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Foreword

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1 Scope

The present document provides the description of the Packet Data Convergence Protocol (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.
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[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.300: "NG Radio Access Network; Overall description".

[3] 3GPP TS 38.331: "NR Radio Resource Control (RRC); Protocol Specification".

[4] 3GPP TS 38.321: "NR Medium Access Control (MAC) protocol specification".

[5] 3GPP TS 38.322: "NR Radio Link Control (RLC) protocol specification".

[6] 3GPP TS 33.501: "Security Architecture and Procedures for 5G System ".

[7] IETF RFC 5795: "The RObust Header Compression (ROHC) Framework".

[8] IETF RFC 3095: "RObust Header Compression (ROHC): Framework and four profiles: RTP, UDP, ESP and uncompressed".

[9] IETF RFC 4815: "RObust Header Compression (ROHC): Corrections and Clarifications to RFC 3095".

[10] IETF RFC 6846: "RObust Header Compression (ROHC): A Profile for TCP/IP (ROHC-TCP)".

[11] IETF RFC 5225: "RObust Header Compression (ROHC) Version 2: Profiles for RTP, UDP, IP, ESP and UDP Lite".

[12] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification".

[13] 3GPP TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".

[14] 3GPP TS 33.536: "Security Aspect of 3GPP Support for Advanced V2X Services".

[15] IEEE Standard 802.3™-2018: "Ethernet".

[16] 3GPP TS 24.587: "Vehicle-to-Everything (V2X) services in 5G System (5GS), Stage 3".

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.

NR sidelink communication: AS functionality enabling at least V2X communication as defined in TS 23.287 [13], between two or more nearby UEs, using NR technology but not traversing any network node.

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.

Split secondary RLC entity: in dual connectivity, the RLC entity other than the primary RLC entity which is responsible for split bearer operation. If the PDCP entity is associated with two RLC entities, the split secondary RLC entity is the RLC entity other than the primary RLC entity. If the PDCP entity is associated with more than two RLC entities, the split secondary RLC entity is configured by upper layers.

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

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
EHC	Ethernet Header Compression
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
SCCH	Sidelink Control Channel
SDU	Service Data Unit
SLRB	Sidelink Radio Bearer carrying NR sidelink communication
SN	Sequence Number

SRB	Signalling Radio Bearer carrying control plane data
STCH	Sidelink Traffic Channel
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UE	User Equipment
UM	Unacknowledged Mode
X-MAC	Computed MAC-I

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].

