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Contents

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 specifies the PDU Session user plane protocol being used over the NG-U, Xn-U and N9 interfaces. Applicability to other interfaces is not precluded.

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 38.300: "NextGen Radio Access Network (NG-RAN); Overall description; Stage 2".

[3] 3GPP TS 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)".

[4] 3GPP TS 37.324: "E-UTRA and NR; Service Data Application Protocol (SDAP) specification".

[5] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[6] IETF RFC 5905 (2010-06): "Network Time Protocol Version 4: Protocol and Algorithms Specification".

[7] 3GPP TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP 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 3GPP TR 21.905 [1].

NG-U: logical interface between NG-RAN node and UPF as described in TS 38.300 [2].

Xn-U: logical interface between NG-RAN nodes as defined in TS 38.300 [2].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

PPI	Paging Policy Indicator
PPP	Paging Policy Presence
QFI	QoS Flow Identifier
RQA	Reflective QoS Attribute
RQI	Reflective QoS Indication

UP User Plane
UPF User Plane Function

4 General

4.1 General aspects

The PDU Session User Plane protocol is located in the User Plane of the Radio Network Layer above the Transport Network Layer of the interface.

Each PDU session User Plane protocol instance is associated to one PDU Session.

In this version of the present document, the PDU session user plane protocol data is conveyed by GTP-U protocol means, more specifically, by means of the "GTP-U Container" GTP-U Extension Header as defined in TS 29.281 [3].

5 PDU Session user plane protocol

5.1 General

The PDU session UP layer uses services of the Transport Network Layer in order to send its packets over the interface.

5.2 PDU Session user plane protocol layer services

The following functions are provided by the PDU Session User Plane protocol:

- Provision of control information elements (e.g. QFI, RQI) associated with a PDU session.

5.3 Services expected from the Transport Network Layer

The PDU session UP layer expects the following services from the Transport Network Layer:

- Transfer of PDU session User Plane PDUs.

5.4 Elementary procedures

5.4.1 Transfer of DL PDU Session Information

5.4.1.1 Successful operation

The purpose of the Transfer of DL PDU Session Information procedure is to send control information elements related to the PDU Session from UPF to NG-RAN.

In the case of uplink and downlink data forwarding the DL PDU Session Information procedure shall be used to send control information elements related to the PDU Session from NG-RAN node to UPF, or from UPF to NG-RAN node, or between NG-RAN nodes.

A PDU Session user plane instance making use of the Transfer of DL PDU Session Information procedure is associated to a single PDU Session. The Transfer of DL PDU Session Information procedure may be invoked whenever packets for that particular PDU Session need to be transferred across the related interface instance.

The DL PDU SESSION INFORMATION frame includes a QoS Flow Identifier (QFI) field associated with the transferred packet. The NG-RAN shall use the received QFI to determine the QoS flow and QoS profile which are associated with the received packet.

The DL PDU SESSION INFORMATION frame shall include the Reflective QoS Indicator (RQI) field to indicate that user plane Reflective QoS shall be activated or not. The NG-RAN shall, if RQA has been configured for the involved QoS flow, take the RQI into account as specified in TS 37.324 [4].

The DL PDU SESSION INFORMATION frame may also include a Paging Policy Indicator (PPI) field associated with the transferred packet. The NG-RAN shall use the received PPI to determine the paging policy differentiation which is associated with the received packet as described in [5].

The DL PDU SESSION INFORMATION frame may also include a QoS Monitoring Packet (QMP) field and a DL sending time stamp field. The NG-RAN shall, if QoS monitoring has been configured for the included QFI field, perform delay measurement and QoS monitoring, as specified in TS 23.501 [5].

The DL PDU SESSION INFORMATION frame may also include a DL QFI Sequence Number field associated with the transferred packet. The NG-RAN shall, if the QoS flow has been configured eligible for redundant transport bearer in TS 38.413 [6], use the received DL QFI Sequence Number field to determine and eliminate duplicated packets for a given QoS flow as specified in TS 23.501 [5].

When needed, the NG-RAN shall propagate the DL PDU Session Information to a peer NG-RAN.

Figure 5.4.1.1-1: Successful Transfer of DL PDU Session Information

5.4.1.2 Unsuccessful operation

Void.

