3GPP TSG-RAN WG2 Meeting #125 Tdoc R2-24xxxxx

Athens, Greece, February 26th - March 1st, 2024

Source: Ericsson (rapporteur)

Title: [POST125][017][XR] PDCP report

Agenda item: 7.5.3.3

Document for: Discussion, Decision

# 1 Introduction

This contribution intends to provide a report for the post meeting discussion as below:

* [POST125][017][XR] PDCP report (Ericsson)

 Intended outcome: Start with joint paper proposal to get further inputs from companies that haven’t yet provided their views, suggest and review the TP.

 Deadline: Long

This email discussion will be organized in two phases. In the 1st phase, we will collect company views on the leftover joint proposals from [2]. In the 2nd phase, based on the outcome of the 1st phase, we will provide a set of proposals and corresponding TPs for perusal and further comments.

The deadline for providing company views are as follows:

|  |  |
| --- | --- |
| 1st Phase  | 22nd March 2024, 10 UTC |
| 2nd Phase  | 29th March 2024, 10 UTC |

# 2 List of Joint Proposals

The following are the agreements from the RAN2#125 meeting [18]:

**Agreements**

1. To define a mechanism for PDCP Transmitter to report to PDCP Receiver about the gap on the PDCP SN (i.e., transmitting PDCP entity can inform the receiving PDCP entity about the discarded SDUs).

2 To agree that the usage of a PDCP SN gap report is under network control (i.e. network configures UE whether/when PDCP SN gap report can be used). The UE should report only if there gaps (i.e. if the UE does re-association and there are not gaps, the UE is not required to transmit).

3 Define a new UE capability to indicate the support of PDCP SN Gap reporting.

The intended outcome as stated above is to get further input from companies on these joint proposals. Further, also gather company inputs on the related TPs. The proposals from the joint contribution [2] are as shown below, given that P1/P2 and part of P4 have already been agreed, we will focus on the other set of proposals.

***Proposal 1.*** *To define a mechanism for PDCP Transmitter to report to PDCP Receiver about the gap on the PDCP SN (i.e., transmitting PDCP entity can inform the receiving PDCP entity about the discarded SDUs).*

***Proposal 2.*** *To agree that the usage of a PDCP SN gap report is under network control (i.e. network configures UE whether/when PDCP SN gap report can be used).*

***Proposal 2.1.*** *To confirm that the usage of a PDCP SN gap reporting is dependent or applicable only when outOfOrderDelivery is not configured.*

***Proposal 3.*** *To agree on PDCP control PDU approach for transmitter to provide PDCP SN Gap reporting to receiver.*

***Proposal 3.1.*** *To discuss whether to enable PDCP SN Gap reporting via: option (A.1) bitmap kind of information, or option (A.2) range kind of information.*

***Proposal 3.2.*** *To discuss whether/which rules needs to be defined in PDCP transmitter entity to trigger PDCP SDU discard report considering e.g. (1) the PDCP entity discards SDU(s) which have not been transmitted (for UM DRBs) or acknowledged (for AM DRBs), due to the expiry of PDCP discard timer; and (2) there is a buffered SDU associated with an SN higher than the SN of the discarded SDU(s), as well as, related TPs included in R2-2401420, R2-2400748 and R2-2313923.*

***Proposal 3.3.*** *To consider the related TPs included in R2-2401420, R2-2400748 and R2-2313923.*

***Proposal 4.*** *To discuss whether to define a new UE capability to indicate the support of PDCP SN Gap reporting. If so, to discuss whether UE supporting PDCP SN Gap reporting shall also support pdu-SetDiscard-r18 and/or psi-BasedDiscard-r18.*

# 3 Discussion

## 3.1 PDCP SN Gap Reporting for *OutofOrderDelivery*

*that the usage of a PDCP SN gap reporting is dependent or applicable only when outOfOrderDelivery is not configured.*

This is a straightforward proposal where if the UE is configured with *OutofOrderDelivery*, then the reordering delays are not applicable. But would be good to confirm company’s views on this proposal.