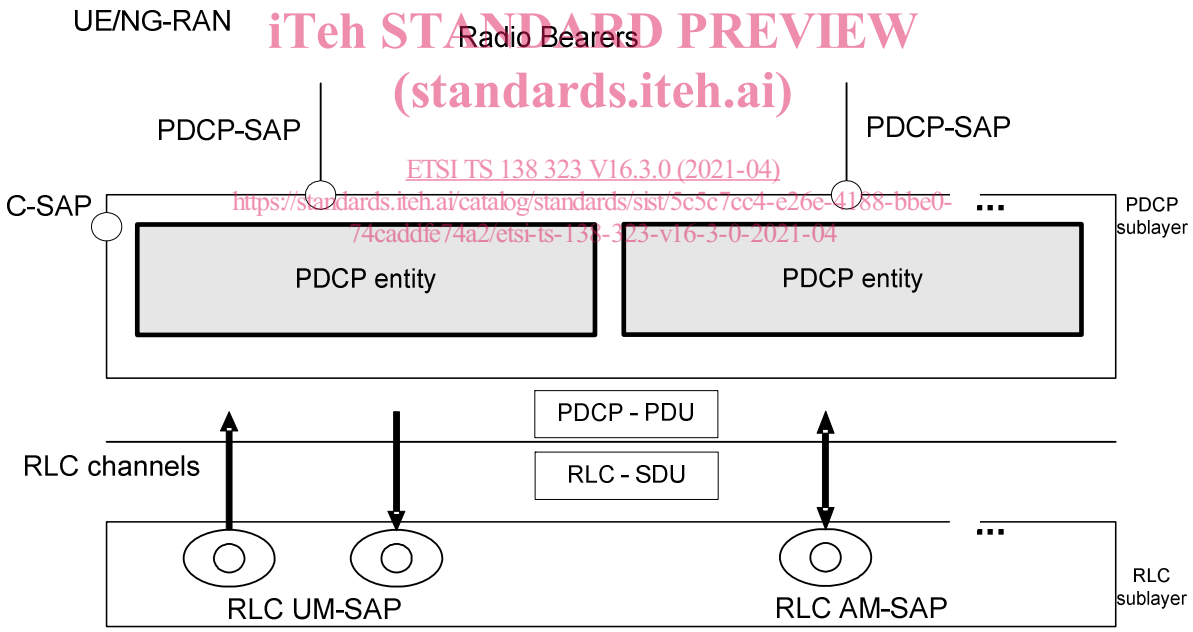

Figure 4.2.1-1: PDCP layer, structure view

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

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

- For split bearers, 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 RBs configured with PDCP duplication, each PDCP entity is associated with N UM RLC entities (for same direction), 2 × N UM RLC entities (N for each direction), or N AM RLC entities, where 2 <= N <= 4;
- 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 (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.

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.

A PDCP entity associated with DRB can be configured by upper layers TS 38.331 [3] to use header compression. In this version of the specification, the robust header compression protocol (ROHC) and the Ethernet header compression protocol (EHC) are supported. Each header compression protocol is independently configured for a DRB.

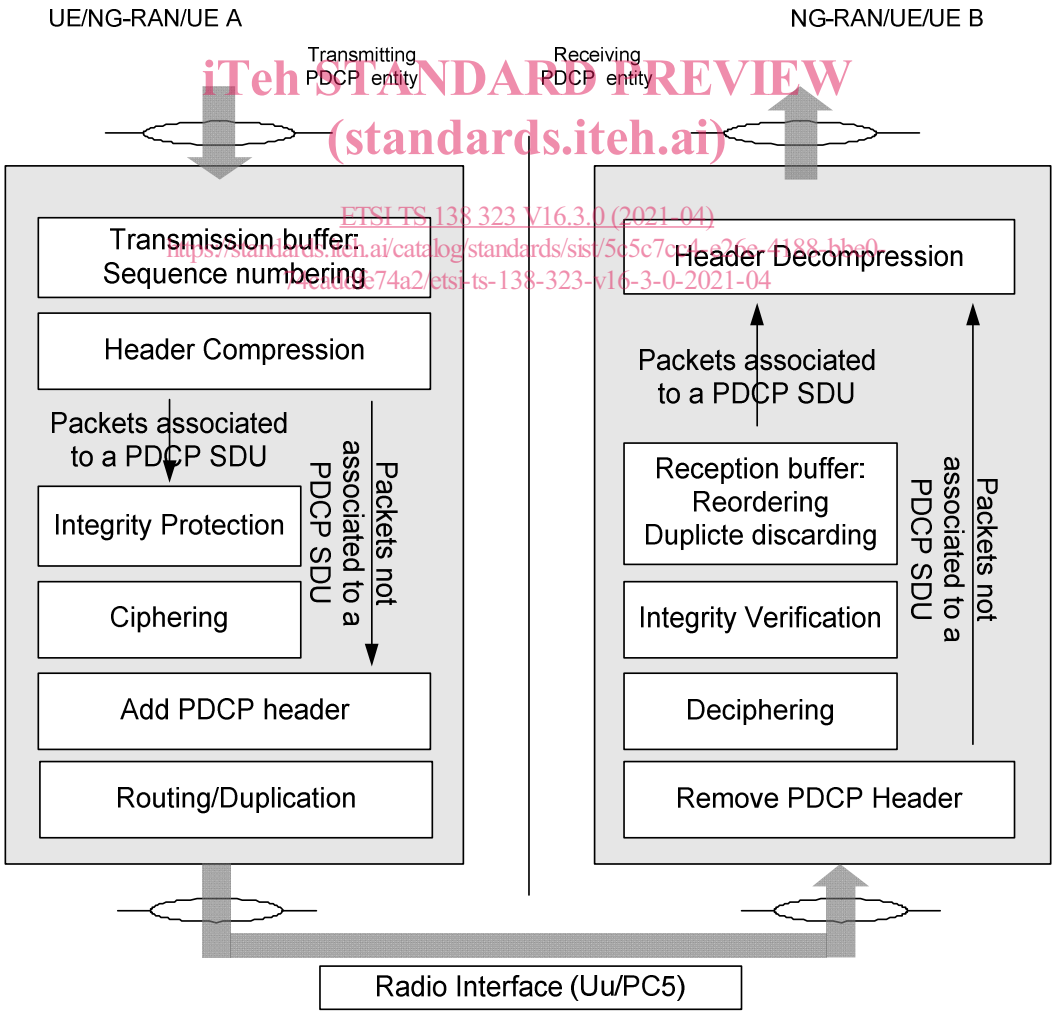

Figure 4.2.2-1: PDCP layer, functional view

Figure 4.2.2-2 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.

