**3GPP TSG-RAN WG2 Meeting #121bis-eR2-23xxxxx**

Electronic, 17th – 26th April, 2023

**Agenda Item: 7.6.2.1**

**Source: OPPO**

**Title: Summary of [AT121bis-e][103][** **IoT NTN Enh] HARQ enhancements (OPPO)**

**Document for: Discussion and Decision**

# Introduction

This document aims to collect companies’ views for the following offline discussion and provide the summary report. Note that the discussion only focuses on HARQ related issues.

**[AT121bis-e][103][IoT NTN Enh] HARQ enhancements (Oppo)**

Initial scope: Discuss the proposals in the submitted contributions in AI 7.6.2.1

Initial intended outcome: Summary of the offline discussion with e.g.:

         List of proposals for agreement (if any)

         List of proposals that require online discussions

         List of proposals that should not be pursued (if any)

Deadline for companies' feedback: Wednesday 2023-04-19 12:00 UTC

Deadline for rapporteur's summary (in R2-2304243): Wednesday 2023-04-19 16:00 UTC

# 2. Contact information

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# Discussion

## 3.1 DL HARQ enhancements

***Correcting previous agreements?***

In following contribution, companies want to correct a previous agreement.

1. For NB-IoT NTN with single HARQ process when the HARQ feedback is disabled, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception plus 12 subframes.

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| Contributions | Relevant proposals: |
| [5] | Proposal 1: To correct a previous agreement as below:  For NB-IoT NTN with single HARQ process when the HARQ feedback is disabled, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception plus 12 subframes plus deltaPDCCH. |
| [4] | Observation 1: The drx-inactivity timer also applies to two DL HARQ processes case.  Observation 2: The drx-inactivity timer is in unit of PP, if it is not started at the beginning of PDCCH period, it will lead to a PDCCH decode failure.  Proposal 1: For NB-Iot NTN, when the HARQ feedback is disabled for the transmission, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception + 12 subframes + PDCCH offset. |

Note that in RAN2#120, comments related to deltaPDCCH was raised but not agreed.

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| Proposal 1 For NB-IoT NTN with single HARQ process when the HARQ feedback is disabled, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception plus 12 subframes.   * Oppo wonders if we need to take into account deltaPDCCH. Nokia thinks this should not be considered * CATT supports this * ZTE would like to reconsider this * Oppo thinks we should keep it simple and align to RAN1. Samsung agrees with Oppo * Ericsson wonders about the situation for eMTC * Agreed |

**Question 1: Do companies support correcting a previous agreement by adding “plus deltaPDCCH”?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree | As drx-inactivity timer is in unit of PP, it would be better if it starts at the beginning of a PDCCH period. |
| CATT |  | Understand the intention, but as the Rapporteur reminded, maybe not necessary to re-open the discussion on this issue. |
| Nokia |  | Though it is a further optimization, we can accept the proposal to revise the agreement if this is the majority review. |
| Xiaomi |  | Do not see strong need to further optimize this. |
| MediaTek | Agree | As mentioned in our Tdoc [4], to avoid monitoring partial PDCCH occasion, PDCCH offset is required. |
| Qualcomm | Agree | This is needed to start the timer from the PDCCH occasion. The value of deltaPDCCH can be zero. |
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***How to enable/configure DCI-based HARQ feedback enabling/disabling indication?***

For DL HARQ feedback enabled/disabled, currently RAN1 is considering both RRC-based and DCI-based solutions. In the last meeting, RAN1 has confirmed the following working assumption, with updates:

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| Confirm the following working assumption with the following update:  Working assumption  For NB-IoT NTN and eMTC NTN for CE Mode B, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission:   * Support Option 1 in case only per-HARQ process bitmap signaling is configured * Support Option 3 DCI direct indication of HARQ feedback enable/disable in case only DCI solution enabling/disabling signaling is configured * Support Option 3 DCI indication to override Option 1 configuration for corresponding transmission in case both per-HARQ process bitmap and DCI solution enabling/disabling signaling are configured   + FFS #1: Option 3 DCI-based overridden mechanism is applied to both semi-statically HARQ feedback enabled and disabled processes or only applied to semi-statically HARQ feedback disabled processes or only applied to semi-statically HARQ feedback enabled processes.   + FFS #2: whether/how to support Option 3 overriding Option 1 configuration for corresponding transmission for multiple TBs scheduled by single DCI   + FFS#3：Option 3 DCI-based overridden mechanism is DCI signaling to reverse the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration or DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration.   RAN1 strives to have a common design (in terms of DCI design, PDCCH monitoring, etc.) for “Option 3” and “Option 3 + Option 1”.  For eMTC NTN, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission, take Option 1 for CE Mode A. |

Some proposals have been raised by companies in RAN2 on the RRC signalling (e.g. per UE or per HARQ process) to enable the DCI-based solution as follows.

* Per UE: if RRC signaling configures Option 3 will be used to configure the HARQ feedback state, the HARQ feedback state of all the HARQ process of the UE can be configured by DCI.
* Per HARQ process: if RRC signaling configures Option 3 will be used to configure the HARQ feedback state of a specific HARQ process, only the HARQ feedback state of the specific HARQ process of the UE can be configured by DCI

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| Contributions | Relevant proposals: |
| [3] | Proposal 6: RAN2 to discuss the following granularity options for RRC signaling enabling Option 3 based on RAN1 further input of DCI design:   * Per UE * Per HARQ progress |
| [9] | Proposal 3a: A single bit is introduced for configuring DCI based HARQ feedback enable/disable. |

Note that according to the latest RAN1 agreement “” above, the additional RRC signalling is not agreed by RAN1 yet.

