**3GPP TSG RAN WG1 Meeting #112bis-e R1-2300xxx**

**e-Meeting, April 17th – 26th, 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*

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. In the last meeting, for eMTC CEMode A, Option 1 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**

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| --- |
| **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. |

Regarding the agreement achieved in last meeting, companies have different understanding on how to interpret the DCI overridden mechanism in FFS#3 (e.g., in case both per-HARQ process bitmap and DCI solution enabling/disabling signaling are configured). As mentioned by [Lenovo], if Option 2 in the following is adopted, it is equivalent that there is no need to configure per-HARQ process bitmap signaling and DCI solution enabling/disabling signaling simultaneously (e.g., Rel.18 IoT NTN HARQ disabling only supports RRC standalone solution and DCI standalone solution), which makes the option 1+option 3 meaningless and is not aligned with the original design for the overridden mechanism. However, as mentioned by [Huawei, Xiaomi, Ericsson] that in order to have a common design for option 3 and option 1+option 3, directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration is preferred, which facilitates the following discussion.

* Option 1: 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

Supported by: OPPO, Lenovo

* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

Supported by: Huawei, Xiaomi, Ericsson, Sharp

Based on the analysis above, the following proposal may reflect the current situation. Since the understanding of the DCI overridden mechanism is fundamental to other issues. As the moderator, I recommend clarifying it before the other discussions.

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

**Conclusion**

For 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, down selection one of the following in RAN1-112bis-e

* Option 1: 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
* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

**ISSUE 1-2**

Note: Depending on the output of the ISSUE 1-1, the ISSUE 1-2 may be invalid. (e.g., if Option 2 of ISSUE 1-1 is adopted)

In case Option 1 of ISSUE 1-1 is adopted, for the DCI based overridden indication applied cases, there is need to separate the discussion for single TB and multiple TB scheduled by single DCI.

For single TB scheduled by DCI and the DCI based overridden indication applied cases, three potential alternatives are discussed in contributions:

* Alternative 1: both semi-statically HARQ enabled and disabled processes

Supported by: Huawei, Spreadtrum, CATT, Nokia, Xiaomi, CMCC, ZTE, Lenovo, Sharp, NEC,

* Alternative 2: only applied to semi-statically HARQ disabled processes

Supported by: OPPO, Nordic, MTK, Mavenir, Qualcomm,

* Alternative 3: only applied to semi-statically HARQ enabled processes

Supported by: OPPO, Samsung, Apple

|  |  |
| --- | --- |
| Alternative | Comments |
| Alternative 1:  both semi-statically HARQ enabled and disabled processes | * [Huawei] there is no additional overhead required to support DCI overriding for both enabled/disabled HARQ process * [Huawei, CATT, Nokia, CMCC] UE with semi-static enabled HARQ feedback benefit from the latency reduction from HARQ disabling and it provides more flexibility for the initial RRC HARQ feedback configuration, especially for UE with only CP solution. * [Huawei] Restricting the application of DCI overriding to process with HARQ feedback either RRC enabled or disabled do not simplify the design. * [Xiaomi]There are clear use cases that a HARQ process need to be dynamically switched from “Disabled” to “enabled” to guarantee the reliability of some important information transmission such as MAC CE. * [E///] All the alternatives can provide full flexibility under some premises. |
| Alternative 2:  only applied to semi-statically HARQ disabled processes | * [Mavenir] no need/scenarios for applying in HARQ enabled processes * [Qualcomm] the existing timers and procedures will follow HARQ disabled (the eNB will not trigger a retransmission based on HARQ-ACK) |
| Alternative 3:  only applied to semi-statically HARQ enabled processes | * [Apple] the dynamic switching from enabled HARQ feedback to disabled HARQ feedback has relatively less UE implementation impact * [Samsung] It is not clear the need for using the DCI-based signaling mechanism to enable a semi-statically HARQ feedback disabled process. |

Based on the analysis above, the following proposal in addition to proposal 1-1 may reflect the current situation.

