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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:

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1 Scope

The present document specifies the NR user plane protocol functions used within NG-RAN and, for EN-DC, within E-UTRAN. NR user plane protocol functions may reside in nodes terminating either the X2-U (for EN-DC) or the Xn-U or the F1-U interface.

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 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)".
- [3] 3GPP TS 37.340: "NR; Multi-connectivity; Overall description; Stage-2".
- [4] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".
- [5] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".
- [6] 3GPP TS 36.322: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification".
- [7] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".
- [8] 3GPP TS 23.501: "System Architecture for the 5G System".

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].

Corresponding node: a node interacting with a node hosting NR PDCP for flow control. In an IAB network, this is the IAB-DU serving the UE for the corresponding data radio bearer.

Master node: as defined in TS 37.340 [3].

Secondary node: as defined in TS 37.340 [3].

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].

EN-DC	E-UTRA-NR Dual Connectivity
IAB	Integrated Access and Backhaul
MR-DC	Multi-RAT Dual Connectivity

4 General

4.1 General aspects

The NR user plane protocol is located in the User Plane of the Radio Network layer over either the Xn or the X2 or the F1 interface.

The NR user plane protocol is used to convey control information related to the user data flow management of data radio bearers.

Each NR user plane protocol instance is associated to one data radio bearer only. There is one NR user plane instance per GTP tunnel. When a GTP tunnel is set up, a new NR user plane instance is set up.

If configured, NR user plane protocol instances exist at the Master node and the Secondary node in the context of DC or at nodes hosting F1-U protocol terminations. The NR user plane protocol supports direct communication between NR user plane protocol entities, regardless of whether they terminate the same or different user plane interfaces.

NOTE: User data radio bearers may be setup for data forwarding purposes during Xn HO or during DC related mobility without requiring the execution of any additional data radio bearer related user plane protocol functions related to an NR user plane protocol instance.

On each data radio bearer, the NR user plane protocol operates with RLC AM or RLC UM.

In this version of the present document, NR user plane protocol data is conveyed by GTP-U protocol means, more specifically, by means of the "NR RAN Container" GTP-U extension header as defined in TS 29.281 [2].

5 NR user plane protocol

5.1 General

The NR user plane protocol layer is using services of the transport network layer in order to allow flow control of user data packets transferred from the node hosting NR PDCP to the corresponding node.

5.2 NR user plane protocol layer services

The following functions are provided by the NR user plane protocol:

- Provision of NR user plane specific sequence number information for user data transferred from the node hosting NR PDCP to the corresponding node for a specific data radio bearer.
- Information of successful in sequence delivery of NR PDCP PDUs to the UE from the corresponding node for user data associated with a specific data radio bearer.
- Information of NR PDCP PDUs that were not delivered to the UE or not transmitted to the lower layers.

- Information of NR PDCP PDUs transmitted to the lower layers for user data associated with a specific data radio bearer.
- Information of downlink NR PDCP PDUs to be discarded for user data associated with a specific data radio bearer;
- Information of the currently desired buffer size at the corresponding node for transmitting to the UE user data associated with a specific data radio bearer.
- Information of the currently desired data rate in bytes at the corresponding node for transmitting to the UE user data associated with a specific data radio bearer;
- Information of successful in sequence delivery of NR PDCP PDUs to the UE from the corresponding node for retransmission user data associate with a specific data radio bearer;
- Information of NR PDCP PDUs transmitted to the lower layers for retransmission user data associated with a specific data radio bearer.
- Information of the specific events at the corresponding node.
- Information on Radio Link Quality from the corresponding node for user data associated with a specific data radio bearer.
- Information for QoS monitoring from the corresponding node for user data associated with a specific data radio bearer.

5.3 Services expected from the Transport Network Layer

The NR user plane protocol layer expects the following services from the Transport Network Layer:

- Transfer of user data.

5.4 Elementary procedures

5.4.1 Transfer of Downlink User Data

5.4.1.1 Successful operation

The purpose of the Transfer of Downlink User Data procedure is to provide NR-U specific sequence number information at the transfer of user data carrying a DL NR PDCP PDU from the node hosting the NR PDCP entity to the corresponding node.

An NR user plane protocol instance making use of the Transfer of Downlink User Data procedure is associated to a single data radio bearer only.

The node hosting the NR PDCP entity shall assign consecutive NR-U sequence numbers to each transferred NR-U packet. A retransmitted NR PDCP PDU shall be assigned a new NR-U sequence number.

The node hosting the NR PDCP entity indicates to the corresponding node whether this NR-U packet is a retransmission of NR PDCP PDU.

The node hosting the NR PDCP entity can indicate to the corresponding node to either discard all NR PDCP PDUs up to and including a defined DL discard NR PDCP PDU SN or discard one or a number of blocks of downlink NR PDCP PDUs.

If the Assistance Information Report Polling Flag is equal to 1, the corresponding node shall, if supported, send the ASSISTANCE INFORMATION DATA to the node hosting the NR PDCP entity.

The corresponding node shall detect whether an NR-U packet was lost and memorise the respective sequence number after it has declared the respective NR-U packet as being "lost".

