ETSI TS 136 323 V8.2.1 (2008-11)

Technical Specification

LTE;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Packet Data Convergence Protocol (PDCP) specification
(3GPP TS 36.323 version 8.2.1 Release 8)

Reference

DTS/TSGR-0236323v821

Keywords

LTE

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

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

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between GSM, UMTS, 3GPP and ETSI identities can be found under http://webapp.etsi.org/key/queryform.asp.

Contents

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:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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 TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description".

[3] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA) Radio Resource Control (RRC); Protocol Specification".

[4] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification".

[5] 3GPP TS 36.322: "Evolved Universal Terrestrial Radio Access (E-UTRA) Radio Link Control (RLC) protocol specification".

[6] 3GPP TS 33.401: "3GPP System Architecture Evolution: Security Architecture".

[7] IETF RFC 4995: "The RObust Header Compression (ROHC) Framework".

[8] IETF RFC 4996: "RObust Header Compression (ROHC): A Profile for TCP/IP (ROHC-TCP)".

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

[10] IETF RFC 3843: "RObust Header Compression (RoHC): A Compression Profile for IP".

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

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

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].

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
DRB	Data Radio Bearer carrying user plane data
EPS	Evolved Packet System
E-UTRA	Evolved UMTS Terrestrial Radio Access
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
eNB	evolved Node B
FMS	First missing PDCP Sequence Number
HFN	Hyper Frame Number
IETF	Internet Engineering Task Force
IP	Internet Protocol
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
MAC	Message Authentication Code
MBMS	Multimedia Broadcast / Multicast Service
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
R	Reserved
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

4 General

4.1 Introduction

The present document describes the functionality of the PDCP.

4.2 PDCP 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 [2].

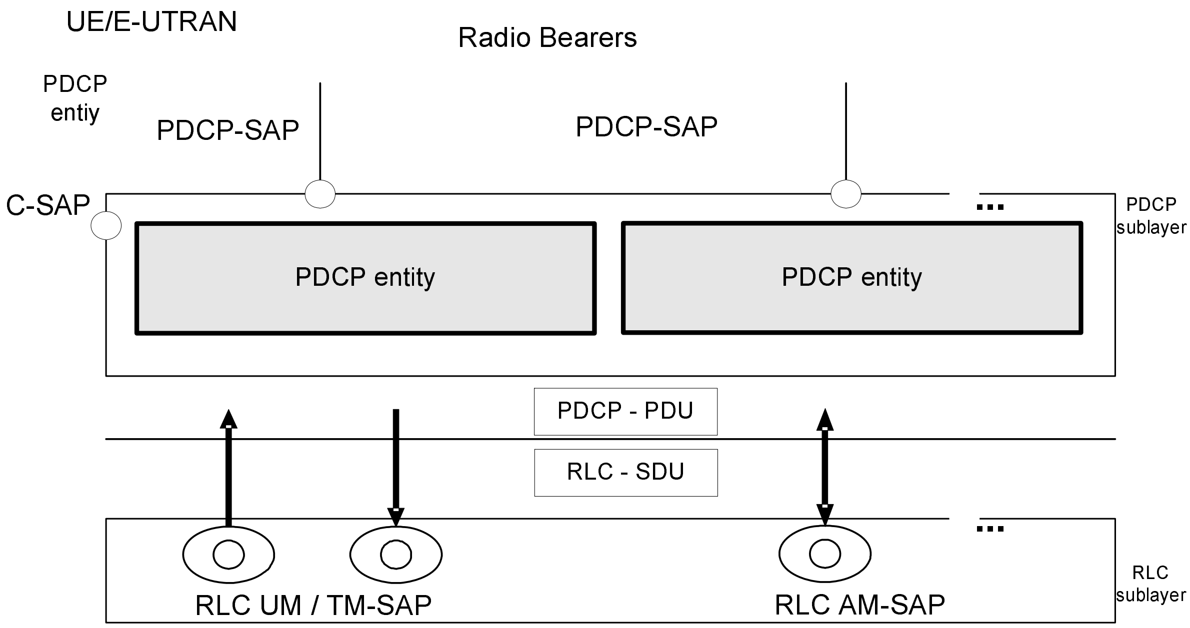

Figure 4.2.1.1 - PDCP layer, structure view

Every EPS bearer is associated with one RB, which in turn is associated with one PDCP entity.

Each PDCP entity is associated with one or two (one for each direction) RLC entities depending on the RB characteristic (i.e. uni-directional or bi-directional) and RLC mode. The PDCP entities are located in the PDCP sublayer.

The PDCP sublayer is configured by upper layers [3].

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 carrying user plane data may be configured to use header compression.

Each PDCP entity is carrying the data of one radio bearer. In this version of the specification, only the robust header compression protocol (RoHC), is supported. Every PDCP entity uses at most one RoHC instance.

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 [2].

