3GPP TSG RAN WG2 Meeting #117-e R2-22xxxxx

e-Meeting, 21st February – 3rd March, 2022

**Agenda item: 8.1.3.2**

**Source: Samsung**

**Title: Report of Offline 042: Invited Tdocs Open Issues UP**

**Document for: Discussion**

# 1 Introduction

This document is a report of the following offline discussion:

* [AT117-e][042][MBS] Invited tdocs open Issues UP (Samsung)

Scope: Take into account submitted tdocs. Address the FFS on CSI and SRS reporting due to MBS DRX, and from the updated OIlist: Small correction on RX\_DELIV formula to avoid HFN<0. Determine agreeable part, pave the way for on-line agreement.

Intended outcome: Report

Deadline: W1 Thursday (for online CB W1 Friday).

According to the Chairman’s guideline, this discussion covers the following issues:

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| FFS to CSI and SRS reporting due to MBS DRX. | 5.7b | Company tdocs invited. |
| Small correction on RX\_DELIV formula to avoid HFN<0 | R2-2202301 | Others. Can be discussed based on proposals |

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# 3 Discussion

## 3.1 DRX CSI and SRS reporting due to MBS DRX

The legacy DRX supports restrictions that UE skips some CSIs and SRS transmissions as follows (for detail, you can refer to clause 5.7 of TS 38.321):

* If a DRX group would not be in Active Time, the MAC entity shall not transmit periodic SRS and semi-persistent SRS defined in TS 38.214 in this DRX group and not report CSI on PUCCH and semi-persistent CSI configured on PUSCH in this DRX group.
* If CSI masking (*csi-Mask*) is setup and *drx-onDurationTimer* of a DRX group would not be running, the MAC entity shall not report CSI on PUCCH in this DRX group.
* The MAC entity transmits aperiodic CSI on PUSCH and aperiodic SRS, regardless of the PDCCH monitoring.

A main issue here is whether UE skip the CSIs and SRS transmissions, when the UE would 1) not be in unicast DRX’s Active Time 2) but be in Multicast DRX’s Active Time.

Looking at the submitted contributions, company views are split.

* **Option 1) Allow UE’s CSI reporting/SRS transmission during the Active Time of multicast DRX and/or during the running of *drx-onDurationTimerPTM*.**
  + Better system performance of multicast transmission
  + Only marginal specs effort is required
  + NW will do the right decision of the scheduling based on CSI.
  + meet the basic quality of service requirement

Contributions supporting Option 1:

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| **Tdoc number** | **Source** | **Proposal** |
| R2-2202301 | Huawei, Qualcomm, HiSilicon | Proposal 1: Allow UE’s CSI reporting during the Active Time of multicast DRX and/or during the running of *drx-onDurationTimerPTM*. |
| R2-2202242 | OPPO | Proposal 1: the following text is proposed in section 5.7. |
| R2-2202333 | MediaTek | Proposal 1: The conditions for not reporting CSI/SRS will not be added to multicast DRX in MAC running CR (i.e. section 5.7b) |
| R2-2202799 | Futurewei | Proposal 1: In MBS only scenario, the UE can simply follow the rule of no transmission of CSI-report/SRS at MBS DRX.  Proposal 2: As long as there is a service is not in DRX regardless it is unicast service or MBS, the UE sends CSI-report/SRS. The UE only stops CSI-report/SRS transmission when both unicast and MBS are in DRX. |
| R2-2203311 | ZTE, Sanechips | Proposal 1. CSI/SRS report in MBS DRX Active Time might be enabled to assist network in the scheduling of the MBS transmission.  Proposal 2. The principle of CSI/SRS reporting transmission in MBS DRX follows with legacy DRX. |

* **Option 2) UE’s CSI reporting/SRS transmission is not affected by Multicast DRX.**
  + Considering multiple DRX patterns, Option 1 will complicate UE behavior unnecessarily.
  + For multicast scenario, network scheduling decision is not just based on single UE. The impact of lacking some UE’s CSI reporting is not so serious.
  + Scheduling updating in PTM mode is not so dynamic
  + Option 1 increases UE power consumption
  + LTE SC-PTM DRX does not impact the reporting of CSI and SRS.
  + For dynamic PTM to PTP switch, PTP leg is configured and CSI can be reported based on unicast/PTP DRX.

