3GPP TSG-RAN WG2 Meeting #116bis-e ***R2-220xxxx***

Electronic Meeting, Jan 17 – 25, 2021

**Agenda item:** 8.1.4

**Source:** Xiaomi Communications

Title: Report of [AT116bis-e][027][MBS] PDCP and RLC initial variables (xiaomi)

**Document for:**  Discussion

# 1. Introduction

This document summarizes the following email discussion:

* [AT116bis-e][027][MBS] PDCP/RLC initial variables (xiaomi)

Scope: HFN applicability / initialization for both multicast and broadcast, how to set RLC initial values.

Intended outcome: Report

Deadline: Friday W1 (attempt offline agreement, can CB if needed W2)

**Phase 1:** Focus on HFN applicability / initialization for both multicast and broadcast, how to set RLC initial values as proposed in the companies’ contributions.

Deadline: Friday 2022-01-20 0300 UTC

**Phase 2:** TBD according to the discussion outcomes of Phase 1.

Deadline: TBD according to the discussion outcomes of Phase 1.

## 1.1 Contacts

Contact person for each participating company:

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| Company | Name | Email Address |
| Xiaomi | Yumin Wu | wuyumin@xiaomi.com |
| MediaTek | Xiaonan Zhang | Xiaonan.Zhang@mediatek.com |
| Samsung | Sangkyu Baek | sangkyu.baek@samsung.com |
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# 2. Phase 1

## 2.1 PDCP

According to the previous RAN2 discussion on the initial values of the PDCP, RAN2 made the following agreements:

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| RAN2#115-e meeting agreements:   * For PTM PDCP state variables setting while configured, the SN part of COUNT values of these variables are set according to the SN of the first received packet (by the UE) and the HFN indicated by the gNB, if needed. |
| RAN2#116-e meeting agreements:   * If HFN is needed (FFS), the initial value of HFN (maybe + related PDCP SN to avoid ambiguity of HFN FFS) is indicated by the gNB by RRC (e.g. during RRC based MRB bearer type change). |

In the endorsed PDCP running CR for MBS in [1], an Editor’s Note is added as follows:

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| The endorsed PDCP running CR for MBS in [1]:  Editor’s Note: FFS whether HFN is needed. |

According the endorsed PDCP running CR for MBS in [1], the HFN is used for the following purposes:

* For multicast
  + HFN is included in the PDCP COUNT, which is used for setting the PDCP state variables of RX\_NEXT, RX\_DELIV and RX\_REORD of the receiving PDCP entity.
  + HFN is included in the PDCP COUNT, which is used for setting the FMC field of the PDCP status report.
* For broadcast
  + HFN is included in the PDCP COUNT, which is used for setting the PDCP state variables of RX\_NEXT, RX\_DELIV and RX\_REORD of the receiving PDCP entity.

From the rapporteur’s understanding, the HFN part is anyway needed by the UE for both the multicast and the broadcast. Otherwise a lot of changes would be needed for setting the values of the PDCP state variables and the value of the FMC field in the PDCP status report.

#### Question 1: Is HFN needed for multicast (i.e. delivery mode 1) and broadcast (i.e. delivery mode 2)?

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| **Company** | **Answer (Yes/No)** | **Comments** |
| MediaTek | Yes | Agree with rapporteur. HFN is needed for both multicast and broadcast. Otherwise there will be many changes to PDCP specs. |
| Xiaomi | Yes |  |
| Samsung | Yes | As mentioned by the rapporteur, HFN is needed for initial status variable and FMC field of the status report. |
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If the HFN is needed, RAN2 needs to discuss how the UE sets the initial value of the HFN. According to companies’ contributions and agreement quoted above, we could have the following options:

* Option 1: If HFN is needed, the initial value of HFN is indicated by the gNB via RRC (RAN2#116-e meeting agreement). [2][3][4][8][9][12]
* Option 2: The initial value of HFN is selected by the UE, if not indicated by the gNB. [2][6][7][11]

From the rapporteur’s understanding, if the initial value of HFN is not indicated by the gNB, the FMC of the PDCP status report and the values of the PDCP state variables will not be aligned between the gNB and the UE.

For the PDCP status report, according to [5], even though the HFN part of the FMC is not aligned between the UE and the gNB, the gNB by implementation is still able to retransmit the lost PDCP PDUs as the Window\_Size of the receiving PDCP entity equals to 2[*pdcp-SN-SizeDL*] – 1. However extra complexity at the gNB is needed to determine the proper HFN of the FMC at the SN wrap-around.