The corresponding node shall transfer the remaining NR PDCP PDUs towards the UE and memorise the highest NR PDCP PDU sequence number of the NR PDCP PDU that was successfully delivered (as defined in TS 36.322 [6] and TS 38.322 [7]) in sequence towards the UE (in case RLC AM is used) and the highest NR PDCP PDU sequence number of the NR PDCP PDU that was transmitted to the lower layers.

The corresponding node shall send the DL DATA DELIVERY STATUS if the Report Polling Flag is set to 1 or when the NR PDCP PDU with the indicated DL report NR PDCP PDU SN has been successfully delivered, unless a situation of overload at the corresponding node is encountered. The DL DATA DELIVERY STATUS sent as a response to a specific DL report NR PDCP PDU SN shall be sent only when all PDCP PDU SNs up to this DL report NR PDCP PDU have been successfully delivered in-sequence.

If the Request OutOfSeq Report is set to 1, the corresponding node shall, if supported, include the NR PDCP PDU sequence number successfully delivered out of sequence in the DL DATA DELIVERY STATUS to the node hosting the NR PDCP entity.

NOTE: The Transfer of Downlink User Data procedure and the associated feedback of lost NR-U packets assist the node hosting the NR PDCP entity in avoiding NR PDCP HFN de-synchronisation. If a deployment decides to not use the Transfer of Downlink User Data procedure, NR PDCP HFN synchronization should be ensured by other means.

If the User data existence flag is set to 1, the corresponding node assumes that the node hosting the NR PDCP entity has some user data for the concerned data radio bearer. The corresponding node decides whether and when to use DRX for the UE (i.e. the corresponding node may indicate the UE to use DRX even if the flag is set to 1 and the received DL USER DATA frame contains no user data).

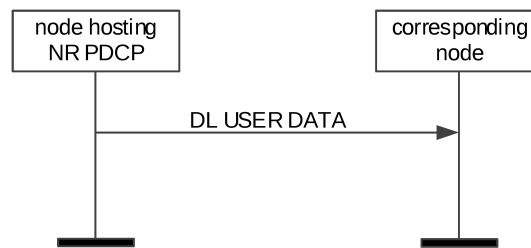


Figure 5.4.1.1-1: Successful Transfer of Downlink User Data

5.4.1.2 Unsuccessful operation

Void.

5.4.2 Downlink Data Delivery Status

5.4.2.1 Successful operation

The purpose of the Downlink Data Delivery Status procedure is to provide feedback from the corresponding node to the node hosting the NR PDCP entity to allow the node hosting the NR PDCP entity to control the downlink user data flow via the corresponding node for the respective data radio bearer. The corresponding node may also transfer uplink user data for the concerned data radio bearer to the node hosting the NR PDCP entity together with a DL DATA DELIVERY STATUS frame within the same GTP-U PDU.

The Downlink Data Delivery Status procedure is also used to provide feedback from the corresponding node to the node hosting the NR PDCP entity to allow the node hosting the NR PDCP entity to control the successful delivery of DL control data to the corresponding node.

When the corresponding node decides to trigger the feedback for Downlink Data Delivery procedure it shall report as specified in section 5.2:

- a) in case of RLC AM, the highest NR PDCP PDU sequence number successfully delivered in sequence to the UE among those NR PDCP PDUs received from the node hosting the NR PDCP entity i.e. excludes those retransmission NR PDCP PDUs;
- b) the desired buffer size in bytes for the concerned data radio bearer;
- c) optionally, the desired data rate in bytes associated with a specific data radio bearer configured for the UE;
- d) the NR-U packets that were declared as being "lost" by the corresponding node and have not yet been reported to the node hosting the NR PDCP entity within the DL DATA DELIVERY STATUS frame;
- e) if retransmission NR PDCP PDUs have been delivered, the NR PDCP PDU sequence number associated with the highest NR-U sequence number among the retransmission NR PDCP PDUs successfully delivered to the UE in sequence of NR-U sequence number;
- f) if retransmission NR PDCP PDUs have been transmitted to the lower layers, the NR PDCP PDU sequence number associated with the highest NR-U sequence number among the retransmission NR PDCP PDUs transmitted to the lower layers in sequence of NR-U sequence number;
- g) the highest NR PDCP PDU sequence number transmitted to the lower layers among those NR PDCP PDUs received from the node hosting the NR PDCP entity i.e. excludes those retransmission NR PDCP PDUs;

NOTE: If a deployment has decided not to use the Transfer of Downlink User Data procedure, d), e) and f) above are not applicable.

- e) in case of RLC AM, the NR PDCP PDU sequence number successfully delivered out of sequence to the UE among those NR PDCP PDUs received from the node hosting the NR PDCP entity i.e. excludes those retransmission NR PDCP PDUs.