Contributions supporting Option 2:

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| **Tdoc number** | **Source** | **Proposal** |
| R2-2202268 | CATT, CBN | Proposal 1: SRS/CSI reporting is not considered in MBS DRX pattern. |
| R2-2202278 | NEC | Proposal 1: CSI/SRS reporting during MBS DRX can follow unicast DRX mechanism, which means no additional spec is expected (i.e. the similar text about CSI/SRS in unicast DRX should not be captured in MAC running CR for MBS DRX). |
| R2-2202425 | Spreadtrum | Proposal 1: CSI and SRS reporting due to MBS DRX is not considered. |
| R2-2202554 | Apple | Proposal 5: The CSI and SRS transmission during the DRX active time is same as legacy. |
| R2-2202624 | CMCC | Proposal 1: RAN2 confirms that CSI reporting and SRS transmission only occur in legacy unicast DRX group, rather than both in the unicast DRX group in the MBS DRX group. |
| R2-2202642 | Intel | Proposal 1: CSI / SRS operation is not affected by MBS DRX. There is no specification impact. |
| R2-2202683 | Samsung | Proposal 1. CSI reporting and SRS transmission are independent of Multicast DRX. (No specification change) |
| R2-2203121 | Xiaomi | Proposal: MBS DRX does not impact the reporting of CSI or SRS, same as LTE SC-PTM. No specification change is needed. |
| R2-2203156 | LGE | Proposal 1. MBS DRX does not impact on CSI and SRS reporting (i.e. no spec. impact). |

To provide a way-forward, the rapporteur would like to ask more companies’ view.

**Q1) Please provide your view.**

* **Option 1) Allow UE’s CSI reporting/SRS transmission during the Active Time of multicast DRX and/or during the running of *drx-onDurationTimerPTM*.**
* **Option 2) UE’s CSI reporting/SRS transmission is not affected by Multicast DRX.**