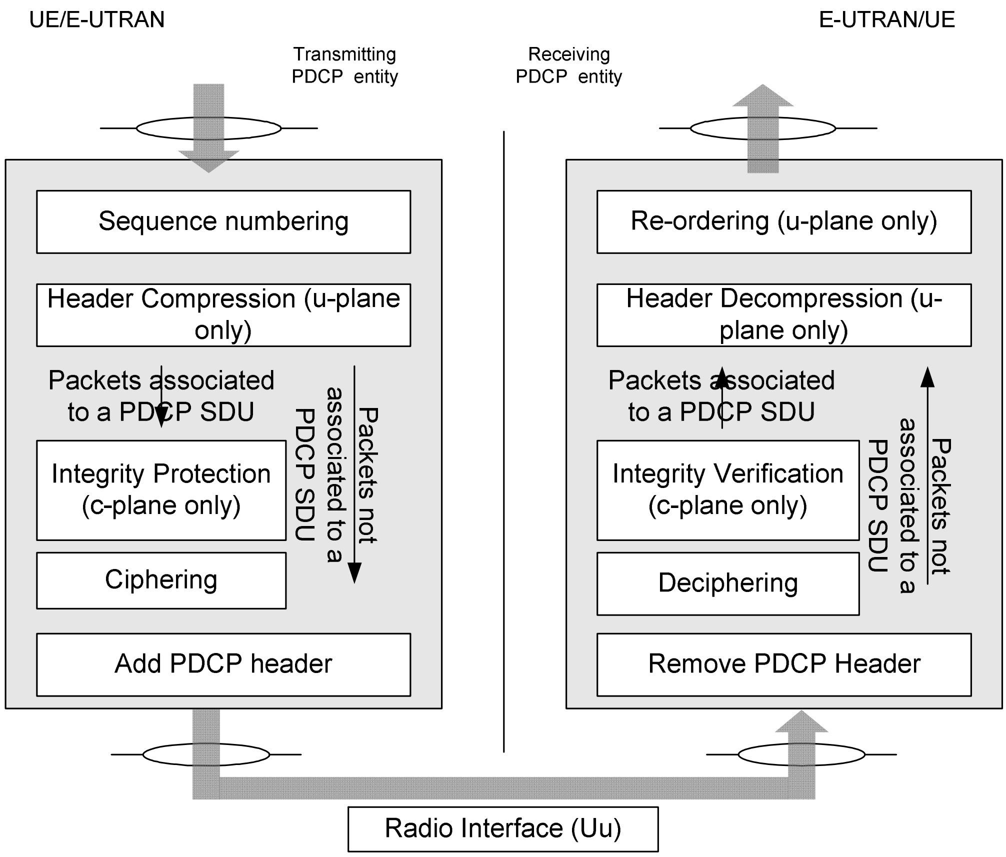

Figure 4.2.2.1 - PDCP layer, functional view

4.3 Services

4.3.1 Services provided to upper layers

PDCP provides its services to the RRC and user plane upper layers at the UE or to the relay at the evolved Node B (eNB). 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.

4.3.2 Services expected from lower layers

For a detailed description of the following functions see [4].

- transparent data transfer service (FFS);
- acknowledged data transfer service, including indication of successful delivery of PDCP PDUs;
- unacknowledged data transfer service;
- in-sequence delivery, except at handover;

- duplicate discarding, except at handover.

4.4 Functions

The Packet Data Convergence Protocol supports the following functions:

- header compression and decompression of IP data flows using the ROHC protocol, at the transmitting and receiving entity, respectively;
- transfer of data (user plane or control plane). This function is used for conveyance of data between users of PDCP services;
- maintenance of PDCP sequence numbers for radio bearers mapped on RLC AM;
- in-sequence delivery of upper layer PDUs at handover;
- duplicate elimination of lower layer SDUs at handover for radio bearers mapped on RLC AM;
- ciphering and deciphering of user plane data and control plane data;
- integrity protection and integrity verification of control plane data;
- timer based discard;
- duplicate discarding.

PDCP uses the services provided by the RLC sublayer.

PDCP is used for SRBs and DRBs mapped on DCCH and DTCH type of logical channels. PDCP is not used for any other type of logical channels.

4.5 Data available for transmission

For the purpose of MAC buffer status reporting, the UE shall consider the following as data available for transmission in the PDCP layer:

For SDUs for which no PDU has been submitted to lower layers:

- the SDU itself, if the SDU has not yet been processed by PDCP, or
- the PDU (control or data) if the SDU has been processed by PDCP.

In addition, for radio bearers that are mapped on RLC AM, if the PDCP entity has previously received an indication from upper layer that a handover has occurred, the UE shall also consider the following as data available for transmission in the PDCP layer:

For SDUs for which a corresponding PDU has only been submitted to lower layers before PDCP has received an indication that a handover has occurred, and for which the successful delivery has not been confirmed by lower layers or by a PDCP status report:

- the SDU, if it has not yet been processed by PDCP, or
- the PDU (data only) once it has been processed by PDCP.

5 PDCP procedures

5.1 Maintenance of PDCP sequence numbers

5.1.1 Reception of a PDCP PDU including a PDCP SN field from lower layers

5.1.1.1 Behaviour for DRBs

Every PDCP SDU is associated with a COUNT value that is composed by a PDCP sequence number and the HFN as specified in subclause 6.3.5.

