**3GPP TSG-RAN2 Meeting #109-e *R2-2001766***

**Electronic meeting, 24 Feb – 6 Mar 2020**

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| *CR-Form-v12.0* |
| **CHANGE REQUEST** |
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|  | **38.323** | **CR** | **0042** | **rev** | **2** | **Current version:** | **15.6.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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|  |
| ***Title:***  | Introduction of DAPS handover |
|  |  |
| ***Source to WG:*** | Huawei, HiSilicon, Mediatek Inc. |
| ***Source to TSG:*** | R2 |
|  |  |
| ***Work item code:*** | NR\_Mob\_enh-Core |  | ***Date:*** | 2020-03-05 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-16 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)Rel-12 (Release 12)**Rel-13 (Release 13)Rel-14 (Release 14)Rel-15 (Release 15)Rel-16 (Release 16)* |
|  |  |
| ***Reason for change:*** | Introduction of DAPS handover for minimizing interruption time during handover. |
|  |  |
| ***Summary of change:*** | Introduction of DAPS handover. |
|  |  |
| ***Consequences if not approved:*** | DAPS handover is not supported. |
|  |  |
| ***Clauses affected:*** | 3.1, 3.2, 4.1, 4.2, 4.4, 5.1, 5.2, 5.4, 5.6, 5.7, 5.8, 5.9, 5.x |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS 38.300 CR0172TS 38.306 CR0250TS 38.331 CR1478TS 38.321 CR0687 |
| ***affected:*** |  | **X** |  Test specifications |  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications |  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

*START OF CHANGES*

# 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].

**AM DRB**:a data radio bearer which utilizes RLC AM.

**DAPS bearer**:a bearer whose radio protocols are located in both the source gNB and the target gNB during DAPS handover to use both source gNB and target gNB resources.

**Non-split bearer**: a bearer whose radio protocols are located in either the MgNB or the SgNB to use MgNB or SgNB resource, respectively.

**PDCP data volume**: the amount of data available for transmission in a PDCP entity.

**Split bearer**: in dual connectivity, a bearer whose radio protocols are located in both the MgNB and the SgNB to use both MgNB and SgNB resources.

**UM DRB**:a data radio bearer which utilizes RLC UM.

*NEXT CHANGE*

## 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].

AM Acknowledged Mode

CID Context Identifier

DAPS Dual Active Protocol Stack

DRB Data Radio Bearer carrying user plane data

gNB NR Node B

HFN Hyper Frame Number

IETF Internet Engineering Task Force

IP Internet Protocol

MAC Medium Access Control

MAC-I Message Authentication Code for Integrity

PDCP Packet Data Convergence Protocol

PDU Protocol Data Unit

RB Radio Bearer

RFC Request For Comments

RLC Radio Link Control

ROHC RObust Header Compression

RRC Radio Resource Control

RTP Real Time Protocol

SAP Service Access Point

SDU Service Data Unit

SN Sequence Number

SRB Signalling Radio Bearer carrying control plane data

TCP Transmission Control Protocol

UDP User Datagram Protocol

UE User Equipment

UM Unacknowledged Mode

X-MAC Computed MAC-I

*NEXT CHANGE*

# 4 General

## 4.1 Introduction

The present document describes the functionality of the PDCP.

## 4.2 Architecture

### 4.2.1 PDCP structure

Figure 4.2.1.1 represents one possible structure for the PDCP sublayer; it should not restrict implementation. The figure is based on the radio interface protocol architecture defined in TS 38.300 [2].



Figure 4.2.1-1: PDCP layer, structure view

The PDCP sublayer is configured by upper layers TS 38.331 [3]. The PDCP sublayer is used for RBs mapped on DCCH and DTCH type of logical channels. The PDCP sublayer is not used for any other type of logical channels.

Each RB (except for SRB0) is associated with one PDCP entity. Each PDCP entity is associated with one, two, or four RLC entities depending on the RB characteristic (e.g uni-directional/bi-directional or split/non-split) or RLC mode:

- For split bearers or for RBs configured with PDCP duplication, each PDCP entity is associated with two UM RLC entities (for same direction), four UM RLC entities (two for each direction), or two AM RLC entities (for same direction);

- For DAPS bearers, each PDCP entity is associated with two UM RLC entities (for same direction, one for source and one for target cell), four UM RLC entities (two for each direction on source cell and target cell), or two AM RLC entities (for same direction, one for source cell and one for target cell);

- Otherwise, each PDCP entity is associated with one UM RLC entity, two UM RLC entities (one for each direction), or one AM RLC entity.