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| **Company** | **Option** | **Comment** |
| Qualcomm | Option 1 | UE should be able to report CSI while MBS DRX is active and even if unicast DRX is not active. This will enable CSI reporting by all active MBS DRX UEs to facilitate better scheduling of Multicast and this does not cause additional UE power consumption since UE calculates periodic CSI in the background and reports only during active time. It is possible many UEs will be receiving only multicast service without any unicast service and network may configure only MRB PTM leg. Additional spec change is not complex. |
| MediaTek | Option 1 | Share the same view with Qualcomm. UE report CSI/SRS will not lead to extra power consumption when multicast DRX is in active time while unicast DRX is not.  We agree to add the text to clause 5.7 to clarify UE’s behavior. |
| Huawei, HiSilicon | Option 1 | 1) Different from LTE MBMS, NR multicast aims at providing services with high QoS, which relies on timely and accurate CSI report from all multicast UEs, especially the ones with poor radio link quality. Without this, the NW may have to schedule multicast based on CSI from only some of the UEs, which will lead to an impropriate scheduling strategy degrading the system performance.  2) The other ways mentioned by contributions, e.g. relying on active time of PTP leg, is not efficient as PTP transmission/retransmission themselves are determined based on the timely and accurate CSI report. This seems a vicious circle.  3) Lastly, the specs effort is marginal as the logic is the same with unicast DRX. And it will not consume much extra UE power as both DRX and CSI report can be controlled by NW implementation. |
| OPPO | Option 1 | It is common understanding that CSI and SRS reporting should be allowed in case of MBS DRX active period and they are also useful for MBS data scheduling.  However, according the wording in section 5.7 (unicast DRX), when UE decide not to report the SRS and CSI report only consider unicast DRX is not in active time, not all DRX, i.e. not including the DRX defined in section 5.7b.  “……when evaluating all DRX Active Time conditions as specified in this clause…..”  If there is no unicast data transmission/reception. The CSI report will not be report due to the above text even if there is MBS reception, i.e. MBS DRX in active time. As results, the network will not receive the CSI-RS and cannot do the right decision of the scheduling. |
| Lenovo | Option 1 | CSI and SRS reporting in multicast active time may be beneficial for multicast scheduling and it does not lead to extra power consumption as Qualcomm commented. |
| Intel | Option 2 | Our preference is that UE’s CSI reporting/SRS transmission is not affected by Multicast DRX, since:  1) Aperiodic CSI on PUSCH and aperiodic SRS (which are not affected by DRX restriction) can be utilized for MBS scheduling.  2) CSI on PUCCH, semi-persistent CSI, and periodic / semi-persistent SRS can be transmitted in unicast Active Time, which is extended when PTP retransmission is expected.  3) Transmitting CSI on PUCCH, semi-persistent CSI, and periodic / semi-persistent SRS outside of unicast Active Time introduces additional specification complexity as well as unnecessary UE power consumption. Since the most relevant CSI for MBS scheduling is from UE(s) with the worst channel condition, requiring transmitting CSI / SRS outside of unicast Active Time causes additional power consumption without clear benefits for UEs with good channel condition. |
| Kyocera | Option 2 | Option 2 is same with LTE SC-PTM baseline. We don’t see much gain to justify the additional behaviour. |
| Samsung | Option 2 | Transmission of CSI report or SRS requires additional power consumption, so it is very basic assumption that additional transmission increases UE’s power consumption.  We admit TP is already prepared and the specification change may not be too much complex. But change is needed for option 1. Considering gain and pain, we do not think this change is actually needed. |
| CATT | Option 2 | It is sufficient that CSI/SRS reporting are only considered in unicast DRX cycle as legacy way. |
| LGE | Option 2 | PTM transmission is shared by multiple UEs. If it is not guaranteed that CSI from multiple UEs are reported at the same time, it is not necessary to report CSI during multicast DRX Active time. Anyway, gNB schedules PTM transmission based on CSI reporting from multiple UEs received at different times.  For MBS services with high QoS, PTP transmission is used when the required QoS is not met, where unicast/PTP DRX is used. |