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

For 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, down selection one of the following in RAN1-112bis-e

* Option 1: 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
  + For single TB scheduled by DCI, the DCI based overridden indication is applied to one of the following options:
    - Option 1-1: both semi-statically HARQ enabled and disabled processes
    - Option 1-2: only applied to semi-statically HARQ disabled processes
    - Option 1-3: only applied to semi-statically HARQ enabled processes
* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

**ISSUE 1-3**

Note: Depending on the output of the ISSUE 1-1, the ISSUE 1-3 may be invalid. (e.g., if Option 2 of ISSUE 1-1 is adopted)

In case Option 1 of ISSUE 1-1 is adopted, regarding the DCI based overridden indication applied to cases for multiple TBs scheduled by single DCI, the potential alternatives are discussed in contributions:

* Option 1: DCI-based overridden mechanism/indication is applied to all scheduled TBs with single indication

Supported by: OPPO, CMCC, ZTE, Lenovo, Sharp,

* Option 2: DCI-based overridden mechanism/indication is applied to subset of scheduled TBs with single indication
  + Option 2a: first TBs scheduled by DCI

Supported by: Nokia, MTK

* + Option 2b: configured HARQ enabled or disabled TBs scheduled by DCI

Supported by: OPPO

* + Option 2c: TB scheduled by DCI also configured by higher layer

Supported by: Spreadtrum

* Option 3: DCI-based overridden mechanism/indication applied TBs is determined by the per-HARQ RRC configuration with single indication (e.g., all HARQ enabled, all HARQ disabled or mixed HARQ enabled/disabled configuration)

Supported by: Huawei

* Option 4: DCI-based overridden mechanism/indication is not applied to multiple TBs scheduled by single DCI

Supported by: Spreadtrum

Based on the analysis above, the following proposal may reflect the current situation.

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

For 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, down selection one of the following in RAN1-112bis-e

* Option 1: 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
  + For single TB scheduled by DCI, the DCI based overridden indication is applied to one of the following options:
    - Option 1-1: both semi-statically HARQ enabled and disabled processes
    - Option 1-2: only applied to semi-statically HARQ disabled processes
    - Option 1-3: only applied to semi-statically HARQ enabled processes
  + For multiple TBs scheduled by single DCI, the DCI based overridden indication with single indication is applied to one of the following options:
    - Option 1-a: all scheduled TBs
    - Option 1-b: subset of scheduled TBs (e.g., first TBs, configured HARQ feedback enabled TBs, configured HARQ feedback disabled TBs or configured specific TBs)
    - Option 1-c: scheduled TBs determined by the per-HARQ RRC configuration (e.g., all HARQ enabled, all HARQ disabled or mixed HARQ enabled/disabled configuration)
* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

**ISSUE 1-4**

Regarding the DCI based HARQ enabling/disabling direct indication applied to cases for multiple TBs scheduled by single DCI, the potential alternatives are discussed in contributions:

* Option 1: DCI-based HARQ enabling/disabling direct indication is applied to all scheduled TBs with single indication

Supported by: Huawei, OPPO, CMCC, ZTE, Sharp, Lenovo, Ericsson

* Option 2: DCI-based HARQ enabling/disabling direct indication is applied to subset of scheduled TBs with single indication (e.g., first TBs scheduled by DCI)

Supported by: Spreadtrum, MTK, Nokia

* Option 3: DCI-based HARQ enabling/disabling direct indication is not applied to multiple TBs scheduled by single DCI

Supported by: Spreadtrum

Based on the analysis above, the following proposal may reflect the current situation.

