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Foreword

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Contents

Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

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x   the first digit:

1   presented to TSG for information;

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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 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.

- 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 TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2".

[2]   3GPP TS 25.331: "Radio Resource Control".

[3]   3GPP TS 25.301: "Radio Interface Protocol Architecture".

[4]   3GPP TS 25.303: "Interlayer Procedures in Connected Mode".

[5]   3GPP TS 25.322: "RLC Protocol Specification".

[6]   IETF RFC 2507: "IP Header Compression".

[7]   3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

3 Definitions and Abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [7] apply.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AS	Access Stratum
C-SAP	Control Service Access Point
HC	Header Compression
IETF	Internet Engineering Task Force
IP	Internet Protocol
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
NAS	Non Access Stratum
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
PID	Packet Identifier
PPP	Point-to-Point Protocol
RB	Radio Bearer
RFC	Request For Comments

RLC	Radio Link Control
RNC	Radio Network Controller
RTP	Real Time Protocol
SDU	Service Data Unit
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network

4 General

4.1 Objective

The present document describes the functionality of the PDCP.

4.2 Overview on sublayer architecture

Figure 1 shows the model of the PDCP within the radio interface protocol architecture. The radio interface protocol architecture is defined in [3]. The PDCP sublayer is defined for the PS domain only.

Every PS domain RAB is associated with one RB, which in turn is associated with one PDCP entity. The PDCP entities are located in the PDCP sublayer.

Every PDCP entity uses zero, one or several different header compression protocol types. Several PDCP entities may be defined for a UE with each using the same or different protocol type. In this version of the specification, only one header compression protocol type, RFC 2507 [6], is supported.

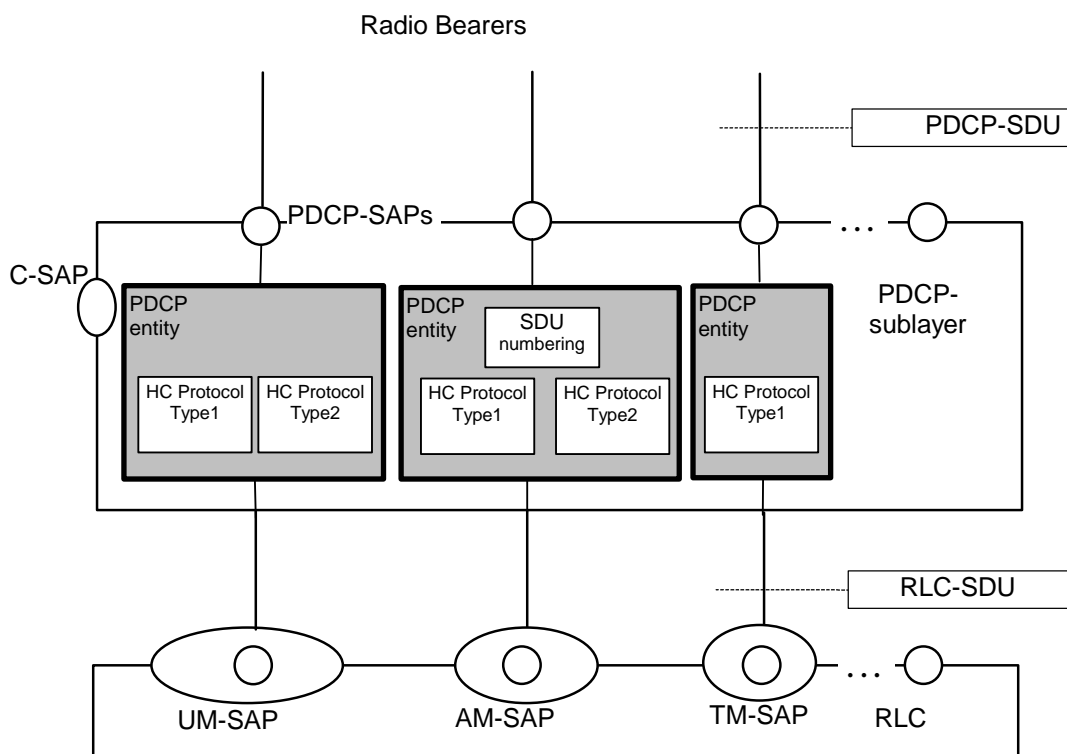The PDCP sublayer is configured by upper layer [2] through the PDCP-C-SAP.

Radio Bearers

Figure 1: PDCP structure

Figure 1 represents one possible structure for the PDCP sublayer and should not restrict implementation.