As soon as the corresponding node detects the successful RACH access by the UE for the corresponding data radio bearer(s), the corresponding node shall send initial DL DATA DELIVERY STATUS frame to the node(s) hosting the

NR PDCP entity(ies). The node hosting NR PDCP entity may start sending DL data before receiving the initial DL DATA DELIVERY STATUS frame. In case the DL DATA DELIVERY STATUS frame is sent before any NR PDCP PDU is transferred to lower layers, the information on the highest NR PDCP PDU sequence number successfully delivered in sequence to the UE and the highest NR PDCP PDU sequence number transmitted to the lower layers may not be provided.

The DL DATA DELIVERY STATUS frame shall also include a final frame indication when this frame is the last DL status report. When receiving such indication, the node hosting the NR PDCP entity considers that no more UL or DL data is expected to be transmitted between the corresponding node and the UE.

The DL DATA DELIVERY STATUS frame may also include an indication of detected radio link outage or radio link resume for the concerned data radio bearer. When receiving an indication of radio link outage detection, the node hosting the NR PDCP entity considers that traffic delivery over the data radio bearer configured for the UE is unavailable at the corresponding node both in UL and DL. When receiving an indication of radio link resume detection, the node hosting the NR PDCP entity considers that traffic delivery over the data radio bearer configured for the UE is available at the corresponding node both in UL and in DL. When receiving an indication of UL or DL radio link outage detection, the node hosting the NR PDCP entity considers that traffic delivery over the data radio bearer configured for the UE is unavailable at the corresponding node for UL or DL, depending on the indicated outage. When receiving an indication of UL or DL radio link resume detection, the node hosting the NR PDCP entity considers that traffic delivery over the data radio bearer configured for the UE is available at the corresponding node in UL or in DL, depending on the indicated resume.

The node hosting the NR PDCP entity, when receiving the DL DATA DELIVERY STATUS frame:

- regards the desired buffer size under b) and the data rate under c) above as the amount of data to be sent from the hosting node:
 - If the value of the desired buffer size is 0, the hosting node shall stop sending any data per bearer.
 - If the value of the desired buffer size in b) above is greater than 0, the hosting node may send up to this amount of data per bearer starting from the last "Highest successfully delivered NR PDCP Sequence Number" for RLC AM if received, or the hosting node may send up to this amount of data per bearer starting from the last "Highest transmitted NR PDCP Sequence Number" for RLC UM if received.
 - The value of the desired data rate in c) above is the amount of data desired to be received in a specific amount of time. The amount of time is 1 sec.
 - The information of the buffer size in b) above and of the data rate in c) above is valid until the next DL DATA DELIVERY STATUS frame is received.
- is allowed to remove the buffered NR PDCP PDUs of a RLC AM bearer, according to the feedback of successfully delivered NR PDCP PDUs;
- decides upon the actions necessary to take for NR PDCP PDUs reported other than transmitted and/or successfully delivered.

In case of RLC AM, after the highest NR PDCP PDU sequence number successfully delivered in sequence is reported to the node hosting the NR PDCP entity, the corresponding node removes the respective NR PDCP PDUs. For RLC UM, the corresponding node may remove the respective NR PDCP PDUs after transmitting to lower layers.

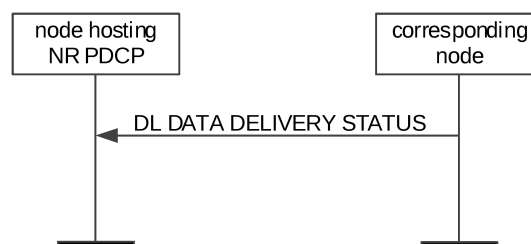


Figure 5.4.2.1-1: Successful Downlink Data Delivery Status

5.4.2.2 Unsuccessful operation

Void.

5.4.3 Transfer of Assistance Information

5.4.3.1 Successful operation

The purpose of the Transfer of Assistance Information procedure is to provide assistance information to the node hosting the NR PDCP entity. Such information may be taken into consideration by the node hosting the NR PDCP entity for UP management and optimisation procedures.

An NR user plane protocol instance making use of the Transfer of Assistance Information procedure is associated to a single data radio bearer only.

The Transfer of Assistance Information procedure may be invoked if

- the corresponding node decides to send the Radio Quality Assistance Information and/or the PDCP duplication activation suggestion to the node hosting the NR PDCP entity for the concerned data radio bearer or,
- the corresponding node decides to send the Radio Quality Assistance Information to the node hosting the NR PDCP entity for the concerned RLC entity.

The Transfer of Assistance Information procedure may be invoked if the corresponding node is configured to perform the QoS monitoring and to send the QoS monitoring results to the node hosting the NR PDCP entity for the concerned data radio bearer.

The ASSISTANCE INFORMATION DATA frame may include one or more Radio Quality Assistance Information. The information shall consist of the information indicated in the Assistance Information Type.

The ASSISTANCE INFORMATION DATA shall be sent, if supported, when the corresponding node receives a DL USER DATA PDU including the Assistance Information Report Polling Flag set to 1.

The ASSISTANCE INFORMATION DATA frame may include the PDCP Duplication Activation Suggestion, which informs the node hosting the NR PDCP entity of the suggestion from the corresponding node on whether to activate or not activate DL PDCP duplication. The node hosting the NR PDCP entity may take this information into account to take a decision on whether to activate or not activate PDCP duplication.

