**3GPP TSG RAN WG1 #114 R1-2308231**

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| **Toulouse, France, August 21st – August 25th, 2023** |

**Agenda Item: 9.9.3**

**Source: Moderator (Lenovo)**

**Title: FLS#1 on disabling of HARQ feedback for IoT NTN**

**Document for: Discussion and decision**

# Introduction

In the RAN#94 plenary meeting, an enhancement work item for Rel.18 IoT NTN was approved. One of the objectives is to specify the following HARQ enhancements to IoT NTN.

*This work considers Rel-17 IoT-NTN as baseline as well as Rel-17 NR-NTN outcome and the further IoT-NTN performance enhancements objectives are listed below:*

*-* ***Disabling of HARQ feedback to mitigate impact of HARQ stalling on UE data rates [RAN1,RAN2]***

*- Study and specify, if needed, improved GNSS operations for a new position fix for UE pre-compensation during long connection times and for reduced power consumption [RAN1]*

The following agreements on disabling of HARQ feedback for IoT NTN were achieved:

**RAN1-109e**

Agreement

*For IoT NTN, to configure/indicate enabling/disabling on HARQ feedback for downlink transmission, one or more of the following options can be considered:*

* *Option 1: per HARQ process via UE specific RRC signaling*
* *Option 2: per HARQ process via SIB signaling*
* *Option 3: explicitly indicated by DCI (e.g., new field or reusing existing field)*
* *Option 4: implicitly determined by existing configured/indicated parameter(s) (e.g., repetition number, TBS)*
* *Option 5: per HARQ process via MAC CE*
* *Other options or combinations are not excluded*

*Note: Option(s) for eMTC and NBIoT can be separately discussed.*

Agreement

*For IoT NTN, further study the potential issues due to enabling/disabling on HARQ feedback for downlink transmission*

* *Issue A: SPS PDSCH*
* *Issue B: (N)PDSCH/(N)PDCCH scheduling restriction*
* *Issue C: HARQ feedback for scheduling multiple TB*
* *Issue D: HARQ bundling for eMTC HD-FDD*
* *Issue F: NPRACH capacity*
* *Issue G: Serving cell/satellite change during data transfer (FFS: for eMTC and/or NB-IoT)*
* *Other issues are not excluded*

*Note: The “Issues” in common for eMTC and NB-IoT can be separately discussed.*

**RAN1-110**

Agreement

*For eMTC NTN, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission, down select one or more from the following options:*

* *Option 1: per HARQ process via UE specific RRC signaling.*
* *Option 3: explicitly indicated by DCI (e.g., new field or reusing existing field).*
* *Option 4: implicitly indicated by existing configured/indicated/combined parameter(s) in the DCI (e.g., repetition number, TBS)*
* *Option 6: combinations of some options above.*

Agreement

*For NB-IoT NTN, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission, down select one or more from the following options:*

* *Option 1: per HARQ process via UE specific RRC signaling*
* *Option 3: explicitly indicated by DCI (e.g., new field or reusing existing field)*
* *Option 4: implicitly indicated by existing configured/indicated/combined parameter(s) in the DCI (e.g., repetition number, TBS)*
* *Option 6: combinations of some options above*

Agreement

*For a DL HARQ process with disabled HARQ feedback in NB-IoT, at least the following UE behavior(s) can be considered:*

* *Option 1: UE is not expected to receive another NPDCCH carrying a DCI scheduling a NPDSCH for a given HARQ process that starts until X(ms) after the end of the reception of the last NPDSCH for that HARQ process.* 
  + *X =12*
* *Option 2: UE is not required to monitor NPDCCH in a period of Y(ms) from the end of reception of the last NPDSCH*
  + *Y=12*

*Note: it may be different UE behaviors for different UE categories (e.g., UE with single/multiple HARQ processes).*

**RAN1-110bis-e**

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.*

Agreement

*For NB-IoT NTN, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission, down select* ***ONE*** *from the following options at RAN1#111:*

* *Option 6a-1: Support RRC signaling configured between Option 1 and Option 3*
* *Option 6a-4: Support Option 1 by default, and support Option 3 to override default configuration for corresponding transmission*

**RAN1-111**

***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 by default, and support Option 3 to override default configuration for corresponding transmission*
  + *Additional RRC signaling to enable Option 3*
  + *If the bitmap for option 1 is not present and if option 3 is configured then the DCI directly indicates HARQ enable/disable. Option 3 can also be configured when the bitmap for option 1 is configured.*
  + *FFS #1: Option 3 DCI-based overridden mechanism is applied to both semi-statically HARQ enabled and disabled processes or only applied to semi-statically HARQ disabled processes or only applied to semi-statically HARQ enabled processes.*
  + *FFS #2: whether/how to support Option 3 overriding default configuration for corresponding transmission for multiple TBs scheduled by single DCI*

*For eMTC NTN, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission, take Option 1 for CE Mode A.*

**RAN1-112**

*Conclusion*

*For eMTC HD-FDD single TB scheduled by single DCI, UE is not expected to receive a DCI with “HARQ-ACK bundling flag” field set to 1 in case the corresponding HARQ process is configured with HARQ feedback disabled by RRC signaling.*

