**3GPP TSG RAN WG1 Meeting #112 R1-23018xx**

**Athens, Greece, February 27th – March 3rd, 2023**

**Agenda Item: 9.11.3**

**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.*

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.

***PDSCH-ServingCellConfig* information element**

-- ASN1START

-- TAG-PDSCH-SERVINGCELLCONFIG-START

PDSCH-ServingCellConfig ::= SEQUENCE {

codeBlockGroupTransmission SetupRelease { PDSCH-CodeBlockGroupTransmission } OPTIONAL, -- Need M

xOverhead ENUMERATED { xOh6, xOh12, xOh18 } OPTIONAL, -- Need S

nrofHARQ-ProcessesForPDSCH ENUMERATED {n2, n4, n6, n10, n12, n16} OPTIONAL, -- Need S

pucch-Cell ServCellIndex OPTIONAL, -- Cond SCellAddOnly

...,

[[

maxMIMO-Layers INTEGER (1..8) OPTIONAL, -- Need M

processingType2Enabled BOOLEAN OPTIONAL -- Need M

]],

[[

pdsch-CodeBlockGroupTransmissionList-r16 SetupRelease { PDSCH-CodeBlockGroupTransmissionList-r16 } OPTIONAL -- Need M

]],

[[

downlinkHARQ-FeedbackDisabled-r17 SetupRelease { DownlinkHARQ-FeedbackDisabled-r17 } OPTIONAL, -- Need M

nrofHARQ-ProcessesForPDSCH-v1700 ENUMERATED {n32} OPTIONAL -- Need R

]]

}

PDSCH-CodeBlockGroupTransmission ::= SEQUENCE {

maxCodeBlockGroupsPerTransportBlock ENUMERATED {n2, n4, n6, n8},

codeBlockGroupFlushIndicator BOOLEAN,

...

}

PDSCH-CodeBlockGroupTransmissionList-r16 ::= SEQUENCE (SIZE (1..2)) OF PDSCH-CodeBlockGroupTransmission

DownlinkHARQ-FeedbackDisabled-r17 ::= BIT STRING (SIZE (32))

-- TAG-PDSCH-SERVINGCELLCONFIG-STOP

-- ASN1STOP

|  |
| --- |
| *PDSCH-ServingCellConfig* field descriptions |
| ***downlinkHARQ-FeedbackDisabled***  Used to disable the DL HARQ feedback, sent in the uplink, per HARQ process ID. The first/leftmost bit corresponds to HARQ process ID 0, the next bit to HARQ process ID 1 and so on. Bits corresponding to HARQ process IDs that are not configured shall be ignored. The bit(s) set to one identify HARQ processes with disabled DL HARQ feedback and the bit(s) set to zero identify HARQ processes with enabled DL HARQ feedback. |

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, 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 to be working assumption. The following table illustrates the moderator’s understanding for updated Option 6a-4.

IF *downlinkHARQ-FeedbackDisabled* is configured

* + HARQ enabled/disabled is determined by *downlinkHARQ-FeedbackDisabled*
* IF *dlHARQ-FeedbackDisabled-dci* is further configured
  + IF HARQ [enabled]/[disabled] for corresponding transmission is overridden by DCI indication (e.g., explicit indication)
    - HARQ [enabled]/[disabled] for the corresponding transmission is overridden from that determined by *downlinkHARQ-FeedbackDisabled*
  + ELSE
    - Follow HARQ enabled/disabled determined by *downlinkHARQ-FeedbackDisabled*
* ELSE
  + Follow HARQ enabled/disabled determined by *downlinkHARQ-FeedbackDisabled*

ELSE

* + IF *dlHARQ-FeedbackDisabled-dci* is configured
* HARQ enabled/disabled for the corresponding transmission is indicated by DCI (e.g., explicit indication)
  + ELSE
* all HARQ enabled

**ISSUE 1-1**

Regarding the work assumption itself, in this meeting, [Spreadtrum, OPPO, NEC, SONY, InterDigital, Apple, Qualcomm, Nordic] propose to confirm the work assumption.