The ASSISTANCE INFORMATION DATA frame may include the UL Delay or/and DL Delay measured by the corresponding node. The node hosting the NR PDCP entity may take this information into account to calculate the whole UL or/and DL delay of RAN.

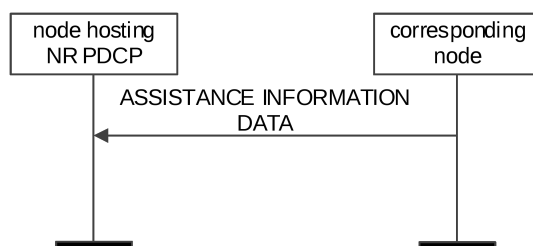


Figure 5.4.3.1-1: Successful Transfer of Assistance Information Data

5.5 Elements for the NR user plane protocol

5.5.1 General

In the present document the structure of frames is 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
Spare				Field 5					1
Field 6								2	Octet 5
Field 6 continue				Padding Bits					Octet 6
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 highest bit position of the field (according to the bit numbers 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).

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

Bits labelled "Spare" 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 total size of the frame shall not exceed 1018 octets (see TS 29.281 [2]).

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 5.5.3.24

5.5.2 Frame format for the NR user plane protocol

5.5.2.1 DL USER DATA (PDU Type 0)

This frame format is defined to allow the corresponding node to detect lost NR-U packets and is associated with the transfer of a Downlink NR PDCP PDU.

The following shows the respective DL USER DATA frame.

Bits								Number of Octets
7	6	5	4	3	2	1	0	

PDU Type (=0)		Spare	DL Discard Blocks	DL Flush	Report polling	1
Spare	Request OutofSeq Report	Report Delivered	User data existence flag	Assistance Info. Report Polling Flag	Retransmission flag	1
NR-U Sequence Number						3
DL discard NR PDCP PDU SN						0 or 3
DL discard Number of blocks						0 or 1
DL discard NR PDCP PDU SN start (first block)						0 or 3
Discarded Block size (first block)						0 or 1
...						
DL discard NR PDCP PDU SN start (last block)						0 or 3
Discarded Block size (last block)						0 or 1
DL report NR PDCP PDU SN						0 or 3
Padding						0-3

Figure 5.5.2.1-1: DL USER DATA (PDU Type 0) Format

5.5.2.2 DL DATA DELIVERY STATUS (PDU Type 1)

This frame format is defined to transfer feedback to allow the receiving node (i.e. the node that hosts the NR PDCP entity) to control the downlink user data flow via the sending node (i.e. the corresponding node).

The following shows the respective DL DATA DELIVERY STATUS frame. The Figure shows an example of how a frame is structured when all optional IEs (i.e. those whose presence is indicated by an associated flag) are present.

Absence of such an IE changes the position of all subsequent IEs on octet level.

Bits								Number of Octets
7	6	5	4	3	2	1	0	
PDU Type (=1)				Highest Transmitted NR PDCP SN Ind	Highest Delivered NR PDCP SN Ind	Final Frame Ind.	Lost Packet Report	1
Spare			Delivered NR PDCP SN Range Ind	Data rate Ind.	Retransmitted NR PDCP SN Ind	Delivered Retransmitted NR PDCP SN Ind	Cause Report	1
Desired buffer size for the data radio bearer								4
Desired Data Rate								0 or 4
Number of lost NR-U Sequence Number ranges reported								0 or 1
Start of lost NR-U Sequence Number range								0 or (6* Number of reported lost NR-U SN ranges)
End of lost NR-U Sequence Number range								
Highest successfully delivered NR PDCP Sequence Number								0 or 3
Highest transmitted NR PDCP Sequence Number								0 or 3
Cause Value								0 or 1
Successfully delivered retransmitted NR PDCP Sequence Number								0 or 3
Retransmitted NR PDCP Sequence Number								0 or 3
Number of successfully delivered out of sequence PDCP Sequence Number range								0 or 1
Start of successfully delivered out of sequence PDCP Sequence Number range								0 or (6* Number of successfully delivered out of sequence PDCP Sequence Number range)
End of successfully delivered out of sequence PDCP Sequence Number range								
Padding								0-3

Figure 5.5.2.2-1: DL DATA DELIVERY STATUS (PDU Type 1) Format

5.5.2.3 ASSISTANCE INFORMATION DATA (PDU Type 2)

This frame format is defined to allow the node hosting the NR PDCP entity to receive assistance information.

The following shows the respective ASSISTANCE INFORMATION DATA frame.