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

For DCI-based HARQ enabling/disabling direct indication in multiple TBs scheduled by single DCI, DCI-based HARQ enabling/disabling direct indication with single indication is applied to one of the following options:

* Option 1: all scheduled TBs.
* Option 2: subset of scheduled TBs (e.g., first TBs scheduled by DCI)

**ISSUE 1-5**

Regarding the Option 3 DCI based indication. the following table lists/summarizes potential indication methods from several companies.

For DCI-based overridden mechanism/indication and DCI-based HARQ enabling/disabling direct indication, down select one of the following

* Option 1: Explicit indication in DCI (e.g., adding one field in DCI)

Supported by: Huawei, CATT, OPPO, NEC, Xiaomi, ZTE

* Option 2: Reuse/reinterpret existing field in DCI

Supported by: Spreadtrum, Sony, Nokia, Samsung, Nordic, CMCC, MTK, InterDigital, Lenovo, Qualcomm

|  |  |  |
| --- | --- | --- |
| Options | Advantage | disadvantage |
| Option 1: Explicit indication in DCI | * [Huawei] keep consistent DCI format for HARQ overridden mechanism and HARQ enabling/disabling direct indication * [Huawei] less standard impact and does not increase UE’s complexity in blind detection | * [Spreadtrum, SONY] increased DCI size and degrade the performance of NPDCCH decoding |
| Option 2: Reuse/reinterpret existing field in DCI | * [Spreadtrum] avoid increasing the DCI size | * [Huawei, Xiaomi] influence the original indication of that field to some extent and reduce the scheduling flexibility |

Regarding the payload size of DCI Format N0/6-0B and that of DCI Format N1/6-1B, here just take the example of Rel.13 eMTC baseline feature and Rel.13 NBIoT baseline feature as comparison along with the consideration of optional features (assuming the eMTC system bandwidth of 20MHz). It is obvious from the following table that the payload size of NBIoT DCI Format N1 and N2 (eMTC DCI Format 6-0B and 6-1B) is same for Rel.13 mandatory feature, and the payload size of NBIoT DCI Format N1 and N2 (eMTC DCI Format 6-0B and 6-1B) may be different considering some optional features. It is hard to achieve the conclusion that whether the payload size of eMTC/NBIoT for uplink scheduling (e.g., DCI format 6-0B, DCI format N0) is smaller than or larger than that of downlink scheduling (e.g., DCI format 6-1B, DCI format N1) since most of the optional features are configured for downlink and uplink separately (e.g., multiple TBs scheduling, resource reserve, uplink sub-PRB resource allocation). Based on that, we must admit that there is possibility that if we use additional bit for HARQ enabling/disabling indication in DCI, the DCI size will increase (e.g., increase to 20 bits and 24 bits for eMTC and NBIoT respectively, in addition to Rel.13 mandatory feature)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Payload sizes of DCI Format 6-0B (UL) | |  | Payload sizes of DCI Format 6-1B (DL) | |
| DCI format 6-0B field | Bit length | DCI format 6-1B field | Bit length |
| Flag for format 6-0B/format 6-1B differentiation | 1-bit | Flag for format 6-0B/format 6-1B differentiation | 1-bit |
| Modulation and coding scheme | 4-bits | Modulation and coding scheme | 4-bits |
| Resource block assignment | 4+3=7-bits | Resource block assignment | 4+1=5-bits |
| Repetition number | 3-bits | Repetition number | 3-bits |
| HARQ process number | 1-bit | HARQ process number | 1-bit |
| New data indicator | 1-bit | New data indicator | 1-bit |
| DCI subframe repetition number | 2-bits | HARQ-ACK resource offset | 2-bits |
| **Total number of bits** | **19-bits** | DCI subframe repetition number | 2-bits |
|  |  | **Total number of bits** | **19-bits** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Payload sizes of DCI Format N0 (UL) | |  | Payload sizes of DCI Format N1 (DL) | |
| DCI format N0 field | Bit number | DCI format N1 field | Bit number |
| Flag for format N0/format N1 differentiation | 1-bit | Flag for format N0/format N1 differentiation | 1-bit |
| Subcarrier indication | 6-bits | NPDCCH order indicator | 1-bit |
| Resource assignment | 3-bits | Scheduling delay | 3-bits |
| Scheduling delay | 2-bits | Resource assignment | 3-bits |
| Modulation and coding scheme | 4-bits | Modulation and coding scheme | 4-bits |
| Redundancy version | 1-bit | Repetition number | 4-bits |
| Repetition number | 3-bits | New data indicator | 1-bit |
| New data indicator | 1-bit | HARQ-ACK resource | 4-bits |
| DCI subframe repetition number | 2-bits | DCI subframe repetition number | 2-bits |
| **Total number of bits** | **23-bits** |  | **Total number of bits** | **23-bits** |