5 Functions

PDCP provides its services to the NAS at the UE or the relay at the Radio Network Controller (RNC).

The Packet Data Convergence Protocol shall perform the following functions:

- header compression and decompression of IP data streams (e.g., TCP/IP and RTP/UDP/IP headers for IPv4 and IPv6) at the transmitting and receiving entity, respectively.

- transfer of user data. This function is used for conveyance of data between users of PDCP services.

- maintenance of PDCP sequence numbers for radio bearers that are configured to support lossless SRNS Relocation.

PDCP uses the services provided by the Radio Link Control (RLC) sublayer.

5.1 Header Compression

The header compression protocol is specific to the particular network layer, transport layer or upper layer protocol combinations e.g. TCP/IP and RTP/UDP/IP. The network layer protocol type, e.g. IP or PPP, is indicated during PDP context activation as defined in [1]. The header compression protocols and their parameters are configured by upper layers for each PDCP entity. Compressor and decompressor initiated signalling between peer PDCP entities, during operation, is accomplished through in-band signalling.

5.1.1 Mapping of PID values

Depending on the configuration by upper layers (i.e. PDCP PDU type to be used and header compressor protocol), the PDCP sublayer shall be able to:

- identify the correct header compression protocol; and

- distinguish different types of header compression packets within a header compression protocol.

The above requirements are realised by utilising the PID field in the PDCP PDU.

The mapping of the PID values shall follow the general rules listed below:

- PID values shall be mapped to the different packet types independently at each PDCP entity;

- PID value "0" shall indicate "no compression". PID value "0" shall be used in a PDCP PDU containing in its Data field a PDCP SDU that is unchanged by the Sender and that shall not be decompressed by the Receiver;

- PID values are mapped in ascending order, starting from 1, for every configured header compression protocol, in the order of configuration by upper layer. The first available PID value is assigned to the first packet type of the header compression protocol as defined in the specification for this header compression protocol. PID values are mapped for all the specified packet types defined for the header compression protocol and in the order defined in subclause 5.1.2.1 for the respective header compression protocol;

- PID values are re-mapped for the PDCP entity after any reconfiguration of the header compression protocols for that entity.

The following table illustrates an example of the PID value mapping to the packet types when three header compression methods are configured for one PDCP entity: RFC 2507[6] with five packet types listed in subclause 5.1.2, Methods A and Method B with two different packet types each. Method A and Method B are imaginary header compression protocols introduced for the purpose of illustration.

Table 1: Example of the PID value mapping table

PID Value	Optimisation method	Packet type
0	No header compression	-
1	RFC 2507	Full header
2	RFC 2507	Compressed TCP
3	RFC 2507	Compressed TCP non-delta
4	RFC 2507	Compressed non-TCP
5	RFC 2507	Context state
6	Method A	Packet Type 1 of Method A
7	Method A	Packet Type 2 of Method A
8	Method B	Packet Type 1 of Method B
9	Method B	Packet Type 2 of Method B
...	Unassigned value	-

5.1.2   IP Header Compression (RFC 2507)

The detailed operation of the RFC 2507 header compression protocol is specified in IETF RFC 2507 [6]. The mechanisms related to error recovery and packet reordering are also described in RFC 2507. These mechanisms shall be included in the functionality of the header compression supported by PDCP. The implementation of the RFC 2507 header compression functionality is not covered in this specification and is left to the implementation.

5.1.2.1   Mapping of PID values for RFC 2507

PID values shall be mapped to the RFC 2507 header compression packet types in the order presented in Table 2 below where "n" is the number of PID values already mapped to other protocol packet types. In this version of the specification, since only one instance and one type of header compression protocol (RFC 2507) per PDCP entity is supported, PID values greater than 5 shall not be mapped (i.e. value of "n" shall always equal 0).

Table 2: Mapping of PID values for RFC 2507 header compression protocol

PID value	Optimisation method	Packet type
n+1	RFC 2507	Full header
n+2	RFC 2507	Compressed TCP
n+3	RFC 2507	Compressed TCP non-delta
n+4	RFC 2507	Compressed non-TCP
n+5	RFC 2507	Context state

5.2 Void

5.3 Data Transfer

If header compression is configured the PDCP entity in the Sender shall:

- perform header compression upon reception of a PDCP SDU from upper layers;

- if the radio bearer is configured for lossless SRNS Relocation:

  - maintain PDCP sequence numbering as specified in subclause 5.4.1.1;

- submit the PDCP PDU to lower layer in the sequence received from the upper layer.

