

Agenda item: 5.2.2
Source: Motorola
Title: RLC PDU SN: To Reuse PDCP SN or not?
Document for: Discussion and Approval

1 Introduction

This document is a resubmit of the document submitted for the conference call held August 9, 2007. It is being re-submitted for completeness since the topic was pushed off to the RAN WG2#59 meeting for a final decision. One open issue identified in [1] is the RLC PDU SN numbering. Two major approaches have been proposed in previous meetings:

Approach 1: RLC PDU based RLC SN numbering. RLC PDU SN is increased by one for each new RLC PDU.

Approach 2: PDCP PDU SN based RLC SN numbering. RLC PDU SN is the same as the SN of the first PDCP PDU/PDU segment contained in the RLC data payload.

This contribution compares the above two approaches from various aspects, with the aim to provide an unbiased view of the advantages and disadvantages of the two approaches.

2 Discussion

The comparison study between approach 1 and 2 is made from three perspectives, namely protocol design and its impact on protocol description and simplicity, radio interface overhead and implementation. The summary is provided in Table 1, 2 and 3 respectively, where “(+)” indicates a perceived advantage and “(-)” indicates a perceived disadvantage.

2.1 Protocol Design

Comparison Criteria	Approach 1: RLC PDU based RLC SN	Approach 2: PDCP SN reused as RLC SN
Different handling of RLC PDU and RLC PDU segment	(-)Yes	(+)No
Header Fields Difference	(-) Separate header formats for PDUs and PDU segments. One bit is needed to differentiate PDU header or PDU segment header. (-) PDU segment header shall contain SN, SO and LSF fields (+) PDU header overhead: Small (SN field only)	(+) No difference between PDUs and PDU segments (+) PDU segment header (the same as PDU header): no LSF field is needed (-) PDU header overhead: more (SN, SO) fields. But optimization is possible to skip SO if first SDU segment starts on a SDU boundary (SI indicating whether first SDU is a segment).
Status report SUFIs for PDU/PDU segment ACK/NACKs	(+/-)PDU based. ACK/NACK is for a PDU or a PDU-segment. (+/-)Different SUFIs for PDUs and PDU segments (FFS). (+) For PDU ACK/NACKs, SN field is enough, and SUFIs such as LIST, BITMAP, RLIST can be used. (+/-) For status reporting on PDU segments the SUFI shall include SN, SO and the length of the segment, e.g. SLIST SUFI proposed in [8].	(+/-)SDU based. ACK/NACK is for a SDU or a SDU-segment. (+/-) Different SUFIs for SDUs and SDU-segments (FFS) (+) For status reporting on full SDUs, SN is sufficient, and SUFIs such as LIST, BITMAP, RLIST can be used (+/-)For status reporting on SDU segments the SUFI shall include SN, SO and the length of the segment, e.g. SLIST SUFI proposed in [8].
RLC SN field sizing when PDCP SN field size is configurable.	(+/-) RLC SN field size is independent of PDCP SN field size.	(+/-) RLC SN field size is related to PDCP SN field size. It may be a fixed size which is the maximum possible PDCP SN size. Alternatively RLC SN size may also be of two or more different sizes as defined for PDCP SN.
RLC SN generation for Control plane traffic which do not have PDCP SN, such as ROHC feedback packets [5][6].	(+) the same RLC SN numbering mechanism.	(-) A fictitious PDCP SN would need to be generated, or some other approaches will need to be applied to cover the case. [3]
RLC SDU discard	(-) indication in SUFI needs to map RLC PDU SN with the SN of RLC SDU to be discarded. A little more processing needed to identify SDU.	(+) indication in SUFI can directly identify RLC SDU SN.
Handover preparation: status report	(-) report on RLC PDU; more processing therefore required to build forward ed SDU list.	(+) report on RLC SDU directly

Table 1: Protocol Design Comparison of RLC PDU based RLC SN vs. reuse of PDCP SN

Conclusion: Overall, the PDCP SN reuse based approach is perceived to help simplify overall protocol design and description.

2.2 Overhead

Comparison Criteria	Approach 1: RLC PDU based RLC SN	Approach 2: PDCP SN reused as RLC SN
Concatenation overhead Example: N RLC SDUs concatenated into one RLC PDU.	(-) One RLC SN in RLC header and one or more PDCP PDU SNs in the RLC payload. Not desirable for small size PDCP PDUs, such as VoIP or TCP ACKs, especially after header compression (+) No need for SO (-) Retransmitted PDU segments cannot be concatenated with retransmitted PDUs or new PDUs. (+) RLC SDUs with non-consecutive SNs can be concatenated into one RLC PDU. (-) 1 RLC SN + N PDCP SNs	(+)One PDCP SN in the header for the entire PDU. Good when small sized PDCP PDUs (VoIP, etc.) are concatenated into a single RLC PDU ^[Note 1] . (-) one SO needed if first SDU does not start on SDU boundary (+) Retransmitted RLC PDUs/PDU segments and the new RLC SDUs can be concatenated into ONE new RLC PDU, as long as SDU SNs are consecutive. (-) RLC SDUs with non-consecutive SNs have to be grouped into separate RLC PDUs. (+) 1 PDCP SN
Segmentation overhead Example: One RLC SDU divided into N RLC SDU segments.	(-)One RLC PDU SN in the RLC header per RLC SDU segment, plus one PDCP SN in the first RLC SDU segment (+) No need for SO N RLC SNs + 1 PDCP SNs	(+)One PDCP SN per RLC SDU segment (-) One SO per RLC SDU segment from second segment onwards N PDCP SNs + (N-1) SOs
Re-segmentation Overhead	(+/-) SN and SO per segment (-) LSF for the last segment	(+) Same as segmentation case (+) No need for LSF

