Sun Management, Inc.

Analysis of U.S. Patent Number 8,386,667 – Techniques for managing the transmission and reception of data fragments

'667 Patent vs. LTE Standard discardTimer function

CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
1. A method for managing data fragments in transmission or reception using a single timer for one connection in transporting the data fragments, the method comprising:	*In particular, we focus our analysis on the Packet Data Convergence Protocol ("PDCP") within the larger LTE 3GPP standard, further still the 'discardTimer' function used in managing data unit fragmentation during transmission through the wireless network.* 3GPP TS 36.323 version 11.1.0 Release 11 6 ETSI TS 136 323 V11.1.0 (2013-02) 1 Scope The present document provides the description of the Packet Data Convergence Protocol (PDCP). Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.6. *Note that regardless of whether data sent over the radio is associated with a Service Data Unit ("SDU") the PDCP structure is used to send it. SDU's are the packets received by a layer in the above model. Control plane data receives extra handling to verify its integrity, but the PDCP protocol is present where data is transmitted over LTE.* Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.9.

[1] The complete text of the standard used in this analysis is available here:
http://www.etsi.org/deliver/etsi_ts/136300_136399/136323/11.01.00_60/ts_136323v110100p.pdf

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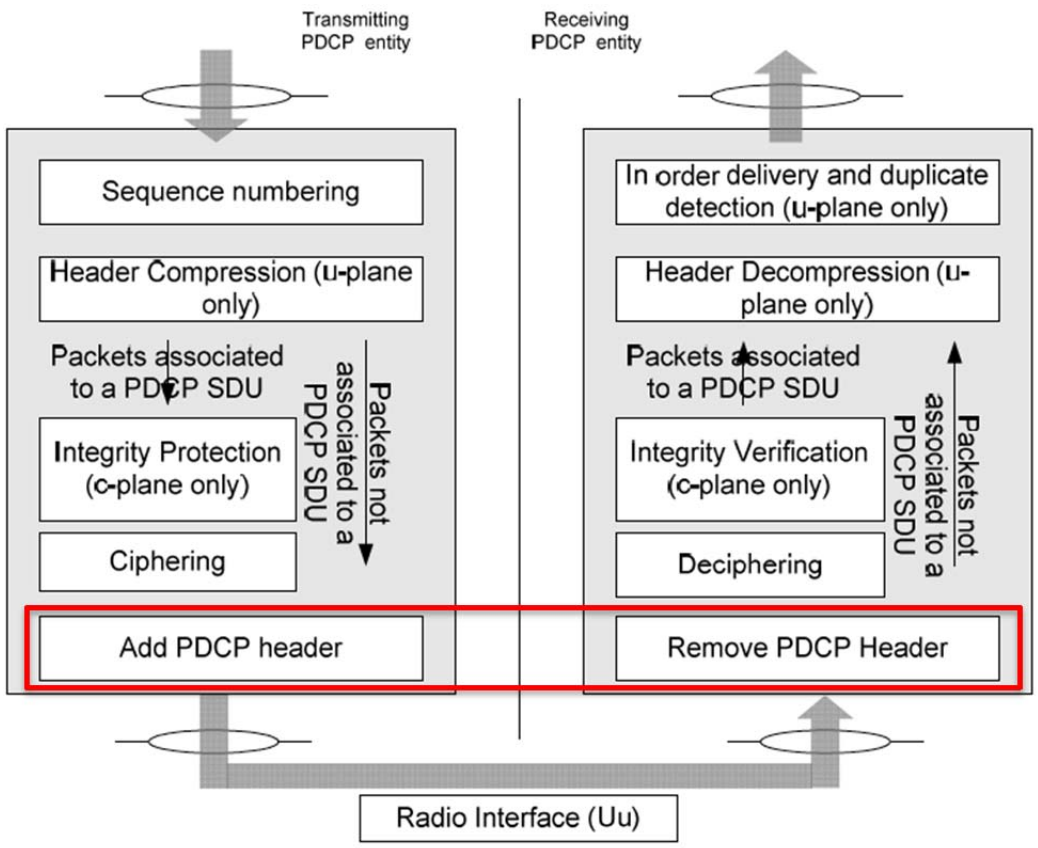
CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
	 *In LTE networks the IP packet data delivered at the top of the stack is called an SDU, while the data that actually gets passed on to be transmitted wirelessly is called a Packet Data Unit (“PDU.”) PDU’s are often smaller than SDU’s resulting in fragmentation of the SDU during transport over the radio bearer.*