Based on the analysis above, if the ISSUE 1-1 to ISSUE 1-4 can achieve common understanding, we can try to down select the following proposal for the DCI-based overridden/direct indication, and further study the detail solution in next meeting.

**[Proposal 1-5a]:**

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 in RAN1-112bis-e

* Option 1: Indication by adding one field in DCI
* Option 2: Indication by reusing/reinterpreting existing field in DCI

## Company views

The following proposals are listed as majority views.

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

**Conclusion**

For 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, down selection one of the following in RAN1-112bis-e

* Option 1: 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
* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

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

For 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, down selection one of the following in RAN1-112bis-e

* Option 1: 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
  + For single TB scheduled by DCI, the DCI based overridden indication is applied to one of the following options:
    - Option 1-1: both semi-statically HARQ enabled and disabled processes
    - Option 1-2: only applied to semi-statically HARQ disabled processes
    - Option 1-3: only applied to semi-statically HARQ enabled processes
* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

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

For 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, down selection one of the following in RAN1-112bis-e

* Option 1: 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
  + For single TB scheduled by DCI, the DCI based overridden indication is applied to one of the following options:
    - Option 1-1: both semi-statically HARQ enabled and disabled processes
    - Option 1-2: only applied to semi-statically HARQ disabled processes
    - Option 1-3: only applied to semi-statically HARQ enabled processes
  + For multiple TBs scheduled by single DCI, the DCI based overridden indication with single indication is applied to one of the following options:
    - Option 1-a: all scheduled TBs
    - Option 1-b: subset of scheduled TBs (e.g., first TBs, configured HARQ feedback enabled TBs, configured HARQ feedback disabled TBs or configured specific TBs)
    - Option 1-c: scheduled TBs determined by the per-HARQ RRC configuration (e.g., all HARQ enabled, all HARQ disabled or mixed HARQ enabled/disabled configuration)
* Option 2: Option 3 DCI-based overridden mechanism is DCI signaling to directly indicate the HARQ feedback enable/disable for the corresponding transmission regardless of per-HARQ process RRC configuration. (e.g., if DCI solution enabling/disabling signaling is configured, UE is expected to ignore the per-HARQ process RRC configuration if any)

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

For DCI-based HARQ enabling/disabling direct indication in multiple TBs scheduled by single DCI, DCI-based HARQ enabling/disabling direct indication with single indication is applied to one of the following options:

* Option 1: all scheduled TBs.
* Option 2: subset of scheduled TBs (e.g., first TBs scheduled by DCI)

**[Proposal 1-5a]:**

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 in RAN1-112bis-e

* Option 1: Indication by adding one field in DCI
* Option 2: Indication by reusing/reinterpreting existing field in DCI