*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.*

*Agreement*

*For HARQ feedback for eMTC SPS PDSCH, at least the following is supported: UE follows the per-process HARQ feedback enabled/disabled configuration for the associated HARQ process except for the first SPS PDSCH after activation*

* *for the first SPS PDSCH after activation,*
  + *Option 1: If HARQ feedback for SPS activation is additionally enabled, ACK/NACK is reported by UE for the first SPS PDSCH after activation regardless of network configuration of enabled/disabled for this HARQ process, and follow per-process HARQ feedback enabled/disabled configuration otherwise.*

*Conclusion*

*For DCI indicating SPS PDSCH release, HARQ-ACK report is performed as legacy in eMTC, regardless of HARQ feedback enabled/disabled configuration.*

*Agreement*

*For DCI-based overridden mechanism/indication in single TB scheduled by DCI, down select one of the following alternatives based on the criteria DCI overhead, PDCCH monitoring/power consumption, HARQ timer, impact on scheduling flexibility, UE implementation complexity*

* *Alternative 1: applies to both semi-statically HARQ enabled and disabled processes*
* *Alternative 2: only applied to semi-statically HARQ disabled processes*
* *Alternative 3: only applied to semi-statically HARQ enabled processes*

*Agreement*

*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.*

*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*

**RAN1-112bis-e**

*Agreement*

*For Option 3 DCI indication:*

* *Option A: when both per-HARQ process bitmap and DCI solution enabling/disabling signaling are configured*
  + *DCI-based overridden mechanism is DCI signaling to reverse the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration*
    - *For single TB scheduled by DCI, the DCI based overridden indication is applied to one of the following options (to be down-selected):*
      * *Option A-1: only applied to semi-statically HARQ disabled processes*
      * *Option A-4: applied to both semi-statically HARQ disabled and enabled processes*
    - *FFS for multiple TBs scheduled by single DCI*
* *Option B: DCI-based HARQ enabling/disabling direct indication in case DCI solution enabling/disabling signaling is configured and per-HARQ process bitmap signaling is not configured (i.e. no bitmap is configured)*
  + *DCI-based mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission*
    - *For single TB scheduled by DCI, DCI-based direct indication is applied to the scheduled TB*
    - *FFS for multiple TBs scheduled by single DCI*

*Agreement*

*For single TB scheduled by DCI, for DCI-based 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 (e.g., 1-bit)* 
  + *Note: Other fields in DCI are the same as legacy.*
* *Option 2: Indication by reusing/reinterpreting existing field in DCI*
  + *Option 2A: HARQ-ACK related field* 
    - *For eMTC CE mode B, one state of “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.*
      * *FFS: detailed state*
    - *For NBIoT, one state of “HARQ-ACK resource” field in DCI format N1 is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.*
      * *FFS: detailed state*
  + *Option 2B: MCS or repetition number field*
    - *Reduce 1bit of legacy MCS or repetition number field and add 1bit new field in DCI format 6-1B and N1 to indicate the HARQ feedback enabled/disabled*
      * *FFS: detailed for interpreting of the reduced MCS or repetition number field*
  + *Option 2C: HARQ-ACK related field v2*
    - *For eMTC CE mode B, reduce 1bit of legacy “HARQ-ACK resource offset” field and add 1bit new field in DCI format 6-1B to indicate the HARQ feedback enabled/disabled*
      * *FFS: detailed for interpreting of the reduced “HARQ-ACK resource offset” field*
    - *For NBIoT, reduce 1bit of legacy “HARQ-ACK resource” field and add 1bit new field in DCI format N1 to indicate the HARQ feedback enabled/disabled*
      * *FFS: detailed for interpreting of the reduced “HARQ-ACK resource” field*
  + *Option 2D: Other indication by reusing/reinterpreting existing field*

**RAN1-113**

***Working assumption***

*For DCI-based direct indication in single TB scheduled by DCI,*

* *Indication by reusing/reinterpreting HARQ-ACK related field in DCI*
  + - *For eMTC CE mode B, one state of “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.*
      * *FFS: detailed state, and whether this state is different across different UEs*
    - *For NBIoT, one state of “HARQ-ACK resource” field in DCI format N1 is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.*
      * *FFS: detailed state, and whether this state is different across different UEs*
* *If reusing/reinterpreting HARQ-ACK related field in DCI is also used for DCI overriding scheme, the interpretation of the state can be different than for DCI-based direct indication.*