Bits								Number of Octets
7	6	5	4	3	2	1	0	
PDU Type (=2)				PDCP Dupl. Ind.	Assistance Info. Ind.	UL Delay Ind.	DL Delay Ind.	1
Spare							PDCP Duplication Activation Suggestion	1
Number of Assistance Information Fields								0 or 1
Assistance Information Type								0 or (2*Number of Assistance Info Fields + sum of Number of octets for Radio Quality Assistance Information Fields)
Number of octets for Radio Quality Assistance Information Fields								
Radio Quality Assistance Information								
UL Delay DU Result								0 or 4
DL Delay DU Result								0 or 4

Figure 5.5.2.3-1: ASSISTANCE INFORMATION DATA (PDU Type 2) Format

5.5.3 Coding of information elements in frames

5.5.3.1 PDU Type

Description: The PDU Type indicates the structure of the NR user plane frame. The field takes the value of the PDU Type it identifies; e.g. "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 USER DATA, 1=DL DATA DELIVERY STATUS, 2= ASSISTANCE INFORMATION DATA, 3-15=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: (0–2ⁿ–1).

Field Length: n bits.

5.5.3.3 Report polling

Description: This parameter indicates that the node hosting the NR PDCP entity requests providing the downlink delivery status report.

Value range: {0=Downlink Data Delivery Status report not requested, 1= Downlink Data Delivery Status report requested}.

Field length: 1 bit.

5.5.3.4 NR-U Sequence Number

Description: This parameter indicates the NR-U sequence number as assigned by the node hosting the NR PDCP entity.

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

Field length: 3 octets.

5.5.3.5 Desired buffer size for the data radio bearer

Description: This parameter indicates the desired buffer size in bytes for the concerned data radio bearer as specified in clause 5.4.2.1.

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

Field length: 4 octets.

5.5.3.6 Desired Data Rate

Description: This parameter indicates the amount of data desired to be received in bytes in a specific amount of time (1 s) for a specific data radio bearer established for the UE as specified in clause 5.4.2.1.

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

Field length: 4 octets.

5.5.3.7 DL Flush

Description: This parameter indicates the presence of DL discard NR PDCP PDU SN.

Value range: {0= DL discard NR PDCP PDU SN not present, 1= DL discard NR PDCP PDU SN present}.

Field length: 1 bit.

5.5.3.8 DL discard NR PDCP PDU SN

Description: This parameter indicates the downlink NR discard PDCP PDU sequence number up to and including which all the NR PDCP PDUs should be discarded.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.9 DL Discard Blocks

Description: This parameter indicates the presence of DL discard Number of blocks, DL discard NR PDCP PDU SN start and Discarded Block size.

Value range: {0= DL discard Number of blocks, DL discard NR PDCP PDU SN start and Discarded Block size not present, 1= DL discard Number of blocks, DL discard NR PDCP PDU SN start and Discarded Block size present}.

Field length: 1 bit.

5.5.3.10 DL discard NR PDCP PDU SN start

Description: This parameter indicates the starting SN of a downlink NR PDCP PDU block to be discarded.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.11 DL discard Number of blocks

Description: This parameter indicates the number of NR PDCP PDU blocks to be discarded.

Value range: $\{1..244\}$.

Field length: 1 octet.

5.5.3.12 Discarded Block size

Description: This parameter indicates the number of NR PDCP PDUs counted from the starting SN to be discarded.

Value range: $\{1..255\}$.

Field length: 1 octet.

5.5.3.13 Lost Packet Report

Description: This parameter indicates the presence of Number of lost NR-U Sequence Number ranges reported, Start of lost NR-U Sequence Number range and End of lost NR-U Sequence Number range.

Value range: $\{0=\text{Number of lost NR-U Sequence Number ranges reported, Start of lost NR-U Sequence Number range and End of lost NR-U Sequence Number range not present}, 1=\text{Number of lost NR-U Sequence Number ranges reported, Start of lost NR-U Sequence Number range and End of lost NR-U Sequence Number range present}\}$.

Field length: 1 bit.

5.5.3.14 Final Frame Indication

Description: This parameter indicates whether the frame is the last DL status report as described in clause 5.4.2.1.

Value range: $\{0=\text{Frame is not final}, 1=\text{Frame is final}\}$.

Field length: 1 bit.

5.5.3.15 Number of lost NR-U Sequence Number ranges reported

Description: This parameter indicates the number of NR-U Sequence Number ranges reported to be lost.

Value range: $\{1..161\}$.

Field length: 1 octet.

5.5.3.16 Start of lost NR-U Sequence Number range

Description: This parameter indicates the start of an NR-U sequence number range reported to be lost.

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

Field length: 3 octets.

5.5.3.17 End of lost NR-U Sequence Number range

Description: This parameter indicates the end of an NR-U sequence number range reported to be lost.

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

Field length: 3 octets.

5.5.3.18 Highest Delivered NR PDCP SN Ind

Description: This parameter indicates the presence of Highest successfully delivered PDCP Sequence Number.

Value range: $\{0=$ Highest successfully delivered PDCP Sequence Number not present, $1=$ Highest successfully delivered PDCP Sequence Number present $\}$.

Field length: 1 bit.

5.5.3.19 Highest successfully delivered NR PDCP Sequence Number

Description: This parameter indicates feedback about the in-sequence delivery status of NR PDCP PDUs at the corresponding node towards the UE.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.20 Highest Transmitted NR PDCP SN Ind

Description: This parameter indicates the presence of the Highest transmitted NR PDCP Sequence Number.

