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Contents

Foreword

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

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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 NR user plane protocol functions used within NG-RAN and, for EN-DC and LTE UP-CP split 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. User plane protocol functions support both E-UTRA PDCP and NR PDCP.

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".

[9] 3GPP TS 36.401: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture description".

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 PDCP for flow control. In an IAB network, this is the IAB-DU serving the UE for the corresponding data radio bearer.

eNB-CP: as defined in TS 36.401 [9].

eNB-UP: as defined in TS 36.401 [9].

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
MBS	Multicast/Broadcast Service
MR-DC	Multi-RAT Dual Connectivity
MRB	MBS Radio Bearer
PTM	Point To Multipoint

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 or the W1 interface or the UP interface between eNB-CP and eNB-UP.

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 or at nodes hosting W1-U protocol terminations or at eNB-CP and eNB-UP. 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 PDCP to the corresponding node.

5.2 NR user plane protocol layer services

NOTE 1: In this section, NR user plane protocol layer services are also applicable to E-UTRA PDCP. With this understanding, each instance of NR PDCP can be replaced by E-UTRA PDCP.

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

NOTE 1: In this section, NR user plane elementary procedures are also applicable to E-UTRA PDCP unless specified otherwise. With this understanding, each instance of NR PDCP can be replaced by E-UTRA PDCP unless specified otherwise.

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 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).

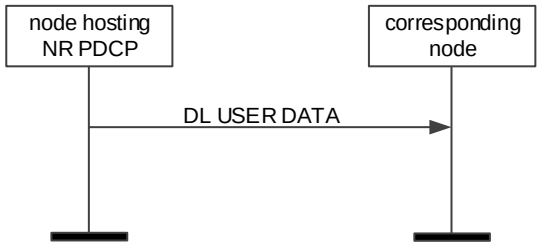

Figure 5.4.1.1-1: Successful Transfer of Downlink User Data

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;

NOTE 1: If the NR user plane protocol instance is associated a single RLC-AM entity for an MRB, specification text in bullet a) is applicable.

For all other cases, if the NR user plane protocol instance is associated with an MRB configured with at least one RLC AM entity and RLC-UM, the highest successfully delivered NR PDCP sequence number indicates the combined feedback of the highest NR PDCP sequence number successfully delivered in sequence to all the involved UEs for which the RLC AM entites have been configured, no retransmissions are performed, and the highest NR PDCP sequence number transmitted to the lower layers for PTM.

b) the desired buffer size in bytes for the concerned data radio bearer or for the MRB;

c) optionally, the desired data rate in bytes associated with a specific data radio bearer configured for the UE or for the MRB;

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 2: If the NR user plane protocol instance is associated with an MRB configured with RLC-UM entities only, the highest NR PDCP PDU sequence number transmitted successfully to all lower layer instances is reported.

NOTE 3: If a deployment has decided not to use the Transfer of Downlink User Data procedure, d), e) and f) above are not applicable.

h) 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. These indications are not applicable to E-UTRA PDCP.

For report polling triggered reporting, the DL DATA DELIVERY STATUS frame may include the feedback delay result and the NR-U sequence number of the frame where Report Polling Flag is included and that triggered the signalling of the DL DATA DELIVERY STATUS.

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:
    - first including the data to be retransmitted;
    - then the new data, starting from the last "Highest successfully delivered NR PDCP Sequence Number" for RLC AM if received, or 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;