At reception from lower layers of a PDCP Data PDU containing a PDCP SN field, the UE shall:

- if the DRB is mapped on RLC UM; or if the DRB is mapped on RLC AM and the timer Flush_Timer is not running:
    - if the PDCP Sequence Number contained in the PDCP SN field < Next_PDCP_RX_SN:
        - increment the variable RX_HFN by one;
    - decipher the PDCP PDU using COUNT based on the value of the variable RX_HFN and the value of the PDCP Sequence Number contained in the SN field of the PDCP PDU header;
    - if the DRB is mapped on RLC AM, set variable Last_Submitted_PDCP_RX_SN to the received PDCP Sequence Number;
    - set the variable Next_PDCP_RX_SN to the received PDCP Sequence Number + 1;
    - if Next_PDCP_RX_SN > Maximum_PDCP_SN:
        - set the variable Next_PDCP_RX_SN to 0;
        - increment the variable RX_HFN by one.

5.1.1.2 Behaviour for SRBs

Every PDCP SDU is associated with a COUNT value that is composed by a PDCP sequence number and the HFN as specified in subclause 6.3.5.

At reception of a PDCP PDU from lower layers the UE shall:

- if the PDCP Sequence Number contained in the PDCP SN field < Next_PDCP_RX_SN:
    - decipher and verify the integrity of the PDU (if applicable) using COUNT based on the value of the variable RX_HFN + 1 and the value of the PDCP Sequence Number contained in the SN field of the PDCP PDU header.
- else
    - decipher and verify the integrity of the PDU (if applicable) using COUNT based on the current value of the variable RX_HFN and the value of the PDCP Sequence Number contained in the PDCP SN field of the PDCP PDU header.
- if integrity protection is applicable and the integrity check is passed successfully; or
- if integrity protection is not applicable:
    - if the PDCP Sequence Number < Next_PDCP_RX_SN:
        - increment the variable RX_HFN by one;

- set the variable Next_PDCP_RX_SN to the received PDCP Sequence Number + 1;
- if the variable Next_PDCP_RX_SN > Maximum_PDCP_SN:
  - set the variable Next_PDCP_RX_SN to 0;
  - increment the variable RX_HFN by one.

5.1.2 Reception of a PDCP SDU from upper layers

At reception of a PDCP SDU from upper layers the UE shall:

- associate the PDCP Sequence Number corresponding to Next_PDCP_TX_SN to this PDCP SDU;
- if the discard function is configured by upper layers for this PDCP entity start the timer Discard_Timer associated with this PDCP SDU;
- perform header compression of the SDU (if configured);
- perform integrity protection of the PDU (if activated) and ciphering using the COUNT based on the value of the variable TX_HFN and the PDCP Sequence Number associated to this PDCP SDU;
- increment the variable Next_PDCP_TX_SN by one;
- if the variable Next_PDCP_TX_SN > Maximum_PDCP_SN:
  - set the variable Next_PDCP_TX_SN to 0;
  - increment the variable TX_HFN by one.

5.1.3 Actions at Handover

When upper layers indicate that a handover has occurred, for each PDCP SDU already associated with a PDCP sequence number but for which a corresponding PDU has not previously been submitted to lower layers for transmission, the UE shall, in the order of increasing COUNT value associated with the PDCP SDU:

- reassociate the PDCP Sequence Number corresponding to the variable Next_PDCP_TX_SN to this PDCP SDU;
- perform header compression of the SDU (if configured);
- perform ciphering using the COUNT based on the value of the variable TX_HFN and the PDCP Sequence Number associated to this PDCP SDU;
- increment the variable Next_PDCP_TX_SN by one;
- if the variable Next_PDCP_TX_SN > Maximum_PDCP_SN:
  - set the variable Next_PDCP_TX_SN to 0;
  - increment the variable TX_HFN by one.

5.2 Header compression

5.2.1 Supported header compression protocols and profiles

The header compression protocol is based on the Robust Header Compression (RoHC) framework [7]. There are multiple header compression algorithms, called profiles, defined for the RoHC framework. Each profile is specific to the particular network layer, transport layer or upper layer protocol combination e.g. TCP/IP and RTP/UDP/IP.

The detailed definition of the RoHC channel is specified as part of the RoHC framework in RFC 4995 [7]. This includes how to multiplex different flows (header compressed or not) over the RoHC channel, as well as how to associate a specific IP flow with a specific context state during initialization of the compression algorithm for that flow.

The implementation of the functionality of the RoHC framework and of the functionality of the supported header compression profiles is not covered in this specification.

In this version of the specification the support of the following profiles is described:

Table 5.2.1.1: Supported header compression protocols and profiles

Profile Identifier	Usage:	Reference
0x0000	No compression	RFC 4995
0x0001	RTP/UDP/IP	RFC 3095, RFC4815
0x0002	UDP/IP	RFC 3095, RFC4815
0x0003	ESP/IP	RFC 3095, RFC4815
0x0004	IP	RFC 3843, RFC4815
0x0006	TCP/IP	RFC 4996
0x0101	RTP/UDP/IP	RFC 5225
0x0102	UDP/IP	RFC 5225
0x0103	ESP/IP	RFC 5225
0x0104	IP	RFC 5225

5.2.2 Configuration of header compression

Whether header compression / decompression is applied for a given PDCP entity associated with u-plane data is configured by upper layers [3].