**Is the PDCP SN gap reporting applicable only when outOfOrderDelivery is not configured?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| LGE | Yes |  |

## 3.2 PDCP Control PDU for PDCP SN Gap Reporting

*On PDCP control PDU approach for transmitter to provide PDCP SN Gap reporting to receiver.*

[3][5][8][9][12][13][14][15] believe a new PDCP Control PDU is the simplest way to perform the PDCP SN gap reporting as the headers of the PDCP data PDU are not impacted [3] and, that it was agreed to not introduce in-band marking in Rel-18 XR [15]. Further, as detailed in [9], using the headers of the data PDU could result in a unwarranted size of the PDCP data PDU and due to preprocessing of the header, any changes would require manipulation of the already processed PDCP PDU header resulting in implementation complexities.

[6] on the other hand, suggests that the control PDU is poorly suited for this type of notification as in-band reception can inform the receiver as soon as possible hence, using the header of the data PDU.

So, based on the majority view, we would like to check company’s views on the use of a new PDCP control PDU to perform the PDCP SN gap reporting as a baseline.

**As the baseline, should a new PDCP Control PDU be used for PDCP SN gap reporting?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| LGE | No | Using a header-only PDU (i.e. PDU without payload) is simple with following reasons:* PDCP Control PDU can be transmitted only after all the buffered data are transmitted. There is no PDCP Control PDU prioritization rule in current specification. Thus, there is no real benefit to use PDCP Control PDU.
* Header-only PDU does not change any state variable handling in Rx operation. On the other hand, with PDCP Control PDU, a new state variable handling operation should be introduced in Rx side.
* The Tx operation with header-only PDU is simple. When a PDCP report is triggered, the UE just removes the payload from the discardTimer-expired PDUs.
* If the header-only PDU is used, further discussion such as 3.2.1 and 3.2.2 are not needed.
 |

### 3.2.1 Indication of Discarded PDCP SNs

*whether to enable PDCP SN Gap reporting via: option (A.1) bitmap kind of information, or option (A.2) range kind of information*

From the contributions, [3][5][8][12][13] alluded to a bitmap-based indication. On the other hand, a couple of other companies prefer the range indication. With [14] mentioning that discarding PDUs in blocks as an entire PDU-set can result in 100 PDUs being discarded if a single PDU is dropped. In [12], suggests three different indications i.e., bitmap-based, two COUNTs and first discard Count + number of SDUs.

Drawing from the options in [12] and based on our understanding of the requirements, at the PDCP Rx entity, it should be sufficient to consider all SNs in the reordering window SN >= RX\_DELIV AND < RX\_NEXT as discarded based on the PDCP SN gap report. In which case, RX\_DELIV would be set to the next non-delivered SN (not discarded) and RX\_NEXT would be set to the COUNT value of the indicated SN in the PDCP SN gap report. Further, it would be sufficient to indicate using a single SN in the PDCP SN gap report. Furthermore, this would also have minimal specification impact and in terms of overhead, the simple mechanism has a fixed length and at most two octets i.e., low overhead.

**For the new PDCP Control PDU, do companies think a simple mechanism of “considering all SNs in the reordering window (i.e., >= RX\_DELIV AND < RX\_NEXT) as discarded by using a single SN in the PDCP Control PDU” is sufficient?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| LGE | Comment | Note that if header-only PDU is used, this discussion is not needed.But, if PDCP Control PDU is used, the triggering event should be discussed first.If SN Gap reporting is triggered when SDUs are discarded discontinuously, FMC + BITMAP is desirable.But, if SN Gap reporting is triggered when SDUs are discarded continuously, only a single value (i.e. highest COUNT among discarded SDUs) is sufficient.However, we think SN Gap reporting is not beneficial when SDUs are discarded continuously, as explained in R2-2401863. Thus, if PDCP Control PDU is used, FMC + BITMAP is better. |

For the bitmap indication, the PDCP Tx entity needs to compile the report on the first discarded SN and each discarded SN within the window into a bitmap. The PDCP Rx entity then delivers all stored SDUs from the COUNT = RX\_DELIV except the SDUs which are not considered discarded and then the state variables need to be updated accordingly. This is not beneficial for PDUs discarded within a PDU sets. [12] also calculates the overhead for the bitmap indication for a maximum data packet size (140625 bytes) is at most 16 bytes with a variable length. The same is applicable for the range indication in terms of the processing required at the PDCP Tx and Rx entity.

Considering the aspect of complexity and in the interest of introducing a solution with minimal spec impact during the maintenance of Rel-18, we would like companies to provide their inputs on whether such complex indications as bitmap or range is necessary as opposed to using the simple mechanism described above.