When the PDCP entity at the Receiver receives the PDCP PDU from lower layers, it shall:

- perform header decompression (if header compression is configured) of the PDCP PDU to obtain the PDCP SDU; and

- deliver the PDCP SDU to the upper layer in the order received from the lower layer;

- if the received PDCP PDU is of type PDCP SeqNum PDU:

  - follow the procedure in subclause 5.4.1.2.

5.3.1 Data transfer over acknowledged mode RLC

Figure 2 shows the PDCP data transfer over acknowledged mode RLC.
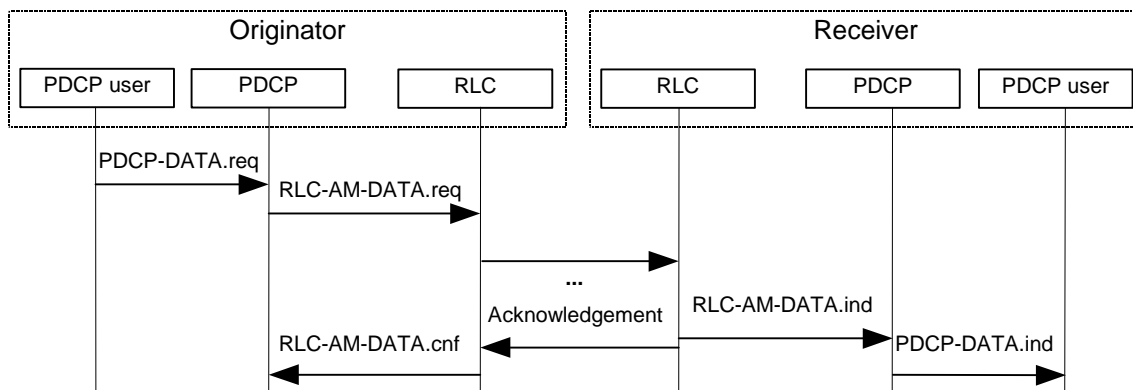

Figure 2: PDCP data transfer over acknowledged mode RLC

5.3.2 Data transfer over unacknowledged and transparent mode RLC

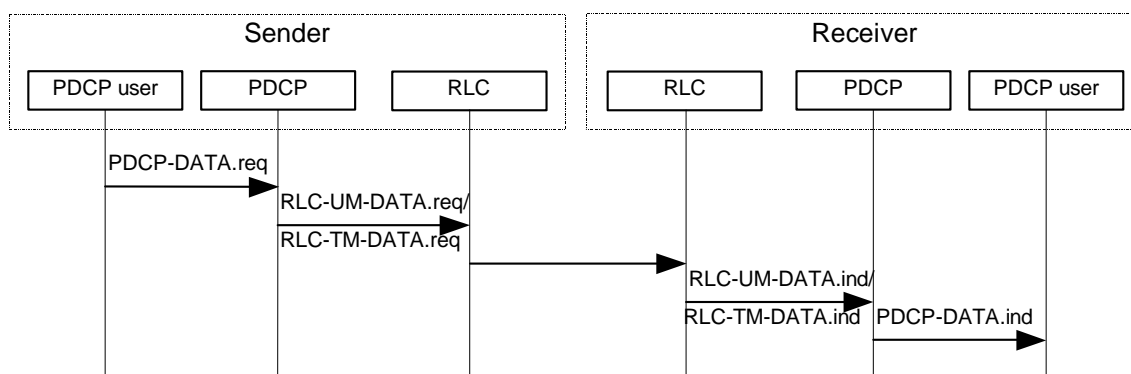Figure 3 shows the PDCP data transfer over unacknowledged or transparent mode RLC.

Figure 3: PDCP data transfer over unacknowledged or transparent mode RLC

5.4 SRNS Relocation

In case of SRNS Relocation upper layer indicates to PDCP to perform the re-initialisation of all compression entities of a RB. This entails the following:

- Configured compression parameters remain valid during re-initialisation.

- All compression state information is initialised, e.g. header compression contexts. Therefore, the first 'compressed' packet type after SRNS Relocation is a full header.

- The PDCP sequence numbers are not changed due to the PDCP header compression protocol re-initialisation.

5.4.1 Lossless SRNS Relocation

Lossless SRNS Relocation is only applicable when RLC is configured for in-sequence delivery and acknowledged mode. The support of lossless SRNS Relocation is configured by upper layer.