Value range: $\{0=$ Highest transmitted NR PDCP Sequence Number not present, $1=$ Highest transmitted NR PDCP Sequence Number present $\}$.

Field length: 1 bit.

5.5.3.21 Highest transmitted NR PDCP Sequence Number

Description: This parameter indicates the feedback about the transmitted status of NR PDCP PDU sequence at the corresponding node to the lower layers.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.22 Cause Report

Description: This parameter indicates the presence of Cause Value.

Value range: $\{0=$ Cause Value not present, $1=$ Cause Value present $\}$.

Field length: 1 bit.

5.5.3.23 Cause Value

Description: This parameter indicates specific events reported by the corresponding node.

Value range: $\{0=$ UNKNOWN, $1=$ RADIO LINK OUTAGE, $2=$ RADIO LINK RESUME, $3=$ UL RADIO LINK OUTAGE, $4=$ DL RADIO LINK OUTAGE, $5=$ UL RADIO LINK RESUME, $6=$ DL RADIO LINK RESUME, $7-228=$ reserved for future value extensions, $229-255=$ reserved for test purposes $\}$

Field length: 1 octet.

5.5.3.24 Padding

Description: The padding is included at the end of the frame to ensure that the NR user plane protocol PDU length (including padding and the Future Extension) is $(n \cdot 4 - 2)$ 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.

5.5.3.28 Void

Void.

5.5.3.29 Retransmission flag

Description: This parameter indicates whether the NR PDCP PDU is a retransmission NR-U packet sent by the node hosting the NR PDCP entity to the corresponding node.

Value range: {0= Not a retransmission NR-U packet, 1= Retransmission NR-U packet}.

Field length: 1 bit.

5.5.3.30 Delivered Retransmitted NR PDCP SN Ind

Description: This parameter indicates the presence of successfully delivered retransmitted PDCP Sequence Number.

Value range: {0= Successfully delivered retransmitted PDCP Sequence Number not present, 1= Successfully delivered retransmitted PDCP Sequence Number present}.

Field length: 1 bit.

5.5.3.31 Retransmitted NR PDCP SN Ind

Description: This parameter indicates the presence of retransmitted NR PDCP Sequence Number.

Value range: {0= Retransmitted NR PDCP Sequence Number not present, 1= Retransmitted NR PDCP Sequence Number present}.

Field length: 1 bit.

5.5.3.32 Successfully delivered retransmitted NR PDCP Sequence Number

Description: This parameter indicates the NR PDCP PDU sequence number associated with the highest NR-U sequence number among the retransmission NR PDCP PDUs successfully delivered to the UE in sequence of NR-U sequence number.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.33 Retransmitted NR PDCP Sequence Number

Description: This parameter indicates the NR PDCP PDU sequence number associated with the highest NR-U sequence number among the retransmission NR PDCP PDUs transmitted to the lower layers in sequence of NR-U sequence number.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.34 Data Rate Indication

Description: This parameter indicates the presence of the Desired Data Rate.

Value range: {0= Desired Data Rate Information is not present, 1= Desired Data Rate Information is present}.

Field length: 1 bit.

5.5.3.35 PDCP Duplication Indication

Description: This field indicates the presence of the PDCP Duplication Activation Suggestion.

Value range: {0= PDCP Duplication Activation Suggestion not present, 1= PDCP Duplication Activation Suggestion present}.

Field length: 1 bit.

5.5.3.36 PDCP Duplication Activation Suggestion

Description: This parameter indicates the suggestion given by the corresponding node on whether PDCP duplication should be activated or not.

Value range: {0= Do not duplicate, 1= Duplicate}.

Field length: 1 bit.

5.5.3.37 Number of Assistance Information Field

Description: This field indicates the number of Assistance Information Type and Radio Quality Assistance Information pairs concatenated.

Value range: {1..2⁸-1}.

Field length: 1 octet.

5.5.3.38 Assistance Information Type

Description: This field describes the type of radio quality assistance information provided, if supported, by the corresponding node to the node hosting the NR PDCP entity. The DL Radio Quality Index is a numerical index expressing the radio quality of the data radio bearer or the RLC entity in DL, where the value 0 represents the lowest quality. The UL Radio Quality Index is a numerical index expressing the radio quality of the data radio bearer or the RLC entity in UL, where the value 0 represents the lowest quality. The averaging window for the Average CQI, Average HARQ Failure and Average HARQ Retransmission is set by means of configuration. Power Headroom Report is PHR MAC control element reported by as defined in 3GPP TS 36.321[4] and 3GPP TS 38.321[5]

Value range: {0=UNKNOWN, 1=Average CQI, 2=Average HARQ Failure, 3=Average HARQ Retransmissions, 4= DL Radio Quality Index, 5= UL Radio Quality Index, 6= Power Headroom Report, 7-228=reserved for future value extensions, 229-255=reserved for test purposes}.

Field length: 1 octet.

5.5.3.39 Radio Quality Assistance Information

Description: This parameter indicates one of the assistance information indicated by the Assistance Information Type.

Value range: {0..2⁸-1}.

Field length: 1 octet.