5.2.3 Protocol parameters

RFC 4995 has configuration parameters that are mandatory and that must be configured by upper layers between compressor and decompressor peers [7]; these parameters define the ROHC channel. The ROHC channel is a unidirectional channel, i.e. there is one channel for the downlink, and one for the uplink. There is thus one set of parameters for each channel, and the same values shall be used for both channels belonging to the same PDCP.

These parameters are categorized in two different groups, as defined below:

- M: Mandatory and configured by upper layers.

- N/A: N/A these are not used in this specification.

The usage and definition of the parameters shall be as specified below.

- MAX_CID (M): This is the maximum CID value that can be used. One CID value shall always be reserved for uncompressed flows.

- LARGE_CIDS: This value is not configured by upper layers, but rather it is inferred from the configured value of MAX_CID according to the following rule:

  If MAX_CID > 15 then LARGE_CIDS = TRUE else LARGE_CIDS = FALSE.

- PROFILES (M): Profiles are used to define which profiles are allowed to be used by the UE in uplink. The list of supported profiles is described in section 5.2.1.

- FEEDBACK_FOR (N/A): This is a reference to the channel in the opposite direction between two compression endpoints and indicates to what channel any feedback sent refers to. Feedback received on one ROHC channel for this PDCP shall always refer to the ROHC channel in the opposite direction for this same PDCP.

- MRRU (N/A): ROHC segmentation is not used.

5.2.4 Header compression

PDCP entities associated with DRBs can be configured by upper layers to use header compression. PDCP SDUs are associated with a PDCP sequence number according to 5.1.2 and are compressed by the compression protocol.

The header compression protocol generates two types of output packets:

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

A compressed packet is associated with the same COUNT values as the related PDCP SDU, and is ciphered as specified in subclause 5.3.

Interspersed ROHC feedback packets are not associated with a PDCP SDU. They are not associated with a PDCP sequence number and are not ciphered.

5.2.5 Header decompression

If header compression is configured by upper layers for PDCP entities associated with u-plane data the PDCP PDUs are de-compressed by the header compression protocol after performing deciphering as explained in subclause 5.3.

5.3 Ciphering and deciphering

The ciphering function includes both ciphering and deciphering and is performed in PDCP. For the control plane, the data unit that is ciphered is the data part of the PDCP PDU (see subclause 6.3.3) and the MAC-I (see subclause 6.3.4). For the user plane, the data unit that is ciphered is the data part of the PDCP PDU (see subclause 6.3.3); ciphering is not applicable to PDCP Control PDUs.

The ciphering algorithm and key to be used for PDCP entities associated with DRBs are the ones configured by upper layers at the moment that a PDCP PDU is received / transmitted [3] and the ciphering method shall be applied as specified in [6]. The ciphering algorithm and key to be used for PDCP entities associated with SRBs are the ones configured by upper layers for each received / transmitted PDCP PDU [3] and the ciphering method shall be applied as specified in [6].

The ciphering function is activated by upper layers [3]. After security activation, the ciphering function shall be applied to all PDCP PDUs indicated by upper layers [3] for the downlink and the uplink, respectively.

The parameters that are required by PDCP for ciphering are defined in [6] and are input to the ciphering algorithm. The parameters required by PDCP which are provided by upper layers [3] are listed below:

- BEARER (defined as the radio bearer identifier in [5]. It will use the value RB identity –1 as in [3]);
- DIRECTION (direction of the transmission: 0 for uplink, 1 for downlink);
- CK (Ciphering Key).

Editors note: The exact list and name of the parameters are FFS.

Editors note: It is FFS how keys can be changed if necessary without transiting through idle mode.

5.4 Integrity Protection and Verification

The integrity protection function includes both integrity protection and integrity verification and is performed in PDCP for PDCP entities associated with SRBs.

The integrity protection algorithm and key to be used for PDCP entities are the ones configured by upper layers for each received PDCP PDU [3] and the integrity protection method shall be applied as specified in [6].

The integrity protection function is activated by upper layers [3]. After security activation, the integrity protection function shall be applied to all PDUs including and subsequent to the PDU indicated by upper layers [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.

The parameters that are required by PDCP for integrity protection are defined in [6] and are input to the integrity protection algorithm. The parameters required by PDCP which are provided by upper layers [3] are listed below:

- BEARER (defined as the radio bearer identifier in [6]. It will use the value RB identity –1 as in [3]);
- DIRECTION (direction of the transmission: 0 for uplink, 1 for downlink);
- IK (Integrity Protection Key).

At transmission, the UE computes the value of the MAC-I field and at reception it verifies the integrity of the PDCP 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, otherwise the interaction with upper layers is FFS.

The data unit that is integrity protected is the unciphered data part of the PDU and the PDU header.

Editors note: This procedure is not yet defined. There are no stage 2 agreements from which to derive the above. The exact list and name of the parameters are FFS.