If the values of the state variable are not aligned between the UE and the gNB, the wrap-around of the PDCP COUNT at the UE could be prior to the wrap-around of the PDCP COUNT at the gNB, as the UE may select a HFN value larger than the HFN value selected by the gNB. Then extra complexity at the UE is needed to avoid the COUNT wrap around.

For the delivery mode 1, if the HFN is indicated by the gNB, the initial value of HFN can be indicated via dedicated RRC message (e.g. the *RRCReconfiguration* message).

#### Question 2: If HFN is needed, which of the following options is used to set the initial value of the HFN at the UE for the multicast (i.e. delivery mode 1)?

* Option 1: If HFN is needed, the initial value of HFN is indicated by the gNB via RRC (RAN2#116-e meeting agreement).
* Option 2: The initial value of HFN is selected by the UE, if not indicated by the gNB.

(Note: Multiple options can be selected, as the HFN can be optionally signalled by the gNB. However the HFN is always needed for the state variables of RX\_NEXT, RX\_DELIV and RX\_REORD of the receiving PDCP entity.)

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| **Company** | **Answer (Option 1 and/or 2)** | **Comments** |
| MediaTek | Option 1 | We prefer option1. In PDCP Receive operation, RCVD\_HFN is set according to the HFN of RX\_DELIV, and the initial value of RX\_DELIV is set to 0 in unicast. But in MBS, UE may join after session start and HFN cannot start from 0. Therefore, UE may not be able to “select” an HFN by comparing with HFN from gNB unless it is indicated to UE. |
| Xiaomi | Option 1 and Option 2 | We think that whether to indicate HFN can be left to the gNB implementation. If the gNB with proper implementation may not need to always indicate the initial value of HFN. |
| Samsung | Option 1 | Multicast MRB is configured by RRC signalling. The RRC message can carry the initial HFN value.  We agree with the rapporteur that the initial HFN by UE implementation makes another problem, unnecessary COUNT wrap-around issue. NR PDCP does not support COUNT wrap around. If COUNT is about to reach the maximum value, NW should release the existing bearer and adding a new bearer. If the UE selects relatively larger value, UE’s HFN may reach the maximum value earlier than gNB’s estimated HFN. Then, UE cannot process the received PDCP packet any more after the maximum COUNT. Since gNB does not know the exact HFN value which UE uses, gNB has no choice to refresh (release and add the bearer) frequently. But it is unnecessary at all.  Moreover, if we go with Option 1, gNB can use the reported FMC for checking HFN desynchronization at UE side. FMC will be anyway reported in the status report. Thus, we think it would be better to make the reported field meaningful, rather than wasting it by reporting useless HFN value. |
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For the delivery mode 2, if the HFN is indicated by the gNB, the initial value of HFN can be indicated via SIB. However as the PDCP status report is not needed for delivery mode 2, the requirement of aligning the initial value of HFN between the UE and the gNB is not the same as that for the delivery mode 1.

#### Question 3: If HFN is needed, which of the following options is used to set the initial value of the HFN at the UE for the broadcast (i.e. delivery mode 2)?

* Option 1: If HFN is needed, the initial value of HFN is indicated by the gNB via RRC (RAN2#116-e meeting agreement).
* Option 2: The initial value of HFN is selected by the UE, if not indicated by the gNB.

(Note: Multiple options can be selected, as the HFN can be optionally signalled by the gNB. However the HFN is always needed for the state variables of RX\_NEXT, RX\_DELIV and RX\_REORD of the receiving PDCP entity.)

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| **Company** | **Answer (Option 1 and/or 2)** | **Comments** |
| MediaTek | Option 1 | Even in broadcast, the HFN desync issue may also occur due to congestion. The initial value of HFN can be indicated via SIB. |
| Xiaomi | Option 2 | For delivery mode 2, as the PDCP status report is not needed, the gNB does not have to provide the initial value of HFN for PDCP SR. On the other hand, indicating the HFN via SIB may cause more issues (e.g. HFN desync) and more standard work. |
| Samsung | Option 1 | The initial HFN value can be signalled via MCCH. |
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As indicated in [2][3], if the initial value of HFN is indicated by the gNB, due to the transmission delay (e.g. HARQ/RLC retransmission), the UE could receive the initial value of HFN at N+1 when the gNB sets the initial value of HFN at HFN=1 and sends the initial transmission of the corresponding RRC message at HFN=1, as illustrated above. Thus to align avoid the HFN desync issue, we could have the follow options:

* Option 1: The HFN desync issue due to the indication of the initial HFN is handled by the gNB implementation. [2]
* Option 2: A reference SN corresponding to the initial value of HFN is indicated to the UE. [3][4][8][12]

For Option 2, the value of HFN and related SN indicates the COUNT of the first PDU that gNB will transmit to UE, according to [4].