**Question 2: On DL HARQ feedback enabling/disabling, how to enable/configure the DCI-based solution (e.g. using RRC signalling)?**

* **Option 1: per UE (using a single bit)**
* **Option 2: per HARQ process**
* **Option 3: wait for RAN1**

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| **Company** | **Option** | **Additional comments** |
| OPPO | Option 1 | From RAN2’s perspective, a RRC signalling is need to enable the DCI-based solution. Regarding the granularity, we see no need to support per HARQ process configured, it is sufficient to introduce a single bit for this configuration. But we are also ok to wait for RAN1 or even check with RAN1. |
| CATT | Option 2/Option 3 | Firstly, if a new DCI format is used, the length of the DCI is different according to including the enabling/disabling bit or not. If the configuration is per HARQ process, the UE can determine whether the received DCI for a given HARQ process has the new enabling/disabling bit. Otherwise, for example, if the network only wants to configure one HARQ process to use DCI-based solution, the DCI for all the HARQ process will have to include the enabling/disabling bit. RAN1 is discussion the DCI format:   |  | | --- | | **Agreement**  For DCI-based overridden/direct indication, down select one of the following based on the criteria DCI overhead, PDCCH monitoring behavior, impact on scheduling flexibility, UE implementation complexity, etc   * Option 1: Indication by adding one field in DCI * Option 2: Indication by reusing/reinterpreting existing field in DCI |   So at least we can wait for RAN1 (Option 3).  Secondly, the HARQ state (enabling/disabling) is configured by RRC signalling per HARQ process, we think we use the same logic, to keep the network configuration flexibility. |
| Nokia | Option 3 | How to configure Option3 (DCI direct indication of HARQ feedback enable/disable) is still open in RAN1. |
| Xiaomi | Option 3 | We are not sure RAN1 has any intention to use RRC signalling to configure option 3. But we are ok to wait for RAN1 further progress on this. |
| MediaTek | Option 3 | We need to wait for RAN1 regarding this, as RAN1 has brought this out and is already discussing this one since quite long. |
| Qualcomm | Option 3 | Let them settle the DCI based solution. |
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***DRX for HARQ process with HARQ feedback disabled***

RAN1 has the following agreement in RAN1#110bist meeting:

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| **Agreement**  For a DL HARQ process with disabled HARQ feedback in NB-IoT, UE is not required to monitor NPDCCH in a period of Y=12(ms) from the end of reception of the NPDSCH. |

In last RAN2 meetings, RAN2 has discussed and made agreement on impact of disabled HARQ feedback on DRX for the case of NB-IoT UEs with single HARQ process. One company thinks RAN2 needs to further discuss the case of NB-IoT UEs with two HARQ processes.

Following proposals are related to drx-InactivityTimer for HARQ process with HARQ feedback disabled for NB-IoT UEs configured with two HARQ processes.

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| Contributions | Relevant proposals: |
| [3] | Proposal 2: For NB-IoT NTN with two HARQ processes, the HARQ feedback of at least one the two HARQ processes is disabled, the UE should stop the drx-inactivity timer if running after the UE receiving a PDSCH and start/restart drx-inactivity timer:   * in the subframe containing the corresponding PDSCH reception plus 12 subframes for the HARQ process with HARQ feedback disabled; * when HARQ RTT Timer expires for the HARQ process with HARQ feedback enabled. |

For P2 in [3], in the discussion part there is no mentioning of multiple TB scheduling, therefore, rapporteur assumes this P2 is related to single TB scheduling (maybe proponent company can help to clarify if rapporteur’s interpretation is wrong). It is also mentioned in the contribution that “The reason that UE stops the drx-inactivity timer if running is to avoid UE PDCCH monitoring”.

**Question 3: Do companies agree to P2 in [3]?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Disagree | We understand the intention of this proposal is to keep drx-inactivity timer from running during the period of 12 subframes after a PDSCH reception with HARQ feedback disabled, given that UE is not required to monitor PDCCH during this period based on RAN1 agreement.  Note that in legacy, a NB-IoT UE is not required to monitor PDCCH during PDSCH reception or PUSCH transmission even if the UE is DRX Active Time due to e.g. drx-inactivity timer is running.   |  | | --- | | - during the Active Time, for a PDCCH-subframe, if the subframe is not required for uplink transmission for half-duplex FDD UE operation, and if the subframe is not a half-duplex guard subframe, as specified in TS 36.211 [7], and if the subframe is not part of a configured measurement gap and if the subframe is not part of a configured Sidelink Discovery Gap for Reception, and for NB-IoT if the subframe is not required for uplink transmission or downlink reception other than on PDCCH; or  - monitor the PDCCH; |   Therefore, we think it may be sufficient to capture this restriction of 12 subframes in RAN1 spec, and there is no need to modify UE behaviour on drx-InactivityTimer in the case of NB-IoT UEs with two HARQ processes and without multiple-TB scheduling.  In our understanding, for the case mentioned in [3], operation of drx-Inactivity Timer should follow legacy, i.e. start the timer after PDCCH reception and no need to introduce the new stop and start/restart operation. |
| CATT | Agree (the proponent) | Yes, the proposal is only related with single TB scheduling, thanks to the Rapporteur for the clarification.  Firstly, we think we need keep the same logic for the similar procedure. RAN1 has agreed that, for a DL HARQ process with disabled HARQ feedback in NB-IoT, UE is not required to monitor NPDCCH in a period of Y=12(ms) from the end of reception of the NPDSCH. There is no restriction whether the DL HARQ process with disabled HARQ feedback is a HARQ process of a UE configured with one or two HARQ process. We should give clear description on this to avoid confusion or unnecessary cross-spec check. Otherwise, if we only give clarification on single HARQ process case, people may assume the clarification is not adaptable to two HARQ processes case, very easily.  Secondly, according the current 36.321:  **Active Time:** Time related to DRX operation, as defined in clause 5.7, during which the MAC entity monitors the PDCCH.  And  When a DRX cycle is configured, the Active Time includes the time while:  *- onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *drx-RetransmissionTimerShortTTI* or *drx-ULRetransmissionTimer* or *drx-ULRetransmissionTimerShortTTI* or *mac-ContentionResolutionTimer* (as described in clause 5.1.5) is running; or  …..  And for the HARQ process with disabled HARQ feedback, one of the intentions to start drx-Inactivity Timer is to monitor potentially blind re-transmission, to guarantee the reliability.  So we can assume the UE will monitor PDCCH during the drx-Inactivity Timer. |
| Nokia | Disagree | The change is not needed. As legacy, if UE receives a PDSCH from one HARQ process, we don’t think the drx-inactivity timer should be stopped since UE may need to monitor PDCCH for the grant for the other HARQ process. |
| Xiaomi | Disagree | No intention to change legacy behavior |
| MediaTek | Disagree | UE does not need to stop the running drx-inactivitiy timer after NPDSCH. The drx-inactivity timer is not HARQ process specific but UE specific. It is possible that UE needs to monitor NPDCCH for another HARQ process after the NPDSCH of this HARQ process. Also, as mentioned in the previous questions, PDCCH offset is needed to avoid monitoring partial PDCCH occasion. |
| Qualcomm | Disagree | No need to stop the timer as the other HARQ process is ongoing. |
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***DCI indicating overriding RRC configuration***