**For the new PDCP Control PDU, do companies believe it is necessary to use a bitmap or range indication over the simple mechanism described above?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments (bitmap or range) |
| LGE | Comment | It should be discussed first in which case the SN Gap reporting is triggered. |

### 3.2.2 Usage of SN or COUNT

This was not discussed in detail during the previous meetings. [15] mentions that COUNT should be used as indication for the first discarded SDU and by reusing the design of the PDCP SR, there would not be too much work.

As explained in [9], the PDCP SN gap reporting is a different type of signaling i.e., originating at the PDCP Tx entity and this is used to indicate to the PDCP Rx entity to not wait for certain SN(s) in cases where the SN >= RX\_DELIV AND < RX\_NEXT. Given that the PDCP Tx entity and PDCP Rx entity are synchronized (i.e., operating under steady state conditions), it is sufficient to include the SN in the new PDCP control PDU as the Rx entity derives the corresponding HFN by operating on the received SNs. On the contrary, the current PDCP SR is used under conditions of reestablishment or data recovery i.e., the PDCP Tx entity and PDCP Rx entity have lost synchronization. Therefore, we would like companies to comment on this aspect.

**For the new PDCP Control PDU, do companies have a preference in using SN or COUNT for indicating discarded PDCP SDUs?**

|  |  |  |
| --- | --- | --- |
| Company | SN or COUNT | Comments |
| LGE | COUNT | But, it is not urgent, and thus can be discussed later. |

## 3.3 Triggering of the PDCP SN Gap Report

*whether/which rules needs to be defined in PDCP transmitter entity to trigger PDCP SDU discard report considering e.g. (1) the PDCP entity discards SDU(s) which have not been transmitted (for UM DRBs) or acknowledged (for AM DRBs), due to the expiry of PDCP discard timer; and (2) there is a buffered SDU associated with an SN higher than the SN of the discarded SDU(s), as well as, related TPs included in R2-2401420, R2-2400748 and R2-2313923*.

In [15], when the SDUs are discarded in the PDCP buffer and at the tail of the buffer, the Tx entity could perform (re-)association of the SNs to the SDUs that arrive later. This has already been covered in the agreement and such (re-)association is up to implementation.

[15] also details the scenario where the PDCP Tx entity can trigger the report based on the conditions in the proposal above. In our understanding, the underlying trigger is the same in both cases, in the RLC buffer, if there are PDCP PDUs not transmitted in UM DRBs or acknowledged in AM DRBs and in the PDCP buffer, if the corresponding SDU associated with a lower SN is discarded (due to the expiry of the discard timer) whilst a SDU associated with a higher SN is buffered, this would trigger the PDCP SN gap report. In essence, the discarding of lower SNs (in the presence of higher SNs) in the PDCP buffer will create gaps in SNs. The dependence on the RLC status of the PDCP PDUs is a precursor for discard but not the trigger for the PDCP SN gap report nor will it affect the gap in the PDCP SNs.

Therefore, the trigger at the PDCP Tx entity is basically an “arbitration” of whether the discard will create a gap at the PDCP Rx entity. Hence, we comebine the two triggering conditions and would like to check company’s views on the same.

**Do companies agree that the PDCP Tx entity triggers the PDCP SN gap report when there is a buffered SDU associated with an SN higher than the SN of the discarded SDU(s) (discarded due to expiry of the discard timer) and these SDU(s) have not been transmitted (for UM DRBs) or acknowledged (for AM DRBs)?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| LGE | No | Even for AM DRBs, the condition should be same as UM DRBs, i.e. “these SDU(s) have not been transmitted“. The “not acknodwledged“ SDU includes SDUs already transmitted. In AM RLC, once a segment is transmitted, the AM RLC entity will keep retransmitting the SDU. Thus, there is no need to report SN Gap. |

## 3.4 New UE-capability for PDCP SN Gap Reporting and Other Discarding Capabilities

To discuss whether to define a new UE capability to indicate the support of PDCP SN Gap reporting. If so, to discuss whether UE supporting PDCP SN Gap reporting shall also support pdu-SetDiscard-r18 and/or psi-BasedDiscard-r18.

The highlighted part of the proposal was not discussed during the meeting. Dependencies between discard capabilities was brought up during the coordination of the summary paper [2], specifically around the question if capability to do PDU Set discard would also mandate the capability to do PDCP SN gap reporting. Earlier discussion around PDCP SN gap reporting has raised the concern that there may be more discards happen when utilizing PDU Set discarding. Hence, we would like companies to provide their views on the relationship between PDCP SN gap reporting and other discarding capabilities.