However, [MTK, Samsung] mention that the working assumption is ambiguous, [MTK] further argues that Option 1 by default implies that a UE-specific RRC configuration for disabling HARQ feedback always exists, and [ZTE, MTK] further propose that option 3 is preferred to be an add-on solution combined with option 1 instead of an independent solution.

From the moderator’s understanding, the current working assumption is essentially a compromise, which enables both options 6a-1 and 6a-4 based on configuration, and three “independent” solutions were supported for HARQ enabling/disabling for downlink transmission:

* Solution A: per HARQ process via UE specific RRC signaling🡪 Option 6a-1
* Solution B: per HARQ process via UE specific RRC signaling and DCI overriding the corresponding transmission🡪 Option 6a-4
* Solution C: DCI direct indication HARQ enabling/disabling🡪 Option 6a-1

Independent configuration of both Option 1 and 3 by RRC configuration enables the eNB scheduler to adapt options semi-statically based on UE capability, channel environment, etc. Based on that, the work assumption should be confirmed with the minor update as also mentioned by [Lenovo] to avoid any misunderstanding.

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

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 ~~by default~~, and support Option 3 to override ~~default~~ Option 1 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~~ Option 1 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.

**ISSUE 1-2**

Regarding the DCI based overridden indication applied to 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, Xiaomi, CATT, ZTE, NEC, Lenovo, CMCC, E///, Interdigital, Nokia,

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

Supported by: Mavenir, Qualcomm, Nordic

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

Supported by: Apple

|  |  |
| --- | --- |
| Alternative | Comments |
| Alternative 1:  both semi-statically HARQ enabled and disabled processes | * [Huawei, 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. * [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///] The enabled/disabled configuration can be momentarily changed (i.e., for a given transmission) on a per need basis. * [Nokia] it will be good to provide full flexibility of both dynamic enabling and disabling HARQ feedback by using Option 3 to override RRC semi-statically configured feedback-enabled and feedback-disabled processes according to the real time traffic/signaling requirement. |
| 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 |

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

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

For single TB scheduled by DCI, DCI-based overridden mechanism/indication is applied to one of the following alternatives:

* Alternative 1: 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

Note: DCI-based overridden mechanism/indication is the DCI signaling to override HARQ enabling/disabling for the corresponding transmission from per-HARQ RRC configuration if per-HARQ RRC configuration is present and DCI-based RRC signaling is configured.

**ISSUE 1-3**

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
  + Option 1a: single indication applied to all scheduled TBs

Supported by: OPPO, Lenovo, E///

* + Option 1b: separate indications for each scheduled TB

Supported by: ZTE

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

Supported by: Spreadtrum, MTK

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

Supported by: OPPO, Apple

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

Supported by: Huawei, CATT

* 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 DCI-based overridden mechanism/indication in multiple TBs scheduled by single DCI, down select one of the following

* Option 1: DCI-based overridden mechanism/indication is applied to all scheduled TBs
  + Option 1a: single indication applied to all scheduled TBs
  + Option 1b: separate indications for each scheduled TB
* Option 2: DCI-based overridden mechanism/indication is applied to subset of scheduled TBs
  + Option 2a: first TBs scheduled by DCI
  + Option 2b: HARQ enabled or disabled TBs scheduled by DCI
* Option 3: DCI-based overridden mechanism/indication applied TBs is determined by the per-HARQ RRC configuration (e.g., all HARQ enabled, all HARQ disabled or mixed HARQ enabled/disabled configuration)
* Option 4: DCI-based overridden mechanism/indication is not applied to multiple TBs scheduled by single DCI

**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
  + Option 1a: single indication applied to all scheduled TBs

Supported by: Huawei, OPPO, Lenovo, E///, Apple,

* + Option 1b: separate indications for each scheduled TB

Supported by: ZTE

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

Supported by: MTK

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

Supported by: [--]