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
	The Packet Data Convergence Protocol supports the following functions: - header compression and decompression of IP data flows using the ROHC protocol; - transfer of data (user plane or control plane); - maintenance of PDCP SNs; - in-sequence delivery of upper layer PDUs at re-establishment of lower layers; - duplicate elimination of lower layer SDUs at re-establishment of lower layers 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; - for RNs, integrity protection and integrity verification of user plane data; - timer based discard; - duplicate discarding. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.10.

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<table>
<tr><th>CLAIM 1</th><th>LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]</th></tr>
<tr><td></td><td>
Segmenting (e.g. "fragmenting") larger SDU's for transport over the radio link is required in LTE TS 136 523-1 v8.1 onward (ca. 2009):

[TS 36.322, clause 6.2.2.6]

Length: 2 bits.

The FI field indicates whether a RLC SDU is segmented at the beginning and/or at the end of the Data field. Specifically, the FI field indicates whether the first byte of the Data field corresponds to the first byte of a RLC SDU, and whether the last byte of the Data field corresponds to the last byte of a RLC SDU. The interpretation of the FI field is provided in Table 6.2.2.6-1.

Table 6.2.2.6-1: FI field interpretation
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>00</td><td>First byte of the Data field corresponds to the first byte of a RLC SDU.
Last byte of the Data field corresponds to the last byte of a RLC SDU.</td></tr>
<tr><td>01</td><td>First byte of the Data field corresponds to the first byte of a RLC SDU.
Last byte of the Data field does not correspond to the last byte of a RLC SDU.</td></tr>
<tr><td>10</td><td>First byte of the Data field does not correspond to the first byte of a RLC SDU.
Last byte of the Data field corresponds to the last byte of a RLC SDU.</td></tr>
<tr><td>11</td><td>First byte of the Data field does not correspond to the first byte of a RLC SDU.
Last byte of the Data field does not correspond to the last byte of a RLC SDU.</td></tr>
</table>

Source: LTE Protocol Conformance Specification Part 1. Standard document p.162.[2]

Finally although the above is directed toward the transmission of data, LTE also provides that packet-oriented data communications can be used for voice calling as well via Voice Over LTE ("VoLTE") as all LTE networks are packet-oriented.[3]
</td></tr>
</table>

[2] This standard document is available here: http://www.etsi.org/deliver/etsi_ts/136500_136599/13652301/08.01.00_60/ts_13652301v080100p.pdf

[3] A useful synopsis of VoLTE and a list of carriers rolling this service out can be found at http://en.wikipedia.org/wiki/VoLTE.

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
processing the fragments sequentially, wherein each of the fragments having one or more data blocks includes a processing index to facilitate the fragments to be processed sequentially;	*PDCP explicitly requires the in-sequence delivery and re-establishment of the data units input to the stack previously in transit:* The Packet Data Convergence Protocol supports the following functions: - header compression and decompression of IP data flows using the ROHC protocol; - transfer of data (user plane or control plane); - maintenance of PDCP SNs; - in-sequence delivery of upper layer PDUs at re-establishment of lower layers; - duplicate elimination of lower layer SDUs at re-establishment of lower layers 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; - for RNs, integrity protection and integrity verification of user plane data; - timer based discard; - duplicate discarding. PDCP uses the services provided by the RLC sublayer. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.10. *User plane data, whether compressed or uncompressed as well as some control plane data contain data blocks, and each of these blocks contains a PDCP serial number ("SN") that is used to reassemble the fragments in proper sequence. Two different size serial numbers are provided depending on how fragmented the type of data packet might become in transit.*

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]