Note 1: Improvement can be as much as 24.5%, and the overall is around 14% according to [3]. However, the analysis in [4] concluded that the overhead reduction gained through PDCP SN reuse is minimal. The discrepancy is mainly due to the different assumptions of Internet traffic composition, the header details, and the usage of ROHC. For example, the TCP ACK packet size is assumed to be 40bytes throughout the analysis in [4], not considering the effect of ROHC compression. Actually the TCP ACK size is assumed to be 8 bytes in [3] based on the newly agreed ROHC-TCP profile. Therefore, the overhead reduction that can be gained from PDCP SN reuse should be larger than what is claimed in [4], and the improvement is not then negligible.

Table 2: Overhead Comparison of RLC PDU based RLC SN vs. reuse of PDCP SN

Conclusion: Approach 1 performs better with SDU segmentation, while Approach 2 is better for concatenation and re-segmentation. If we agree that majority of IP traffic is small packets [9], the PDCP SN reuse based approach is expected to achieve reduce the overhead overall.

2.3 Implementation

Comparison Criteria	Approach 1: RLC PDU based RLC SN	Approach 2: PDCP SN reused as RLC SN
Differentiation between RLC PDU and PDU segment handling	(-)Yes	(+)No. Simple, cleaner, unified procedure for pdus and segments
PDCP SN at the transmitter side	(+/-) PDCP SN in PDCP PDU already. They are passed to RLC as one entity. (-) additional resource needed to generate RLC SN.	(+/-) PDCP SN and PDCP PDU are passed to RLC as two entities, but are associated. (+) no resource needed for RLC SN generation.
PDCP SN at the receiver side	(+) PDCP SN in RLC SDU already. No extra processing needed.	(-) PDCP SN has to be re-generated by RLC entity. PDCP SN and RLC SDU shall be passed to PDCP.
Re-Assembly of RLC SDUs from RLC PDU segments	(-)Complicated, two-pass: first PDU reconstruction and then SDU reassembly	(+)Easy, single-pass: SDU reassembly directly.
RLC SDU discard	(-) Indication in SUFI needs to map RLC PDU SN with the SN of RLC SDU to be discarded. A little more processing needed to identify SDU.	(+) Indication in SUFI can be RLC SDU SN directly.
Retransmission handling	(-) Sender: separate information shall be maintained for unacknowledged PDUs and PDU segments under retransmission.	(+) Sender: no need to store information on PDUs / PDU-segments for retransmission.
Handover preparation: status report	(-) report on RLC PDU; more processing therefore required to build forwarded SDU list.	(+) report on RLC SDU directly

Table 3: Implementation Comparison of RLC PDU based RLC SN vs. reuse of PDCP SN

Conclusion: The PDCP SN reuse based approach clearly leads to more simplified and efficient implementation.

3 Conclusions

As can be seen from Table 1, 2 and 3, both approaches have some advantages and disadvantages. However, both from protocol simplicity and implementation simplicity PDCP SN re-use has clear advantages over no-reuse. The overhead impact for either approach is not significantly different to warrant a choice based on that. Hence even if there is disagreement on the methodology used to quantify the overhead advantage this in itself is probably not sufficiently different to pick one over the other.

From a strictly technical perspective, the comparison indicates that approach 2's pros out-weigh its cons. Given the simplicity of implementation, the clear efficiency in re-assembly process, together with the direct SDU identification from PDUs, we believe approach 2 is preferable over approach 1 and propose that RLC reuses the PDCP SN as the RLC PDU SN.

References

- [1] R2-07xxxx, Open issues for Stage 3 E-UTRA RLC, NTT DoCoMo, Inc. (Editor)
- [2] R2-071837, "L2 Sequence Number in LTE", Ericsson
- [3] R2-072473, "On RLC SN: PDU-based vs. reusing PDCP SN", InterDigital

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- [5] R2-072641, R2-071778, "PDCP SN reuse in RLC PDU for LTE", Panasonic
- [6] R2-072425, R2-072087, "Considerations on ROHC feedback for L2 design", LGE
- [7] R2-072691, "Comparison of different SN handling at Layer 2", Alcatel-Lucent
- [8] R2-07xxxx, "RLC Status Report SUFIs", Motorola
- [9] R2-061858, "Most IP Packets are small", Ericsson