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

For DCI-based HARQ enabling/disabling direct indication in multiple TBs scheduled by single DCI, down select one of the following

* Option 1: DCI-based HARQ enabling/disabling direct indication is applied to all scheduled TBs
  + Option 1a: single indication applied to all scheduled TBs
  + Option 1b: separate indications for each scheduled TB
* Option 2: DCI-based HARQ enabling/disabling direct indication is applied to subset of scheduled TBs (e.g., first TB scheduled by DCI)
* Option 3: DCI-based HARQ enabling/disabling direct indication is not applied to multiple TBs scheduled by single DCI

Note: DCI-based HARQ enabling/disabling direct indication is the DCI signaling to indicate HARQ enabling/disabling for the corresponding transmission if per HARQ RRC configuration is not present and DCI-based RRC signaling is configured.

**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, OPPO, Xiaomi, CATT, ZTE, E///, InterDigital, Apple,

* Option 2: Reuse/reinterpret existing field in DCI

Supported by: Spreadtrum, Sony, Lenovo, CMCC, MTK, Qualcomm, Mavenir, Nokia

|  |  |  |
| --- | --- | --- |
| 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 |

As also recommended by[E///] that before re-purposing any bit from a legacy DCI field, companies are encouraged to compare 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** |

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

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)
* Option 2: Reuse/reinterpret existing field in DCI

## Company views

The following proposals are listed as majority views.

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

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 ~~by default~~, and support Option 3 to override ~~default~~ Option 1 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~~ Option 1 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.

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

For single TB scheduled by DCI, DCI-based overridden mechanism/indication is applied to one of the following alternatives:

* Alternative 1: 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

Note: DCI-based overridden mechanism/indication is the DCI signaling to override HARQ enabling/disabling for the corresponding transmission from per-HARQ RRC configuration if per-HARQ RRC configuration is present and DCI-based RRC signaling is configured.

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

For DCI-based overridden mechanism/indication in multiple TBs scheduled by single DCI, down select one of the following

* Option 1: DCI-based overridden mechanism/indication is applied to all scheduled TBs
  + Option 1a: single indication applied to all scheduled TBs
  + Option 1b: separate indications for each scheduled TB
* Option 2: DCI-based overridden mechanism/indication is applied to subset of scheduled TBs
  + Option 2a: first TBs scheduled by DCI
  + Option 2b: HARQ enabled or disabled TBs scheduled by DCI
* Option 3: DCI-based overridden mechanism/indication applied TBs is determined by the per-HARQ RRC configuration (e.g., all HARQ enabled, all HARQ disabled or mixed HARQ enabled/disabled configuration)
* Option 4: DCI-based overridden mechanism/indication is not applied to multiple TBs scheduled by single DCI

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

For DCI-based HARQ enabling/disabling direct indication in multiple TBs scheduled by single DCI, down select one of the following

* Option 1: DCI-based HARQ enabling/disabling direct indication is applied to all scheduled TBs
  + Option 1a: single indication applied to all scheduled TBs
  + Option 1b: separate indications for each scheduled TB
* Option 2: DCI-based HARQ enabling/disabling direct indication is applied to subset of scheduled TBs (e.g., first TB scheduled by DCI)
* Option 3: DCI-based HARQ enabling/disabling direct indication is not applied to multiple TBs scheduled by single DCI

Note: DCI-based HARQ enabling/disabling direct indication is the DCI signaling to indicate HARQ enabling/disabling for the corresponding transmission if per HARQ RRC configuration is not present and DCI-based RRC signaling is configured.