***Agreement***

*For single TB scheduled by DCI,*

* *Working assumption 1 DCI based overridden indication is applied to both semi-statically HARQ disabled and enabled processes*
  + *For DCI based overridden indication, adopt indication by reusing/reinterpreting HARQ-ACK related field in DCI*
    - *For eMTC CE mode B, “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of maintaining/reversing the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration and corresponding HARQ-ACK resource in case of indication of HARQ feedback enabled.*
      * *HARQ feedback disabled is reversed to enabled in case of any states other than state A in “HARQ-ACK resource offset”, otherwise is maintained as disabled.*
      * *HARQ feedback enabled is maintained in case of any states other than state A in “HARQ-ACK resource offset”, otherwise is reversed to disabled.*
        + *FFS: detailed state A, and whether this state A is different across different UEs*
    - *For NBIoT, “HARQ-ACK resource” field in DCI format N1 is used for indication of maintaining/reversing the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration and corresponding HARQ-ACK resource in case of indication of HARQ feedback enabled.*
      * *The same DCI indication functionality as eMTC is adopted.*
* *Working assumption 2 For Option 1 + Option 3 DCI based overridden mechanism, for a HARQ process configured as HARQ feedback disabled by per-HARQ process bitmap signaling and further reversed to HARQ feedback enabled by DCI, the NBIoT UE does not wait for an RTT+3ms (i.e., till subframe n+Kmac+3 in TS36.213 section 16.6) before monitoring NPDCCH for the same HARQ process (or monitoring any NPDCCH for the case of single HARQ process configuration).*
* *Send an LS to RAN2 with the following contents:*
  + *RAN1 respectfully ask RAN2 for the feasibility of Working assumption 2 (taking into account potential RAN2 spec impact).*

***Agreement***

*The draft LS in R1-2306205 is endorsed. Final LS in R1-2306245.*

***Agreement***

*For the RRC configuration of DCI solution enabling/disabling of HARQ feedback for NB-IoT and LTE-MTC in CE Mode B, the RRC configuration is UE-specific.*

***Agreement***

*for NB-IoT and LTE-MTC in CE Mode B, if multiple TBs is configured, for DCI-based HARQ enabling/disabling direct indication in multiple TBs scheduled by single DCI, the same indication is applied to all scheduled TBs, i.e. HARQ is enabled or disabled for all TBs.*

This document provides the proposals and summary of discussions with detailed proposals from each company listed in appendix according to the inputs. Companies are encouraged to provide the inputs in the discussion.

# [Active]Issue-1 Indication/configuration of disabling HARQ feedback

## Background

In NR NTN, disabling HARQ feedback for downlink transmission is semi-static configured by RRC signaling. The configuration is indicated per HARQ process index by a bitmap manner, e.g., 32bit bitmap if the configured HARQ process number is 32.

Regarding indication/configuration of disabling HARQ feedback for downlink transmission for IoT NTN, several options were discussed in previous RAN1 meeting. For eMTC CEMode A, RRC based solution was agreed to be the only solution for HARQ enabling/disabling configuration, while for NBIoT and eMTC CEMode B, the combined solution (e.g., updated Option 6a-4) were agreed. The following parts are the remaining issues to be solved for indication/configuration of disabling HARQ feedback for Rel.18 NTN IoT.

**ISSUE 1-1 Working Assumption**

In previous RAN1 meeting, the detailed DCI based HARQ feedback enabled/disabled indication solution have been agreed. For both DCI-based direct indication and DCI based overridden indication of single TB scheduled by DCI, reusing/reinterpreting HARQ-ACK related field in DCI were agreed to be the working assumption. Considering the DCI overhead, the reusing/reinterpreting existing DCI field is a good compromise solution for the indication of HARQ feedback enabled/disabled in IoT NTN. As proposed by [Huawei, Spreadtrum, Nokia, SONY, NEC, Lenovo, Samsung, Ericsson, Qualcomm, Nordic], the working assumption should be confirmed.

Based on that, the following proposal is listed for discussion.

**[Proposal 1-1a]:**

Confirm the following working assumption:

Working assumption

For DCI-based direct indication in single TB scheduled by DCI,

* Indication by reusing/reinterpreting HARQ-ACK related field in DCI
  + - For eMTC CE mode B, one state of “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.
      * FFS: detailed state, and whether this state is different across different UEs
    - For NBIoT, one state of “HARQ-ACK resource” field in DCI format N1 is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.
      * FFS: detailed state, and whether this state is different across different UEs
* If reusing/reinterpreting HARQ-ACK related field in DCI is also used for DCI overriding scheme, the interpretation of the state can be different than for DCI-based direct indication.

For single TB scheduled by DCI,

* Working assumption 1 DCI based overridden indication is applied to both semi-statically HARQ disabled and enabled processes
  + For DCI based overridden indication, adopt indication by reusing/reinterpreting HARQ-ACK related field in DCI
    - For eMTC CE mode B, “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of maintaining/reversing the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration and corresponding HARQ-ACK resource in case of indication of HARQ feedback enabled.
      * HARQ feedback disabled is reversed to enabled in case of any states other than state A in “HARQ-ACK resource offset”, otherwise is maintained as disabled.
      * HARQ feedback enabled is maintained in case of any states other than state A in “HARQ-ACK resource offset”, otherwise is reversed to disabled.
        + FFS: detailed state A, and whether this state A is different across different UEs
    - For NBIoT, “HARQ-ACK resource” field in DCI format N1 is used for indication of maintaining/reversing the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration and corresponding HARQ-ACK resource in case of indication of HARQ feedback enabled.
      * The same DCI indication functionality as eMTC is adopted.

