunnel Endpoint Identifier (2 nd Octet)							
7	Tunnel Endpoint Identifier (3 rd Octet)							
8	Tunnel Endpoint Identifier (4 th Octet)							
9	Sequence Number (1 st Octet) ^{1) 4)}							
10	Sequence Number (2 nd 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, see Figure 5.2.1-2. 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 or a G-PDU, send a Supported Extension Headers Notification to the originator of the GTP-PDU, discard the message and 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.
0000 0011	Long PDCP PDU Number. See NOTE 2.
0010 0000	Service Class Indicator
0100 0000	UDP Port. Provides the UDP Source Port of the triggering message.
1000 0001	RAN Container
1000 0010	Long PDCP PDU Number. See NOTE 3.
1000 0011	Xw RAN Container
1000 0100	NR RAN Container
1000 0101	PDU Session Container. See NOTE 4.
1100 0000	PDCP PDU Number [4]-[5]. See NOTE 1.
1100 0001	Reserved - Control Plane only.
1100 0010	Reserved - Control Plane only.
<p>NOTE 1: As an exception to the comprehension rule specified above, for a G-PDU with a Next Extension Header Field set to the value "1100 0000", the SGW shall consider this corresponding extension header as 'comprehension not required'.</p> <p>NOTE 2: This value shall be used by a source eNB or gNB complying with this release of the specification.</p> <p>NOTE 3: This value shall not be used by a source eNB or gNB complying with this release of the specification. It may be received from a source eNB complying with an earlier release of the specification, i.e. not supporting the extension header value "0000 0011".</p> <p>NOTE 4: For a GTP-PDU with several Extension Headers, the PDU Session Container should be the first Extension Header.</p>	

Figure 5.2.1-3: Definition of Extension Header Type

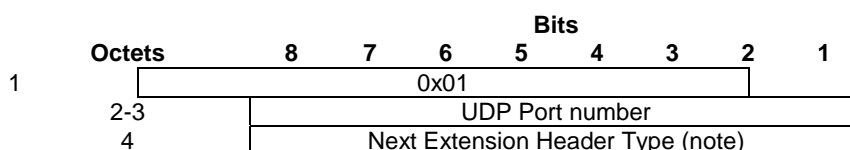
5.2.2 Extension Header types

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 clauses 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.



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

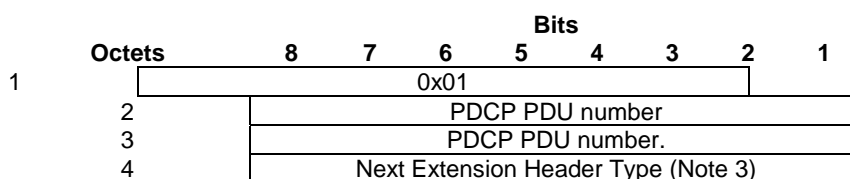
This extension header is transmitted, for example in UTRAN, at SRNS relocation time, to provide the PDCP sequence number of not yet acknowledged N-PDUs. It is 4 octets long, and therefore the Length field has value 1.

When used during a handover procedure between two eNBs at the X2 interface (direct DL data forwarding) or via the S1 interface (indirect DL data forwarding) in E-UTRAN, bit 8 of octet 2 is spare and shall be set to zero.

When used during a handover procedure between two NG-RANs at the Xn interface (direct DL data forwarding) or via the N3 interface (indirect DL data forwarding), bits 5-8 of octet 2 are spare and shall be set to zero.

NOTE 1: The PDCP PDU number field of the PDCP PDU number extension header has a maximum value which requires 15 bits (see 3GPP TS 36.323 [24]); thus, bit 8 of octet 2 is spare.

NOTE 2: The PDCP PDU number field of the PDCP PDU number extension header has a maximum value which requires 12 bits (see 3GPP TS 38.323 [35]); thus, bit 5-8 of octet 2 are spare.



NOTE 3: The value of this field is 0 if no other Extension header follows.