*NEXT CHANGE*

### 4.2.2 PDCP entities

The PDCP entities are located in the PDCP sublayer. Several PDCP entities may be defined for a UE. Each PDCP entity is carrying the data of one radio bearer. A PDCP entity is associated either to the control plane or the user plane depending on which radio bearer it is carrying data for.

Figure 4.2.2.1 represents the functional view of the PDCP entity for the PDCP sublayer; it should not restrict implementation. The figure is based on the radio interface protocol architecture defined in TS 38.300 [2].

For split bearers and DAPS bearers, routing is performed in the transmitting PDCP entity.



Figure 4.2.2-1: PDCP layer, functional view

Figure 4.2.2.x represents the functional view of the PDCP entity associated with the DAPS bearer for the PDCP sublayer; it should not restrict implementation. The figure is based on the radio interface protocol architecture defined in TS 38.300 [2].

For DAPS bearers, the PDCP entity is configured with two sets of security functions and keys and two sets of header compression protocols.

*FFS: how to handle PDCP entities of SRB, DAPS DRB and non-DAPS DRB in case of DAPS HO without key change.*



**Figure 4.2.2.x – PDCP layer with DAPS, functional view**

*NEXT CHANGE*

## 4.4 Functions

The PDCP layer supports the following functions:

- transfer of data (user plane or control plane);

- maintenance of PDCP SNs;

- header compression and decompression using the ROHC protocol;

- ciphering and deciphering;

- integrity protection and integrity verification;

- timer based SDU discard;

- for split bearers and DAPS bearers, routing;

- duplication;

- reordering and in-order delivery;

- out-of-order delivery;

- duplicate discarding.

*NEXT CHANGE*

# 5 Procedures

## 5.1 PDCP entity handling

### 5.1.X PDCP entity reconfiguration

When upper layers request a PDCP entity reconfiguration and DAPS is configured for a data radio bearer, UE shall:

- establish a ciphering function for the radio bearer and apply the ciphering algorithm and key provided by upper layers for the ciphering function;

- establish an integrity protection function for the radio bearer and apply the integrity protection algorithm and key provided by upper layers for the integrity protection function;

- establish a header compression protocol for the radio bearer and apply the header compression configuration provided by upper layers for the header compression protocol.

When upper layers request a PDCP entity reconfiguration and the associated RLC entity is released for a radio bearer, UE shall:

- release the ciphering function associated to the released RLC entity for the radio bearer;

- release the integrity protection function associated to the released RLC entity for the radio bearer;

- release the header compression protocol associated to the released RLC entity for the radio bearer.

NOTE 1: The state variables which control the transmission and reception operation should not be reset, and the timers including *t-Reordering* and *discardTimer* keep running during PDCP entity reconfiguration procedure.

NOTE 2: Before releasing the header compression protocol associated to the released RLC entity, how to handle all stored PDCP SDUs received from the released RLC entity is left up to UE implementation.

*NEXT CHANGE*

## 5.2 Data transfer

### 5.2.1 Transmit operation

At reception of a PDCP SDU from upper layers, the transmitting PDCP entity shall:

- start the *discardTimer* associated with this PDCP SDU (if configured).For a PDCP SDU received from upper layers, the transmitting PDCP entity shall:

- associate the COUNT value corresponding to TX\_NEXT to this PDCP SDU;

NOTE 1: Associating more than half of the PDCP SN space of contiguous PDCP SDUs with PDCP SNs, when e.g., the PDCP SDUs are discarded or transmitted without acknowledgement, may cause HFN desynchronization problem. How to prevent HFN desynchronization problem is left up to UE implementation.

- perform header compression of the PDCP SDU as specified in the clause 5.7.4;

- perform integrity protection, and ciphering using the TX\_NEXT as specified in the clause 5.9 and 5.8, respectively;

- set the PDCP SN of the PDCP Data PDU to TX\_NEXT modulo 2[*pdcp-SN-SizeUL*];

- increment TX\_NEXT by one;

- submit the resulting PDCP Data PDU to lower layer as specified below.