RAN1 has agreed to support both RRC-based and DCI-based solutions for indicating HARQ feedback enabled/disabled. In [5], DRX impact is further discussed when DCI indication overrides RRC configuration.

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| Contributions | Relevant proposals: |
| [5] | Proposal 2a: For NB-IoT NTN with two HARQ processes and eMTC NTN for CE Mode B, if the HARQ feedback has been enabled for a HARQ process by RRC and later a DCI for disabling the HARQ feedback of this HARQ process is received, the UE won’t start/restart the corresponding HARQ RTT timer.  Proposal 2b: For NB-IoT NTN with single HARQ process, if the HARQ feedback has been enabled by RRC and disabled by DCI and later a DCI for disabling the HARQ feedback is received, the UE will start/restart drx-inactivity timer.  Proposal 4: An indication from PHY is introduced to indicate to MAC that the HARQ feedback of a HARQ process is enabled/disabled by DCI. |

**Question 4: Do companies agree to P2a, P2b and P4 in [5]?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree |  |
| CATT | Agree with P2a and P2b | For P4, we think no agreement is needed. Just like NDI, the HARQ enabling/disabling bit in DCI (if included) will of course be delivered to MAC. |
| Nokia | See comments. | P2a: Agree. But it is already covered by current RAN2 agreement for HARQ feedback disabled case.   1. RAN2 agree to take R17 NR NTN DRX solution as baseline for IoT NTN, e.g. for HARQ process with DL HARQ feedback disabled, the UE will not start the corresponding DL HARQ RTT timer.   P2b: Disagree. UE should follow the single HARQ process behaviour when the HARQ feedback is disabled. E.g. the agreement as below and further update as question1.   |  | | --- | | Agreements:  1. For NB-IoT NTN with single HARQ process when the HARQ feedback is disabled, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception plus 12 subframes. |   P4: FFS. It is not clear how to indicate the HARQ feedback disabling or enabling in DCI. Therefore, it is not clear whether MAC can directly know the information. Can be discussed after RAN1 reach conclusion. |
| Xiaomi | See comments | Agree with Nokia |
| MediaTek | Disagree: P2a, P2b  Agree: P4 | P2a and P2b: We need RAN1's input whether enable by RRC and disable by DCI is finally agreed.  P4 could be agreed if we assume that HARQ process is enabled/disabled by DCI. |
| Qualcomm | Wait for RAN1 | See Q2, how can we now decide on this when Q2 depends on RAN1.  This is also being discussed by RAN1 on how to use DCI based solution together with RRC-based, we can wait RAN1 progress. |
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***DL multiple TB scheduling***

With DL HARQ feedback disabled being introduced, multiple TB scheduling needs to be discussed. Following proposals are mentioned by companies.

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| Contributions | Relevant proposals: |
| [1] | Proposal 1: For DL, it is up to RAN1 to decide how to support multiple TB scheduling with a single DCI in NTN, i.e. allow those HARQ processes corresponding to the scheduled multiple TBs to be configured with different HARQ modes or restrict all the HARQ processed corresponding to the scheduled multiple TBs always configured with the same HARQ mode.  Proposal 4: For a NB-IoT UE configured with two HARQ processes, if PDCCH indicates the transmission is for multiple TBs and if at least one DL HARQ process is configured with disabled HARQ feedback, UE starts drx-InactivityTimer in the subframe containing the last repetition of the PDSCH corresponding to the last scheduled TB plus 12 subframes.  Proposal 5: For DL multiple-TB scheduling, if the scheduled multiple TBs are configured with different HARQ modes, HARQ RTT Timer is calculated based on the scheduled TBs for which the corresponding HARQ process is configured with DL HARQ feedback enabled. |
| [3] | Proposal 5: Postpone the discussion for enhancements for the case for a multi-TB block until RAN1 has made decision on the solutions for transmitting HARQ feedback for this case. |
| [6] | Proposal 5: RAN2 discuss how to address the issue of HARQ processes for the multiple TBs scheduled by the same PDCCH. |
| [11] | Proposal 1: Whether the HARQ RTT timer calculation needs to be changed for Multiple TBs scheduling, should wait for RAN1’s outcome. |
| [12] | Proposal 2: From RAN2 point of view, there is no need to enhance for Multiple TBs scheduling, unless RAN1 requests to do so. |