5.5.3.40 Assistance Information Report Polling Flag

Description: This parameter indicates that the node hosting the NR PDCP entity requests the corresponding node to send an ASSISTANCE INFORMATION DATA PDU.

Value range: {0= Assistance Information Data not requested, 1= Assistance Information Data requested}.

Field length: 1 bit.

5.5.3.41 Report Delivered

Description: This parameter indicates the presence of DL report NR PDCP PDU SN.

Value range: {0= DL report NR PDCP PDU SN not present, 1= DL report NR PDCP PDU SN present}.

Field length: 1 bit.

5.5.3.42 DL report NR PDCP PDU SN

Description: This parameter indicates that the node hosting PDCP entity requests providing the down link delivery status report when the NR PDCP PDU with this sequence number has been successfully delivered.

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

Field length: 3 octets.

5.5.3.43 User data existence flag

Description: This parameter indicates whether the node hosting the NR PDCP entity has some user data for the concerned data radio bearer.

Value range: {0= the node hosting the NR PDCP entity has no more user data for the concerned data radio bearer, 1= the node hosting the NR PDCP entity has some user data for the concerned data radio bearer}.

Field length: 1 bit.

5.5.3.44 Number of octets for Radio Quality Assistance Information Field

Description: This field indicates the number of octets for Radio Quality Assistance Information exists. For Average CQI, Average HARQ Failure, Average HARQ Retransmissions, DL Radio Quality Index, UL Radio Quality Index, this field shall indicate as "1." For Power Headroom Report, this field shall indicate octet length of Power Headroom Report as defined in 3GPP TS 36.321[4] and 3GPP TS 38.321[5].

Value range: {0.. 2^8 -1}.

Field length: 1 octets.

5.5.3.45 Assistance Information Indication

Description: This field indicates the presence of the Number of Assistance Information Fields.

Value range: {0= Number of Assistance Information Fields not present, 1= Number of Assistance Information Fields present}.

5.5.3.46 UL Delay Indicator

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

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

Field length: 1 bit.

5.5.3.47 DL Delay Indicator

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

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

Field length: 1 bit.

5.5.3.48 UL Delay DU Result

Description: This field indicates UL delay measured at the corresponding node in milliseconds for the concerned DRB over Uu interface. It is encoded as an Unsigned32 binary integer value. The node hosting PDCP entity shall, if supported, use this information to calculate the total UL delay for the concerned DRB and report to the UPF for the purpose of QoS monitoring as specified in [8].

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

Field length: 4 octets.

5.5.3.49 DL Delay DU Result

Description: This field indicates DL delay measured at the corresponding node in milliseconds for the concerned DRB over Uu interface. It is encoded as an Unsigned32 binary integer value. The node hosting PDCP entity shall, if supported, use this information to calculate the total DL delay for the concerned DRB and report to the UPF for the purpose of QoS monitoring as specified in [8].

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

Field length: 4 octets.

5.5.3.50 Delivered NR PDCP SN Range Ind

Description: This field indicates the presence of the Number of successfully delivered out of sequence PDCP Sequence Number range, Start of successfully delivered out of sequence PDCP Sequence Number range and End of successfully delivered out of sequence PDCP Sequence Number range.

Value range: {0= Number of successfully delivered out of sequence PDCP Sequence Number range, Start of successfully delivered out of sequence PDCP Sequence Number range and End of successfully delivered out of sequence PDCP Sequence Number range not present, 1= Number of successfully delivered out of sequence PDCP Sequence Number range, Start of successfully delivered out of sequence PDCP Sequence Number range and End of successfully delivered out of sequence PDCP Sequence Number range present}.

5.5.3.51 Number of successfully delivered out of sequence PDCP Sequence Number range

Description: This parameter indicates the number of PDCP Sequence Number ranges reported to be successfully delivered out of sequence.

Value range: {1..255}.

Field length: 1 octet.

5.5.3.52 Start of successfully delivered out of sequence PDCP Sequence Number range

Description: This parameter indicates the start of a PDCN sequence number range reported to be successfully delivered out of sequence.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.53 End of successfully delivered out of sequence PDCP Sequence Number range

Description: This parameter indicates the end of a PDCN sequence number range reported to be successfully delivered out of sequence.

Value range: $\{0..2^{18}-1\}$.

Field length: 3 octets.

5.5.3.54 Request OutOfSeq Report

Description: This parameter indicates that the node hosting the NR PDCP entity requests the corresponding node to report the NR PDCP PDU sequence number successfully delivered out of sequence in downlink delivery status report.

Value range: {0= NR PDCP PDU sequence number successfully delivered out of sequence reporting in downlink delivery status report not requested, 1= NR PDCP PDU sequence number successfully delivered out of sequence reporting in downlink delivery status report requested}.

Field length: 1 bit.

5.5.4 Timers

Not applicable.

5.6 Handling of unknown, unforeseen and erroneous protocol data

Void.