When submitting a PDCP PDU to lower layer, the transmitting PDCP entity shall:

- if the transmitting PDCP entity is associated with one RLC entity:

- submit the PDCP PDU to the associated RLC entity;

- else, if the transmitting PDCP entity is associated with two RLC entities:

- if the PDCP duplication is activated:

- if the PDCP PDU is a PDCP Data PDU:

- duplicate the PDCP Data PDU and submit the PDCP Data PDU to both associated RLC entities;

- else:

- submit the PDCP Control PDU to the primary RLC entity;

- else:

- if the two associated RLC entities belong to the different Cell Groups; and

- if the transmitting PDCP entity is not associated with a DAPS bearer; and

- if the total amount of PDCP data volume and RLC data volume pending for initial transmission (as specified in TS 38.322 [5]) in the two associated RLC entities is equal to or larger than *ul-DataSplitThreshold*:

- submit the PDCP PDU to either the primary RLC entity or the secondary RLC entity;

- else, if the transmitting PDCP entity is associated with the DAPS bearer:

- if the uplink data switching has not been requested:

- submit the PDCP PDU to the RLC entity associated with the source cell;

- else:

- if the PDCP PDU is a PDCP Data PDU:

- submit the PDCP Data PDU to the RLC entity associated with the target cell;

- else:

- if the PDCP Control PDU is associated with source cell:

 - submit the PDCP Control PDU to the RLC entity associated with the source cell;

- else:

 - submit the PDCP Control PDU to the RLC entity associated with the target cell;

- else:

- submit the PDCP PDU to the primary RLC entity.

NOTE 2: If the transmitting PDCP entity is associated with two RLC entities, the UE should minimize the amount of PDCP PDUs submitted to lower layers before receiving request from lower layers and minimize the PDCP SN gap between PDCP PDUs submitted to two associated RLC entities to minimize PDCP reordering delay in the receiving PDCP entity.

*NEXT CHANGE*

## 5.4 Status reporting

### 5.4.1 Transmit operation

For AM DRBs configured by upper layers to send a PDCP status report in the uplink (*statusReportRequired* in TS 38.331 [3]), the receiving PDCP entity shall trigger a PDCP status report when:

- upper layer requests a PDCP entity re-establishment;

- upper layer requests a PDCP data recovery;

- upper layer requests a uplink data switching;

- upper layer requests a PDCP entity reconfiguration and the associated RLC entity is released for a radio bearer.

If a PDCP status report is triggered, the receiving PDCP entity shall:

- compile a PDCP status report as indicated below by:

- setting the FMC field to RX\_DELIV;

- if RX\_DELIV < RX\_NEXT:

- allocating a Bitmap field of length in bits equal to the number of COUNTs from and not including the first missing PDCP SDU up to and including the last out-of-sequence PDCP SDUs, rounded up to the next multiple of 8, or up to and including a PDCP SDU for which the resulting PDCP Control PDU size is equal to 9000 bytes, whichever comes first;

- setting in the bitmap field as '0' for all PDCP SDUs that have not been received, and optionally PDCP SDUs for which decompression have failed;

- setting in the bitmap field as '1' for all PDCP SDUs that have been received;

- submit the PDCP status report to lower layers as the first PDCP PDU for transmission via the transmitting PDCP entity as specified in clause 5.2.1.

*FFS: whether PDCP status reporting for DAPS bearers is needed for UL or DL for RLC UM.*

*NEXT CHANGE*

## 5.6 Data volume calculation

For the purpose of MAC buffer status reporting, the transmitting PDCP entity shall consider the following as PDCP data volume:

- the PDCP SDUs for which no PDCP Data PDUs have been constructed;

- the PDCP Data PDUs that have not been submitted to lower layers;

- the PDCP Control PDUs;

- for AM DRBs, the PDCP SDUs to be retransmitted according to clause 5.1.2;

- for AM DRBs, the PDCP Data PDUs to be retransmitted according to clause 5.5.

If the transmitting PDCP entity is associated with two RLC entities, when indicating the PDCP data volume to a MAC entity for BSR triggering and Buffer Size calculation (as specified in TS 38.321 [4] and TS 36.321 [12]), the transmitting PDCP entity shall:

- if the PDCP duplication is activated:

- indicate the PDCP data volume to the MAC entity associated with the primary RLC entity;

- indicate the PDCP data volume excluding the PDCP Control PDU to the MAC entity associated with the secondary RLC entity;

- else:

- if the two associated RLC entities belong to the different Cell Groups; and

- if the transmitting PDCP entity is not associated with a DAPS bearer; and

- if the total amount of PDCP data volume and RLC data volume pending for initial transmission (as specified in TS 38.322 [5]) in the two associated RLC entities is equal to or larger than *ul-DataSplitThreshold*:

- indicate the PDCP data volume to both the MAC entity associated with the primary RLC entity and the MAC entity associated with the secondary RLC entity;

- else, if the transmitting PDCP entity is associated with the DAPS bearer:

- if the uplink data switching has not been requested:

 - indicate the PDCP data volume to the MAC entity associated with the source cell;

- else:

- indicate the PDCP data volume excluding the PDCP Control PDU for interspersed ROHC feedback associated with the source cell to the MAC entity associated with the target cell;

- indicate the PDCP data volume of PDCP Control PDU for interspersed ROHC feedback associated with the source cell to the MAC entity assocaited with the source cell;- else:

- indicate the PDCP data volume to the MAC entity associated with the primary RLC entity;

- indicate the PDCP data volume as 0 to the MAC entity associated with the secondary RLC entity.