**Question 5: On DL multiple TB scheduling, which of below options do companies agree to?**

* **Option 1: RAN2 to discuss the change of inactivity timer and HARQ RTT Timer based on [1] and [6]**
* **Option 2: postpone the discussion until RAN1 makes decision.**

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| **Company** | **Option** | **Additional comments** |
| OPPO | Option 1 | From RAN2’s perspective, we can first discuss DRX impact for the potential cases. Once RAN1 makes decision on the cases to be supported, we can work on the MAC spec based on RAN1 agreements. |
| CATT | Option 2 | It is necessary to have a clear and stable assumption, before we start our work. |
| Nokia | Option 2. | RAN2 can wait for RAN1 decision on multi-TB HARQ feedback indication. |
| Xiaomi | Option 2 |  |
| MediaTek | Option 1 | Discussion can be started, but need to consider RAN1’s progress as well. |
| Qualcomm | See comments  (Option 3: discuss) | Ok to consider the RAN1 progress. It is not necessarily about changing DRX inactivity timer and HARQ RTT timer.  But at least we should discuss whether network implementation can resolve it by configuring same HARQ type for the multiple TBs. |
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***eMTC with single HARQ process***

RAN2 made the following agreement for eMTC in RAN1# 112 meeting:

**Agreement**

For a DL HARQ process with disabled HARQ feedback in eMTC, UE is not expected to receive another MPDCCH carrying a DCI scheduling a PDSCH for a given HARQ process or to receive another PDSCH without corresponding MPDCCH for the given HARQ process that starts at a BL/CE DL subframe until X=3 (ms) have passed after the end of the reception of the last PDSCH for that HARQ process.

Following proposals are related to drx-InactivityTimer for eMTC with single HARQ process.

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| Contributions | Relevant proposals: |
| [3] | Proposal 4: For eMTC NTN with single HARQ process when the HARQ feedback is disabled, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception plus 3 subframes. |
| [7] | Proposal 1. For the case where only one DL HARQ process with disabled HARQ feedback in a MAC entity of an eMTC UE, the UE will start/restart drx-inactivity timer in the subframe containing end of reception of the last PDSCH plus 3 subframes. |

Rapporteur understands that the above two proposals are mentioning the same thing. Perhaps proponent companies can help to clarify if this is not the case.

Note that in the current spec, single HARQ process is only mentioned for NB-IoT

**Question 6: Do companies agree to P4 in [3]?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Disagree | In legacy, we did not mention the case of eMTC configured with single HARQ process in MAC spec. We are not sure whether to include it for NTN.  Plus, the P4 in [3] may also require that a stop operation would be needed for the drx-Inactivity Timer after PDCCH/PDSCH reception. |
| CATT | Agree(the proponent) | In legacy, the UE behaviour can be described uniformly, regardless the UE is configured with one or more than one HARQ processes.  However, for HARQ disabling scenario, the UE behaviour is different according to single HARQ process or more than one HARQ processes configured:   * For single HARQ process case, when the HARQ feedback is disabled, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PDSCH reception plus 3 subframes * For more than one HARQ processes case, no gap is needed, because the UE can receive another MPDCCH carrying a DCI or another PDSCH without corresponding MPDCCH, for any other HARQ process, the HARQ feedback of which can be enabled or disabled   So we think we need to make it clear. |
| Nokia | Disagree | For eMTC, the drx-inactivity timer should be started if the PDCCH indicates a new transmission. No special handling for single HARQ process for eMTC as what specified for NB-IoT. |
| Xiaomi | Disagree | Agree with Nokia |
| MediaTek | Agree |  |
| Qualcomm | Disagree | Agree with Nokia |
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***ACK/NACK for SPS activation***

In [5], following proposal is mentioned.

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| Contributions | Relevant proposals: |
| [5] | Proposal 6: For eMTC NTN, a parameter harq-FeedbackEnablingforSPSactive could be configured for a UE. If harq-FeedbackEnablingforSPSactive is configured to enable HARQ feedback, UE reports ACK/NACK for the first SPS PDSCH after activation, regardless of if HARQ feedback is enabled or disabled corresponding to the first SPS PDSCH after activation. |

**Question 7: Do companies agree to P6 in [5]?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree | Fine to follow RAN1 agreement. |
| CATT | Agree | Keep align with the CR in NR NTN. |
| Nokia | Agree | Follow NR NTN is fine. |
| Xiaomi | Agree |  |
| MediaTek | Agree |  |
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## 3.2 UL HARQ enhancements

***Processing time for NB-IoT with single HARQ process in HARQ mode B***

For UL HARQ mode B, following proposals are mentioned on the processing time for drx-InactivityTimer.