For the support of lossless SRNS Relocation PDCP maintains sequence numbers for PDCP SDUs, as described in subclause 5.4.1.1. These sequence numbers are synchronised between PDCP Sender and Receiver, as described in subclause 5.4.1.2. When a lossless SRNS Relocation is performed sequence numbers are exchanged between UE and UTRAN. They are used to confirm PDCP SDUs transmitted but not yet acknowledged by the Receiver, as described in subclause 5.4.1.3. After relocation the data transfer begins with the first unconfirmed PDCP SDU.

5.4.1.1 PDCP Sequence Numbering

PDCP sequence numbering shall be applied when lossless SRNS Relocation is supported. PDCP Sequence Numbers serve to acknowledge previously transmitted PDCP SDUs prior to relocation. The value of the PDCP sequence number ranges from 0 to 65535. The PDCP SN window size indicates the maximum number of PDCP SDUS, not confirmed to have been successfully transmitted to the peer entity by lower layer, that can be numbered at any given time. The PDCP SN window size is configured by upper layers. PDCP sequence numbers are set to "0" when the PDCP entity is set-up for the first time.

In the following the "submission/reception of a PDCP SDU to/from lower layer" is used as a synonym for the submission/reception of a PDCP Data PDU or a PDCP SeqNum PDU to/from lower layer that carries in its Data field a compressed or uncompressed PDCP SDU. In case PDCP sequence numbers are applied, for each radio bearer:

- in the UE:

  - the UL_Send PDCP sequence number shall be set to "0" for the first PDCP SDU submitted to lower layer;

  - the UL_Send PDCP sequence number shall be incremented by "1" when a PDCP SDU is submitted to lower layer;

  - the DL_Receive PDCP sequence number shall be set to "0" for the first PDCP SDU received from lower layer;

- the DL_Receive PDCP sequence number shall be incremented by "1" when a PDCP SDU is received from lower layer.

- in the UTRAN:

    - the DL_Send PDCP sequence number should be set to "0" for the first PDCP SDU submitted to lower layer;

    - the DL_Send PDCP sequence number should be incremented by "1" when a PDCP SDU is submitted to lower layer;

    - the UL_Receive PDCP sequence number should be set to "0" for the first PDCP SDU received from lower layer;

    - the UL_Receive PDCP sequence number should be incremented by "1" when a PDCP SDU is received from lower layer.

PDCP sequence numbers shall not be decremented in a PDCP entity.

5.4.1.2   PDCP Sequence Number synchronization

For radio bearers that are configured to support lossless SRNS Relocation, the PDCP entity shall:

- if upper layer indicates to a PDCP entity that it should synchronise the PDCP SN following a RLC reset or RB reconfiguration; or

- if the UE/UTRAN PDCP entity receives an invalid "next expected UL/DL Receive PDCP sequence number" from upper layer after Relocation:

    - trigger the PDCP SN synchronisation procedure by submitting one PDCP SeqNum PDU to lower layer;

    - consider that the synchronisation procedure is complete on confirmation by lower layer of the successful transmission of the PDCP SeqNum PDU.

In the UE/UTRAN, the "next expected UL/DL_Receive PDCP sequence number" is considered invalid if its value is less than the Send PDCP SN of the first transmitted but not yet acknowledged PDCP SDU or greater than that of the first unsent PDCP SDU.

On receiving a PDCP SeqNum PDU:

- the UE PDCP entity shall:

    - set the value of the DL_Receive PDCP sequence number to the value indicated in the PDCP SeqNum PDU;

- the UTRAN PDCP entity should:

    set the value of the UL_Receive PDCP sequence number to the value indicated in the PDCP SeqNum PDU.

5.4.1.3   Sequence Number and Data Forwarding

In case of a lossless SRNS Relocation procedure, as described in [1]:

- the UTRAN should send to the UE the UL_Receive PDCP sequence number; and

- the UE shall send to the UTRAN the DL_Receive PDCP sequence number.

This information exchange synchronises the Sequence Numbers at the UE and UTRAN PDCP entities.

When requested by the upper layer, for each radio bearer configured to support lossless SRNS Relocation, the PDCP sublayer in the source RNC should forward the following to the target RNC:

- the Receive PDCP SN of the next PDCP SDU expected to be received from the UE;

- the Send PDCP SN of the first transmitted but not yet acknowledged PDCP SDU;

- the transmitted but not yet acknowledged PDCP SDUs together with their related Send PDCP SNs;

- the not yet transmitted PDCP SDUs.