From the rapporteurs understanding, the gNB by implementation is able to avoid sending the same HFN at the SN wrap around. For example, when the retransmission is across the SN boundary, the gNB by implementation can send a new RRC message with an updated HFN value via new transmission. However this would also put extra complexities for the gNB implementation, and the HFN synchronization may not be always guaranteed by all gNB implementations. On the other hand, when the indication of the initial value of the HFN is not at the SN wrap around, the reference SN of Option 2 is not needed.

#### Question 4: If the initial value of HFN is indicated by the gNB, can a reference SN corresponding to the initial value of HFN be indicated to the UE?

(Note: This question is for delivery mode 1 and/or delivery mode 2, if the initial value of HFN is indicated by the gNB for delivery mode 1 and/or delivery mode 2.)

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| **Company** | **Answer (Yes/No)** | **Comments** |
| MediaTek | Yes | A reference SN with HFN can help UE to avoid HFN desync when SN wrap around. We believe indicating the reference SN will not introduce too much complexity to gNB compared with HFN only. It also benefits to the initialization of PDCP state variables (in terms of latency and packet loss). |
| Xiaomi | No strong view | If the network vendor can ensure that a proper gNB implementation can avoid the HFN desync, maybe we do not have to introduce a standard solution. |
| Samsung | Yes | Option 1 increases gNB implementation, or the desynchronization cannot be resolved. We think signalling of the reference SN is a clean approach. |
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According to the discussion on RX\_NEXT and RX\_DELIV in the RAN2#116-e meeting, RAN2 made the following agreements:

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| RAN2#116-e meeting agreements:   * for multicast MRB, the initial value of the SN part of RX\_NEXT is (x +1) modulo (2[*PDCP-SN-Size*]), where x is the SN of the first received PDCP Data PDU. * the initial value of RX\_DELIV is set to a value before RX\_NEXT, e.g. the initial value of the SN part of RX\_DELIV is (x – 0.5 × 2[*PDCP-SN-Size*–1]) modulo (2[*PDCP-SN-Size*]), where x is the SN of the first received PDCP Data PDU. |

According to [4], if the initial value of the SN part of RX\_DELIV is set to (x – 0.5 × 2[PDCP-SN-Size–1]) modulo (2[PDCP-SN-Size]) (where x is the SN of the first received PDCP Data PDU), the UE could have potential data loss/latency in the following scenarios, since UE do not know the COUNT value of the first transmitted PDU:

* Scenario 1: The COUNT of the first transmitted PDU is smaller than RX\_DELIV.
* Scenario 2: The COUNT of the first transmitted PDU is bigger than RX\_DELIV.

For Scenario 1, PDUs with COUNT<RX\_DELIV will be discarded. For Scenario 2, extra latency for delivering the PDCP PDU will occur as t-reordering will always expire since the PDUs with COUNT smaller than the first transmitted PDU will never be received.

In [4], company proposes that “UE set RX\_DELIV to the HFN and related PDCP SN indicated by gNB. The value of HFN and related SN indicates the COUNT of the first PDU that gNB will transmit to UE”. Then we could have the following options of setting the RX\_DELIV:

* Option 1: The initial value of the SN part of RX\_DELIV is (x – 0.5 × 2[*PDCP-SN-Size*–1]) modulo (2[*PDCP-SN-Size*]), where x is the SN of the first received PDCP Data PDU. (RAN2#116-e meeting agreement)
* Option 2: The UE sets RX\_DELIV to the HFN and related PDCP SN indicated by gNB. The value of HFN and related SN indicates the COUNT of the first PDU that gNB will transmit to UE. [4]
* Option 3: it is up to UE implementation to set the initial value of RX\_DELIV to a value before RX\_NEXT. [6]

#### Question 5: Which of the following options can be used to set the initial value of RX\_DELIV to a value before RX\_NEXT for multicast (i.e. delivery mode 1)?

* Option 1: The initial value of the SN part of RX\_DELIV is (x – 0.5 × 2[*PDCP-SN-Size*–1]) modulo (2[*PDCP-SN-Size*]), where x is the SN of the first received PDCP Data PDU. (RAN2#116-e meeting agreement)
* Option 2: The UE sets RX\_DELIV to the HFN and related PDCP SN indicated by gNB. The value of HFN and related SN indicates the COUNT of the first PDU that gNB will transmit to UE.
* Option 3: It is up to UE implementation to set the initial value of RX\_DELIV to a value before RX\_NEXT.