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | * **[Proposal 1-1a]:**  Aiming for a common design, we prefer Option 2. * **[Proposal 1-2a]:** This proposal depends on the resolution on “**[Proposal 1-1a]**”. If I’m not wrong, Option 2 in this proposal reads the same as in the previous proposal. Thus, it is better to conclude on **[Proposal 1-1a]** before we can take **[Proposal 1-2a]**. * **[Proposal 1-3a]:** Similarly, it is better to conclude on **[Proposal 1-1a]** before we can take **[Proposal 1-3a]**. Moreover, option 2 does not elaborate on multi-TB scheduling, and I noticed that the next proposal (i.e., **[Proposal 1-4a]**) talks about it, thus it feels as if **[Proposal 1-4a]** should have been written as Option2. * **[Proposal 1-5a]:** Overall, this proposal also depends on decisions to be made on previous proposals. Option1 seems to be cleaner and basically no impact (or very minor) is foreseen if the field is only 1-bit. We are also open to discuss re-using one existing field, but in that case it needs to be discussed what will be the limitation/restriction on the legacy field that will be re-used (e.g., how many and which entries will remain available).   PS: If the intention is to have a common design, it would be good to discuss what will be the assumptions for “Option 3 only”. Since there is no bitmap, one key aspect is to decide is what is going to be the default status of the “HARQ feedback” for the configured HARQ processes. Is the “HARQ feedback” assumed to be “enabled” by default? Or is the “HARQ feedback” assumed to be “disabled”? |
| Apple | **[Proposal 1-1a]: [Proposal 1-2a]:**  This proposal may depend on the “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.”  For example, if DCI-based overridden mechanism is applied to only semi-statically HARQ feedback enabled or disabled processes, we prefer Option 1. Otherwise, we prefer Option 2.  **[Proposal 1-3a]:**  For multiple TB cases, we support Option 1-b.  **[Proposal 1-4a]:**  In case Option 2 of Proposal 1-1a is adopted (i.e., direct indication), we are fine with Option 1. But this proposal could be discussed after Proposal 1-1a. |

# [Active]Issue-2 SPS PDSCH

## Background

For SPS PDSCH, it was agreed that for HARQ feedback of each PDSCH, UE follows the per-process HARQ feedback enabled/disabled configuration for the associated HARQ process except for the first SPS PDSCH after activation if additionally enabled, where ACK/NACK is always reported by UE for the first SPS PDSCH.

In addition to above SPS PDSCH HARQ feedback enabling/disabling determination, [Nokia] further proposes that the configuration allows a process to report one HARQ-ACK for every n TBs received in SPS (e.g., for a feedback-enabled HARQ process), while allows no HARQ feedback for a feedback-disabled HARQ process.

## Company views

According to the above summary, companies are encouraged to consider the issue proposed by Nokia in R1-2302837 for detail. If possible, please give your views and potential updates for the following proposal 2-1.

**[Proposal 2-1a]**

Further study the mechanism on only reporting one HARQ-ACK feedback for every N TB received for configured HARQ feedback enabled processes in SPS.

Please provide your views and comments.

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| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | The issue (if any) seems to be related with “HARQ feedback” enabled, rather than with HARQ feedback disabled.  One question, if in legacy SPS can be overridden at any time by a dynamic scheduling, what is the legacy no-monitoring rule that applies? Having the full picture will allow us to understand whether there is an issue or not. |
| Apple | This seems to be enhancement/optimization. We do not see the necessity of this optimization, considering the first SPS PDSCH HARQ feedback based on configuration is already supported. |

# [Active]Issue-3 (N)PDSCH/(N)PDCCH scheduling restriction

## Background

In RAN1# 110-bis-e, the following was endorsed over e-mail:

|  |
| --- |
| **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 RAN1# 112, the following was agreed:

|  |
| --- |
| 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. |

In addition to the above MPDCCH/NPDCCH monitoring restriction, [Ericsson] further proposes to make the conclusion/clarification that it is RAN1 understanding that the “scheduling restriction for NB-IoT” can handle “hybrid enabling/disabling HARQ feedback scenarios” when combined with legacy procedures to avoid issues related with e.g., a simultaneous Transmission/Reception, or not having time to perform an UL-to-DL re-tunning, although it is obvious from the moderator’s understanding.