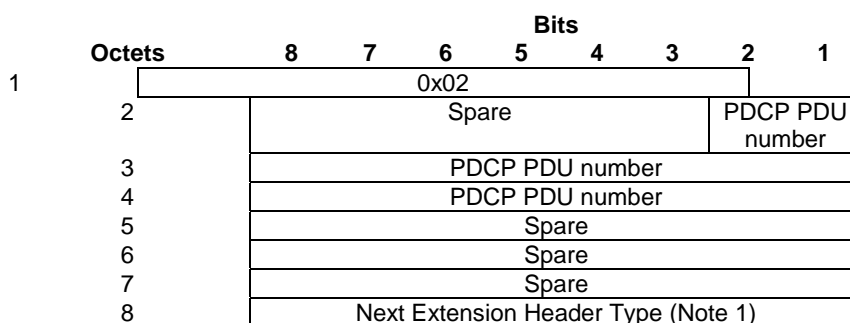
Figure 5.2.2.2-1: PDCP PDU Number Extension Header

5.2.2.2A Long PDCP PDU Number

This extension header is used for direct X2 or indirect S1 DL data forwarding during a Handover procedure between two eNBs. This extension header is also used for direct Xn or indirect N3 DL data forwarding during a Handover procedure between two NG-RANs. The Long PDCP PDU number extension header is 8 octets long, and therefore the Length field has value 2.

The PDCP PDU number field of the Long PDCP PDU number extension header has a maximum value which requires 18 bits (see 3GPP TS 36.323 [24] and 3GPP TS 38.323 [35]). Bit 2 of octet 2 is the most significant bit and bit 1 of octet 4 is the least significant bit, see Figure 5.2.2.2A-1. Bits 8 to 3 of octet 2, and Bits 8 to 1 of octets 5 to 7 shall be set to 0.

NOTE: A G-PDU which includes a PDCP PDU Number contains either the extension header PDCP PDU Number or Long PDCP PDU Number.



NOTE 1: The value of this field is 0 if no other Extension header follows.

Figure 5.2.2A-1: Long PDCP PDU Number Extension Header

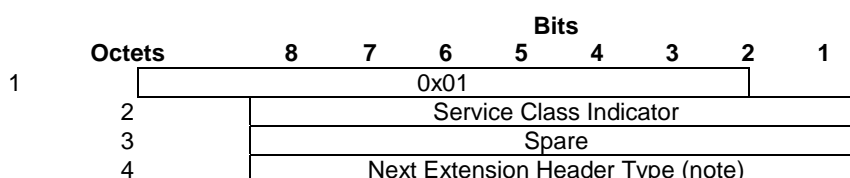
5.2.2.3 Service Class Indicator

This extension header identifies the service class indicator (SCI) associated with the T-PDU carried by the downlink G-PDU. This information may be used by the A/Gb mode GERAN access for improved radio utilisation (see clause 5.3.5.3 of 3GPP TS 23.060 [4]).

In this version of the specification, this extension header may be transmitted over the Gn/Gp, S5/S8 and S4 interface. An eNodeB, RNC or MME shall ignore this information if received over the S1-U, S12, Iu, S11-U or any other interfaces not defined above, but still shall handle the G-PDU.

NOTE1: This extension header is also sent over the S1-U, S12, Iu interface and S11-U if the SGW receives the Service Class Indicator from S5/S8 for a UE having a user plane connection with an RNC or an eNodeB. This can happen when the PGW does not have an accurate knowledge of the current RAT of the user e.g. after a handover from GERAN to (E)UTRAN.

It is 4 octets long and therefore the Length field has the value 1.



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

Figure 5.2.2.3-1: Service Class Indicator Extension Header

If the bit 8 of octet 2 is set to 0, this indicates an operator specific Service Class Indicator value is included. Otherwise, it shall indicate that a standardised SCI is included.

NOTE 2: No standardized SCI value is defined in this release, it is intended to standardize SCIs in a future release.

Bits 8 to 1 of the octet 2 represent the binary coded value of the SCI, applications with similar Radio Resource Management treatment in GERAN shall be represented by the same value.

The octet 2 is coded as shown in Table 5.2.2.3-1.

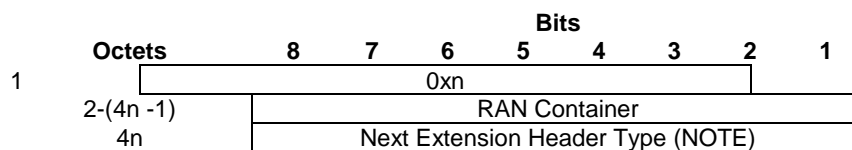
Bits 8 to 1 of the octet 3 are spare bits and shall be set to zero.