5.5 PDCP Behaviour at Handover

5.5.1 DRBs mapped on RLC AM

5.5.1.1 Actions at handover

When upper layers indicate that a handover has occurred, for radio bearers that are mapped on RLC AM, the UE shall:

- start the Flush_Timer, or restart if already running;
- perform actions as specified in 5.5.1.2.1, using the security algorithm and parameters in use prior to handover for PDCP PDUs, if any, that are received from lower layers due to the re-establishment of the lower layers and for which in-sequence delivery is not guaranteed;
- if the radio bearer is configured by upper layers to send a PDCP status report, compile a status report as indicated below and submit it to lower layers as the first PDCP PDU for the transmission, by:
    - setting the FMS field to the PDCP Sequence Number of the first missing PDCP SDU;
    - if there are more than one missing PDCP SDUs, allocating a Bitmap field of length in bits equal to the number of PDCP Sequence Numbers from and not including the first missing PDCP PDU up to and including the last out-of-sequence PDCP PDU, rounded up to the next multiple of 8;
    - setting as "0" in the corresponding position in the bitmap field all PDCP SDUs that have not been received as indicated by lower layers and optionally, PDCP PDUs for which decompression has failed;
    - indicating in the bitmap field as "1" all other PDCP SDUs.
- reset the header compression protocol in the transmitting and receiving sides of the PDCP entity;
- perform in-order delivery and duplicate elimination in the downlink as specified in subclause 5.5.1.2.1, using the security algorithm and parameters in use after handover, until the reordering function is finished as indicated in 5.5.1.2.2;
- perform re-transmission of PDCP SDUs in the uplink as specified in subclause 5.5.1.3.

5.5.1.2 In-order delivery and duplicate elimination function in the downlink

5.5.1.2.1 Activation and procedure

When a PDCP PDU associated with a PDCP Sequence Number is received from lower layers the UE shall:

- if received PDCP Sequence Number – Last_Submitted_PDCP_RX_SN > Reordering_Window or 0 <= Last_Submitted_PDCP_RX_SN – received PDCP Sequence Number < Reordering_Window:
    - if received PDCP Sequence Number > Next_PDCP_RX_SN:

        - decipher the PDCP PDU according to 5.3, using COUNT based on the value of the variable RX_HFN - 1 and the value of the PDCP Sequence Number contained in the SN field of the PDCP PDU header;
    - else
        - decipher the PDCP PDU according to 5.3, using COUNT based on the value of the variable RX_HFN and the value of the PDCP Sequence Number contained in the SN field of the PDCP PDU header;
    - perform header decompression, if configured as specified in 5.2.5;
    - discard this PDCP SDU;
- else if Next_PDCP_RX_SN – received PDCP Sequence Number > Reordering_Window:
    - increment the variable RX_HFN by one;
    - use the COUNT based on the value of the variable RX_HFN and the received PDCP Sequence Number contained in the PDCP SN field for deciphering the PDCP PDU;
    - set the variable Next_PDCP_RX_SN to received PDCP Sequence Number + 1;
- else if received PDCP Sequence Number – Next_PDCP_RX_SN > Reordering_Window:
    - use the COUNT based on the value RX_HFN – 1 and the received PDCP Sequence Number contained in the PDCP SN field for deciphering the PDCP PDU;
- else if received PDCP Sequence Number >= Next_PDCP_RX_SN:
    - use the COUNT based on the value of the variable RX_HFN and the received PDCP Sequence Number contained in the PDCP SN field for deciphering the PDCP PDU;
    - set the variable Next_PDCP_RX_SN to received PDCP Sequence Number + 1;
    - if the variable Next_PDCP_RX_SN is larger than the Maximum_PDCP_SN:
        - set the variable Next_PDCP_RX_SN to 0;
        - increment the variable RX_HFN by one;
- else if received PDCP Sequence Number < Next_PDCP_RX_SN:
    - use the COUNT based on the value of the variable RX_HFN and the received PDCP Sequence Number contained in the PDCP SN field for deciphering the PDCP PDU;
- if the PDCP PDU has not been discarded in the above:
    - perform deciphering and header decompression as indicated in subclauses 5.2 and 5.3.
    - if a PDCP SDU with the same PDCP Sequence Number is stored:
        - discard this PDCP SDU;
    - else:
        - store the PDCP SDU for later delivery;
- if the received PDCP PDU is not received due to the re-establishment of the lower layers:
    - submit to upper layer in ascending order of the associated COUNT value:
        - all stored PDCP SDU(s) with an associated COUNT value less than or equal to the COUNT value associated with the received PDCP SDU;
        - all stored PDCP SDU(s) with consecutive associated COUNT value(s) starting from the COUNT value associated with the received PDCP SDU + 1, if any.
- else:

  - set the variable Last_Submitted_PDCP_RX_SN to the PDCP Sequence Number of the last PDCP SDU delivered to upper layers

5.5.1.2.2 Stop of the reordering function

If the timer Flush_Timer expires the UE shall:

- deactivate the in-order delivery and duplicate elimination function in the downlink

When the in-order delivery and duplicate elimination function in the downlink is deactivated, the UE shall:

- deliver all stored PDCP SDUs in ascending order of the associated COUNT value to upper layers;
- set the variable Last_Submitted_PDCP_RX_SN to the SN of the last PDCP SDU that was delivered to the upper layers;

5.5.1.3 Re-transmission of PDCP SDUs in the uplink

When upper layers indicate that a handover has occurred, for radio bearers that are mapped on RLC AM the UE shall:

- re-transmit all uplink PDCP SDUs starting from the first PDCP SDU for which the successful delivery of the corresponding PDCP PDU has not been confirmed by lower layers;
- perform header compression if applicable and ciphering as specified in subclauses 5.2 and 5.3. on the PDCP SDUs.