| Apple | Option 2 | It’s sufficient to keep UE only reporting the CSI/SRS during the unicast active time.  CSI/SRS transmission is used for the PTM scheduling for retransmission and new transmission.  > For potential PTM retransmission, UE will start the unicast DRX RTT/reTx timer and be in the unicast active time, then legacy CSI/SRS transmission in unicast active time is sufficient.  > For the PTM new transmission, NW can use the multiple UEs’ CSI/SRS report during the unicast active time for scheduling. It’s also sufficient. |
| ZTE | Option 1 | The logic is quite straightforward:   1. CSI report is essential for per UE transmission (including PTP transmission for Multicast;) 2. RAN1 does not define a per MBS CSI report, and it assumes per UE CSI report is able to help network with the scheduling. We need per UE CSI to work during MBS reception. 3. CSI will be helpful in following scenarios:   - there might be per UE PTP re-transmission for PTM initial transmission, and the PTP transmission depends on per UE CSI report, we are not so sure whether the temporary opened PTP transmission window can really benefit from the impromptu CSI report.  - network might need per UE CSI report for dynamic mode switching;  - network might need per UE CSI report for basic scheduling (e.g, link adaptation) .  not so much spec impacts is needed.  as for power consumption of per UE CSI report  - well, why is no one questioning the power consumption for legacy unicast services?  as for timing difference of CSI report from different UEs:  - it depend on network strategy and configuration, better than none. |
| vivo | Option 2 | For MBS DRX, multiple UEs will have different DRX active times even though those UEs are provided with a common MBS DRX configuration. For example, UEs which decode the MAC PDU successfully will not start the HARQ RTT timer and retransmission timer while UEs which fail to decode the MAC PDU will not start the HARQ RTT timer and retransmission timer. Thus, it is a large possibility that CSI from multiple UEs will be reported at different times. Under this case, as LG pointed out, it is not necessary to report CSI during multicast DRX Active time. So the benefit of using multicast DRX Active time is not obvious, but only making the spec more complicated. |
| Ericsson | Option 1 |  |
| Futurewei | Option 1 | We consider the UE transmit CSI-report and SRS to the network is part of basic operation of high-quality NR MBS. CSI-report and SRS should be transmitted by the UE when the MBS transmission is active. It should not be stopped by the unicast DRX inactive state. Similarly, as a default work assumption, CSI-report and SRS should be transmitted by the UE when the unicast transmission is active. It should not be stopped by the MBS DRX inactive state.  Some of benefits are discussed in R2-2202799. We don’t see the issue with the UEs’ MBS active time being different due to PTP retransmissions etc. it just as if there is simultaneous uncast be active. CSI-report will serve both active PTP and PTM… CSI-report is a per UE activity and beam level resource allocation would also be per UE accordingly.  We don’t see big specification impact to allow CSI-report and SRS transmission in Option 1. |
| Nokia | Option 1&2 | We would like to have CSI reported also during multicast active time, i.e., Option 1 BUT for csi-Mask we would prefer to follow only unicast DRX onDuration, which would happen with Option 2. |
| Xiaomi | Option 2 | Due to that there is no MBS-specific CSI designed in this release, the benefits of allowing CSI reporting during the Active Time of multicast DRX are not clear as the unicast service is not to be provided during the active time of mulicast DRX whe the unicast DRX is in Inactive Time. It is probably better to reallocate the PUCCH resource of the CSI reporting to the unicast service of other UEs, so as to make a better utilization of the radio resources. |
| NEC | Option 2 | UE anyway can report CSI during unicast DRX active time. Or if DCP is configured, indeed there could be a chance that no any unicast DRX active time, but we still have chance to report periodic CSI based on *ps-TransmitPeriodicL1-RSRP* or *ps-TransmitOtherPeriodicCSI*. Even if UE can not report CSI during MBS DRX, lack of some RS feedback is not really serious for multicast scheduling decision. We woulk like to keep things simple. |
| CMCC | Option 2 | We prefer Option 2, considering that:   1. More CSI and SRS reporting come up with not only more accurate link adaptation, but also more UE power consumption and complexity. 2. The scheduling updating in PTM mode will not be so dynamic as that in unicast data transmission since the selection of the TB size and MSC will be relative conservative, due to the worst radio condition of the UE within the MBS group determining the selection of the TB size and MSC.   RAN1 agreed that existing CSI feedback can be used for multicast transmission, no MBS-specific CSI feedback is specified in this release. |
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If RAN2 agrees Option 1, text change in clause 5.7 is expected. The following TPs were provided:

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| R2-2202301 (Huawei, Qualcomm, HiSilicon)  2> in current symbol n, if a DRX group would not be in Active Time considering grants/assignments scheduled on Serving Cell(s) in this DRX group and DRX Command MAC CE/Long DRX Command MAC CE received and Scheduling Request sent until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause; and  2> in current symbol n, if multicast DRX would not be in Active Time considering multicast grants/assignments when evaluating all DRX Active Time conditions as specified in Clause 5.7b:  3> not transmit periodic SRS and semi-persistent SRS defined in TS 38.214 [7] in this DRX group;  3> not report CSI on PUCCH and semi-persistent CSI configured on PUSCH in this DRX group.  2> if CSI masking (*csi-Mask*) is setup by upper layers:  3> in current symbol n, if *drx-onDurationTimer* of a DRX group would not be running considering grants/assignments scheduled on Serving Cell(s) in this DRX group and DRX Command MAC CE/Long DRX Command MAC CE received until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause; and  3> in current symbol n, if *drx-onDurationTimerPTM* would not be running considering grants/assignments when evaluating all DRX Active Time conditions as specified in Clause 5.7b:  4> not report CSI on PUCCH in this DRX group.  NOTE 4: If a UE multiplexes a CSI configured on PUCCH with other overlapping UCI(s) according to the procedure specified in TS 38.213 [6] clause 9.2.5 and this CSI multiplexed with other UCI(s) would be reported on a PUCCH resource either outside DRX Active Time of the DRX group in which this PUCCH is configured and multicast DRX or outside the on-duration period of the DRX group in which this PUCCH is configured and multicast DRX if CSI masking is setup by upper layers, it is up to UE implementation whether to report this CSI multiplexed with other UCI(s). |
| R2-2202242 (OPPO)  1> if DCP monitoring is configured for the active DL BWP as specified in TS 38.213 [6], clause 10.3; and  1> if the current symbol n occurs within *drx-onDurationTimer* duration; and  1> if *drx-onDurationTimer* associated with the current DRX cycle is not started as specified in this clause and clause 5.7b:  2> if the MAC entity would not be in Active Time considering grants/assignments/DRX Command MAC CE/Long DRX Command MAC CE received and Scheduling Request sent until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause and clause 5.7b:  3> not transmit periodic SRS and semi-persistent SRS defined in TS 38.214 [7];  3> not report semi-persistent CSI configured on PUSCH;  3> if *ps-TransmitPeriodicL1-RSRP* is not configured with value *true*:  4> not report periodic CSI that is L1-RSRP on PUCCH.  3> if *ps-TransmitOtherPeriodicCSI* is not configured with value *true*:  4> not report periodic CSI that is not L1-RSRP on PUCCH.  1> else:  2> in current symbol n, if a DRX group would not be in Active Time considering grants/assignments scheduled on Serving Cell(s) in this DRX group and DRX Command MAC CE/Long DRX Command MAC CE received and Scheduling Request sent until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause and clause 5.7b:  3> not transmit periodic SRS and semi-persistent SRS defined in TS 38.214 [7] in this DRX group;  3> not report CSI on PUCCH and semi-persistent CSI configured on PUSCH in this DRX group.  2> if CSI masking (*csi-Mask*) is setup by upper layers:  3> in current symbol n, if *drx-onDurationTimer* of a DRX group would not be running considering grants/assignments scheduled on Serving Cell(s) in this DRX group and DRX Command MAC CE/Long DRX Command MAC CE received until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause and clause 5.7b; and  4> not report CSI on PUCCH in this DRX group. |
| R2-2202683 (Samsung)  1> if DCP monitoring is configured for the active DL BWP as specified in TS 38.213 [6], clause 10.3; and  1> if the current symbol n occurs within *drx-onDurationTimer* duration; and  1> if *drx-onDurationTimer* associated with the current DRX cycle is not started as specified in this clause:  2> if the MAC entity would not be in Active Time considering grants/assignments/DRX Command MAC CE/Long DRX Command MAC CE received and Scheduling Request sent until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause, and the MAC entity would not be in Multicast DRX’s Active Time defined in clause 5.7b:  3> not transmit periodic SRS and semi-persistent SRS defined in TS 38.214 [7];  3> not report semi-persistent CSI configured on PUSCH;  3> if *ps-TransmitPeriodicL1-RSRP* is not configured with value *true*:  4> not report periodic CSI that is L1-RSRP on PUCCH.  3> if *ps-TransmitOtherPeriodicCSI* is not configured with value *true*:  4> not report periodic CSI that is not L1-RSRP on PUCCH.  1> else:  2> in current symbol n, if a DRX group would not be in Active Time considering grants/assignments scheduled on Serving Cell(s) in this DRX group and DRX Command MAC CE/Long DRX Command MAC CE received and Scheduling Request sent until 4 ms prior to symbol n when evaluating all DRX Active Time conditions as specified in this clause, and the MAC entity would not be in Multicast DRX’s Active Time defined in clause 5.7b:  3> not transmit periodic SRS and semi-persistent SRS defined in TS 38.214 [7] in this DRX group;  3> not report CSI on PUCCH and semi-persistent CSI configured on PUSCH in this DRX group. |