Table 5.2.2.3-1: Service Class Indicator

Service Class Indicator (SCI), octet 2	
Bit	
8	
0	Operator-specific SCI
Bits	
7 6 5 4 3 2 1	
0 0 0 0 0 0 0	
to	
0 0 0 1 1 1 1	Operator-specific SCIs
0 0 1 0 0 0 0	
to	
1 1 1 1 1 1 1	Spare for future use
Bit	
8	
1	Standardised SCI
Bits	
7 6 5 4 3 2 1	
0 0 0 0 0 0 0	
to	
1 1 1 1 1 1 1	Spare for future use

5.2.2.4 RAN Container

This extension header may be transmitted in a G-PDU over the X2 user plane interface between the eNBs. The RAN Container has a variable length and its content is specified in 3GPP TS 36.425 [25]. A G-PDU message with this extension header may be sent without a T-PDU.

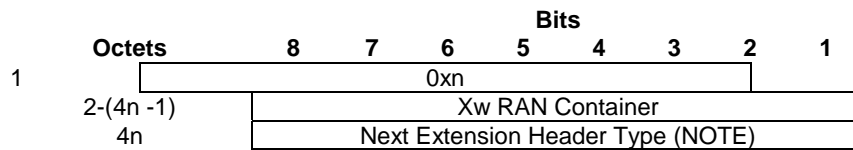


NOTE: The value of this field is '0' if no other Extension header follows.

Figure 5.2.2.4-1: RAN Container Extension Header

5.2.2.5 Xw RAN Container

This extension header may be transmitted in a G-PDU over the Xw user plane interface between the eNB and the WLAN Termination (WT). The Xw RAN Container has a variable length and its content is specified in 3GPP TS 36.465 [27]. A G-PDU message with this extension header may be sent without a T-PDU.

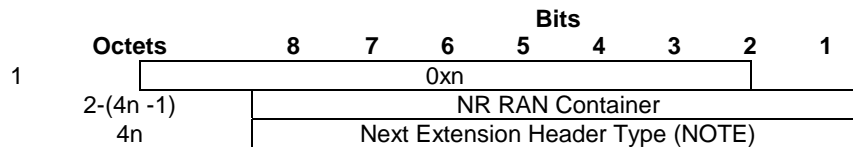


NOTE: The value of this field is '0' if no other Extension header follows.

Figure 5.2.2.5-1: Xw RAN Container Extension Header

5.2.2.6 NR RAN Container

This extension header may be transmitted in a G-PDU over the X2-U, Xn-U and F1-U user plane interfaces, within NG-RAN and, for EN-DC, within E-UTRAN. The NR RAN Container has a variable length and its content is specified in 3GPP TS 38.425 [30]. A G-PDU message with this extension header may be sent without a T-PDU.

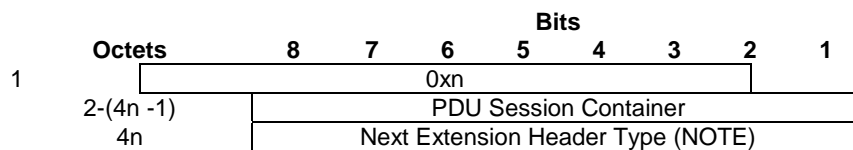


NOTE: The value of this field is '0' if no other Extension header follows.

Figure 5.2.2.6-1: NR RAN Container Extension Header

5.2.2.7 PDU Session Container

This extension header shall be transmitted in a G-PDU over the N3 and N9 user plane interfaces, between NG-RAN and UPF, or between two UPFs. It shall also be transmitted in End Marker packets over data forwarding tunnels in 5GS, for data forwarding between 5GS and EPS. The PDU Session Container has a variable length and its content is specified in 3GPP TS 38.415 [31].



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

Figure 5.2.2.7-1: PDU Session Container 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, Gn, Gp, S1-U, S11-U, S2a, S2b, S4, S5, S8, S12, X2, M1, Sn, Xn, N3, N9 and N19.

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, Ethernet frame or unstructured PDU Data, 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], clause 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 clause 7.2 of the present document, and tunnel management messages, defined in clause 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 clause 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, PDU Session, 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.

Even if there is no path in use, 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 G-PDU for which no EPS Bearer context, PDP context, PDU Session, MBMS Bearer context, or RAB exists, the GTP-U node shall discard the G-PDU. If the TEID of the incoming G-PDU is different from the value 'all zeros' the GTP-U node shall also 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] and 3GPP TS 23.527 [33].