Annex A (informative): Example of using future Extension

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 X.Y: 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 indicaes 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
2017-04	R3#95b	R3-171173	-	-	-	TS skeleton	0.0.0
2017-04	R3#95b	R3-171318	-	-	-	Merged TPs from R3#95b: R3-171346	0.0.0
2017-05	R3#96	R3-171743	-	-	-	Editorial changes	0.0.2
2017-06	R3#ad-hoc2		-	-	-	Submission	0.1.0
2017-10	R3#97bis	R3-173978 R3-174222	-	-	-	Incorporated agreed pCRs from R3#97bis	0.2.0
2017-11	R3#98	R3-174957 R3-174792 R3-175031 R3-174982	-	-	-	Incorporated agreed pCRs from R3#98	0.3.0
2017-12	RP-78					TS submitted to RAN plenary for Approval	1.0.0
2017-12	RP-78					TS approved by RAN plenary	15.0.0
2018-03	RP-79	RP-180468	0001	1	F	Rapporteur's update to TS38.425	15.1.0
2018-03	RP-79	RP-180468	0002	-	F	Corrections to NR UP protocol	15.1.0
2018-03	RP-79	RP-180468	0003	1	B	Data Retransmission Indication	15.1.0
2018-03	RP-79	RP-180468	0006	2	F	Avoiding exceeding the max size of the NR RAN Container	15.1.0
2018-03	RP-79	RP-180468	0010	2	F	Clarification and correction on U-plane for EN-DC	15.1.0
2018-03	RP-79	RP-180468	0014	1	F	Correction of frame structure and Spare extension	15.1.0
2018-03	RP-79	RP-180468	0015	1	F	Triggering of DDDS delivery	15.1.0
2018-03	RP-79	RP-180468	0016	-	F	Correction to DL Discard	15.1.0
2018-03	RP-79	RP-180468	0017	1	F	Clarifications on UP IE presence	15.1.0
2018-06	RP-80	RP-181238	0022	1	F	Correction on Initial DDDS triggering	15.2.0
2018-06	RP-80	RP-181238	0024	1	F	Clarification of the use of the desired buffer size	15.2.0
2018-06	RP-80	RP-181238	0028	1	F	Correction of Reporting PDCP SN	15.2.0
2018-06	RP-80	RP-181373	0029	-	F	Correction the max value of one octet	15.2.0
2018-06	RP-80	RP-181272	0032	3	F	Introduction of assistance information for DL PDCP duplication (38.425 Baseline CR covering RAN3 agreements)	15.2.0
2018-06	RP-80	RP-181239	0034	1	F	Final Frame Indication	15.2.0
2018-06	RP-80	RP-181238	0035	-	F	Correction on padding	15.2.0
2018-06	RP-80	RP-181238	0037	1	F	UL and DL outage	15.2.0
2018-06	RP-80	RP-181239	0039	1	F	Various corrections for the NR UP	15.2.0
2018-06	RP-80	RP-181239	0045	1	F	Rapporteur's update to TS38.425 v15.1.0	15.2.0
2018-06	RP-80	RP-181239	0047	-	F	Correction on length for retransmission	15.2.0
2018-09	RP-81	RP-181922	0049	4	F	NR Corrections (38.425 Baseline CR covering RAN3-101 agreements)	15.3.0
2018-09	RP-81	RP-181920	0050	2	F	CR on data existence indication for split bearer	15.3.0
2018-09	RP-81	RP-181920	0051	1	F	CR on Radio Quality Assistance Information for PHR	15.3.0
2018-09	RP-81	RP-181920	0054	-	F	Correct the range of the DL discard Number of blocks IE	15.3.0
2018-09	RP-81	RP-181921	0057	2	F	Correction on PDCP duplication indication	15.3.0
2018-12	RP-82	RP-182446	0061	1	F	Clarification of the NR UP initialisation	15.4.0
2018-12	RP-82	RP-182446	0066	-	F	Differentiate RLC AM and UM for user plane	15.4.0
2018-12	RP-82	RP-182446	0067	-	F	Corrections on DL USER DATA frame	15.4.0
2018-12	RP-82	RP-182446	0068	-	F	Miscellaneous corrections for User Plane	15.4.0
2018-12	RP-82	RP-182447	0070	-	F	DDDS polling clarification	15.4.0
2018-12	RP-82	RP-182447	0073	1	F	Retransmission Status in UP	15.4.0
2019-03	RP-83	RP-190555	0078	1	F	Final Frame Indication in NR-UP	15.5.0
2019-07	RP-84	RP-191394	0083	2	F	Clarification on desired buffer size	15.6.0
2020-03	RP-87-e	RP-200425	0105	2	B	E2E delay measurement for Qos monitoring for URLLC	16.0.0
2020-07	RP-88-e	RP-201079	0102	8	B	Resource efficient PDCP duplication: enhancement 3	16.1.0
2020-07	RP-88-e	RP-201077	0103	7	B	BL CR to 38.425: Support for IAB	16.1.0
2020-07	RP-88-e	RP-201085	0107		F	Rapporteur's correction for TS 38.425	16.1.0
2020-09	RP-89-e	RP-201955	0110	-	A	Correction of Downlink Data Delivery Status	16.2.0