(Note: From rapporteur’s understanding, Option 2 is an addition to Option 1. Companies selecting Option 2 can also select Option 2. However Option 3 is mutually exclusive to Option 1 or 2.)

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| **Company** | **Answer (Option 1/2/3)** | **Comments** |
| MediaTek | Option2 | Op2 has more benefits, as shown below:   1. Op1 may introduce more data loss (if the fixed value is larger than the first transmitted PDU) or latency (if the fixed value is smaller than the first transmitted PDU, also mentioned in R2-2200860, t-reordering will always expire). 2. If HFN+reference SN is agreed in Q4, we see no extra complexity for UE to set this [HFN+SN] to RX\_DELIV 3. If Op1 is agreed, we may also need to specify the handling for HFN desync issue by using HFN+SN. While with Op2, This discussion is not needed, since it is already in PDCP receive operation:  |  | | --- | | if RCVD\_SN < SN(RX\_DELIV) – Window\_Size:  - RCVD\_HFN = HFN(RX\_DELIV) + 1.  - else if RCVD\_SN >= SN(RX\_DELIV) + Window\_Size:  - RCVD\_HFN = HFN(RX\_DELIV) – 1.  - else:  - RCVD\_HFN = HFN(RX\_DELIV);  - RCVD\_COUNT = [RCVD\_HFN, RCVD\_SN]. | |
| Xiaomi | No strong view | It seems that the issues raised by MediaTek is valid. However it is not clear whether the issues are critical as the gNB by implementation may avoid the transmission gap between the COUNT of the first transmitted PDU and the RX\_DELIV. |
| Samsung | 1 or 2 | We think the best option to minimize the loss and latency is Option 2, HFN+SN of RX\_DELIV is set by RRC signalling. If companies prefer V2X solution, we are ok with this although it has some inefficiency.  But we do not support Option 3, which does not guarantee any UE behaviour. |
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#### Question 6: Which of the following options can be used to set the initial value of RX\_DELIV to a value before RX\_NEXT for broadcast (i.e. delivery mode 2)?

* Option 1: The initial value of the SN part of RX\_DELIV is (x – 0.5 × 2[*PDCP-SN-Size*–1]) modulo (2[*PDCP-SN-Size*]), where x is the SN of the first received PDCP Data PDU. (RAN2#116-e meeting agreement)
* Option 2: The UE sets RX\_DELIV to the HFN and related PDCP SN indicated by gNB. The value of HFN and related SN indicates the COUNT of the first PDU that gNB will transmit to UE.
* Option 3: It is up to UE implementation to set the initial value of RX\_DELIV to a value before RX\_NEXT.

(Note: From rapporteur’s understanding, Option 2 is an addition to Option 1. Companies selecting Option 2 can also select Option 2. However Option 3 is mutually exclusive to Option 1 or 2.)

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| **Company** | **Answer (Option 1/2/3)** | **Comments** |
| MediaTek | Option 2 | we prefer option2 if Q4 is agreed for broadcast.  For broadcast, Op2 can still simplify the handling of HFN desync issue even if out-of-order delivery may not happen. |
| Xiaomi | No strong view | Same view as provided in Question 5. |
| Samsung | 1 or 2 | Same as multicast |
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## 2.2 RLC

According to the discussion on the RLC state variables, RAN2 made the following agreements:

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| RAN2#115-e meeting agreements:   * Initialize the PTM RLC entity for an MRB configuration, the value of RX\_Next\_Highest and RX\_Next\_Reassembly are set according to the SN of the first received packet containing an SN. * RLC state variables of PTP RLC reception window can be set to initial value, i.e. 0, due to MRB configuration. |
| RAN2#116-e meeting agreements:   * for multicast PTM, the RX\_Next\_Highest is initially set to the SN of the first received UMD PDU containing an SN * for multicast PTM, the initial value of RX\_Next\_Reassembly is set to a value before the RX\_Next\_Highest. |

According to [6], company proposes that it is up to UE implementation to set the initial value of RX\_Next\_Reassembly to a value before RX\_Next\_Highest for multicast.

#### Question 7: Is it up to UE implementation to set the initial value of RX\_Next\_Reassembly to a value before RX\_Next\_Highest for multicast (i.e. delivery mode 1)?

(Note: Companies providing the answer “No” are encourage to provide the solution of setting the initial value of RX\_Next\_Reassembly.)