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, ePDG, eNodeB, TWAN, MME, gNB, N3IWF, or UPF address. The TEID and GTP-U peer Address together uniquely identify the related PDP context, RAB, PDU session 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

The End Marker message(s) shall be sent after sending the last G-PDU that needs to be sent on a GTP-U tunnel as specified in 3GPP TS 23.401 [5] or after receiving an End Marker Indication as specified in clause 5.7.1 of 3GPP TS 23.402 [23].

The End Marker message(s) shall also be sent after sending the last G-PDU that needs to be sent on a GTP-U tunnel or after receiving an End Marker Indication as specified in 3GPP TS 23.501 [28] and 3GPP TS 23.502 [29]. End marker packets sent over data forward tunnels in 5GS, for data forwarding between 5GS and EPS, shall be sent with the PDU Session Container extension header including the Qos Flow Identifier of one of the QoS flows mapped to the same E-RAB.

The End Marker message(s) shall be sent for each GTP-U tunnel, except for the case of an E-UTRAN Initiated E-RAB modification procedure. During an E-UTRAN Initiated E-RAB modification procedure, the SGW shall send End marker message(s) to the eNodeB on the old S1-U tunnel for the tunnel(s) that are switched, i.e. if the S1 eNodeB F-TEID of the GTP-U tunnel provided by the MME in a Modify Bearer Request or Modify Access Bearer Request is not the same as the one previously stored in the SGW. Each GTP-U tunnel is identified with a respective TEID value in the GTP-U header. 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.

End Marker messages shall not be sent over the N19 interface.

If an End Marker message is received with a TEID for which there is no context, then the receiver shall ignore this message.

An MME may receive End Marker packets over an S11-U tunnel during the following procedures:

- Inter-MME TAU procedure;
- Establishment of S1-U bearer during Data Transport in Control Plane CIoT EPS optimisation.

The MME shall discard the End Marker packets. The MME may also initiate the release of the corresponding S11-U resources; however the release of the S11-U resources is implementation dependent.

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.

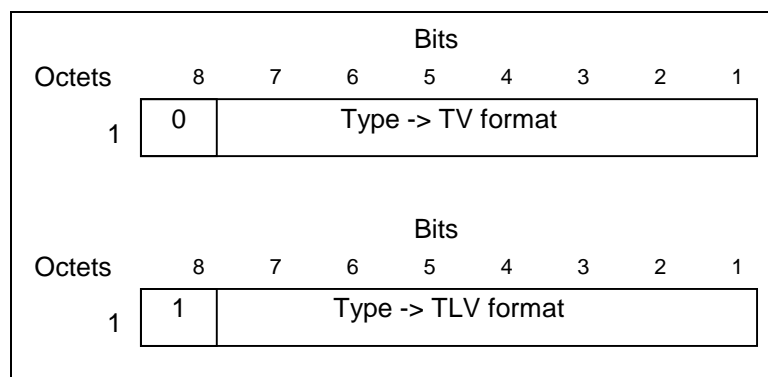


Figure 8.1-1: Type field for TV and TLV format

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. See NOTE 1.	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
NOTE 1: This IE is named as " GTP-U Peer Address" in the rest of this specification.			

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.

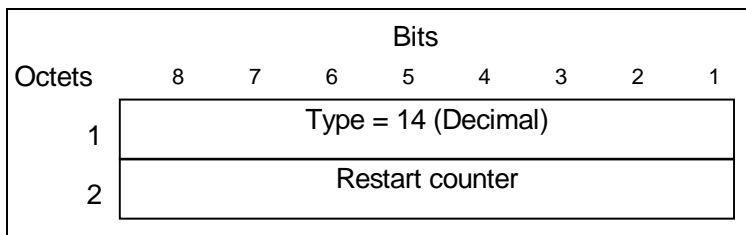


Figure 8.2-1: Restart Counter Information Element

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.

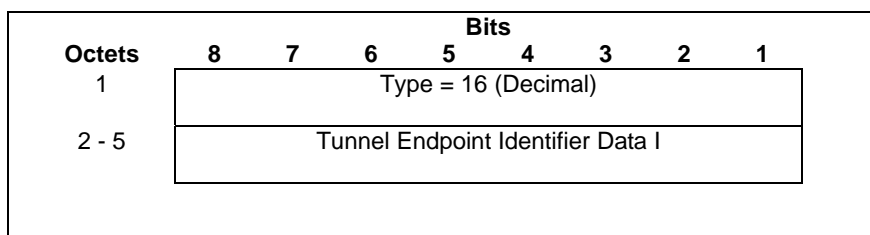


Figure 8.3-1: Tunnel Endpoint Identifier Data I Information Element

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 4291 [11].