Those TPs proposed similar changes but a difference is whether the procedure upon DCP monitoring is applicable for Multicast DRX. OPPO/Samsung TP assumes DCP monitoring, whereas Huawei/Qualcomm TP does not.

Since the discussion on DRX and CSI/SRS may have impact to WUS, it would be better to discuss how existing DCP monitoring/WUS affects Multicast DRX operation. Thus rapporteur suggest to discuss how to support DCP monitoring/WUS together with Multicast DRX.

**Q2) Please provide your view.**

* **Option A) DCP monitoring/WUS is not configured when Multicast DRX is configured. (similar to R2-2202301)**
* **Option B) DCP monitoring/WUS can be configured when Multicast DRX is configured. *drx-onDurationTimerPTM* may not be started by DCP monitoring/WUS. (similar to R2-2202242)**
* **Option C) DCP monitoring/WUS can be configured when Multicast DRX is configured. *drx-onDurationTimerPTM* is always started regardless of DCP monitoring/WUS. (similar to R2-2202683)**
* **Option D) Other (please add)**

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| **Company** | **Option** | **Comment** |
| Qualcomm | Option 1 | [Samsung-rapp] Option A in our understanding. |
| MediaTek | Option 1 | [Samsung-rapp] Option A in our understanding. |
| Huawei, HiSilicon | Option A or Option C | We can accept Option C, in case RAN2 assumes DCP monitoring/WUS can be configured together with multicast DRX. And the detailed specs change can be discussed during the CR review. |
| OPPO | Option B | We can only also consider the MBS DRX case when evaluating the CSI/SRS reporting. |
| Lenovo | Option 1 | [Samsung-rapp] Option A in our understanding. |
| Intel | See comments | Our understanding is that DCP monitoring / WUS is a separate discussion from CSI/SRS. Regardless of whether Option 1 in Q1 is agreed or not, we still need to discuss the relationship between DCP monitoring / WUS and Multicast DRX.  Our preference is Option C for the general discussion regarding DCP monitoring / WUS and Multicast DRX. DCP is introduced for unicast DRX. Since the general principle is that unicast DRX and multicast DRX have independent operations, it is natural that DCP monitoring / WUS can be configured when Multicast DRX is configured. In addition, as there is only one DCP configuration for unicast DRX, and a UE may be configured with multiple Multicast DRX patterns, it is also natural that *drx-onDurationTimerPTM* is always started regardless of DCP monitoring/WUS. This is already implemented in MAC running CR R2-2202245 clause 5.7b, as below:  1> if [(SFN × 10) + subframe number] modulo (*drx-LongCycle-PTM*) = *drx-StartOffset-PTM*:  2> start *drx-onDurationTimerPTM* after *drx-SlotOffsetPTM* from the beginning of the subframe.  [Samsung-rapp] We understand Intel prefers Option C. |
| Kyocera | Option A |  |
| Samsung | Option C | We prefer to make unicast DRX and multicast DRX independent as possible. |
| CATT | Option A |  |
| LGE | Option A |  |
| Apple | Option A |  |
| ZTE | Option A |  |
| vivo | Option A |  |
| Ericsson | Option A |  |
| Futurewei | Option A |  |
| Nokia | Option A | This is the simplest. |
| Xiaomi | Option A |  |
| NEC | See comments | If majority want to enhance CSI reporting/SRS transmission for MBS DRX, we accept that make modification on clause 5.7 rather than 5.7b.  For options above, basically same view with intel. We prefer option C. DCP is only configured for unicast DRX, it is dependent with MBS DRX. What we need to focus is if there is any active time for UE to report. That is to say, the principle of option C is to explain that no matter DCP is configured for unicast DRX or not, UE can report CSI/SRS in unicast DRX Active Time **OR** MBS DRX Active Time (i.e. not transmit CSI/SRS in unicast DRX non-Active Time **AND** MBS DRX non-Active Time). |
| CMCC |  | It’s not clear whether the current DCP could be used for MBS DRX without extra specification work.  If DCP is only used for unicast, Option A is not rational, since multicast operation and unicast operation is independent, drx-onDurationTimerPTM will be started regardless of DCP monitoring/WUS.  Otherwise, a multicast specific DCP is used, network could coordinate the DPC configuration for a group UEs to monitor the same location to wake up in drx-onDurationTimerPTM. |
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## 3.2 Small correction on RX\_DELIV formula to avoid HFN<0