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| **Company** | **Answer (Yes/No)** | **Comments** |
| MediaTek | Yes |  |
| Xiaomi | Yes |  |
| Samsung | No | We think standardized solution makes a common UE behaviour among different UE implementations. Possible ways could be PDCP-like solutions, e.g. RX\_Next\_Highest-0.5\*window, or indication by RRC. |
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According to the discussion in the RAN2#116-e meeting, for the delivery mode 1 of multicast, the initial value of RX\_Next\_Reassembly is set to a value before the RX\_Next\_Highest, and the RX\_Next\_Highest is initially set to the SN of the first received UMD PDU containing an SN. The initial value of the RX\_Next\_Reassembly and the RX\_Next\_Highest for the delivery mode 2 of broadcast has not been decided. According to companies’ contributions and the agreement for multicast, we could have the following options for RX\_Next\_Reassembly for broadcast:

* Option 1: The initial value of RX\_Next\_Reassembly is set to the SN of the first received UMD PDU containing an SN, i.e. same as RX\_Next\_Highest. [6]
* Option 2: The initial value of RX\_Next\_Reassembly is set to a value before the RX\_Next\_Highest, i.e. same as multicast.

In [6], company states that Option 1 can be used for broadcast, as there may not be out-of-order reception case,

#### Question 8: Which of the following options can be used to set the initial value of RX\_Next\_Reassembly for broadcast (i.e. delivery mode 2)?

* Option 1: The initial value of RX\_Next\_Reassembly is set to the SN of the first received UMD PDU containing an SN, i.e. same as RX\_Next\_Highest. [6]
* Option 2: The initial value of RX\_Next\_Reassembly is set to a value before the RX\_Next\_Highest, i.e. same as multicast.

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| **Company** | **Answer (Option 1 or 2)** | **Comments** |
| MediaTek | Option1 | If out-of-order reception does not occur in broadcast, the initial value of RX\_Next\_Reassembly can be set to the same as RX\_Next\_Highest. |
| Xiaomi | No strong view | For Option 1, it is still not clear whether out-of-order reception will not occur in broadcast, as RAN1 may still want to use the blind retransmission for HARQ. If we go for Option 1, we may anyway revisit Option 1 after getting some inputs from RAN1. For Option 2, aligning the UE behaviours for both multicast and broadcast could simplify the UE implementation. |
| Samsung | Option 2  (no strong view) | In option 1, there will be out-of-order reception. PTM RLC is always UM where only segmented PDU will have SN part. If segmentation didn’t occur, RLC receiver side does not know if the out-of-order reception happened. It is detected by NR PDCP.  Option 2 can further detect out-of-order reception of segmented SDU. Thus, Option 2 covers more cases. Thus we prefer Option 2. |
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In [6], company proposes that the initial value of RX\_Next\_Highest for broadcast is set to the SN of the first received UMD PDU containing an SN.

#### Question 9: Is the initial value of RX\_Next\_Highest for broadcast set to the SN of the first received UMD PDU containing an SN, i.e. same as multicast?

(Note: Companies providing the answer “No” are encourage to provide the solution of setting the initial value of RX\_Next\_Highest.)

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| **Company** | **Answer (Yes/No)** | **Comments** |
| MediaTek | Yes |  |
| Xiaomi | Yes |  |
| Samsung | Yes |  |
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# 3. Phase 2

TBD…

# 4. Summary

TBD…

Phase 1 summary:

TBD…

# 5. Reference

[1] R2-2111666, Xiaomi Communications, “38.323 running CR for NR MBS”

[2] R2-2201381 Remaining issues of MBS PDCP Xiaomi Communications discussion Rel-17 NR\_MBS-Core

[3] R2-2200758 Discussion on initial value of HFN Lenovo, Motorola Mobility discussion Rel-17

[4] R2-2200825 Discussion on initial HFN and PDCP state variables MediaTek inc. discussion Rel-17 NR\_MBS-Core

[5] R2-2201415 Discussion on HFN initialization of NR MBS ZTE, Sanechips discussion Rel-17 NR\_MBS-Core

[6] R2-2200346 Discussion on user plane open issues Huawei, HiSilicon discussion Rel-17 NR\_MBS-Core

[7] R2-2201262 Remaining UP issues for Rel-17 MBS vivo discussion Rel-17 NR\_MBS-Core

[8] R2-2201366 User Plane Aspects for MBS Samsung discussion Rel-17 NR\_MBS-Core

[9] R2-2200860 Discussion on PDCP remaining issues CMCC discussion Rel-17 NR\_MBS-Core

[10] R2-2201354 MBS 38.323 remaining issue TCL Communication Ltd. discussion

[11] R2-2201584 Discussion on PDCP open issues for NR MBS LG Electronics Inc. discussion Rel-17 NR\_MBS-Core

[12] R2-2201670, Consideration on UP Remaining Issues of MBS, CATT