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| Contributions | Relevant proposals: |
| [1] | Proposal 1: For a NB-IoT UE configured with a single HARQ process, if the HARQ process is configured with HARQ mode B, UE starts drx-InactivityTimer in the subframe containing the last repetition of the corresponding PUSCH transmission plus 3 subframes. |
| [3] | Proposal 3: For the processing time for inactivity timer of HARQ mode B, RAN2 wait for the input of RAN1. |
| [4] | Propose 2: For NB-IoT NTN with a HARQ process in HARQ mode B, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH transmission + 1ms + PDCCH offset. |
| [5] | Proposal 5: To clarify a previous agreement as below:  For NB-IoT NTN with single HARQ process in HARQ mode B, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH reception plus 3 subframes plus deltaPDCCH. |
| [6] | Proposal 1: For NB-IoT NTN with single HARQ process in HARQ mode B, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH transmission plus 4 + deltaPDCCH subframes. |
| [7] | Proposal 2: The decision on the additional processing time for drx-inactivity timer for HARQ mode B can be left to RAN1, similarly to DL discussion. |
| [9] | Proposal 4: For IoT NTN with single HARQ process in HARQ mode B, the UE shall start/restart drx-inactivity timer after the end of (N)PUSCH + 3 subframes. |
| [10] | Proposal 1: RAN2 to discuss for HARQ mode B, whether the drx-InactivityTimer is (re)started after a period equal to the minimum time between two grants for the same HARQ process.  Proposal 2: Send LS to RAN1 asking about the minimum time between two grants for the same HARQ process. |
| [12] | Proposal 1: Send LS to RAN1 to clarify whether the behavior of NPDCCH monitoring need to be changed to support HARQ mode B, and if so, asks RAN1 to change it accordingly. |

In [1], it is mentioned that the additional processing time of 3 subframes follows the legacy for the same HARQ process in 36.213, i.e. UE is not expected to receive NPDCCH within 3 ms after NPUSCH transmission.

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| If a NB-IoT UE is configured with higher layer parameter *twoHARQ-ProcessesConfig*  - and if the UE has a NPUSCH transmission ending in subframe *n*,  - the UE is not required to receive transmissions in the Type B half-duplex guard periods as specified in [3]for FDD ; and  - the UE is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission in any subframe starting from subframe n+1 to subframe n+3 or in a NTN serving cell, in any downlink subframe that overlaps with uplink subframe *n*+1 to subframe *n*+*K*mac+3*;*  else if the UE is not using higher layer parameter *edt-Parameters* or if the UE is using higher layer parameter *edt-Parameters* and  - if the NB-IoT UE has a NPUSCH transmission ending in subframe *n* , the UE is not required to monitor NPDCCH in any subframe starting from subframe *n+1* to subframe *n+3* or in a NTN serving cell, in any downlink subframe that overlaps with uplink subframe *n*+*1* to subframe *n*+*K*mac+*3*.  otherwise,  - If the NB-IoT UE has a NPUSCH transmission for Msg3 ending in subframe with transport block size , whereas if would have been selected the NPUSCH transmission would have ended in subframe *n*, the UE is not required to monitor NPDCCH in any subframe starting from subframe *n'+1* to subframe *n+3* or in a NTN serving cell, in any downlink subframe that overlaps with uplink subframe *n'*+*1* to subframe *n*+*K*mac+*3*. |

In [4], it is mentioned that the minimum gap between the PUSCH transmission and the next possible PDCCH occasion is Type B half duplex guard periods as specified in 36.211, which is 1ms.

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| 36.211 6.2.5 Guard period for half-duplex FDD operation For type A half-duplex FDD operation, a guard period is created by the UE by  - not receiving the last part of a downlink subframe immediately preceding an uplink subframe from the same UE.  For type B half-duplex FDD operation, guard periods, each referred to as a half-duplex guard subframe, are created by the UE by  - not receiving a downlink subframe immediately preceding an uplink subframe from the same UE, and  - not receiving a downlink subframe immediately following an uplink subframe from the same UE. |

In [6], it is mentioned that “For TN, this gap between PUSCH and NPDCCH is 3 + deltaPDCCH subframes. Therefore, we propose to have same gap length between PUSCH and PDCCH in UL HARQ mode B”.

**Question 8: For a NB-IoT UE configured with a single HARQ process in HARQ mode B, which of below options do companies support for the additional processing time for drx-InactivityTimer?**

* **Option 1: UE starts drx-InactivityTimer in the subframe containing the last repetition of the corresponding PUSCH transmission plus 3 subframes [1] [9]**
* **Option 2: the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH transmission + 1ms + PDCCH offset [4]**
* **Option 3: the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH reception plus 3 subframes plus deltaPDCCH [5]**
* **Option 4: the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH transmission plus 4 + deltaPDCCH subframes [6]**
* **Option 5: wait for RAN1’s decision [3]**
* **Option 6: send LS to RAN1 and ask [10] [12]**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Additional comments** |
| OPPO | Option 3 or option 6 | In legacy, processing time of 3 subframes is defined for the same HARQ process in 36.213, and we think it suits here for the case with single HARQ process.  We are also ok to check with RAN1. |
| CATT | Option 5 |  |
| Nokia | Option 5 and Option 6 | We prefer to ask RAN1 on the minimum gap between the PUSCH transmission and PDSCH reception in HARQ ModeB. Send LS to RAN1 is fine. |
| Xiaomi | Option 5 and 6 | We think it should be RAN1 to decide when to start PDCCH monitoring for the HARQ Mode B case. RAN2 can then decide the start of DRX inactivity timer based on RAN1 agreement. |
| MediaTek | Option 2 | We think only 1 ms is needed, as 3 subframes contains the network processing time for UL transmission, which is not needed for HARQ mode B. We have explained it in [4]. |
| Qualcomm | Option 4/3/1 | The counting starts from the last subframe (including) so it should be processing time + 1.  We think it is better to follow current HARQ definition which is 3 subframes gap.  We understand Option 1, Option 3 and Option 4 are same, its just wording issue how we capture in the specification. |
|  |  |  |

***Ambiguity in PUSCH subframe***

In [6], the ambiguity issue for PUSCH subframe was mentioned as follows:

In case of starting HARQ RTT timer, there is no ambiguity between UE and network as the timer is extended by UE-eNB RTT which includes UE’s TA. However, in case of starting DRX inactivity timer from the subframe containing the last repetition of the corresponding PUSCH transmission, the UE and network may not be synchronized.