5.4.2 Transfer of UL PDU Session Information

5.4.2.1 Successful operation

The purpose of the Transfer of UL PDU Session Information procedure is to send control information elements related to the PDU Session from NG-RAN to UPF.

An UL PDU Session user plane instance making use of the Transfer of UL PDU Session Information procedure is associated to a single PDU Session. The Transfer of UL PDU Session Information procedure may be invoked whenever packets for that particular PDU Session need to be transferred across the related interface instance.

The UL PDU SESSION INFORMATION frame includes a QoS Flow Identifier (QFI) field associated with the transferred packet.

If QoS monitoring has been requested for the included QFI field, the UL PDU SESSION INFORMATION frame may include a QoS Monitoring Packet (QMP) field, a DL sending time stamp repeated field, a DL receiving time stamp field, a UL sending time stamp field, and/or delay result for UL or DL. If QoS monitoring with N3/N9 delay reporting has been requested for the included QFI field, the I-UPF may include in the UL PDU SESSION INFORMATION frame a N3/N9 Delay Ind. field, a N3/N9 Delay Result field and delay result for UL and DL if received from the RAN. The UPF shall, if supported, use this information to calculate UL, DL, or RTT delay as specified in TS 23.501 [5].

The UL PDU SESSION INFORMATION frame may also include a UL QFI Sequence Number field associated with the transferred packet. The UPF shall, if the QoS flow has been configured eligible for redundant transport bearer in TS 38.413 [6], use the received UL QFI Sequence Number field to determine and eliminate duplicated packets for a given QoS flow as specified in TS 23.501 [5].

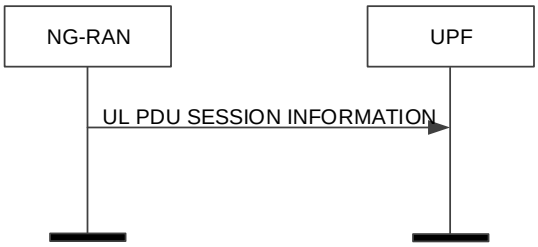

Figure 5.4.2.1-1: Successful Transfer of UL PDU Session Information

5.4.2.2 Unsuccessful operation

Void.

5.5 Elements for the PDU Session user plane protocol

5.5.1 General

In the present document the structure of frames are specified by using figures similar to figure 5.5.1-1.

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
Field 1				Field 2				1	Octet 1
Field 3						Field 4		2	Octet 2
Field 4 continue				Spare					Octet 3
Field 6								2	Octet 4
Field 6 continue				Padding bits					Octet 5
Future Extension								0-m	
Padding								0-3	

Figure 5.5.1-1: Example frame format

Unless otherwise indicated, fields which consist of multiple bits within an octet have the most significant bit located at the higher bit position (indicated above frame in figure 5.5.1-1). In addition, if a field spans several octets, most significant bits are located in lower numbered octets (right of frame in figure 5.5.1-1).

On the NG interface, the frame is transmitted starting from the lowest numbered octet. Within each octet, the bits are sent according to decreasing bit position (bit position 7 first).

Spare bits should be set to "0" by the sender and should not be checked by the receiver.

The header part of the frame is always an integer number of octets. The payload part is octet aligned (by adding 'Padding Bits' when needed).

The receiver should be able to remove an additional Future Extension field that may be present.
See description of Future Extension field in A.1.

Padding octets may be added at the end of the frame, see Padding in 5.5.3.5.

5.5.2 Frame format for the PDU Session user plane protocol

5.5.2.1 DL PDU SESSION INFORMATION (PDU Type 0)

This frame format is defined to allow the NG-RAN to receive some control information elements which are associated with the transfer of a packet over the interface.

The following shows the respective DL PDU SESSION INFORMATION frame.

Bits								Number of Octets
7	6	5	4	3	2	1	0	
PDU Type (=0)				QMP	SNP	Spare		1
PPP	RQI	QoS Flow Identifier						1
PPI			Spare					0 or 1
DL Sending Time Stamp								0 or 8
DL QFI Sequence Number								0 or 3
Padding								0-3

Figure 5.5.2.1-1: DL PDU SESSION INFORMATION (PDU Type 0) Format

5.5.2.2 UL PDU SESSION INFORMATION (PDU Type 1)

This frame format is defined to allow the UPF to receive some control information elements which are associated with the transfer of a packet over the interface.