6.1.1 PDCP Data PDU

The PDCP Data PDU is used to convey:

- a PDCP SDU SN; and
- user plane data containing an uncompressed PDCP SDU; or
- user plane data containing a compressed PDCP SDU; or
- control plane data; and
- a MAC-I field for SRBs; or
- for RNs, a MAC-I field for DRB (if integrity protection is configured);

Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.19

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

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

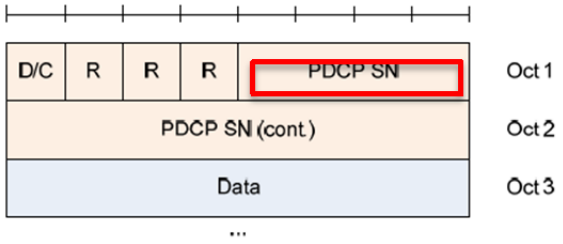

Figure 6.2.3.1: PDCP Data PDU format for DRBs using a 12 bit SN

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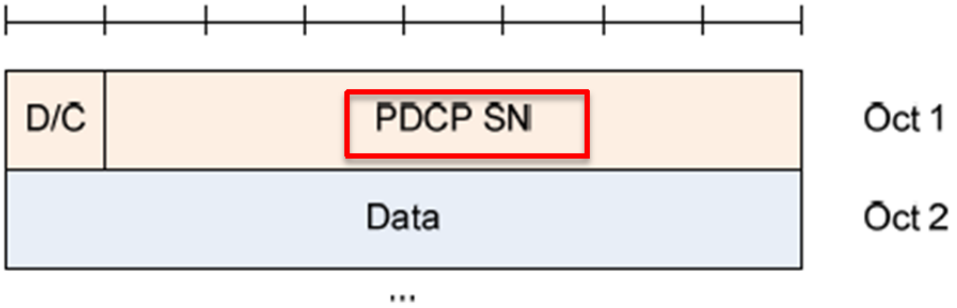
'667 Patent vs. LTE Standard discardTimer function

CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
	6.2.4 User plane PDCP Data PDU with short PDCP SN (7 bits) Figure 6.2.4.1 shows the format of the PDCP Data PDU when a 7 bit SN length is used. This format is applicable for PDCP Data PDUs carrying data from DRBs mapped on RLC UM.  Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.20-21.
processing each of the fragments until one of first pre-defined conditions is met, wherein the first pre-defined conditions include that the timer assigned to the each of the fragments is timed out or an acknowledgement of at least one of the data blocks in the each of the fragments is received, wherein said processing each of the fragments includes:	*PDCP datagrams are serialized with a number allowing their re-assembly after transport of the original packet data. This operation continues for a given SDU until either a timer runs out, or the acknowledgement is made that the fragmented data blocks have been received for re-assembly using said serial numbers. PDCP also explicitly performs processing of the SDU fragments.* 4.5 Data available for transmission For the purpose of MAC buffer status reporting, the UE shall consider PDCP Control PDUs, as well as 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 if the SDU has been processed by PDCP. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.10.

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
	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. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.9. *Note that both the user equipment ("UE") or handset AND the evolved Node B base station practice the method.* **5.1 PDCP Data Transfer Procedures** **5.1.1 UL Data Transfer Procedures** At reception of a PDCP SDU from upper layers, the UE shall: - start the *discardTimer* associated with this PDCP SDU (if configured); For a PDCP SDU received from upper layers, the UE shall: - associate the PDCP SN corresponding to Next_PDCP_TX_SN to this PDCP SDU; Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.11.