As the network may not know exact UE’s TA, it will not know the exact subframe where UE performs UL transmission. If UE’s TA is less than scheduling Koffset, then UE will be starting DRX inactivity timer later than eNB expected because (Koffset – UE’s TA) is the ambiguity period.

We think the network implementation can resolve the issue by not scheduling the NPDCCH back-to-back during the ambiguity period (i.e., Koffset – UE’s TA).

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| --- | --- |
| Contributions | Relevant proposals: |
| [6] | Proposal 2: network implementation resolves the issue of ambiguity on start of DRX inactivity timer after the PUSCH transmission by not scheduling the NPDCCH back-to-back during the ambiguity period (i.e., Koffset – UE’s TA). |

**Question 9: Do companies agree to P2 in [6]?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree |  |
| CATT | Agree | But maybe adding “No spec impact is needed” |
| Nokia |  | We are not sure the issue is valid since the NW know exactly when the UE should start the PUSCH transmission which is based on NW configured Koffset instead of TA. |
| Xiaomi | Agree |  |
| MediaTek | Agree |  |
| Qualcomm | Agree | Ok Nokia’s claim is new to us. NW only knows its own UL timing but not the UE’s UL timing. |
|  |  |  |

***UL multiple TB scheduling***

Following proposals are related to DRX operation for UL multiple TB scheduling.

|  |  |
| --- | --- |
| Contributions | Relevant proposals: |
| [1] | Proposal 2: For UL, RAN2 discuss how to support multiple TB scheduling with a single DCI in NTN.   * Option 1: Allow those HARQ processes corresponding to the scheduled multiple TBs to be configured with different HARQ modes. * Option 2: Restrict all the HARQ processed corresponding to the scheduled multiple TBs always configured with the same HARQ mode.   Proposal 6: For a NB-IoT UE configured with two HARQ processes, if PDCCH indicates the transmission is for multiple TBs and if at least one HARQ process is configured with HARQ mode B, UE starts drx-InactivityTimer in the subframe containing the last repetition of the PUSCH corresponding to the last scheduled TB plus 3 subframes. |
| [12] | Proposal 2: From RAN2 point of view, there is no need to enhance for Multiple TBs scheduling, unless RAN1 requests to do so. |

**Question 10: On UL multiple TB scheduling, which of below options do companies agree to?**

* **Option 1: P2 and P6 in [1]**
* **Option 2: P2 in [12]**

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| --- | --- | --- |
| **Company** | **Option** | **Additional comments** |
| OPPO | Option 1 | Different from disabling HARQ feedback for DL, UL HARQ mode A/B is introduced in RAN2. In our understanding, the impact of UL HARQ mode A/B is mainly on MAC spec, i.e. DRX and LCP, except the UE processing time for HARQ mode B, which needs to be checked by RAN1. So it should be RAN2 to decide how to support multiple TB scheduling and the impact on DRX procedure. |
| CATT | Option 2 | There is no strong motivation on the enhancement. |
| Nokia | None | We think how to support multiple TB scheduling with a single DCI in UL should also be discussed in RAN1. (For example, any restriction on HARQ mode for different TBs as proposed in Option1 or Option2 above). Maybe RAN2 can include this point in LS to RAN1 as well. On the drx-inactivityTimer start in case of no HARQ process available after multi-TB scheduling, it can just follow single HARQ process behaviour. |
| Xiaomi | See comment | We think we can wait for RAN1 progress on this. |
| MediaTek | see comments | For P2 in [1], mediatek prefer option 2. For NB-IoT, UE cannot select specific UL HARQ process to send the UL data, so there no point to configure different HARQ mode when multiple TBs are configured.  For P6 in [1], we think it should be “1 subframe + PDCCH offset”, where 1 subframe is for tx-rx transition and PDCCH offset is to align with PDCCH occasion to avoid partial PDCCH occasion.  As mentioned before, 3 subframes contains the network processing time for UL transmission, which is not needed for HARQ mode B. |
| Qualcomm | Option 1 | It should be discussed whther P2, option 2 in [1] can resolve the issue. |
|  |  |  |

***Signalling of UL HARQ mode***

For UL HARQ mode, following contributions discussed the signalling options, e.g. RRC and/or DCI.

|  |  |
| --- | --- |
| Contributions | Relevant proposals: |
| [6] | Proposal 3: The configuration for UL HARQ mode is kept simple with only option 1, i.e., per HARQ process via UE specific RRC signaling. |
| [7] | Proposal 3: The same mechanism can be applied to configure/indicate enabling/disabling of HARQ feedback for downlink and uplink transmission, i.e. support of the configuration via RRC signaling or DCI indication per HARQ process, and support of the DCI indication to override RRC configuration. |
| [9] | Proposal 5: RAN2 to consider whether uplink HARQ mode based on DCI should be supported.  If so, then:  Proposal 5b: Send an LS to RAN1 indicating RAN2 conclusion.  Proposal 5c: Specify in MAC that a HARQ process use Uplink HARQ mode A or B, based on RRC configuration or DCI indication.  Proposal 5d: Study whether any further changes are needed to support DCI based HARQ mode setting (E.g. timer handling, LCP restriction handling) |
| [11] | Proposal 1: The way of indicating enabling/disabling of UL HARQ should follow the mechanism designed for DL HARQ. |

The main arguments for having both RRC-based and DCI-based solutions (similar as for DL HARQ) is to have more flexibility for network control. Having RRC-based solution only is trying to be simple as mentioned in [6] that “RAN2 has agreed to support HARQ mode A and B for UL HARQ process but RAN1 has not yet discussed the solution on DCI-based dynamically switching the HARQ mode”.