The encoded address might belong not only to a GSN, but also to an RNC, eNodeB, SGW, ePDG, gNB, N3IWF, UPF, PGW or TWAN.

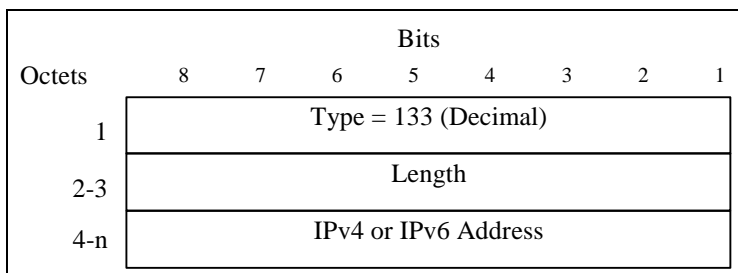


Figure 8.4-1: GTP-U Peer Address Information Element

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.

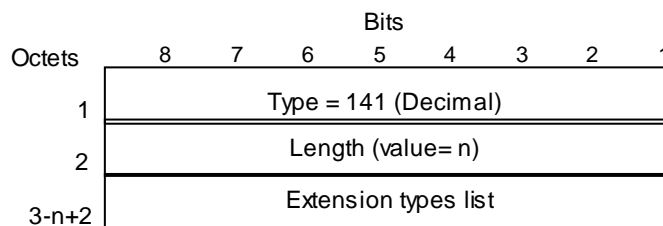


Figure 8.5-1: Extension Header Type List Information Element

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.

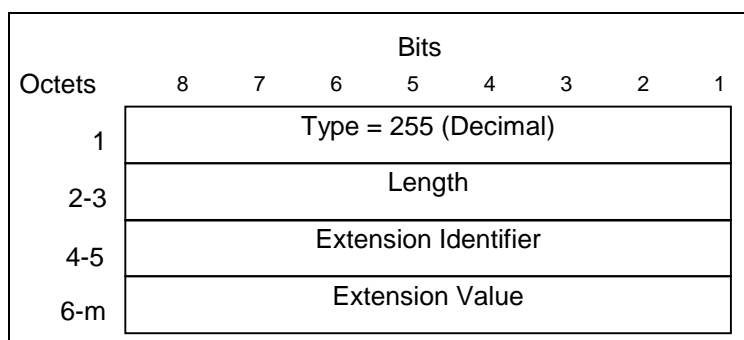


Figure 8.6-1: Private Extension Information Element

9 Error Handling

9.1 Protocol Errors

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

9.2 Path Failure

Path failure handling procedures are specified in 3GPP TS 23.007 [17] and 3GPP TS 23.527 [33].

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 clause '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 clauses.

13.2 Tunnelling between SGWs

GTP T-PDU tunnelling is applicable from the old SGW to the new S 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 SGWs, path maintenance messages do not need to be sent.

GTP T-PDU tunnelling is applicable from the old SGW to the forwarding SGW during a TAU/RAU with SGW change procedure when indirect data forwarding is used to forward DL data buffered in the old SGW to the UE via the forwarding SGW, as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

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 Routing Update procedure described in 3GPP TS 23.060 [4]. Some T-PDUs may still be on their way from the GGSN/PGW 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].

The GTP T-PDU tunnelling between SGSNs is applicable also for RAU interaction with a Gn/Gp SGSN when forwarding DL data buffered in the old Gn/Gp SGSN to the UE, via the new SGSN (e.g. when direct tunnel is not established) as described in the 3GPP TS 23.060 [4].

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.

13.7 Tunnelling between RNC and eNodeB

GTP T-PDU tunnelling is applicable between RNC and eNodeB during an inter-RAT handover between E-UTRAN and UTRAN Iu mode procedure as described in the 3GPP TS 23.401 [5].

13.8 Tunnelling between SGSN and eNodeB

GTP T-PDU tunnelling is applicable between SGSN and eNodeB during an inter-RAT handover between E-UTRAN and GERAN A/Gb mode/UTRAN Iu mode procedure as described in the 3GPP TS 23.401 [5].