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
	5.4 PDCP discard When the *discardTimer* expires for a PDCP SDU, or the successful delivery of a PDCP SDU is confirmed by PDCP status report, the UE shall discard the PDCP SDU along with the corresponding PDCP PDU. If the corresponding PDCP PDU has already been submitted to lower layers the discard is indicated to lower layers. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.16. *Note that in the above description of the PDCP data transfer procedure the statements are made using ‘shall’ requiring that the steps illustrated are always performed by a compliant device or service.*
starting the timer assigned to the each of the fragments, wherein the timer has a timeout value being a function depending on a life of the each of the fragments and time parameters thereof;	*“UL” refers to “uplink” and is an action performed by both handsets and base stations alike; the term only refers to the relative direction for the data transfer.* 5.1 PDCP Data Transfer Procedures 5.1.1 UL Data Transfer Procedures At reception of a PDCP SDU from upper layers, the UE shall: - start the *discardTimer* associated with this PDCP SDU (if configured); For a PDCP SDU received from upper layers, the UE shall: - associate the PDCP SN corresponding to Next_PDCP_TX_SN to this PDCP SDU; Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.11.

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]
	5.3.2 Receive operation When a PDCP status report is received in the downlink, for radio bearers that are mapped on RLC AM: - 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 successful delivery of the corresponding PDCP SDU is confirmed, and the UE shall process the PDCP SDU as specified in the subclause 5.4. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.16. *Subclause 5.4 is the timer discard function detailed earlier in this analysis. Also this operation is performed on EACH fragment SDU.*
running said timer until said processing of the each of the fragments is terminated;	7.2 Timers The transmitting side of each PDCP entity for DRBs shall maintain the following timers: a) *discardTimer* The duration of the timer is configured by upper layers [3]. In the transmitter, a new timer is started upon reception of an SDU from upper layer. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.25. *Handsets and small-cell relays (UE's) also perform additional specific functions while running a timer.*

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]

	When upper layers request a PDCP re-establishment, the UE shall:
	- reset the header compression protocol for uplink if the DRB is configured with the header compression protocol and *drb-ContinueROHC* is not configured [3];
	- set Next_PDCP_TX_SN, and TX_HFN to 0;
	- apply the ciphering algorithm and key provided by upper layers during the re-establishment procedure;
	- if connected as an RN, apply the integrity protection algorithm and key provided by upper layers (if configured) during the re-establishment procedure;
	- for each PDCP SDU already associated with a PDCP SN but for which a corresponding PDU has not previously been submitted to lower layers:
	  - 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, as specified in the subclause 5.1.1 without restarting the *discardTimer*.
	Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.14.

reassigning the timer to a next one of the fragments before the next one of the fragments is processed.	*Each PDCP for each SDU has an associated timer, and each later submitted PDU fragment is then associated with that stream of smaller fragmented PDU's that make up the original SDU. Again to be compliant with the LTE standard devices must perform the steps in the conformance specification precisely.* 7.2 Timers The transmitting side of each PDCP entity for DRBs shall maintain the following timers: a) *discardTimer* The duration of the timer is configured by upper layers [3]. In the transmitter, a new timer is started upon reception of an SDU from upper layer. Source: LTE Technical Standard 36.323 v.11.0.1. Standard document p.25.

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CLAIM 1	LTE 3GPP TS 36.323 version 11.1.0 Release 11[1]

	[TS 36.323, clause 5.1.1]
	At reception of a PDCP SDU from upper layers, the UE shall:
	- start the Discard_Timer associated with this PDCP SDU (if configured);
	For a PDCP SDU received from upper layers, the UE shall:
	- associate the PDCP SN corresponding to Next_PDCP_TX_SN to this PDCP SDU;
	- perform header compression of the PDCP SDU (if configured) as specified in the subclause 5.5.4;
	- perform integrity protection (if applicable), and ciphering (if applicable) using COUNT based on TX_HFN and the PDCP SN associated with this PDCP SDU as specified in the subclause 5.7 and 5.6, respectively;
	- increment Next_PDCP_TX_SN by one;
	- if Next_PDCP_TX_SN > Maximum_PDCP_SN:
	  - set Next_PDCP_TX_SN to 0;
	  - increment TX_HFN by one;
	- submit the resulting PDCP Data PDU to lower layer.
	Source: LTE Protocol Conformance Specification Part 1. Standard document p.243

Notes:

- No FRAND patent declarations associated with participation in the standard setting body at 3GPP are known to impact this essential patent.
- A useful tutorial on the complex series of protocols that make up the 4G data transmission stack can be found at http://www.tutorialspoint.com/lte/lte_protocol_stack_layers.htm