The following shows the respective UL PDU SESSION INFORMATION frame.

Bits								Number of Octets
7	6	5	4	3	2	1	0	
PDU Type (=1)				QMP	DL Delay Ind.	UL Delay Ind.	SNP	1
N3/N9 Delay Ind.	New IE Flag	QoS Flow Identifier						1
DL Sending Time Stamp Repeated								0 or 8
DL Received Time Stamp								0 or 8

UL Sending Time Stamp								0 or 8
DL Delay Result								0 or 4
UL Delay Result								0 or 4
UL QFI Sequence Number								0 or 3
N3/N9 Delay Result								0 or 4
New IE flag 7(E)	New IE Flag 6	New IE Flag 5	New IE Flag 4	New IE Flag 3	New IE Flag 2	New IE Flag 1	New IE Flag 0	0 or 1 New IE Flags Octet
Spare							D1 UL PDCP Delay Result Ind	0 or 1
Padding								0-3

Figure 5.5.2.2-1: UL PDU SESSION INFORMATION (PDU Type 1) Format

The New IE Flag in bit 6 of 2nd octet in UL PDU SESSION INFORMATION (PDU Type 1) indicates if the first octet of New IE Flags Octet is present or not.

Bit 0 of New IE Flags Octet in UL PDU SESSION INFORMATION (PDU Type 1) indicates if the D1 UL PDCP Delay Result Ind is present (1) or not (0)

5.5.3 Coding of information elements in frames

5.5.3.1 PDU Type

Description: The PDU Type indicates the structure of the PDU session UP frame. The field takes the value of the PDU Type it identifies; i.e. "0" for PDU Type 0. The PDU type is in bit 4 to bit 7 in the first octet of the frame.

Value range: {0= DL PDU SESSION INFORMATION, 1=UL PDU SESSION INFORMATION, 2-15=reserved for future PDU type extensions}.

Field length: 4 bits.

5.5.3.2 Spare

Description: The spare field is set to "0" by the sender and should not be interpreted by the receiver. This field is reserved for later versions.

Value range: $(0–2^n-1)$.

Field Length: n bits.

5.5.3.3 QoS Flow Identifier (QFI)

Description: When present this parameter indicates the QoS Flow Identifier of the QoS flow to which the transferred packet belongs.

Value range: $\{0..2^6-1\}$.

Field length: 6 bits.

5.5.3.4 Reflective QoS Indicator (RQI)

Description: This parameter indicates activation of the reflective QoS towards the UE for the transferred packet as described in clause 5.4.1.1. It is used only in the downlink direction. If RQA (Reflective QoS Activation) has not been configured for the involved QoS flow, the RQI shall be ignored by the NG-RAN node.

Value range: {0= Reflective QoS activation not triggered, 1= Reflective QoS activation triggered}.

Field length: 1 bit.

5.5.3.5 Padding

Description: The padding is included at the end of the frame to ensure that the PDU Session user plane protocol PDU length (including padding and the future extension) is (n*4– 2) octets, where n is a positive integer. If there is any future extension, the padding should be added after the future extensions.

Field Length: 0–3 octets.

5.5.3.6 Paging Policy Presence (PPP)

Description: This parameter indicates the presence of the Paging Policy Indicator (PPI).

Value range: {0= Paging Policy Indicator not present, 1= Paging Policy Indicator present}.

Field length: 1 bit.

5.5.3.7 Paging Policy Indicator (PPI)

Description: When present, the Paging Policy Indicator is used for paging policy differentiation (see details in 3GPP TS 23.501 [5]). This field applies to PDU sessions of IP type.

Value range: {0..2^3-1}.

Field length: 3 bits.

5.5.3.8 QoS Monitoring Packet (QMP)

Description: This parameter indicates that the transferred packet is used for QoS monitoring as described in clause 5.4.1.1 and clause 5.4.2.1. This parameter also indicates the presence of the DL Sending Time Stamp in the DL PDU Session Information frame and the presence of the DL Sending Time Stamp Repeated, the DL Receiving Time Stamp, the UL Sending Time Stamp in the UL PDU Session Information frame. If QoS monitoring has not been configured for the involved QoS flow, the QMP shall be ignored by the NG-RAN node.

Value range: {0= not used for QoS monitoring, 1= used for QoS monitoring}.

Field length: 1 bit.