**Do companies think that there should be any dependencies between the UE capability to support PDCP SN Gap reporting and support pdu-SetDiscard-r18/psi-BasedDiscard-r18?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
| LGE | Yes | As explained in our paper (R2-2401863), the SN Gap reporting is beneficial only when RLC SDUs stored in RLC Tx buffer are discarded discontinuously. This case happens in following conditions:* pdu-SetDiscard is configured
* PDU sets arrive at PDCP buffer with interleaving
* Lots of PDCP SDUs are pre-processed and stored in RLC Tx buffer
* RLC SDUs are not transmitted until the discard timer expires

For other cases (i.e. continuous discard case), SN re-association or relying on t-Reordering is sufficient. Thus, the SN Gap reporting should be used only when pdu-SetDiscard is configured. |

## 3.5 Receiver Behaviour

In [15], the behaviour is described for when the PDCP SN gap report is received at the PDCP Rx entity. For the upper bound of the reordering window, if RX\_NEXT is not larger than the max COUNT indicated as discarded, it should be updated to the max COUNT + 1 and for the lower bound, if the RX\_DELIV corresponds to an SDU which has been discarded, the receiving PDCP entity shall deliver subsequent received SNs consecutively and skip the discarded SNs and update RX\_DELIV to the COUNT which has not been discarded or delivered.

As a baseline, we would like to get company views on the receiver behaviour up on receiving the PDCP SN gap report.

**Do companies agree that RX\_DELIV and RX\_NEXT should be updated at the PDCP Rx entity when the PDCP SN gap report is received?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comments |
|  |  |  |

## 3.6 Related TPs (Phase 2, TODO)

As the TPs are be based on the outcome of the above discussion, we will provide different versions of the TPs to cover all the proposals in the 2nd phase of the email discussion as explained in the introduction.

# 4 References

1. R2-2313923, Report of [AT124][019] PDCP discard (CATT), RAN2#124, Chicago, USA, November 2023.
2. R2-2401837, PDCP SN Gap Reporting, Intel Corporation, CATT, Fujitsu, Ericsson, Canon, Apple, InterDigital, Futurewei, Huawei, HiSilicon, ZTE, Vivo, NTT DOCOMO, MediaTek Inc., Nokia, Nokia Shangai Bell, RAN2#125, Athens, Greece, February 2024
3. R2-2400390, PDCP SN Gap Notification, Intel Corporation, RAN2#125, Athens, Greece, February 2024
4. R2-2400440, Need for PDCP discard notifications to receiving PDCP entity, LG Electronics, Xiaomi, NEC, Oppo, Samsung, RAN2#125, Athens, Greece, February 2024
5. R2-2400452, Discussion on PDCP discard notification to receiver, vivo, RAN2#125, Athens, Greece, February 2024
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7. R2-2400480, Corrections and Considerations for PDCP and Discard Operation, Samsung, RAN2#125, Athens, Greece, February 2024
8. R2-2400748, PDCP discard notification for XR, ZTE Corporation, Sanechips, Futurewei, Canon, RAN2#125, Athens, Greece, February 2024
9. R2-2400797, Indication of PDCP SN Gaps, Ericsson, RAN2#125, Athens, Greece, February 2024
10. R2-2400834, Discussion on SN gap issue, CANON Research Centre France, CATT, RAN2#125, Athens, Greece, February 2024
11. R2-2400845, PDCP and discard operation, InterDigital, RAN2#125, Athens, Greece, February 2024
12. R2-2400902, PDCP discard operation, MediaTek Inc., RAN2#125, Athens, Greece, February 2024
13. R2-2400926, Views on PDCP Discard Notification for Rel-18 XR, Apple, RAN2#125, Athens, Greece, February 2024
14. R2-2401326, On PDCP Discard Notification for XR, Google Inc., RAN2#125, Athens, Greece, February 2024
15. R2-2401420, Discussion on receiving window update for PDCP discard, Huawei, HiSilicon, RAN2#125, Athens, Greece, February 2024
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17. R2-2401448, Remaining issues related to PDCP discard, Sony, RAN2#125, Athens, Greece, February 2024
18. Chair notes, RAN2#125, Athens, Greece, February 2024.