## Company views

According to the above summary, companies are encouraged to consider the issue proposed by Ericsson in R1-2303020 for detail. If possible, please give your views and potential updates for the following proposal 3-1.

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

**Conclusion:**

It is RAN1 understanding that in scenarios having HARQ processes with HARQ feedback enabled and disabled, the scheduling restriction for Rel.18 eMTC/NB-IoT is combined with legacy procedures to avoid issues related with e.g., a simultaneous Transmission/Reception, or not having time to perform an UL-to-DL re-tunning.

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | The “scheduling restriction for NB-IoT/LTE-MTC”, can handle a scenario where all HARQ processes have their HARQ feedback disabled. However, it cannot handle on its own more complex scenarios (i.e., “hybrid enabling/disabling scenario”). Thus, it is important to reach a conclusion that the “scheduling restriction” with no further modifications will be able to handle more complex scenarios (i.e., “hybrid enabling/disabling scenario”) when properly combined with legacy procedures/statements.  This will allow us knowing when the subsequent (M/N)PDCCH can be expected to be received for HARQ processes with disabled HARQ feedback as per the Rel-18 “scheduling restriction,” and when the subsequent (M/N)PDCCH can be expected to be received for HARQ processes with enabled HARQ feedback as per legacy no-monitoring rules. |
|  |  |

# [Active]Issue-4 HARQ bundling for eMTC HD-FDD

## Background

The following conclusion was reached:

|  |
| --- |
| **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. |

With the above conclusion, from the moderator’s understanding, it is obvious that for eMTC HD-FDD single TB scheduled by single DCI, HARQ feedback is not reported for HARQ processes with HARQ feedback disabled.

## Company views

According to the above summary, companies are encouraged to consider the clarification proposed by Ericsson in R1-2303020. If possible, please give your views and potential updates for the following proposal 4-1.

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

**Conclusion:**

For eMTC HD-FDD single TB scheduled by single DCI, HARQ feedback is not reported for downlink transmission with HARQ process disabled.

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | Ok with **[Proposal 4-1a]**. It is derived from the conclusion reached in RAN1# 112, because if the HARQ processes with HARQ feedback disabled will have the “HARQ-ACK bundling flag” set to 0, then those HARQ processes with HARQ feedback disabled won’t be “Transport blocks in a bundle” and there won’t be a need to indicate a “HARQ-ACK delay” for them. |
| Apple | We do not see the necessity of this conclusion. |

# [Active]Issue-5 HARQ feedback for scheduling multiple TB

## Background

eMTC/NBIoT multiple TB scheduling with single DCI is introduced in Rel.16. In HARQ feedback disabling for downlink transmission, solutions should be designed for the case of transmitting HARQ feedback for a multi-TB block where some TBs (or TB bundles) have feedback enabled, while some others have feedback disabled.

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, ZTE, Sharp, CATT], 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, Huawei], UE only reports the HARQ information for the HARQ enabled process. Specially for NBIoT, as proposed by [Huawei], UE do not feedback HARQ-ACK if two TBs are scheduled by single DCI and HARQ feedback is disabled for both processes, and HARQ feedback are assumed enabled for both of the scheduled TBs if the two TBs have different HARQ feedback assumptions for multiple TB scheduling with single DCI.

As proposed by [NEC], HARQ feedback enabling/disabling is indicated by NDI field of DCI or a new DCI field. 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.

## Company views

According to the above summary, similar as discussion in NR HARQ codebook Type 1, Type 2 enhancement, before we conclude the impact of multiple TB scheduling with HARQ disabling, we should firstly achieve the high-level UE behavior for the downlink transmission with the HARQ process disabled no matter what kinds of indication are adopted and the following proposals are listed as majority views:

Note: Depending on the output of the ISSUE 1-3, ISSUE 1-4, the following proposals may be updated accordingly, companies are encouraged to give your views and potential updates for the following proposals.