*NEXT CHANGE*

### 5.7.2 Configuration of header compression

PDCP entities associated with DRBs can be configured by upper layers TS 38.331 [3] to use header compression. Each PDCP entity carrying user plane data may be configured to use header compression. In this version of the specification, only the robust header compression protocol (ROHC) is supported. For DRBs other than DAPS bearers, the PDCP entity uses at most one ROHC compressor instance and at most one ROHC decompressor instance. For DAPS bearers, the PDCP entity uses at most one ROHC compressor instance and at most two ROHC decompressor instances.

*NEXT CHANGE*

### 5.7.4 Header compression

If header compression is configured, the header compression protocol generates two types of output packets:

- compressed packets, each associated with one PDCP SDU;

- standalone packets not associated with a PDCP SDU, i.e. interspersed ROHC feedback.

A compressed packet is associated with the same PDCP SN and COUNT value as the related PDCP SDU. The header compression is not applicable to the SDAP header and the SDAP Control PDU if included in the PDCP SDU.

For DAPS bearers, the PDCP entity shall perform the header compression for the PDCP SDU using the ROHC protocol either configured for the source cell or configured for the target cell, based on to which cell the PDCP SDU is transmitted.

Interspersed ROHC feedback are not associated with a PDCP SDU. They are not associated with a PDCP SN and are not ciphered.

NOTE: If the MAX\_CID number of ROHC contexts are already established for the compressed flows and a new IP flow does not match any established ROHC context, the compressor should associate the new IP flow with one of the ROHC CIDs allocated for the existing compressed flows or send PDCP SDUs belonging to the IP flow as uncompressed packet.

*FFS: whether/how to specify network behavior and how to handle source/target, regarding agreement “The target cell always transmits the PDCP PDUs containing IR packet until releasing the source cell”*

*NEXT CHANGE*

### 5.7.5 Header decompression

If header compression is configured by upper layers for PDCP entities associated with user plane data, the PDCP Data PDUs are decompressed by the header compression protocol after performing deciphering as explained in clause 5.8. The header decompression is not applicable to the SDAP header and the SDAP Control PDU if included in the PDCP Data PDU.

For DAPS bearers, the PDCP entity shall perform the header decompression for the PDCP SDU using the ROHC protocol either configured for the source cell or configured for the target cell, based on from which cell the PDCP SDU is received.

*NEXT CHANGE*

### 5.7.6 PDCP Control PDU for interspersed ROHC feedback

#### 5.7.6.1 Transmit Operation

When an interspersed ROHC feedback is generated by the header compression protocol, the transmitting PDCP entity shall:

- submit to lower layers the corresponding PDCP Control PDU as specified in clause 6.2.3.2 i.e. without associating a PDCP SN, nor performing ciphering, as specified in clause 5.2.1.

#### 5.7.6.2 Receive Operation

At reception of a PDCP Control PDU for interspersed ROHC feedback from lower layers, the receiving PDCP entity shall:

- deliver the corresponding interspersed ROHC feedback to the associated header compression protocol without performing deciphering.

*NEXT CHANGE*

## 5.8 Ciphering and deciphering

The ciphering function includes both ciphering and deciphering and is performed in PDCP, if configured. The data unit that is ciphered is the MAC-I (see clause 6.3.4) and the data part of the PDCP Data PDU (see clause 6.3.3) except the SDAP header and the SDAP Control PDU if included in the PDCP SDU. The ciphering is not applicable to PDCP Control PDUs.

The ciphering algorithm and key to be used by the PDCP entity are configured by upper layers TS 38.331 [3] and the ciphering method shall be applied as specified in TS 33.501 [6].

The ciphering function is activated/suspended/resumed by upper layers TS 38.331 [3]. When security is activated and not suspended, the ciphering function shall be applied to all PDCP Data PDUs indicated by upper layers TS 38.331 [3] for the downlink and the uplink, respectively.