**Question 11: which option do companies prefer for the signalling of UL HARQ mode?**

* **Option 1: RRC only**
* **Option 2: RRC and DCI**

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| --- | --- | --- |
| **Company** | **Option** | **Additional comments** |
| OPPO | Option 1 | We see no motivation to introduce DCI based configuration for UL HARQ mode. Prefer to reuse NR solution. |
| CATT |  | Suggest confirming with RAN1 if there is any necessity for uplink to support DCI-based solution. |
| Nokia | Option 2 | We would like to have a unified solution for both DL and UL. Furthermore, the motivation on why DCI solution should be supported for DL is appliable to UL as well. |
| Xiaomi | Option 1 | RAN2 can introduce option 2 only if RAN1 askes to do so |
| MediaTek | Option 1 | We cannot see any user case for option 2. If HARQ mode B is configured, network predict the next UL data is important and might needs a retransmission, network can 1) send a blind retransmission UL grant right after the first UL grant. 2) wait for receiving the UL data and decide whether to retransmit the last UL data. There is no need to change the UL HARQ mode dynamically. |
| Qualcomm | Option 1 | There is no need of DCI-based solution in UL HARQ as network knows what to do, new transmission or retransmission. |
|  |  |  |

There are also some proposals in [5] about DRX impact when DCI indication overrides RRC configuration, but those can be discussed after RAN2 has made agreements on the signalling options for indicating UL HARQ mode.

***SPS and PUR configured with HARQ mode B?***

It is mentioned in [4] that when the HARQ mode B apply to SPS and PUR, it is beneficial for the purpose of blind retransmission

|  |  |
| --- | --- |
| Contributions | Relevant proposals: |
| [4] | Proposal 4: UL transmission using SPS can be configured with HARQ mode B.  Proposal 5: UL transmission using PUR can be configured with HARQ mode B. |

**Question 12: Do companies agree to P4 and P5 in [4]?**

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| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree | It is up to NW implementation. |
| CATT | Agree |  |
| Nokia | Agree |  |
| Xiaomi | Agree |  |
| MediaTek | Agree |  |
| Qualcomm | Agree |  |
|  |  |  |

***UL HARQ ACK feedback***

In [5], following proposal is mentioned.

|  |  |
| --- | --- |
| Contributions | Relevant proposals: |
| [5] | Proposal 7: For eMTC NTN, it can be left to eNB’s implementation to enable HARQ feedback if mpdcch-UL-HARQ-ACK-FeedbackConfig is configured. |

**Question 13: Do companies agree to P7 in [5]?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree |  |
| CATT | See the comments | Agree the intention, but maybe the proposal should be:  Proposal 7: For eMTC NTN, it can be left to eNB’s implementation to ~~enable~~ disable HARQ feedback if mpdcch-UL-HARQ-ACK-FeedbackConfig is configured. |
| Nokia |  | We are not sure the issue is valid since the early termination for PUSCH repetition relies on the PDCCH-based Ack in DL instead of HARQ feedback in UL. |
| Xiaomi | Agree |  |
| MediaTek | Agree |  |
| Qualcomm | No spec impact | There is nothing needs to be done. It is up to network whether it will send feedback in DL to UE or not. Regardless of HARQ mode, network can decide whether UE needs to terminate PUSCH transmission or not. |
|  |  |  |

***TA report transmission issue***

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| --- | --- |
| Contributions | Relevant proposals: |
| [8] | Observation 1: The eNB may maintain an outdated Timing Advance information if the TAR MAC CE was not transmitted to eNB successfully, especially when the MAC CE was transmitted in UL HARQ Mode B.  Observation 2: The outdated Koffset will be used by UE for PUSCH transmission if the eNB maintain an outdated Timing Advance information.  Observation 3: The outdated Koffset may cause PUSCH transmission failure in eMTC NTN.  Proposal 1: RAN2 confirm that, if NR NTN solution is reused by eMTC NTN in which the LCP restriction based on allowed HARQ mode is not applicable for TAR MAC CE, the UE may suffer from PUSCH transmission failure.  Proposal 2: Enhancements on TAR MAC CE transmission should be considered for eMTC NTN to avoid or mitigate the outdated TA and Koffset impact. |

It is also mentioned in [8] that the relevant issue was discussed for NR NTN in late stage of Rel-17 while the solution was not concluded due to time limitation. Therefore, the issue was not resolved in NR NTN as well.

**Question 14: Do companies agree to P1 and P2 in [8]?**

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| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Disagree | Prefer to follow NR. We see no strong need for enhancement. |
| CATT | Disagree |  |
| Nokia | Agree (Proponent) | Indeed, the issue was discussed but not concluded for NR NTN due to time limitation in the late stage of Rel-17. We propose to discuss the issue now in Rel-18 since it may result in PUSCH transmission failure and waste system resource in vain because of TA Report transmission error.  The typical case is that, when the UE’s TA is increased due to the increase of UE-Satellite-eNB distance, the UE may trigger a TA report to update the latest TA to NW. However, if the TAR MAC CE was not transmitted to eNB successfully (*e.g. due to MAC CE transmission in HARQ Mode B and MAC CE has no RLC retx*), the eNB would not know TA is updated/increased in UE hence the outdated TA is maintained in eNB. Therefore, the eNB has no way to update/increase its Koffset based on the outdated TA. In the end, when the *UE’s actual TA* is larger than (*UE's outdated Koffset + 4 - UE's UL processing delay*), the UE cannot perform UL transmission at all due to not enough processing time in UE in between PDCCH grant and the corresponding PUSCH transmission.  Furthermore, the motivation to report TA to NW is to facilitate NW configure proper Koffset hence reduce the latency for UE located in the cell centre. Configuring a larger Koffset to mitigate the issue is not a reasonable solution since NW has to configure a Koffset which can cover largest TA of all the UEs under the cell. While this solution will kill the motivation to support TA report which implies the TA report is not useful at all. |
| Xiaomi | No strong view | If time allow, we are ok to consider this. |
| MediaTek | No Strong Preference |  |
| Qualcomm | Agree | We agree with Nokia. Support of UE specific Koffset is important, that’s why we have TA report MAC CE. |
|  |  |  |