**ISSUE 1-2 Details for DCI-based solution**

Regarding the detail states of HARQ-related field in DCI format 6-1B and DCI format N1 to indicate the HARQ feedback enable/disable, several solutions are discussed in this meeting.

The states of HARQ-related field to indicate the HARQ feedback disabled is remaining issue.

* *For eMTC CE mode B, one state of “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.*
  + *FFS: detailed state, and whether this state is different across different UEs*

**[Proposal 1-2a]:**

For DCI-based direct/overridden indication in single TB scheduled by DCI, down-select one of the following options for the state of HARQ-related field (i.e., “HARQ-ACK resource offset” field for eMTC, “HARQ-ACK resource” field for NBIoT) in DCI to indicate the HARQ feedback enabled/disabled.

* Option 1: one common state is used for all UEs
  + Option 1-1: the state of indication of HARQ feedback disabled and state A are state of “11” for eMTC and state of “1111” for NBIoT respectively.
  + Option 1-2: the state of indication of HARQ feedback disabled and state A are state of “00” for eMTC, state of “0010” for NBIoT with NPUSCH 15kHz and state of “0000” for NBIoT with NPUSCH 3.75kHz respectively.
  + Option 1-3: the state of indication of HARQ feedback disabled and state A are state of “00” for eMTC and state of “0000” for NBIoT respectively.
  + Option 1-4: the state of indication of HARQ feedback disabled and state A are state of “01” for eMTC and state of “0000” for NBIoT respectively.
  + Option 1-5: the detail state of indication of HARQ feedback disabled and state A are common for UEs and up to the editor.
* Option 2: the state is UE-specific determined.
  + Option 2-1: the state of indication of HARQ feedback disabled and state A are RRC UE-specific configured.
  + Option 2-2: the state of indication of HARQ feedback disabled and state A are determined by UE ID or RNTI.

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| Solution | Comments |
| Option 1:  one common state is used for all Ues  Supported by: Spreadtrum, Apple |  |
| Option 1-1  the state of indication of HARQ feedback disabled and state A are state of “11” for eMTC and state of “1111” for NBIoT respectively.  Supported by: Huawei, CMCC, Xiaomi, Ericsson, Nordic | [Huawei] the largest time domain offset is rarely used considering the large RTT in NTN scenario. The benefit to configure different values of HARQ-ACK resource field for disabled HARQ feedback for different UEs is not clear because such flexibility can be achieved by eNB scheduling. |
| Option 1-2  the state of indication of HARQ feedback disabled and state A are state of “00” for eMTC, state of “0010” for NBIoT with NPUSCH 15kHz and state of “0000” for NBIoT with NPUSCH 3.75kHz respectively.  Supported by: ZTE | [ZTE] For 15kHz subcarrier spacing, considering packing of multiple ACK/NACK resources with the resource for multi-tone data transmission and reducing resource segmentation, the larger the subcarrier index and the smaller  is, the less the original design principle will be destroyed and the more consecutive frequency resources and time resources can be used for data transmission.  For 3.75kHz subcarrier spacing, choosing smaller subcarrier index (e.g., 38) for DCI-based overridden/direct indication can reduce the possibility of resource segmentation, since more continuous number of subcarriers can be allowed for data transmission |
| Option 1-3:  the state of indication of HARQ feedback disabled and state A are state of “00” for eMTC and state of “0000” for NBIoT respectively.  Supported by: Sony, MTK | [Sony] do not see that any one of the states of the HARQ-ACK related fields is necessarily preferable over any other state. The choice of state could either be left to the spec editor, or (preferably) RAN1 could agree to. |
| Option 1-4:  the state of indication of HARQ feedback disabled and state A are state of “01” for eMTC and state of “0000” for NBIoT respectively.  Supported by: OPPO | [OPPO] “HARQ-ACK resource offset” field is used to indicate the value of ACK/NACK resource offset is 0, -1, -2, or 2. The state of indicating -1 can be selected as state A, so that the remaining candidate values are equally spaced. |
| Option 1-5:  the detail state of indication of HARQ feedback disabled and state A are common for UEs and up to the editor.  Supported by: Sony | [Sony] The choice of state could either be left to the spec editor, or (preferably) RAN1 could agree to. |
| Option 2-1:  the state of indication of HARQ feedback disabled and state A are RRC UE-specific configured.  Supported by: Nokia | [Nokia]Using a fixed state of DCI “HARQ-ACK resource” and “HARQ-ACK resource offset” fields to indicate HARQ feedback disable will reduce the network’s HARQ-ACK scheduling capacity. |
| Option 2-2:  the state of indication of HARQ feedback disabled and state A are determined by UE ID or C-RNTI.  Supported by: CATT, Qualcomm | [CATT] A simple way is related with UE ID, such as UEID mod 4.  [Qualcomm] making this state different across UEs may be beneficial from resource utilization perspective: a fixed reserved value would make some HARQ-ACK resources unusable across the whole set of UEs, which may create scheduling blocking (i.e., DL resources are available for scheduling but uplink is fully used) |

**ISSUE 1-3 DCI direct indication for multiple TB case**

For multiple TB scheduled by DCI, it is agreed the unified indication is adopted to all scheduled TB for DCI based direct indication. *For NB-IoT and LTE-MTC in CE Mode B, if multiple TBs is configured, for DCI-based HARQ enabling/disabling direct indication in multiple TBs scheduled by single DCI, the same indication is applied to all scheduled TBs, i.e. HARQ is enabled or disabled for all TBs.* Regarding the detail indication in corresponding DCI, as proposed by [Huawei, ZTE, Nokia, CMCC, OPPO, Lenovo, Ericsson, Nordic], it is preferred to reuse/reinterpret the HARQ-ACK related field in corresponding DCI for indication of HARQ feedback enabled/disabled.