**[Proposal 5-1a]:**

* For NBIoT two TBs scheduled by single DCI, the following UE behaviors are considered for the downlink transmission with HARQ process disabled：
  + Option 1: ACK is assumed/reported for the downlink transmission with HARQ process disabled regardless of decoding results of corresponding transmission
  + Option 2: HARQ feedback is reported only for downlink transmission with HARQ process enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ process disabled)
  + Option 3: HARQ feedback is reported or not depending on the other TBs HARQ-enabled/HARQ-disabling scheduled by DCI
  + Other options are not excluded

**[Proposal 5-2a]:**

* At least for eMTC FDD/HD-FDD multiple TBs scheduled by single DCI without HARQ bundling, the following UE behaviors are considered for the downlink transmission with HARQ process disabled：
* Option 1: ACK is assumed/reported for the downlink transmission with HARQ process disabled regardless of decoding results of corresponding transmission
* Option 2: HARQ feedback is reported only for downlink transmission with HARQ process enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ process disabled)
* Other options are not excluded
* FFS: scenarios for eMTC FDD/HD-FDD multiple TBs scheduled by single DCI with HARQ bundling

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | * **[Proposal 5-1a]:** To be consistent with the proposal in section 4, we prefer: “Option 2: HARQ feedback is reported only for downlink transmission with HARQ process enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ process disabled)”. * **[Proposal 5-2a]:** We prefer: “Option 2: HARQ feedback is reported only for downlink transmission with HARQ process enabled (e.g., HARQ feedback is not reported for downlink transmission with HARQ process disabled)”. |
| Apple | We support Option 1 in both proposals for simplicity. |

# [Active]Issue-6 NPRACH capacity

## Background

With the support of disabling HARQ feedback, NPRACH capacity issue is raised up by [Nokia] that if HARQ feedback is disabled, NB-IoT UE will need to transmit the SR on NPRACH, while if HARQ feedback is always enabled in legacy, NB-IoT UE can transmit the SR piggyback with HARQ feedback. The impact of NB-IoT scheduling request when HARQ feedback is disabled needs further study. [Nokia] observes that when SR is only indicated by NPRACH, the required NPRACH capacity may be very high for a NTN cell and further proposes that when HARQ feedback is disabled, NPUSCH format 2 resources can be allocated for SR and ACK/NACK transmission to reduce the load requirement on PRACH.

However, [Sharp] mentions that with dynamic HARQ disabling, the issues on NPRACH capacity starvation and lack of reference for open loop link adaptation can be alleviated by eNB implementation.

## Company views

According to the above summary, further studies on the issue and potential solution of disabling HARQ feedback impact on NPRACH capacity are needed for companies. We can revisit the issue after the fundamental issues solved.

# [Active]Others

## Background

NOTE: The issues in this section identified by companies are related to HARQ disabling and corresponding standard impact/enhancement. Since the views from companies are still diverged and the necessity for corresponding enhancement is not fully justified. Then, from moderator’s perspective, it is better to discuss these issues more. Companies are encouraged to give comments on these issues and show views in this meeting and even next meeting contributions.

Performance enhancement for disabling HARQ feedback

For enhancing transmission performance, different solutions including potential parameter configurations are proposed by companies. Following aspects are categorized according to the views from each company:

* UCI/UE assistant information
  + a new CSI reporting method or a one-bit feedback to suggest an increase or decrease in MCS or repetition value of NPDSCH [Nordic, Nokia], reporting buffer status for HARQ operation, explicit indication to request enabling/disabling HARQ feedback [Samsung].

## Company views

According to the above summary, further studies on the issue and potential solution on performance enhancement for disabling HARQ feedback are needed for companies. We can revisit the issue after the fundamental issues solved.

# Proposals for discussion at Offline sessions

# Contact information

In order to facilitate the contact among the chairman, moderator and delegates, please feel free to add your company/responsible delegates/email information in the following table.

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