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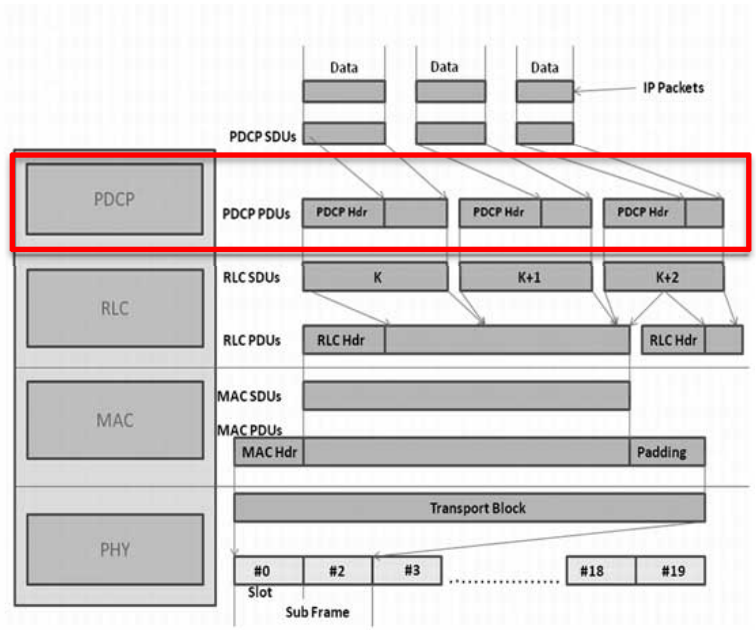
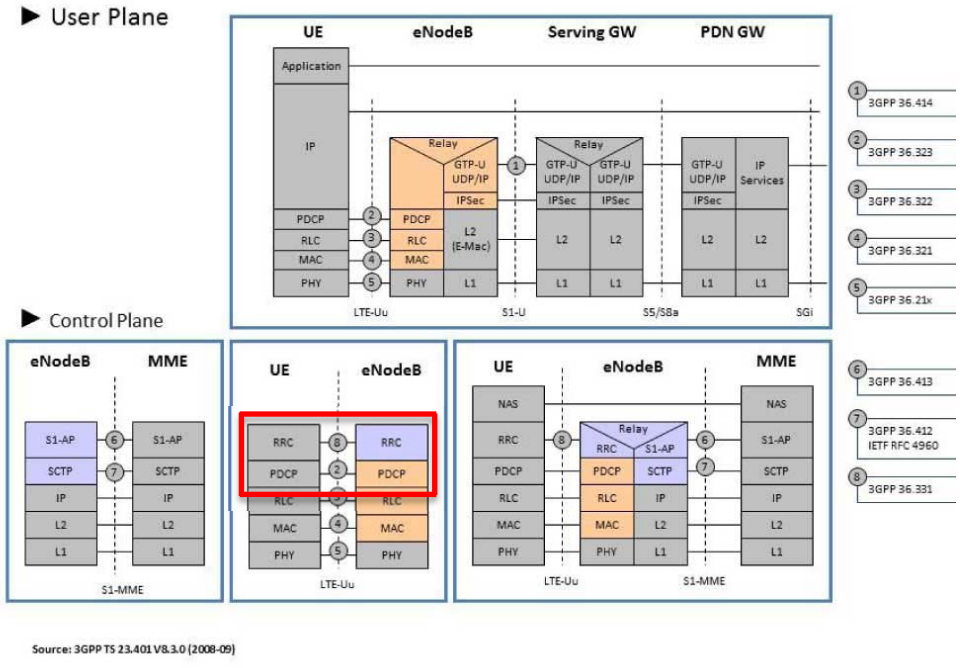
- PDCP is an essential part of how packet data (e.g. Internet services, photos, video and text communications) transit a 4G LTE network **between both handsets (UE's) and base stations (eNodeB's)** as illustrated below:





Source: 3GPP TS 23.401 V8.3.0 (2008-09)