6 Services

6.1 Services provided to upper layers

The following services are provided by PDCP to upper layers:

- transfer of user data;

- maintenance of PDCP SDU sequence numbers.

6.2 Services expected from RLC layer

For a detailed description of the following functions see [5].

- transparent data transfer Service;

- unacknowledged data transfer Service;

- acknowledged data transfer Service.

7 Elements for layer-to-layer communication

The interaction between the PDCP layer and other layers are described in terms of primitives where the primitives represent the logical exchange of information and control between the PDCP layer and other layers. The primitives shall not specify or constrain implementations.

7.1 Primitives between PDCP and upper layers

The primitives between PDCP and upper layers are shown in Table 3.

Table 3: Primitives between PDCP and upper layers

Generic Name	Parameter			
	Req.	Ind.	Resp.	Conf.
PDCP-DATA	Data	Data	Not Defined	Not Defined
CPDCP-CONFIG	PDCP-Info, RLC-SAP SN_Sync, R/I	Not Defined	Not Defined	Not Defined
CPDCP-RELEASE	RLC-SAP	Not Defined	Not Defined	Not Defined
CPDCP-SN	PDCP SN	Not Defined	Not Defined	Not Defined
CPDCP-RELOC	Receive_SN	Not Defined	Not Defined	Receive_SN, Send_SN

Each Primitive is defined as follows:

a) PDCP-DATA-Req./Ind.

- PDCP-DATA-Req is used by upper user-plane protocol layers to request a transmission of upper layer PDU. PDCP-DATA-Ind is used to deliver PDCP SDU that has been received to upper user plane protocol layers.

b) CPDCP-CONFIG-Req.

- CPDCP-CONFIG Req is used to configure and – in case of already existing PDCP entity – to reconfigure a PDCP entity and to assign it to the radio bearer associated with that entity.

c) CPDCP-RELEASE-Req.

- CPDCP-RELEASE-Req is used by upper layers to release a PDCP entity.

d) CPDCP-SN-Req.

- This primitive is used at the UTRAN. CPDCP-SN-Req is used to transfer the PDCP SN to PDCP.

e) CPDCP-RELOC-Req/Conf.

- CPDCP-RELOC-Req initiates the SRNS Relocation procedure in PDCP for those radio bearers that are configured to support lossless SRNS Relocation. The Receive_SN is only included at the UE side.

- CPDCP-RELOC-Conf is used to transfer the Receive_SN and/or Send_SN to upper layers for lossless SRNS Relocation. The Send_SN is only included at the source RNC.

The following parameters are used in the primitives:

1) PDCP-Info:

- Contains the parameters for each of the header compression protocols configured to be used by one PDCP entity.

2) RLC-SAP:

- The RLC-SAP (TM/UM/AM) used by PDCP entity when communicating with RLC sublayer.

3) SN_Sync:

- Indicates that PDCP should start PDCP SN synchronisation procedure.

4) Send_SN:

- The Send PDCP SN of the next PDCP SDU to be sent. There is one in the uplink (UL_Send_SN) and one in the downlink (DL_Send_SN). Refer to subclause 5.4.1.

5) Receive_SN:

- The Receive PDCP SN of the next PDCP SDU expected to be received. There is one in the uplink (UL_Receive_SN) and one in the downlink (DL_Receive_SN). Refer to subclause 5.4.1.

6) PDCP SN:

- This includes a PDCP sequence number.

7) R/I:

- Indicates that PDCP should Re-initialise/Initialise the header compression protocols.

8 Elements for peer-to-peer communication

8.1 Protocol data units

Different PDU formats are defined for the PDCP protocol, one not introducing any overhead to the (compressed) PDCP SDU, others introducing such overhead.

8.2 Formats

A PDCP PDU shall be a multiple of 8 bits, if the RLC entity is configured for unacknowledged or acknowledged mode. Otherwise, if the RLC entity is configured for transparent mode, it is bit-aligned. In Tables 4, 5 and 6, bit strings are represented as follows: the first bit is the leftmost one on the first line of the table, the last bit is the rightmost on the last line of the table, and more generally the bit string is to be read from left to right and then in the reading order of the lines.

SDUs are bit strings, with any non-null length. If not compressed within PDCP an SDU is included from first bit onward.

8.2.1   PDCP-No-Header PDU

The PDCP-No-Header PDU does not introduce any overhead to the PDCP SDU. The use of the PDCP-No-Header PDU is configured by the upper layer.

The format of the PDCP-No-Header PDU is shown in Table 4.