The following proposals are listed as majority views.

**[Proposal 1-3a]:**

For DCI-based direct indication in multiple TBs scheduled by single DCI, reuse/reinterpret the HARQ-ACK related field in corresponding DCI for indication of HARQ feedback enabled/disabled.

* The same DCI direct indication functionality as single TB scheduled by DCI scenarios.

**ISSUE 1-4 DCI overridden indication for multiple TB case**

Regarding the DCI based overridden indication, for single TB scheduled by DCI, reusing/reinterpreting HARQ-ACK related field in DCI were agreed to be the working assumption. For multiple TBs scheduled by single DCI, several indication solutions/considerations are discussed in contributions:

* Option 1: reuse/reinterpret the HARQ-ACK related field in corresponding DCI for overridden indication of HARQ feedback enabled/disabled.
  + The same DCI overridden indication functionality as single TB scheduled by DCI scenarios. (i.e., one state of HARQ-related field in DCI is used for indication of scheduled TBs reversing to HARQ feedback disabled in case of RRC configured HARQ feedback enabled and scheduled TBs maintaining HARQ feedback disabled in case of RRC configured HARQ feedback disabled)

Supported by: Huawei, ZTE, CMCC, OPPO, Lenovo, Samsung, Ericsson, Nordic

* Option 2: the DCI overridden indication is not supported for multiple TBs case.

Supported by: Qualcomm

Especially as proposed by [Spreadtrum], if multiple TBs is configured, for DCI based overridden indication in multiple TBs scheduled by single DCI, the indication is to reverse the HARQ-ACK feedback state configured through by per-HARQ process bitmap signaling of all TBs.

The following proposals are listed as majority views.

**[Proposal 1-4a]:**

For the DCI based overridden indication for multiple TBs scheduled by single DCI, down-select one of the following options:

* Option 1: reuse/reinterpret the HARQ-ACK related field in corresponding DCI for overridden indication of HARQ feedback enabled/disabled.
  + The same DCI overridden indication functionality as single TB scheduled by DCI scenarios. (i.e., one state of HARQ-related field in DCI is used for indication of scheduled TBs reversing to HARQ feedback disabled in case of RRC configured HARQ feedback enabled and scheduled TBs maintaining HARQ feedback disabled in case of RRC configured HARQ feedback disabled)
* Option 2: the DCI based overridden indication is not supported for multiple TBs case.

## Company views

The following proposals are listed as majority views.

**[Proposal 1-1a]:**

Confirm the following working assumption:

Working assumption

For DCI-based direct indication in single TB scheduled by DCI,

* Indication by reusing/reinterpreting HARQ-ACK related field in DCI
  + - For eMTC CE mode B, one state of “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.
      * FFS: detailed state, and whether this state is different across different UEs
    - For NBIoT, one state of “HARQ-ACK resource” field in DCI format N1 is used for indication of HARQ feedback disabled, other states are used for indication of HARQ feedback enabled and corresponding HARQ-ACK resource.
      * FFS: detailed state, and whether this state is different across different UEs
* If reusing/reinterpreting HARQ-ACK related field in DCI is also used for DCI overriding scheme, the interpretation of the state can be different than for DCI-based direct indication.

For single TB scheduled by DCI,

* Working assumption 1 DCI based overridden indication is applied to both semi-statically HARQ disabled and enabled processes
  + For DCI based overridden indication, adopt indication by reusing/reinterpreting HARQ-ACK related field in DCI
    - For eMTC CE mode B, “HARQ-ACK resource offset” field in DCI format 6-1B is used for indication of maintaining/reversing the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration and corresponding HARQ-ACK resource in case of indication of HARQ feedback enabled.
      * HARQ feedback disabled is reversed to enabled in case of any states other than state A in “HARQ-ACK resource offset”, otherwise is maintained as disabled.
      * HARQ feedback enabled is maintained in case of any states other than state A in “HARQ-ACK resource offset”, otherwise is reversed to disabled.
        + FFS: detailed state A, and whether this state A is different across different UEs
    - For NBIoT, “HARQ-ACK resource” field in DCI format N1 is used for indication of maintaining/reversing the HARQ feedback enable/disable for the corresponding transmission from per-HARQ process RRC configuration and corresponding HARQ-ACK resource in case of indication of HARQ feedback enabled.
      * The same DCI indication functionality as eMTC is adopted.