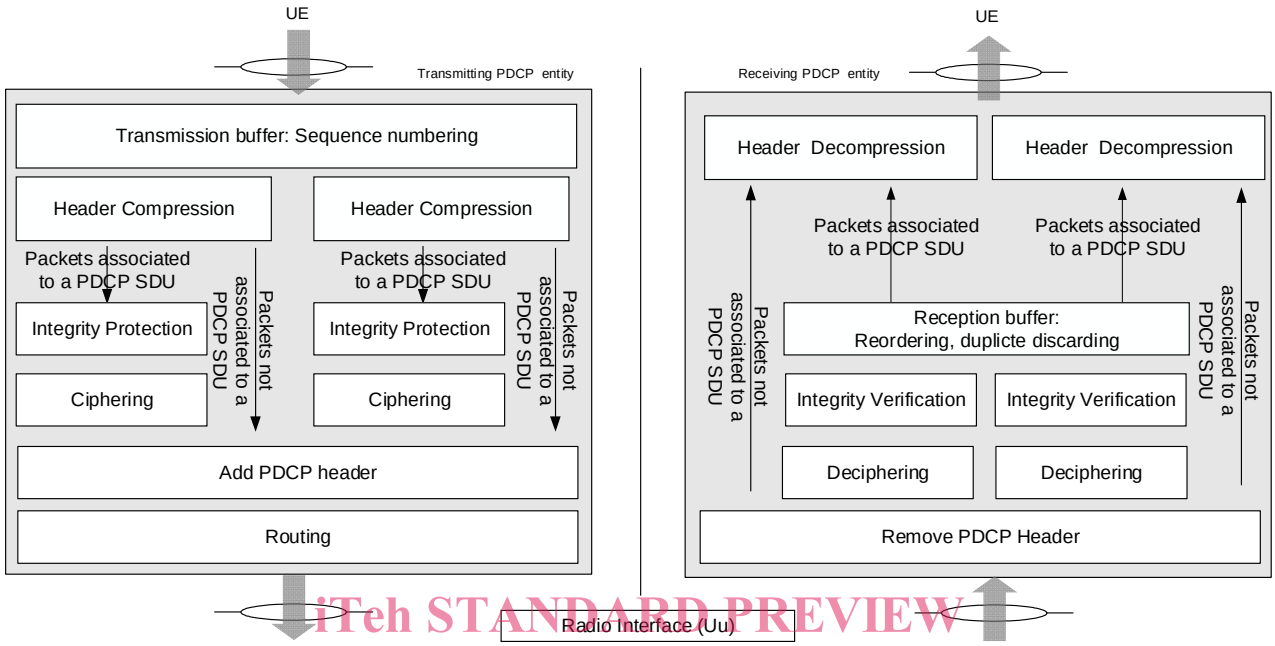

Figure 4.2.2-2: PDCP layer associated with DAPS bearer, functional view

4.3 Services

4.3.1 Services provided to upper layers

The PDCP layer provides its services to the RRC or SDAP layers. The following services are provided by PDCP to upper layers:

- transfer of user plane data;
- transfer of control plane data;
- header compression;
- ciphering;
- integrity protection.

The maximum supported size of a PDCP SDU is 9000 bytes. The maximum supported size of a PDCP Control PDU is 9000 bytes.

4.3.2 Services expected from lower layers

A PDCP entity expects the following services from lower layers per RLC entity (for a detailed description see TS 38.322 [5]):

- acknowledged data transfer service, including indication of successful delivery of PDCP PDUs;
- unacknowledged data transfer service.

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;
- header compression and decompression using the EHC protocol;
- ciphering and deciphering;
- integrity protection and integrity verification;
- timer based SDU discard;
- for split bearers and DAPS bearer, routing;
- duplication;
- reordering and in-order delivery;
- out-of-order delivery;
- duplicate discarding.