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

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)
* Option 2: Reuse/reinterpret existing field in DCI

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| **Ericsson** | * **[Proposal 1-1a]:** Ok with confirming the WA. * **[Proposal 1-2a]:** Alternative 1: both semi-statically HARQ enabled and disabled processes. * **[Proposal 1-3a]:** We think the decision here depends very much on how the overriding is to be indicated. We prefer “**Option 1a: single indication applied to all scheduled TBs.**” using 1-bit indication where “0: HARQ feedback enabled” and “1: HARQ feedback disabled”.   For example, when the 1-bit indicates “0: HARQ feedback enabled”, then if HARQ process 0 had enabled HARQ feedback and HARQ process 1 had disabled HARQ feedback, after the overriding both HARQ processes change to HARQ feedback enabled.   * **[Proposal 1-4a]:** It seems that there is a close connection with the previous proposal, perhaps is better to unify them. Similar comment as above we prefer “Option 1a: single indication applied to all scheduled TBs”. * **[Proposal 1-5a]:** For NB-IoT we are open to discuss option 1 and option 2. Just one comment about “option 2”, even if we “Reuse/reinterpret existing field in DCI” it is still an Explicit indication. So, probably a better description to avoid misunderstandings would be:   + Option 1: Explicit indication in DCI (e.g., adding one field in DCI)   + Option 2: Explicit indication by Reusing/reinterpreting existing field in DCI   For LTE-MTC, it seems possible to make use of one of the zeros appended to the DL DCI Format for matching the payload size of the UL DCI Format, so we would not like to discard yet that option which will bring no specification impact. |
| Spreadtrum | [Proposal 1-1a]: Support.  [Proposal 1-2a]: We prefer Alternative 1.  [Proposal 1-3a]: For Option 2, we think the following options need to be added.  - Option 2c: The subset of scheduled TBs can be configured by network.  [Proposal 1-4a]: Support.  [Proposal 1-5a]: We prefer Option 2. |
| Qualcomm | 1-1a: We do not see the need to update the WA, we prefer to confirm as it is.  1-2a: For this, it would be good to discuss a bit online / offline what is the expected UE behavior on the DRX timers and also on the PDCCH monitoring timers. We think if we take all these aspects into account it would be preferable to support only overriding disabled processes.  1-3a: We are OK to list all the options initially, we can discuss the details later (after we conclude the behavior for single TB).  Others: need discussion on the previous |

# [Active]Issue-2 SPS PDSCH

## Background

Since SPS is only supported in CE mode A and the corresponding SPS period can be configured from 10ms to 640ms. While the reference value of RTT for LEO and GEO are 25.77ms and 541.46ms respectively. The HARQ stalling issue is not obvious in LEO scenario but do exist in GEO scenarios. Based on that, it is beneficial to configure HARQ disabling at least for GEO scenarios in eMTC. Similarly, for NR NTN SPS, the SPS period can also be configured from 10ms to 640ms, and the supported HARQ process is even larger than that of eMTC, the SPS HARQ disabling was introduced in Rel.17 NR NTN.

In NR NTN, 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.

For IoT NTN, As highlighted by [Spreadtrum, OPPO, Xiaomi, CATT, ZTE, CMCC, Lenovo, Apple, Sharp, Qualcomm], that the same mechanism for NR NTN could be applied to IoT NTN. UE follows the per-process HARQ feedback enabled/disabled configuration for the associated HARQ process except for the first SPS PDSCH after activation. For SPS PDSCH, ACK/NACK is reported by UE for the first SPS PDSCH regardless of network configuration of enabled/disabled for this HARQ process if additional signal indicated.

However, As proposed by [Nokia, NEC], HARQ feedback should be always enabled for the first SPS PDSCH after activation to avoid the repetition resource wasted, [NEC] proposes that HARQ feedback enabled/disabled for the first SPS PDSCH after activation is indicated by DCI. [Nokia] further proposes that the configuration allows a process to report one HARQ-ACK for every n TBs received in SPS. From moderator’s understanding, the HARQ process number is determined by subframe index for SPS, so whether to report HARQ-ACK or not can be implemented by proper SPS configuration and HARQ enabling/disabling configuration. The solution adopted in NR can be the baseline that the HARQ feedback for SPS PDSCH follow the per-process HARQ feedback enabled/disabled configuration. We are still open to consider Nokia proposed solution for further study to check the benefit of reporting HARQ-ACK every n TB in addition to NR solution.