**[Proposal 1-2a]:**

For DCI-based direct/overridden indication in single TB scheduled by DCI, down-select one of the following options for the state of HARQ-related field (i.e., “HARQ-ACK resource offset” field for eMTC, “HARQ-ACK resource” field for NBIoT) in DCI to indicate the HARQ feedback enabled/disabled.

* Option 1: one common state is used for all UEs
  + Option 1-1: the state of indication of HARQ feedback disabled and state A are state of “11” for eMTC and state of “1111” for NBIoT respectively.
  + Option 1-2: the state of indication of HARQ feedback disabled and state A are state of “00” for eMTC, state of “0010” for NBIoT with NPUSCH 15kHz and state of “0000” for NBIoT with NPUSCH 3.75kHz respectively.
  + Option 1-3: the state of indication of HARQ feedback disabled and state A are state of “00” for eMTC and state of “0000” for NBIoT respectively.
  + Option 1-4: the state of indication of HARQ feedback disabled and state A are state of “01” for eMTC and state of “0000” for NBIoT respectively.
  + Option 1-5: the detail state of indication of HARQ feedback disabled and state A are common for UEs and up to the editor.
* Option 2: the state is UE-specific determined.
  + Option 2-1: the state of indication of HARQ feedback disabled and state A are RRC UE-specific configured.
  + Option 2-2: the state of indication of HARQ feedback disabled and state A are determined by UE ID or RNTI.

**[Proposal 1-3a]:**

For DCI-based direct indication in multiple TBs scheduled by single DCI, reuse/reinterpret the HARQ-ACK related field in corresponding DCI for indication of HARQ feedback enabled/disabled.

* The same DCI direct indication functionality as single TB scheduled by DCI scenarios.

**[Proposal 1-4a]:**

For the DCI based overridden indication for multiple TBs scheduled by single DCI, down-select one of the following options:

* Option 1: reuse/reinterpret the HARQ-ACK related field in corresponding DCI for overridden indication of HARQ feedback enabled/disabled.
  + The same DCI overridden indication functionality as single TB scheduled by DCI scenarios. (i.e., one state of HARQ-related field in DCI is used for indication of scheduled TBs reversing to HARQ feedback disabled in case of RRC configured HARQ feedback enabled and scheduled TBs maintaining HARQ feedback disabled in case of RRC configured HARQ feedback disabled)
* Option 2: the DCI based overridden indication is not supported for multiple TBs case.

Please provide your views and comments.

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| **Company** | **Comments and Views** |
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# [Active]Issue-2 HARQ feedback for scheduling multiple TB

## Background

eMTC/NBIoT multiple TB scheduling with single DCI is introduced in Rel.16. With single DCI, multiple TBs are scheduled with interleaved or non-interleaved manner and corresponding feedback for each TB is performed after the data transmission with HARQ bundling or non-bundling manner.

For the multiple TBs scheduled by single DCI, regarding the HARQ feedback enabled/disabled, there could be one of the following 3 scenarios:

* Scenario 1: all TBs are configured with HARQ feedback enabled
* Scenario 2: all TBs are configured with HARQ feedback disabled
* Scenario 3: some TBs are configured with HARQ feedback enabled while the other TBs are configured with HARQ feedback disabled.

Based on above DCI based indication of HARQ feedback enabled/disabled, at least for DCI direct indication, multiple TBs scheduled by single DCI can be either all TBs HARQ feedback or all TBs HARQ not feedback, as scenarios 1 or scenarios 2. The functionality of HARQ feedback is same as single TB scheduled cases. (i.e., all TBs are with HARQ feedback, or all TBs are without HARQ feedback)

At least for RRC configured HARQ feedback enabled/disabled without DCI indication (e.g., only RRC configuration), it is possible to support all three scenarios above, including scheduled TBs are with mixed HARQ feedback enabling/disabling scheduling as in Scenario 3.

In the last meeting FLS in [3], the following proposal was discussed. Majority of companies propose to support the mixed HARQ feedback enabling/disabling since it is up to gNB scheduling flexibility and implementation.

For the multiple TBs scheduled by single DCI in NBIoT, whether and how to support mixed HARQ feedback enabling/disabling scheduling, the following directions can be considered:

* Direction 1: mixed HARQ feedback enabling/disabling is not supported (e.g., by eNB scheduling implementation, UE is not expected to receive a DCI scheduling 2 TBs with different HARQ feedback enabled/disabled configuration/indication, or specifying UE behavior to either all HARQ feedback enabling or all HARQ feedback disabling when mixed scheduling)

Supported by: MTK

* Direction 2: mixed HARQ enabling/disabling is supported (e.g., one TB with HARQ feedback and the other TB w/o HARQ feedback)

Supported by: Ericsson, OPPO, Qualcomm, ZTE, Xiaomi, Spectrum, Nokia, Huawei

The following proposals are listed as majority views.

**[Proposal 2-1a]:**

For the multiple TBs scheduled by single DCI, mixed HARQ enabling/disabling is supported (i.e., some TBs with HARQ feedback and the other TBs w/o HARQ feedback)

* [FFS] Note: The mixed HARQ enabling/disabling is only adopted for scenario that RRC-based solution is configured and DCI based solution is not configured.