GTP T-PDU tunnelling between SGSN and eNodeB is applicable also for a TAU interaction with a Gn/Gp SGSN when forwarding DL data buffered in the old Gn/Gp SGSN to the UE via the target eNodeB, if such forwarding is supported by the eNodeB as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

13.9 Tunnelling between Source eNodeB and Target eNodeB

GTP T-PDU tunnelling is applicable between eNodeBs during an X2-based handover and E-UTRAN initiated E-RAB modification procedure as described in the 3GPP TS 23.401 [5].

13.10 Tunnelling between SGSN and RNC

GTP T-PDU tunnelling between SGSN and RNC is applicable also for a TAU interaction with a Gn/Gp SGSN when forwarding DL data buffered in the old Gn/Gp SGSN to the UE, via the new RNC (e.g. when direct tunnel is established), if such forwarding is supported by the RNC as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

13.11 Tunnelling between SGSN and SGW

GTP T-PDU tunnelling is applicable from the old Gn/Gp SGSN to the forwarding SGW during a TAU/RAU interaction with a Gn/Gp SGSN when indirect data forwarding is used to forward DL data buffered in the old Gn/Gp SGSN to the UE via the forwarding SGW, as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

13.12 Tunnelling between SGW and eNodeB

GTP T-PDU tunnelling between SGW and eNodeB is applicable also for a TAU with SGW change procedure when forwarding DL data buffered in the old SGW to the UE via the target eNodeB, if such forwarding is supported by the eNodeB as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

13.13 Tunnelling between SGW and RNC

GTP T-PDU tunnelling between SGW and RNC is applicable also for a RAU with SGW change procedure when forwarding DL data buffered in the old SGW to the UE via the new RNC when Direct Tunnel is used at the target side, if such forwarding is supported by the RNC as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

13.14 Tunnelling between SGW and SGSN

GTP T-PDU tunnelling between SGW and SGSN is applicable also for a RAU with SGW change procedure when forwarding DL data buffered in the old SGW to the UE via the new SGSN when Direct Tunnel is not used at the target side as described in the clause 5.3.3.1A of 3GPP TS 23.401 [5].

Annex A (Normative): PDU session user plane protocol over N9

The PDU session user plane protocol shall be supported over the N9 interface as specified in 3GPP TS 38.415 [31].