5.5.1.4 Reception of a PDCP status report in the downlink

When a PDCP status report is received in the downlink, for radio bearers that are mapped on RLC AM, the UE shall:

- for each PDCP SDU, if any, with the bit in the bitmap set to '1', or with the associated COUNT value less than the COUNT value of the PDCP SDU identified by the FMS field, the corresponding PDCP PDU and PDCP SDU are discarded. If the corresponding PDCP PDU has already been submitted to lower layers, the discard is indicated to lower layers.

5.5.2 DRBs mapped on RLC UM

5.5.2.1 Actions at handover

When upper layers indicate that a handover has occurred, for DRBs mapped on RLC UM the UE shall:

- perform maintenance of PDCP sequence numbers, header decompression and deciphering as indicated in subclauses 5.1.1.1, 5.2 and 5.3 for PDCP PDUs received from lower layers, using the ciphering algorithm and key in use prior to handover;
- reset the header compression and de-compression protocol;
- set the variables Next_PDCP_TX_SN, Next_PDCP_RX_SN, TX_HFN and RX_HFN to 0;
- perform the actions as indicated in subclause 5.1.3, using the ciphering algorithm and key in use after handover.

5.5.3 SRBs

5.5.3.1 Actions at handover

When upper layers indicate that a handover has occurred, for SRBs the UE shall:

- set the variables Next_PDCP_TX_SN, Next_PDCP_RX_SN, TX_HFN and RX_HFN to 0.
- discard all stored PDCP SDUs and PDCP PDUs.

5.6 Header compression for MBMS

Void

NOTE: MBMS is not supported in this version of the specification.

5.7 Handling of unknown, unforeseen and erroneous protocol data

Editors note: The subsection on "Handling of unknown, unforeseen and erroneous protocol data" should be the last subsection of Section "PDCP procedures".

Editors note: There is no clause defined at this point. FFS if anything related to security can be relevant here.

5.8 Initialisation of a PDCP entity

At initialisation of the PDCP entity the UE shall:

- set the variables Next_PDCP_TX_SN and Next_PDCP_RX_SN to 0.
- set the variables TX_HFN and RX_HFN to the values indicated by upper layers.
- set the variable Last_Submitted_PDCP_RX_SN to 4095.

5.9 PDCP discard

When the Discard_Timer expires for a PDCP SDU the UE shall discard the PDCP PDU along with the corresponding PDCP SDU. If the corresponding PDCP PDU has already been submitted to lower layers the discard is indicated to lower layers.

6 Protocol data units, formats and parameters

6.1 Protocol data units

6.1.1 PDCP Data PDU

The PDCP Data PDU is used to convey:

- a PDCP SDU sequence number; and
- user plane data containing an uncompressed PDCP SDU; or
- user plane data that has been obtained from PDCP SDU after header compression; or
- control plane data; and
- a MAC-I field for SRBs only;

6.1.2 PDCP Control PDU

The PDCP Control PDU is used to convey:

- a PDCP status report on missing or acknowledged PDCP SDUs following a handover.
- Header compression control information, e.g. interspersed ROHC feedback.

6.2 Formats

6.2.1 General

A PDCP PDU is a bit string that is byte aligned (i.e. multiple of 8 bits) in length. In the figures in sub clause 6.2, bit strings are represented by tables in which the most significant bit is the leftmost bit of the first line of the table, the least significant bit is the rightmost bit 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. The bit order of each parameter field within a PDCP PDU is represented with the first and most significant bit in the leftmost bit and the last and least significant bit in the rightmost bit.

PDCP SDUs are bit strings that are byte aligned (i.e. multiple of 8 bits) in length. A compressed or uncompressed SDU is included into a PDCP PDU from the first bit onward.

6.2.2 Control plane PDCP Data PDU SRBs

Figure 6.2.2.1 shows the format of the PDCP Data PDU carrying data for control plane SRBs.

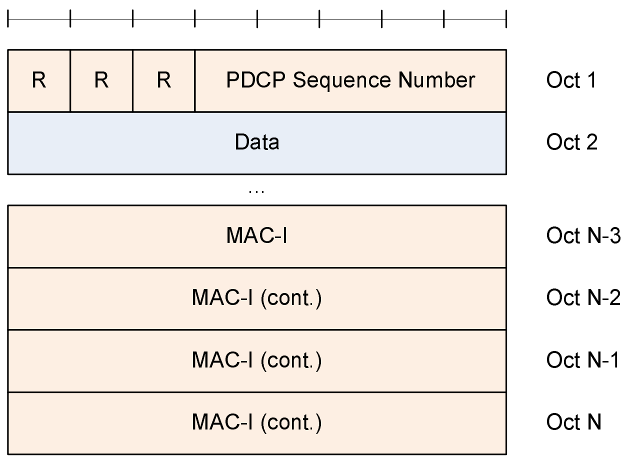

Figure 6.2.2.1: PDCP Data PDU format for SRBs

6.2.3 User plane PDCP Data PDU with long sequence number (12 bits)

Figure 6.2.3.1 shows the format of the PDCP Data PDU when a 12 bit sequence number length is used. This format is applicable for PDCP Data PDUs carrying data from DRBs mapped on RLC AM or RLC UM.