5.5.3.9 DL Sending Time Stamp

Description: This field indicates the time when the UPF sends the DL PDU Session Information frame with the QMP field set to 1. It is used only in the downlink direction and encoded in the same format as the 64-bit timestamp format as defined in Section 6 of IETF RFC 5905 [6].

Value range: {0..2^{64}-1}.

Field length: 8 octets.

5.5.3.10 DL Sending Time Stamp Repeated

Description: This field indicates the value of the DL Sending Time Stamp field that the NG-RAN has received in the DL PDU Session Information frame with the QMP field set to 1 for the involved QoS flow. It is used only in the uplink direction and encoded in the same format as the 64-bit timestamp format as defined in Section 6 of IETF RFC 5905 [6]. The UPF shall, if supported, use this information to calculate DL or RTT delay between the NG-RAN and the UPF as specified in [5].

Value range: {0..2^{64}-1}.

Field length: 8 octets.

5.5.3.11 DL Received Time Stamp

Description: This field indicates the time when the NG-RAN node receives the DL PDU Session Information frame with the QMP field set to 1 for the involved QoS flow. It is used only in the uplink direction and encoded in the same format as the 64-bit timestamp format as defined in Section 6 of IETF RFC 5905 [6]. The UPF shall, if supported, use this information to calculate DL or RTT delay between the NG-RAN and the UPF as specified in [5].

Value range: {0..2^{64}-1}.

Field length: 8 octets.

5.5.3.12 UL Sending Time Stamp

Description: This field indicates the time when the NG-RAN node sends this UL PDU Session Information frame. It is used only in the uplink direction and encoded in the same format as the 64-bit timestamp format as defined in Section 6 of IETF RFC 5905 [6]. The UPF shall, if supported, use this information to calculate UL or RTT delay between the NG-RAN and the UPF as specified in [5].

Value range: {0..2^{64}-1}.

Field length: 8 octets.

5.5.3.13 DL Delay Ind.

Description: This parameter indicates the presence of DL Delay Result.

Value range: {0= DL Delay Result not present, 1= DL Delay Result present}.

Field length: 1 bit.

5.5.3.14 DL Delay Result

Description: This field indicates the downlink delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU) and the delay over Uu interface in milliseconds for the involved QoS flow. It is used only in the uplink direction and encoded as an Unsigned32 binary integer value. The UPF shall, if supported, use this information to calculate DL or RTT delay as specified in [5].

Value range: {0..2^{32}-1}.

Field length: 4 octets.

5.5.3.15 UL Delay Ind.

Description: This parameter indicates the presence of UL Delay Result.

Value range: {0= UL Delay Result not present, 1= UL Delay Result present}.

Field length: 1 bit.

5.5.3.16 UL Delay Result

Description: This field indicates the uplnk delay measurement result which is the sum of the delay incurred in NG-RAN (including the delay at gNB-CU-UP, on F1-U and on gNB-DU), the delay over Uu interface and the delay in the UE in milliseconds for the involved QoS flow. It is used only in the uplink direction and encoded as an Unsigned32 binary integer value. The UPF shall, if supported, use this information to calculate UL or RTT delay as specified in [5].

Value range: {0..2^{32}-1}.

Field length: 4 octets.

5.5.3.17 Sequence Number Presence (SNP)

Description: This parameter indicates the presence of the DL QFI Sequence Number in the DL PDU Session Information frame or the presence of the UL QFI Sequence Number in the UL PDU Session Information frame.

Value range: {0= DL/UL QFI Sequence Number not present, 1= DL/UL QFI Sequence Number present}.

Field length: 1 bit.

5.5.3.18 DL QFI Sequence Number

Description: This parameter indicates the sequence number as assigned by the UPF associated with a given QoS Flow.

Value range: {0..2^{24}-1}.

Field length: 3 octets.

5.5.3.19 UL QFI Sequence Number

Description: This parameter indicates the sequence number as assigned by the NG-RAN node associated with a given QoS flow.

Value range: {0..2^{24}-1}.

Field length: 3 octets.

5.5.3.20 N3/N9 Delay Ind.

Description: This parameter indicates the presence of N3/N9 Delay Result.

Value range: {0= N3/N9 Delay Result not present, 1= N3/N9 Delay Result present}.

Field length: 1 bit.