For NR NTN HARQ disabling, two types of HARQ codebook are enhanced as:

* For Type-1 HARQ codebook in NR NTN, the UE will consistently report NACK-only for the feedback-disabled HARQ process regardless of decoding results of corresponding PDSCH.
* For Type-2 HARQ codebook in NTN:
* Reduce codebook size with HARQ-ACK codebook only including HARQ-ACK of PDSCH with feedback-enabled HARQ processes
* For the DCI of PDSCH with feedback-enabled HARQ processes, the C-DAI and T-DAI are the count of only feedback-enabled processes

Similar as enhancement of NR NTN HARQ codebook Type-1, as proposed by [Spreadtrum, CATT, Apple], ACK is assumed for a feedback-disabled HARQ process in the HARQ feedback for scheduling multiple TB scenario.

While similar as enhancement of NR NTN HARQ codebook Type-2, as proposed by [Xiaomi, Sharp, Lenovo, Qualcomm, Nordic], UE only reports the HARQ information for the HARQ enabled process. Optionally, the indication of new DCI field can be applied to all scheduled TBs, the first scheduled TB, the last scheduled TB or the middle-scheduled TB.

Especially as proposed by [ZTE], for multiple TBs scheduled by single DCI without HARQ bundling, UE should only report the HARQ-ACK for the HARQ feedback enabled process, while for multiple TBs scheduled by single DCI with HARQ-ACK bundling, ACK/NACK for each bundle is generated by considering only the TBs associated with feedback enabled HARQ processes.

Especially for NBIoT, as proposed by [Huawei], if only the bitmap for HARQ feedback enabling/ disabling is configured by high layer parameter, UE feedback HARQ-ACK for both TBs if at least one of the HARQ process is feedback enabled; otherwise, UE does not feedback HARQ-ACK for either of the HARQ processes.

Especially for HARQ timing, as proposed by [Qualcomm], for the case of mixed enable/disable HARQ-ACK feedback, the HARQ-ACK timing needs to be modified for eMTC and NB-IoT.

From the moderator’s understanding, if mixed HARQ enabling/disabling is supported, the corresponding NPDCCH monitoring restriction should be clarified. For example, for the UE behavior after the downlink transmission with mixed HARQ enabling/disabling.

”

The following proposal is listed for discussion.

**[Proposal 2-2a]:**

* For NBIoT two TBs scheduled by single DCI, down-select one of the following UE behaviors for the downlink transmission with HARQ feedback disabled：
  + Option 1: ACK is assumed/reported for the downlink transmission with HARQ feedback disabled regardless of decoding results of corresponding transmission.
    - FFS: for case that all scheduled TBs are with HARQ feedback disabled.
  + Option 2: HARQ feedback is reported only for downlink transmission with HARQ feedback enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ process disabled)
    - FFS: HARQ timing, NPDCCH monitoring restriction
  + Option 3: HARQ feedback is reported or not depending on the other TBs HARQ-enabled/HARQ-disabled scheduled by DCI.

**[Proposal 2-3a]:**

* For eMTC FDD/HD-FDD multiple TBs scheduled by single DCI without HARQ bundling, down-select one of the following UE behaviors for the downlink transmission with HARQ feedback disabled：
* Option 1: ACK is assumed/reported for the downlink transmission with HARQ feedback disabled regardless of decoding results of corresponding transmission.
  + - FFS: for case that all scheduled TBs are with HARQ feedback disabled.
* Option 2: HARQ feedback is reported only for downlink transmission with HARQ feedback enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ feedback disabled).
  + - FFS: HARQ timing

**[Proposal 2-4a]:**

* For eMTC FDD/HD-FDD multiple TBs scheduled by single DCI with HARQ bundling, the following UE behaviors are considered for the downlink transmission with HARQ feedback disabled：
* Option 1: ACK is assumed/reported for the downlink transmission with HARQ feedback disabled regardless of decoding results of corresponding transmission.
  + - FFS: for case that all scheduled TBs within a bundle are with HARQ feedback disabled.
* Option 2: HARQ feedback is reported only for downlink transmission with HARQ feedback enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ feedback disabled).
  + - FFS: HARQ timing

## Company views

According to the above summary, the following proposals are listed as majority views:

**[Proposal 2-1a]:**

For the multiple TBs scheduled by single DCI, mixed HARQ enabling/disabling is supported (i.e., some TBs with HARQ feedback and the other TBs w/o HARQ feedback)

* [FFS] Note: The mixed HARQ enabling/disabling is only adopted for scenario that RRC-based solution is configured and DCI based solution is not configured.

**[Proposal 2-2a]:**

* For NBIoT two TBs scheduled by single DCI, down-select one of the following UE behaviors for the downlink transmission with HARQ feedback disabled：
  + Option 1: ACK is assumed/reported for the downlink transmission with HARQ feedback disabled regardless of decoding results of corresponding transmission.
    - FFS: for case that all scheduled TBs are with HARQ feedback disabled.
  + Option 2: HARQ feedback is reported only for downlink transmission with HARQ feedback enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ process disabled)
    - FFS: HARQ timing, NPDCCH monitoring restriction
  + Option 3: HARQ feedback is reported or not depending on the other TBs HARQ-enabled/HARQ-disabled scheduled by DCI.