A negative HFN value occurs once the SN of first received packet is smaller than 0.5 × 2[PDCP-SN-Size–1] and the configured HFN is 0. One way to avoid this problem is to always configure the initial HFN>0 by the network, but for lossless handover with PDCN SN synchronization, RAN3 already agreed to introduce a 32 bit “MBS QFI SN” to guide the gNB on the HFN and SN allocation as below:

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| **RAN3 agreements:**  **1) introduce a new 32bits “MBS QFI SN” in 38.415.**  **1-1) CN shall include the MBS QFI SN for all the Qos flows for MBS services.**  **2) Sync in terms of QoS flow to MRB mapping among NG-RAN nodes is achieved by network implementation.** |

Thus, it may be difficult for the network to avoid a negative HFN value during initialization by configuring a large initial HFN. [R2-2202301] proposed to set RX\_DELIV = 0 when the negative HFN is expected, i.e.

RX\_DELIV = MAX (0, COUNT(x) - 0.5 × 2[*PDCP-SN-Size*–1]), where x is the SN of the first received PDCP Data PDU

**Q3) Do companies support the following proposal for the negative HFN issue?**

**Proposal: Change the RX\_DELIV formula as: RX\_DELIV = MAX (0, COUNT(x) - 0.5 × 2[*PDCP-SN-Size*–1]), where x is the SN of the first received PDCP Data PDU.**

* **Option 1) Yes**
* **Option 2) No (NW implementation can avoid HFN<0 by configuration of initial HFN.)**
* **Option 3) No (prefer other solution, please add.)**