Table 4: PDCP-No-Header PDU

Data

8.2.2   PDCP Data PDU

The PDCP Data PDU is used to convey:

- data containing an uncompressed PDCP SDU; or

- header compression related control signalling; or

- data that has been obtained from PDCP SDU after header compression.

The format of the PDCP Data PDU is shown in Table 5.

Table 5: PDCP Data PDU format

PDU type	PID
Data	

8.2.3   PDCP SeqNum PDU

The PDCP SeqNum PDU is used to convey a PDCP SDU sequence number and:

- data containing an uncompressed PDCP SDU; or

- data that has been obtained from PDCP SDU after header compression.

The format of the PDCP SeqNum PDU is shown in Table 6.

Table 6: PDCP SeqNum PDU format

PDU type	PID
Sequence number	
Data	

8.3   Parameters

If not otherwise mentioned in the definition of each field then the bits in the parameters shall be interpreted as follows: the left most bit string is the first and most significant and the right most bit is the last and least significant bit.

Unless otherwise mentioned, integers are encoded in standard binary encoding for unsigned integers. In all cases the bits appear ordered from MSB to LSB when read in the PDU.

8.3.1 PDU Type

Length: 3 bits.

The PDU type field indicates the PDCP Data PDU type.

Bit	PDU Type
000	PDCP Data PDU (Table 5)
001	PDCP SeqNum PDU (Table 6)
010-111	Reserved (PDUs with this encoding are invalid for this version of the protocol)

8.3.2 PID

Length: 5 bits.

The PID field indicates the used header compression and packet type.

Bit	Description
00000	No header compression
00001-11111	Dynamically negotiated header compression identifier, as described in subclause 5.1.1

The PID field value indicates the used header compression protocol type and packet type. A specific header compression protocol may utilize a certain range of consecutive values from the PID field value space for different packet types. The Receiving PDCP entity performs the necessary operation (e.g. header decompression) according to the PID field value.

8.3.3 Data

The Data field may include either one of the following:

- Uncompressed PDCP SDU;

- Header compressed PDCP SDU;

- Header compression protocol feedback information.

8.3.4 Sequence number

Length: 16 bits

PDCP SDU sequence number.

9 Handling of unknown, unforeseen and erroneous protocol data

9.1 Invalid PDU type

If a PDCP entity receives a PDCP PDU with a PDU Type set to Reserved (see subclause 8.3.1), it shall:

- discard the PDCP PDU.

If a PDCP entity is not configured for lossless SRNS Relocation and receives a PDCP SeqNum PDU, it shall:

- discard the PDCP SeqNum PDU.

9.2   Invalid PID value

If a PDCP entity receives a PDCP PDU with a PID value that is not mapped with a valid packet type (see subclause 5.1.1), it shall:

- discard the PDCP PDU.

Annex A (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
12/1999	RP-06	RP-99645	-		Approved at TSG-RAN #6 and placed under Change Control	-	3.0.0
03/2000	RP-07	RP-000041	004		Bit order of PDCP PDUs	3.0.0	3.1.0
	RP-07	RP-000041	005		Changes to PDCP	3.0.0	3.1.0
06/2000	RP-08	RP-000221	006	4	Changes in PDCP PDU format due to PDCP sequence numbering	3.1.0	3.2.0
09/2000	RP-09	RP-000359	009	3	Clarification of PDCP Sequence Numbering	3.1.0	3.2.0
	RP-09	RP-000359	011		Clarification on how to handle invalid PDUs	3.2.0	3.3.0
	RP-09	RP-000359	012	2	Primitives required for SRNS relocation	3.2.0	3.3.0
	RP-09	RP-000359	015		Handling of invalid PDCP PDU sequence number	3.2.0	3.3.0
03/2001	RP-11	RP-010027	018	1	Editorial Corrections	3.3.0	3.4.0
	RP-11	RP-010027	019	1	Updates necessary for Rel-4 specification	3.3.0	3.4.0
06/2001	RP-12	RP-010310	020	1	Clarification on PDCP Sequence numbering	3.4.0	3.5.0
09/2001	RP-13	RP-010543	027		Header compression protocol reinitialisation during SRNS relocation	3.5.0	3.6.0
	RP-13	RP-010543	029	1	PDCP SDU Sequence Numbering	3.5.0	3.6.0
	RP-13	RP-010543	035	1	Corrections to PDCP	3.5.0	3.6.0
12/2001	RP-14	RP-010762	037	1	General PDCP corrections	3.6.0	3.7.0

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