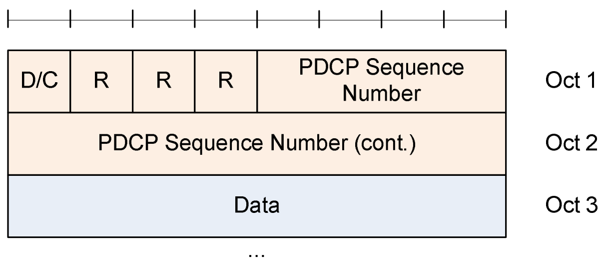

Figure 6.2.3.1: PDCP Data PDU format for DRBs using a 12 bit sequence number

6.2.4 User plane PDCP Data PDU with short sequence number (7 bits)

Figure 6.2.4.1 shows the format of the PDCP Data PDU when a 7 bit sequence number length is used. This format is applicable for PDCP Data PDUs carrying data from DRBs mapped on RLC UM.

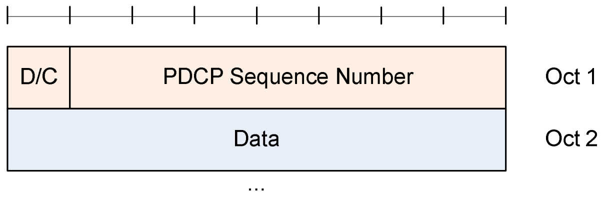

Figure 6.2.4.1: PDCP Data PDU format for DRBs using 7 bit sequence number

6.2.5 PDCP Control PDU for interspersed ROHC feedback packet

Figure 6.2.5.1 shows the format of the PDCP Control PDU carrying one interspersed ROHC feedback packet.

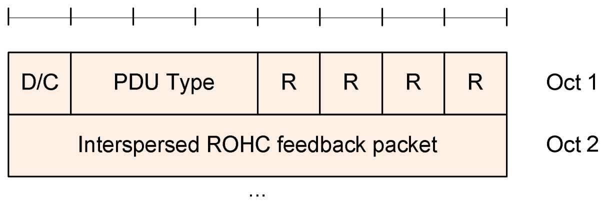

Figure 6.2.5.1: PDCP Data PDU format for interspersed ROHC feedback packet

6.2.6 PDCP Control PDU for PDCP status report

Figure 6.2.6.1 shows the format of the PDCP Control PDU carrying data from the user plane for PDCP status report with a 12 bits sequence number.

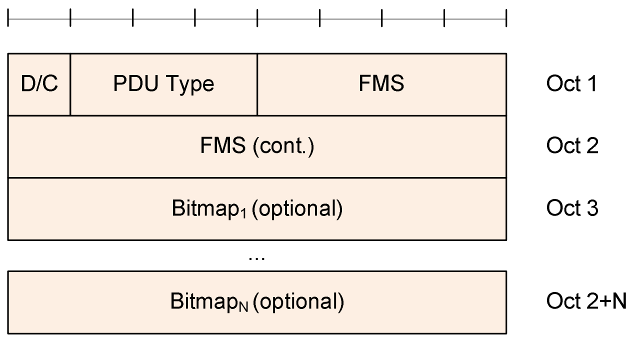

Figure 6.2.6.1: PDCP Data PDU format for PDCP status report

6.2.7 PDCP Data PDU for u-plane data over MBSFN (FFS)

NOTE: MBSFN is not supported in this version of the specification.

6.3 Parameters

6.3.1 General

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.

6.3.2 PDCP Sequence Number

Length: 5, 7 or 12 bits as indicated in table 6.3.2.1.

Table 6.3.2.1 PDCP Sequence number length

Length	Description
5	SRBs
7	DRBs, if configured by upper layers
12	DRBs, if configured by upper layers

6.3.3 Data

Length: Variable

The Data field may include either one of the following:

- Uncompressed PDCP SDU (user plane data, or control plane data); or
- Compressed PDCP SDU (user plane data only).

6.3.4 MAC-I

Length: 32 bits

The MAC-I field carries a message authentication code calculated as specified in subclause 5.4.

For control plane data that are not integrity protected, the MAC-I field is still present and should be padded with padding bits set to 0.

6.3.5 COUNT

Length: 32 bits

For ciphering and integrity a COUNT value is maintained. The COUNT value is composed of a HFN and the PDCP Sequence Number. The length of the PDCP Sequence Number is configured by upper layers.

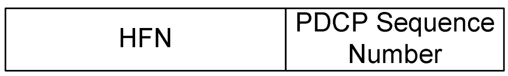

Figure 6.3.5.1: Format of COUNT

The size of the HFN part in bits is equal to 32 minus the length of the PDCP Sequence Number.

6.3.6 R

Length: 1 bit

Reserved. In this version of the specification reserved bits shall be set to 0. Reserved bits shall be ignored by the receiver.

6.3.7 D/C

Length: 1 bit

Table 6.3.7.1 D/C field

Bit	Description
0	Control PDU
1	Data PDU

6.3.8 PDU type

Length: 3 bits

Table 6.3.8.1 PDU type

Bit	Description
000	PDCP Status report
001	Header Compression Feedback Information
010-111	reserved

6.3.9 FMS

Length: 12 bits

Sequence number of the first missing PDCP SDU.