5 Procedures

5.1 PDCP entity handling

5.1.1 PDCP entity establishment

When upper layers request a PDCP entity establishment for a radio bearer for Uu or PC5 interface; or for NR sidelink communication for groupcast and broadcast, when receiving the first PDCP PDU, and there is not yet a corresponding PDCP entity, the UE shall:

- establish a PDCP entity for the radio bearer;
- set the state variables of the PDCP entity to initial values;
- follow the procedures in clause 5.2.

5.1.2 PDCP entity re-establishment

When upper layers request a PDCP entity re-establishment, the UE shall additionally perform once the procedures described in this clause for Uu or PC5 interface. After performing the procedures in this clause, the UE shall follow the procedures in clause 5.2.

When upper layers request a PDCP entity re-establishment, the transmitting PDCP entity shall:

- for UM DRBs and AM DRBs, reset the ROHC protocol for uplink and start with an IR state in U-mode (as defined in RFC 3095 [8] and RFC 4815 [9]) if *drb-ContinueROHC* is not configured in TS 38.331 [3];
- for UM DRBs and AM DRBs, reset the EHC protocol for uplink if *drb-ContinueEHC-UL* is not configured in TS 38.331 [3];
- for UM DRBs and SRBs, set TX_NEXT to the initial value;
- for SRBs, discard all stored PDCP SDUs and PDCP PDUs;

- apply the ciphering algorithm and key provided by upper layers during the PDCP entity re-establishment procedure;
- apply the integrity protection algorithm and key provided by upper layers during the PDCP entity re-establishment procedure;
- for UM DRBs, for each PDCP SDU already associated with a PDCP SN but for which a corresponding PDU has not previously been submitted to lower layers, and;
- for suspended AM DRBs for Uu interface, from the first PDCP SDU for which the successful delivery of the corresponding PDCP Data PDU has not been confirmed by lower layers, for each PDCP SDU already associated with a PDCP SN:
  - consider the PDCP SDUs as received from upper layer;
  - perform transmission of the PDCP SDUs in ascending order of the COUNT value associated to the PDCP SDU prior to the PDCP re-establishment without restarting the *discardTimer*, as specified in clause 5.2.1;
- for AM DRBs which were not suspended, from the first PDCP SDU for which the successful delivery of the corresponding PDCP Data PDU has not been confirmed by lower layers, 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 the PDCP entity re-establishment as specified below:
  - perform header compression of the PDCP SDU using ROHC as specified in the clause 5.7.4 and/or using EHC as specified in the clause 5.12.4;
  - 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.

When upper layers request a PDCP entity re-establishment, the receiving PDCP entity shall:

- process the PDCP Data PDUs that are received from lower layers due to the re-establishment of the lower layers, as specified in the clause 5.2.2.1;

- for SRBs, discard all stored PDCP SDUs and PDCP PDUs;
- for SRBs and UM DRBs, if *t-Reordering* is running:
  - stop and reset *t-Reordering*;
  - for UM DRBs, deliver all stored PDCP SDUs to the upper layers in ascending order of associated COUNT values after performing header decompression;
- for AM DRBs for Uu interface, perform header decompression using ROHC for all stored PDCP SDUs if *drb-ContinueROHC* is not configured in TS 38.331 [3];
- for AM DRBs for PC5 interface, perform header decompression using ROHC for all stored PDCP IP SDUs;
- for AM DRBs for Uu interface, perform header decompression using EHC for all stored PDCP SDUs if *drb-ContinueEHC-DL* is not configured in TS 38.331 [3];
- for UM DRBs and AM DRBs, reset the ROHC protocol for downlink and start with NC state in U-mode (as defined in RFC 3095 [8] and RFC 4815 [9]) if *drb-ContinueROHC* is not configured in TS 38.331 [3];
- for UM DRBs and AM DRBs, reset the EHC protocol for downlink if *drb-ContinueEHC-DL* is not configured in TS 38.331 [3];
- for UM DRBs and SRBs, set RX_NEXT and RX_DELIV to the initial value;
- apply the ciphering algorithm and key provided by upper layers during the PDCP entity re-establishment procedure;
- apply the integrity protection algorithm and key provided by upper layers during the PDCP entity re-establishment procedure.