Annex B (informative): Change history

Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	New
2008-12	CT#42	CP-080716			V2.0.0 approved in CT#42	8.0.0
2009-03	CT#43	CP-090048	0001	1	Correction on GTP-U path failure	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	8.2.0
			0008	2	GTP-U updates for MBMS HSPA Evolution	
2009-09	CT#45	CP-090539	0010	1	Forwarding Tunnel Error Indication handling	8.3.0
			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 clause	
			0016		Eliminating Editor's Notes	
			0018	1	Path Failure text correction	
2009-09	CT#45	CP-090559	0013	1	MBMS for EPS support in GTPv1-U	9.0.0
2009-12	CT#46	CP-090773	0023	2	End Marker in S1 based handover and Inter RAT handover procedures	9.1.0
			0025		GTP-U sequence number handling	
2010-03	CT#47	CP-100023	0027	1	Sequence Number corrections	9.2.0
2010-06	CT#48	CP-100287	0028	1	Message applicability of MBMS in GTP-U	9.3.0
2010-12	CT#50	CP-100686	0031	1	Addition of GTP-U interface over S2b	10.0.0
			0033	2	End Marker message	
			0035	1	Echo Request & Echo Response	
2011-03	CT#51	CP-110258	0037	2	TEID value 0 for GTP-U tunnel	10.1.0
			0038	3	GTP-U protocol missing information	
			0039		Scope of GTPv1	
2011-06	CT#52	CP-110374	0040		eNB Error Indication Handling	10.2.0
			0042	1	Addition of the MBMS reference points	
2011-09	CT#53	CP-110567	0044		User plane path failure handling	10.3.0
2011-09	CT#53	CP-110580	0043		Default inner MTU size	11.0.0
		CP-110577	0045	1	Correction to references	
2011-12	CT#54	CP-110810	0046	1	Add the definition of C-TEID	11.1.0
			0048	1	Dynamic allocation of UDP source ports	
			0049		Requirement for sending Error Indication	
2012-03	CT#55	CP-120036	0050		Tunnelling between eNodeB and RNC	11.2.0
		CP-120036	0053	1	GTP-U header	
			0052	1	Addition of GTP based S2a	
2012-06	CT#56		0054		Tunnelling Scenarios	11.3.0
2012-09	CT#57	CP-120682	0059	6	New extension header in GTP-U for SIRIG	11.4.0
2012-12	CT#58	CP-120751	0060	2	Length of PDCP PDU number	11.5.0
		CP-120735	0061	-	Removal of editor's note in extension header in GTP-U for SIRIG	
2013-03	CT#59	CP-130021	0062	-	Clarification on support of GTP-U over the S2a interface	11.6.0
2014-09	CT#65	CP-140521	0064	2	Introduction of Dual Connectivity Function	12.0.0
			0065	-	Correct the ambiguous GTP-U PDU	
2014-12	CT#66	CP-140789	0067	1	Definition of RAN Container for flow control during X2UP handover	12.1.0
		CP-140972	0068	1	End Marker used in PMIP-based S5/S8 case	
		CP-140972	0069	2	Correct the GSN Address IE name	
2015-09	CT#69	CP-150454	0071	2	Tunnelling scenarios for supporting High Latency communication	13.0.0
		CP-150448	0072	3	G-PDU extension header handling	
2016-03	CT#71	CP-160033	0074	1	S11-U tunneling for MO/MT data transport in control plane (SGi based)	13.1.0
		CP-160033	0075	1	End Marker handling by MME	
		CP-160038	0076	1	Comprehension requirement for PDCP PDU Number	
		CP-160040	0077	2	18 bits PDCP PDU Number	
2016-06	CT#72	CP-160228	0078	1	Handling of End Marker packets over S11-U by MME	13.2.0
2017-03	CT#75	CP-170032	0080	1	Support for transport level packet marking over GTP-U interfaces	14.0.0
2017-06	CT#76	CP-171019	0082	-	Xw RAN Container for LTE-WLAN Aggregation (LWA)	14.1.0
2017-09	CT#77	CP-172025	0083	1	GTP-U Extension Header Handling	15.0.0
2017-12	CT#78	CP-173034	0084	1	Supports N3, N9 and Xn userplane interface	15.1.0
2018-03	CT#79	CP-180026	0086	1	New GTP-U extension header for 5GS	15.2.0
2018-03	CT#79	CP-180026	0087	1	Support End Marker in 5GS	15.2.0
2018-03	CT#79	CP-180026	0089	1	New GTP-U Extension Header for the PDU Session Container	15.2.0
2018-03	CT#79	CP-180023	0088	1	Unpredictability of GTP TEID for PGW GTP-U	15.2.0

2018-06	CT#80	CP-181128	0092	1	Change of Comprehension for 'Long PDCP PDU Number' extension header	15.3.0
2018-06	CT#80	CP-181132	0093	2	Fix the location of the PDU Session Container	15.3.0
2018-06	CT#80	CP-181132	0095	-	User Plane Protocol over N9	15.3.0
2018-09	CT#81	CP-182084	0096	1	General 5G Corrections	15.4.0
2018-09	CT#81	CP-182084	0097	2	GTP-U Tunnel Endpoint Description	15.4.0
2018-09	CT#81	CP-182084	0099	1	DSCP Marking on IPv4 Outer Header based on 5QI/ARP	15.4.0
2018-12	CT#82	CP-183092	0100	1	T-PDU content	15.5.0
2018-12	CT#82	CP-183092	0101	-	Referencing F1-U in the Introduction clause	15.5.0
2018-12	CT#82	CP-183092	0102	-	Data forwarding between 5GS and EPS	15.5.0
2018-12	CT#82	CP-183092	0103	-	Receiving packets from multiple remote GTP-U endpoints	15.5.0
2019-09	CT#85	CP-192116	0104	1	Error Indication and Path Failure in 5GS	15.6.0
2019-12	CT#85	CP-193024	0108	1	PDCP PDU Number	15.7.0
2019-12	CT#85	CP-193041	0109	-	Implementing the conclusions of TR 29.892 for GTP-U	16.0.0
2019-12	CT#85	CP-193050	0107	-	N19 user plane interface for 5G VN group communication	16.0.0

History

Document history		
V16.0.0	November 2020	Publication