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| **Company** | **Option** | **Comment** |
| Qualcomm | Option 1 | Option 1 is clean approach than Option 2. |
| MediaTek | Option 3 | Op1 is difficult for the network to avoid a negative HFN, Op2 seems not concise enough.  In fact, setting RX\_DELIV to a fixed value will always cause unalignment between RX\_DELIV and the COUNT of the first transmitted PDU and lead to extra modification.  For the simplicity, we prefer to change the RX\_DELIV formula as RX\_DELIV=[HFN+SN] indicated by RRC to solve both this issue and HFN desync issue discussed before. |
| Huawei, HiSilicon | Option 1 | 1. With option 1, UE can deduct a correct and positive HFN value regardless of gNB’s configuration. 2. Option 2 doesn’t work as it is not gNB’s decision of how to set the HFN as lossless handover requires the gNB to set COUNT value according to a 32bit CN SN. 3. Option mentioned by MediaTek may be inconsistent with the initial motivation of setting RX\_DELIV to a value before the RE\_NEXT to minimize data loss. |
| OPPO | Option 1 | It is more clear. |
| Lenovo | Option 1 | We tend to agree with Huawei. |
| Intel | Option 2 | Network can configure a suitable initial HFN to avoid the issue.  ***[Huawei]：***As we commented above, there are cases where gNB set COUNT value according to the 32 bit CN SN. Then we have to set restrictions to CN implementation to achieve this**.** |
| Kyocera | No | Although we understand the current formula may lead to a negative RX\_DELIV and the proposed formula (i.e., Option 1) is correct, the PDCP specification clearly states that “*All state variables are non-negative integers, and take values from 0 to [232 – 1].*” So, we don’t think the UE sets any negative value to the initial value of RX\DELIV.  ***[Huawei]：***It is better to have a clear UE behavior to avoid ambiguity**.** |
| Samsung | Option 2 | If every gNB starts with HFN >=1, such change is no needed. We already agreed initial HFN value is signaled by RRC. In other words, NW implementation can avoid the problem.  ***[Huawei]：***Please see the reply to Intel**.** |
| CATT | - | We think no solution is needed, UE implementation according to the NOTE in 38.323 CR is sufficient.  NOTE: For MRB, the provisioning of the initial value of HFN from the upper layer may cause HFN desynchronization. It is up to UE implementation to prevent HFN desynchronization by using the reference PDCP SN associated to the initial value of HFN.  ***[Huawei]：***We don’t clearly see how this NOTE can solve the issue as it is meant to avoid HFN desynchronization. |
| LGE | No | We think there is no problem at all with the current agreement, and the current agreement can be kept. In the running CR, the SN part of the RX\_DELIV is set as follows.  For MRBs, 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.  As the SN part is determined by the modulo operation, the value will not be negative. And for the HFN part, it is either selected by the UE or indicated by the network, and this value cannot be negative because COUNT does not wrap around.  In R2-2202301, Huawei pointed out that the HFN may be negative if, for example, network indicates HFN=0 and the UE receives PDCP PDU with SN=0. But that’s not correct. In this case, the UE initializes RX\_DELIV such that HFN=0 and SN = (0 – 1024) modulo 4096 = 3072. Thus, RX\_DELIV is still positive value.  Then, let’s check whether any problem occurs.  In the above example, RCVD\_SN=0, SN(RX\_DELIV)=3072, Window\_Size=2048.  Then, the UE determines RCVD\_HFN as HFN(RX\_DELIV) + 1 = 1, according to 5.2.2.1 of TS 38.323.  As the RX\_DELIV = [0, 3072] and RCVD\_COUNT = [1, 0], the UE considers the received PDU as a new PDU above RX\_DELIV, and there is no problem in reception procedure.  One may argue that there is HFN desynchronization between UE and network in this case. However, as HFN does not impact UE’s reception procedure and security, we don’t see any problem with de-synchronized HFN.  If this is really a problem, the network should set the initial HFN value larger than 0. If initial HFN value is larger than 0, there is no problem at all.  ***[Huawei]：***We think the given example is based on the assumption that HFN is not synchronized.But isn’t the motivation of HFN+SN indication to prevent HFN desynchronization in the first place**?** For the solution by NW implementation, please see our reply to Intel. |
| Apple | Option 1 | Option 1 is preferred if the NW implementation cannot avoid the negative HFN. |
| ZTE | Option 2 or 3 | - Network shall be able to handle this (although we don't really like the idea of letting UPF handle the PDCP Count, what a design from our dear colleagues from RAN3!).  - or one smart UE shall not define a negative HFN.  - CATT also provided good reference. |
| vivo | Option 2 | Smart NW implementation can avoid this issue, similarly to sideline communication.  **TS 38.323 section 7.1**  NOTE: For NR sidelink communication for broadcast and groupcast, it is up to UE implementation to select the HFN part for RX\_NEXT such that initial value of RX\_DELIV should be a positive value. |
| Ericsson | - | Not sure any solution is needed as outlined by LG |
| Futurewei | Option 1 | It is an easy fix. |
| Nokia | - | Agree with Ericsson and LG. |
| Xiaomi | No | I guess companies are mixing up the “modulo operation” (using mod) with the “Remainder Operation” (using %). For “modulo operation”, the result is always positive. Both “r = a mod b” and “r = a % b” uses the same formula of “r = a - c\*b” where c = [a/b] is the interger part. However “c” in modula operation is to get the closet integer value to the “negative infinite”, and “c” in remainder operation is to get the closet integer to “0”. Then let’s see the following example:  r = (-3 mod 4). In modulo operation, c=[-3/4] = -1, and r=(-3)-(-1) \*4=1  r = (-3 % 4). In remainder operation, c=[-3/4] = 0, and r=(-3)-(0) \*4=-3 |
| NEC | Option 2 | Same view with Kyocera. The current PDCP spec has already restricted state variables (e.g. RX\_DELIV) to non-negative integers. Thus we prefer to leave this issue to implementation to avoid HFN<0.  Same view with Xiaomi, modulo operation means no negative value (i.e. SN(RE\_DELIV) is also a non-negative). |
| CMCC | Option 2 | Network can configure a suitable initial HFN to avoid the issue, as it was agreed that HFN is indicated by RRC signalling. |
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# 4 Conclusion

# 5 References

[1] R2-2203316, Open issue list for NR MBS, Huawei, HiSilicon