***HARQ-based LCP restriction***

In [9], it is observed that to minimise the risk of protocol stalling at RLC when using higher data rates, initial RLC transmission could be sent using HARQ processes configured with HARQ Mode B to improve throughput, and RLC retransmissions and RLC STATUS PDUs could be sent using HARQ processes configured with HARQ mode A to ensure reliable delivery. Following proposal are given.

|  |  |
| --- | --- |
| Contributions | Relevant proposals: |
| [9] | Proposal 1: At least for eMTC: LCP restriction based on uplinkHARQ-Mode can be configured for different RLC PDU types, such that RLC initial transmissions, retransmission, and STATUS PDUs can be restricted to a particular HARQ Mode. |

**Question 15: Do companies agree to P1 in [9]?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Disagree | This not IoT NTN-specific issue. Prefer to not have this enhancement. |
| CATT | Disagree |  |
| Nokia | Disagree | It seems not reasonable to mix the RLC layer function and MAC layer function (LCP). |
| Xiaomi | Disagree |  |
| MediaTek | Agree |  |
| Qualcomm | Disagree | It is sufficient to align with NR NTN. We prefer to avoid RLC impacts. |
|  |  |  |

## 3.3 Others

***LS to RAN1 to inform RAN2’s agreements?***

|  |  |
| --- | --- |
| Contributions | Relevant proposals: |
| [1] | Proposal 7: Send a LS to RAN1 regarding RAN2 agreements on disabling HARQ feedback and UL HARQ mode B. |
| [4] | Proposal 6: RAN2 should send an LS to RAN1 to notify the RAN2’s agreement about HARQ mode B and the possible RAN1 spec impact. |

Maybe the LS to RAN1 can include relevant RAN2 agreements and also questions to be checked with RAN1.

**Question 16: Do companies agree to send LS to RAN1 informing RAN2’s agreements together with questions to be checked with RAN1?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| OPPO | Agree | In the LS, RAN2 can   * inform RAN1 of RAN2’s agreements on UL HARQ mode B and check with RAN1 on the processing time * on DCI-based solution for indicating DL HARQ feedback enable/disable, check RAN1’s views on RRC signalling’s granularity, e.g. per UE or per HARQ process * check RAN1’s views on whether to introduce DCI-based solution for UL HARQ mode A/B indication |
| CATT | Agree | One LS can be sent to inform RAN2 agreements, and check the view of RAN1 on RAN2 concerned issue, not only HARQ aspect. |
| Nokia | Agree with comments | Also the aspects discussed in Question 8 and Question 10 can be included. |
| Xiaomi | Agree |  |
| MediaTek | Agree |  |
| Qualcomm | See comments | RAN1 has not worked on UL HARQ process. It is because it is left to RAN2 as it is in RAN2 scope. There is no need to ask RAN1 on UL HARQ.  But sending LS on informing RAN2 agreements will be OK. |
|  |  |  |

# 4. Summary and Proposals

This section summarizes the main proposals:

# 5. References

1. R2-2302533 Discussion on HARQ enhancement for IoT NTN OPPO discussion Rel-18 IoT\_NTN\_enh-Core
2. R2-2302534 Draft LS to RAN1 on HARQ enhancement for IoT NTN OPPO LS out Rel-18 IoT\_NTN\_enh-Core To:RAN1
3. R2-2302557 Discussion on the HARQ enhancements in IoT NTN CATT discussion Rel-18 IoT\_NTN\_enh-Core
4. R2-2302672 On Disabling HARQ Feedback in IoT-NTN MediaTek Inc. discussion
5. R2-2302819 Further discussion on HARQ enhancements ZTE Corporation, Sanechips discussion Rel-18 IoT\_NTN\_enh-Core
6. R2-2303041 Enhancement for UL and DL HARQ processes Qualcomm Incorporated discussion Rel-18 IoT\_NTN\_enh-Core R2-2300889
7. R2-2303517 Discussion on the HARQ enhancement for IoT-NTN CMCC discussion Rel-18 IoT\_NTN\_enh-Core
8. R2-2303644 Discussion on Timing Advance Report MAC CE transmission in eMTC NTN Nokia, Nokia Shanghai Bell, Huawei, HiSilicon discussion Rel-18 IoT\_NTN\_enh-Core R2-2301659
9. R2-2303713 Disabling HARQ feedback for IoT-NTN Interdigital, Inc. discussion Rel-18 IoT\_NTN\_enh-Core
10. R2-2303837 R18 IoT NTN HARQ enhancements Ericsson discussion Rel-18 IoT\_NTN\_enh
11. R2-2303964 Discussion on HARQ enhancements Huawei, HiSilicon discussion Rel-18 IoT\_NTN\_enh-Core
12. R2-2304030 Discussion on HARQ enhancement Xiaomi discussion Rel-18
13. R2-2304032 LS on NPDCCH monitoring for HARQ mode B Xiaomi LS out Rel-18 To:RAN1