For DAPS bearers, the PDCP entity shall perform the ciphering or deciphering for the PDCP SDU using the ciphering algorithm and key either configured for the source cell or configured for the target cell, based on to/from which cell the PDCP SDU is transmitted/received.

For downlink and uplink ciphering and deciphering, the parameters that are required by PDCP for ciphering are defined in TS 33.501 [6] and are input to the ciphering algorithm. The required inputs to the ciphering function include the COUNT value, and DIRECTION (direction of the transmission: set as specified in TS 33.501 [6]).The parameters required by PDCP which are provided by upper layers TS 38.331 [3] are listed below:

- BEARER (defined as the radio bearer identifier in TS 33.501 [6]. It will use the value RB identity –1 as in TS 38.331 [3]);

- KEY (the ciphering keys for the control plane and for the user plane are KRRCenc and KUPenc, respectively).

*NEXT CHANGE*

## 5.9 Integrity protection and verification

The integrity protection function includes both integrity protection and integrity verification and is performed in PDCP, if configured. The data unit that is integrity protected is the PDU header and the data part of the PDU before ciphering. The integrity protection is always applied to PDCP Data PDUs of SRBs. The integrity protection is applied to PDCP Data PDUs of DRBs for which integrity protection is configured. The integrity protection is not applicable to PDCP Control PDUs.

The integrity protection algorithm and key to be used by the PDCP entity are configured by upper layers TS 38.331 [3] and the integrity protection method shall be applied as specified in TS 33.501 [6].

The integrity protection function is activated/suspended/resumed by upper layers TS 38.331 [3]. When security is activated and not suspended, the integrity protection function shall be applied to all PDUs including and subsequent to the PDU indicated by upper layers TS 38.331 [3] for the downlink and the uplink, respectively.

NOTE: As the RRC message which activates the integrity protection function is itself integrity protected with the configuration included in this RRC message, this message needs first be decoded by RRC before the integrity protection verification could be performed for the PDU in which the message was received.

For DAPS bearers, the PDCP entity shall perform the integrity protection or verfication for the PDCP SDU using the integrity protection algorithm and key either configured for the source cell or configured for the target cell, based on to/from which cell the PDCP SDU is transmitted/received.

For downlink and uplink integrity protection and verification, the parameters that are required by PDCP for integrity protection are defined in TS 33.501 [6] and are input to the integrity protection algorithm. The required inputs to the integrity protection function include the COUNT value, and DIRECTION (direction of the transmission: set as specified in TS 33.501 [6]). The parameters required by PDCP which are provided by upper layers TS 38.331 [3] are listed below:

- BEARER (defined as the radio bearer identifier in TS 33.501 [6]. It will use the value RB identity –1 as in TS 38.331 [3]);

- KEY (the integrity protection keys for the control plane and for the user plane are KRRCint and KUPint, respectively).

At transmission, the UE computes the value of the MAC-I field and at reception it verifies the integrity of the PDCP Data PDU by calculating the X-MAC based on the input parameters as specified above. If the calculated X-MAC corresponds to the received MAC-I, integrity protection is verified successfully.

*NEXT CHANGE*

## 5.x Uplink data switching

For DAPS bearers, when upper layers request uplink data switching, the transmitting PDCP entity shall:

- for AM DRBs, from the first PDCP SDU for which the successful delivery of the corresponding PDCP Data PDU has not been confirmed by the RLC entity associated with the source cell, perform retransmission or transmission of all the PDCP SDUs already associated with PDCP SNs in ascending order of the COUNT values associated to the PDCP SDU prior to uplink data switching to the RLC entity associated with the target cell as specified below:

- perform header compression of the PDCP SDU using ROHC as specified in the clause 5.7.4;

- perform integrity protection and ciphering of the PDCP SDU using the COUNT value associated with this PDCP SDU as specified in the clause 5.9 and 5.8;

- submit the resulting PDCP Data PDU to lower layer, as specified in clause 5.2.1.

- for UM DRBs, for all PDCP SDUs which have been processed by PDCP but which have not yet been submitted to lower layers, perform transmission of the PDCP SDUs in ascending order of the COUNT values to the RLC entity associated with the target cell as specified below:

- perform header compression of the PDCP SDU using ROHC as specified in the clause 5.7.4;

- perform integrity protection and ciphering of the PDCP SDU using the COUNT value associated with this PDCP SDU as specified in the clause 5.9 and 5.8;

- submit the resulting PDCP Data PDU to lower layer, as specified in clause 5.2.1.

*END OF CHANGES*