**[Proposal 2-3a]:**

* For eMTC FDD/HD-FDD multiple TBs scheduled by single DCI without HARQ bundling, down-select one of the following UE behaviors for the downlink transmission with HARQ feedback disabled：
* Option 1: ACK is assumed/reported for the downlink transmission with HARQ feedback disabled regardless of decoding results of corresponding transmission.
  + - FFS: for case that all scheduled TBs are with HARQ feedback disabled.
* Option 2: HARQ feedback is reported only for downlink transmission with HARQ feedback enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ feedback disabled).
  + - FFS: HARQ timing

**[Proposal 2-4a]:**

* For eMTC FDD/HD-FDD multiple TBs scheduled by single DCI with HARQ bundling, the following UE behaviors are considered for the downlink transmission with HARQ feedback disabled：
* Option 1: ACK is assumed/reported for the downlink transmission with HARQ feedback disabled regardless of decoding results of corresponding transmission.
  + - FFS: for case that all scheduled TBs within a bundle are with HARQ feedback disabled.
* Option 2: HARQ feedback is reported only for downlink transmission with HARQ feedback enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ feedback disabled).
  + - FFS: HARQ timing

Please provide your views and comments.

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| **Company** | **Comments and Views** |
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# [Active]Others

## Background

ISSUE 3-1 (N)PDSCH/(N)PDCCH scheduling restriction.

For DCI-based overridden mechanism, we have a working assumption regarding NB-IoT UE’s NPDCCH monitoring behavior. As mentioned by [Nokia] The assumption (i.e., Working assumption 2) suggests the UE should start NPDCCH monitoring after HARQ-ACK transmission and 1ms UL-to-DL switch time. This NPDCCH monitoring timing is different from HARQ-feedback enabled case (RTT+3ms after sending HARQ-ACK) and from HARQ-feedback disabled case (12ms after receiving NPDSCH). The working assumption would create more scheduling opportunities for the UE when a feedback disabled HARQ process is dynamically enabled, but the network has to avoid scheduling in the time during HARQ-ACK transmission. The benefit of the UE’s “exceptional behavior” in WA2 is not clear. As commented by [Qualcomm] on the “Working assumption 2”, since this working assumption is pending RAN2 feedback. In our view, once RAN2 confirms the feasibility of this technique, RAN1 can proceed to confirm the working assumption.

Furthermore, [Nokia] propose to clarify that when a semi-statically HARQ feedback enabled process is reversed to feedback disabled. Should the UE wait for additional RTT+3ms after a 12ms delay for data decoding before monitoring NPDCCH for the same HARQ process. From the moderator’s understanding, in case the HARQ process is overridden from HARQ feedback enabled to HARQ feedback disabled, UE is not required to monitor any NPDCCH in the following 12ms after the reception of the NPDSCH, as specified in TS36.213 16.5 “*If a NB-IoT UE receives a NPDSCH transmission ending in subframe n, and if the UE is not required to transmit a corresponding NPUSCH format 2, the UE is not required to monitor NPDCCH in any subframe starting from subframe n+1 to subframe n+12*.”

**[Conclusion 3-1a]:**

Working assumption 2 is pending RAN2 feedback. No discussion is needed for RAN1-114.

ISSUE 3-2 Out of sync for NDI

As mentioned by [Nokia], an out of sync issue is pointed out when HARQ feedback is disabled. The issue occurs when a 1st TB scheduled by the first DCI is not decoded correctly, the 2nd DCI scheduling 2nd new TB is missed, the 3rd new TB scheduled by 3rd DCI is regarded as retransmission of the 1st TB as the NDI field is not toggled from UE perspective. [Huawei] further proposes that RAN1 should clarify whether blind retransmission is allowed and whether UE would combine the re-transmissions and the initial transmission with HARQ feedback disabling. [Nokia] further proposes to use HARQ-ACK resource field for TB identifier indication to mitigate NDI out of sync when HARQ feedback is disabled.

Similar issue was discussed in NR NTN [R1-2202623], majority of companies agreed the conclusion that blind retransmission is allowed for TB with HARQ feedback disabled, and it is up to UE implementation that UE will try to decode each TB as new TB, or UE will try to decode each TB with or without LLR combining as multiple hypothesis in case of TB with HARQ feedback disabled.

For HARQ disabling in IoT NTN, similar mechanism can be taken, so this issue can be addressed by implementation and no spec impact is preferred as NR NTN discussion.

**[Conclusion 3-2a]:**

Out of sync for NDI can be addressed by implementation and no spec impact is preferred.

## Company views

**[Conclusion 3-1a]:**

Working assumption 2 is pending RAN2 feedback. No discussion is needed for RAN1-114.

**[Conclusion 3-2a]:**

Out of sync for NDI can be addressed by implementation and no spec impact is preferred.

Please provide your views and comments.

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| **Company** | **Comments and Views** |
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# Proposals for discussion at Offline sessions (Monday)

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