6.3.10 Bitmap

Length: Variable

The length of the bitmap field can be 0.

The MSB of the first octet of the type "Bitmap" indicates whether or not the PDCP PDU with the SN (FMS + 1) modulo 4096 has been received and, optionally decompressed correctly. The LSB of the first octet of the type "Bitmap" indicates whether or not the PDCP PDU with the SN (FMS + 8) modulo 4096 has been received correctly.

Table 6.3.10.1 Bitmap

Bit	Description
0	PDCP PDU with PDCP Sequence Number = (FMS + bit position) modulo 4096 is missing in the receiver. The bit position of N^{th} bit in the Bitmap is N, i.e., the bit position of the first bit in the Bitmap is 1.
1	PDCP PDU with PDCP Sequence Number = (FMS + bit position) modulo 4096 does not need to be retransmitted. The bit position of N^{th} bit in the Bitmap is N, i.e., the bit position of the first bit in the Bitmap is 1.

The UE fills the bitmap indicating what SDUs are missing (unset bit - "0"), i.e. whether an SDU has not been received or optionally has been received but has not been decompressed correctly, and what SDUs do not need retransmission (set bit - "1"), i.e. whether an SDU has been received correctly and may or may not have been decompressed correctly.

6.3.11 Interspersed ROHC feedback packet

Length: Variable

Contains one ROHC packet with only feedback, i.e. a ROHC packet that is not associated with a PDCP SDU as defined in subclause 5.2.4.

7 Variables, constants and timers

7.1 State variables

This sub clause describes the state variables used in PDCP entities in order to specify the PDCP protocol.

All state variables are non-negative integers.

The transmitting side of each PDCP entity shall maintain the following state variables:

a) Next_PDCP_TX_SN

The variable Next_PDCP_TX_SN indicates the PDCP sequence number of the next PDCP SDU for a given PDCP entity. At establishment of the PDCP entity, the Next_PDCP_TX_SN is set to 0.

b) TX_HFN

The variable TX_HFN indicates the HFN value for the generation of the COUNT value used for PDCP PDUs for a given PDCP entity. At establishment of the PDCP entity, the TX_HFN is set to the value indicated by upper layers.

The receiving side of each PDCP entity shall maintain the following state variables:

c) Next_PDCP_RX_SN

The variable Next_PDCP_RX_SN indicates the next expected PDCP sequence number by the receiver for a given PDCP entity. At establishment of the PDCP entity, the Next_PDCP_RX_SN is set to 0.

d) RX_HFN

The variable RX_HFN indicates the HFN value for the generation of the COUNT value used for the received PDCP PDUs for a given PDCP entity. At establishment of the PDCP entity, the RX_HFN is set to the value indicated by upper layers.

e) Last_Submitted_PDCP_RX_SN

For PDCP entities mapped on RLC AM the variable Last_Submitted_PDCP_RX_SN indicates the upper edge of the discard window. At establishment of the PDCP entity the variable Last_Submitted_PDCP_RX_SN is set to 4095.

7.2 Timers

The transmitting side of each PDCP entity for DRBs shall maintain the following timers:

a) Discard_Timer

The value of the timer is signalled by upper layers. In the transmitter, a new timer is started upon reception of an SDU from upper layer.

The receiving side of each PDCP entity, for DRBs that are mapped on RLC AM, shall maintain the following timers:

b) Flush_Timer

The value of the timer is signalled by upper layers. The timer is started when upper layers indicate that a handover has occurred.

7.3 Constants

a) Reordering_Window

Indicates the size of the reordering window. The size equals to 2048, i.e. half of the PDCP sequence number space, for radio bearers that are mapped on RLC AM.

b) Maximum_PDCP_SN is:

- 4095 if the PDCP entity is configured for the use of 12 bit sequence numbers
- 127 if the PDCP entity is configured for the use of 7 bit sequence numbers
- 31 if the PDCP entity is configured for the use of 5 bit sequence numbers

Annex A (informative): Change history

Change history after change control							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
12/2007	RP-38	RP-070919	-	-	Approved at TSG-RAN #38 and placed under Change Control	2.0.0	8.0.0
03/2008	RP-39	RP-080197	0001	-	CR to 36.323 with Update of E-UTRAN PDCP specification	8.0.0	8.1.0
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
05/2008	RP-40	RP-080412	0002	-	Clarification of the BSR calculation	8.1.0	8.2.0
	RP-40	RP-080412	0003	1	PDCP minor changes	8.1.0	8.2.0
	RP-40	RP-080387	0004	3	Addition of a duplicate discard window	8.1.0	8.2.0
	RP-40	RP-080412	0006	-	Reference to ROHCv2 profiles	8.1.0	8.2.0
	RP-40	RP-080412	0010	-	Bitmap in the DL PDCP status report	8.1.0	8.2.0
05/2008	-	-	-	-	Corrections to sections 5.5.1.1, 5.5.1.2.1 and 5.8 to correctly implement CR0004 Rev 3 (instead of CR0004 Rev 2 of RP-080412).	8.2.0	8.2.1

History

Document history		
V8.2.1	November 2008	Publication