5.5.3.21 N3/N9 Delay Result

Description: This field indicates the accumulated N3 and N9 packet delay as specified in [5], and is reported by the I-UPF. The reported value is expressed in milliseconds and encoded as an Unsigned32 binary integer value.

Value range: {0..2^{32}-1}.

Field length: 4 octets.

5.5.3.22 D1 UL PDCP Delay Result Ind

Description: This parameter indicates if the UL Delay Result includes or not includes the D1 measurement (UL PDCP Packet Average Delay). This parameter shall be ignored if the UL Delay Ind is set to “0”.

Value range: {0= D1 UL PDCP Packet Average Delay measurement is not included, 1= D1 UL PDCP Packet Average Delay measurement is included}.

Field length: 1 bit.

5.5.4 Timers

Void.

5.6 Handling of unknown, unforeseen and erroneous protocol data

Void.

Annex A (informative): Example of using Future Extension Field

A.1 Example of using Future Extension field

New IE flag 7(E)	New IE flag 6	New IE flag 5	New IE flag 4	New IE flag 3	New IE flag 2	New IE flag 1	New IE flag 0	1 Octet New IE Flags
New IE 1								3 Octets
New IE 2								2 Octets

Figure A.1-1: Example of future Extension Field

In the Example of the future Extension Field, New IE flag 0 indicates if the New IE 1 is present or not. New IE flag 1 indicates if the new IE 2 is present or not.

A.1.1 New IE Flags

Description: The *New IE Flags* IE is only present if at least one new IE is present. The *New IE Flags* IE contains flags indicating which new IEs that are present following the *New IE Flags* IE. The last bit position of the *New IE Flags* IE is used as the Extension Flag to allow the extension of the *New IE Flags* IE in the future. Extension octets of the *New IE Flags* IE shall follow directly after the first octet of the *New IE Flags* IE. When an extension octet of the *New IE Flags* IE is present, then all previous extension octets of the *New IE Flags* IE and the *New IE Flags* IE shall also be present, even if they have all their flag bits indicating no presence of their respective new IEs.

Annex B (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2018-04	R3#99bis	R3-181720				TS skeleton.	0.0.1
2018-04	R3#99bis	R3-182525				Integration of R3-182399 with sections 4 and 5 and annex A1.	0.1.0
2018-05	R3#100	R3-183594				Integration of R3-182619 to remove editor's notes, remove FFS and fix some editorials; integration of R3-183413 introducing PDU type for downlink and uplink; removing the FFS of uplink frame type in line with R3-182619 for downlink frame type; integration of R3-183000 solving the FFS on QFI.	0.2.0
2018-06	RAN#80	RP-180740				For approval.	1.0.0
2018-06	RAN#80		-	-	-	Specification approved at TSG-RAN and placed under change control	15.0.0
2018-09	RAN#81	RP-181922	0001	4	F	NR Corrections (38.415 Baseline CR covering RAN3#101 agreements)	15.1.0
2018-12	RAN#82	RP-182446	0003	-	F	Rapporteur's CR for TS38.415	15.2.0
2020-03	RAN#87-e	RP-200425	0012	3	B	E2E delay measurement for QoS monitoring for URLLC	16.0.0
2020-07	RAN#88-e	RP-201079	0010	5	B	Introduction of NR_IIOT support to TS 38.415	16.1.0
2020-07	RAN#88-e	RP-201085	0013	1	F	QoS monitoring for URLLC	16.1.0
2020-09	RAN#89-e	RP-201950	0014	-	F	Need of D1 and Reporting interval for Qos monitoring for URLLC	16.2.0
2020-09	RAN#89-e	RP-201948	0015	1	F	Rapporteur Correction of QoS Flow Redundancy	16.2.0
2020-12	RAN#90-e	RP-202313	0016	1	F	N3/N9 packet delay reporting for GTP-U path QoS monitoring	16.3.0
2021-03	RAN#91-e	RP-210240	0019	2	F	UE support for D1 part of UL Delay and adding New IE Flag for extensibility	16.4.0
2021-06	RAN#92-e	RP-211333	0027		A	Correction of PDU Type Frame	16.5.0
2021-12	RAN#94-e	RP-212863	0030	2	F	Correction for UL PDU Session Information	16.6.0

History

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V16.4.0	April 2021	Publication
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V16.6.0	January 2022	Publication