As mentioned by [Samsung], for IoT NTN, the considered scenarios are not latency sensitive. The gNB can activate at a time where the first SPS PDSCH has a HARQ process with enabled HARQ-ACK report, so the additional HARQ feedback for SPS activation is not needed.

As mentioned by [E///] that when SPS is overridden by dynamic scheduling then such a dynamic scheduling will dictate the transmission characteristics as per “Option-1” and/or “Option-3”. However, based on the latest working assumption that *for eMTC NTN, to configure/indicate enabling/disabling of HARQ feedback for downlink transmission, take Option 1 for CE Mode A.* So there is no configuration/indication option switching for eMTC SPS PDSCH since SPS is only supported in CE mode A.

In this meeting, preference options from companies are summarized as follow:

For HARQ feedback for eMTC SPS PDSCH, UE at least 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.

Supported by: Spreadtrum, OPPO, Xiaomi, CATT, ZTE, CMCC, Lenovo, Apple, Sharp, Qualcomm

* + Option 2: ACK/NACK is always reported by UE for the first SPS PDSCH after activation regardless of network configuration of enabled/disabled for this HARQ process.

Supported by: Nokia, NEC

* + Option 3: follow the per-process HARQ feedback enabled/disabled configuration for the associated HARQ process.

Supported by: Samsung

As highlighted by [Spreadtrum, Lenovo, Apple], for DCI indicating SPS PDSCH release, HARQ-ACK report is performed as legacy.

## Company views

From moderator’s perspective, if the indication/configuration of disabling HARQ feedback in eMTC follows that of NR NTN in previous section, the NR configuration of HARQ feedback enabling/disabling for SPS PDSCH can be the starting point /baseline for eMTC NTN. Furthermore, further study the benefit of reporting HARQ-ACK every n TB (e.g., reporting HARQ-ACK every SPS occasion) and if DCI based HARQ enabled/disabled indication is supported for eMTC, study on whether the corresponding solution can be used for SPS PDSCH.

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

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

For HARQ feedback for eMTC SPS PDSCH, UE at least 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.

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

For DCI indicating SPS PDSCH release, HARQ-ACK report is performed as legacy in eMTC.

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | * **[Proposal 2-1a]:** ok in principle. * **[Proposal 2-2a]:** ok in principle. |
| Spreadtrum | We support the both two proposals. |
| Qualcomm | We would propose to follow the same approach as in NR NTN, i.e., there is a separate flag that indicates whether the activation DCI has HARQ-ACK. |

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

## Background

In NR NTN, additional gap is considered to avoid the continuous reception of PDSCH with same HARQ process at UE side as specified in TS38.214.

**TS38.214 Section 5.1**

When HARQ feedback for the HARQ process ID is disabled, the UE is not expected to receive another PDCCH carrying a DCI scheduling a PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process or to receive another PDSCH without corresponding PDCCH for the given HARQ process that starts until Tproc,1 after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process.

For NBIoT, it was agreed that *UE is not required to monitor NPDCCH in a period of Y=12(ms) from the end of reception of the NPDSCH* to align the NBIoT legacy behavior that UE is not required to monitor NPDCCH and decode NPDSCH simultaneously.

However, in addition to the above NPDCCH monitoring restriction, [Ericsson] further make the conclusion 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.

For eMTC, as proposed by [Xiaomi, CATT, ZTE, CMCC, Apple, Sharp, Lenovo, Qualcomm], following NR PDSCH/PDCCH scheduling restriction, the similar mechanism should be introduced to eMTC NTN. However, as mentioned by [Ericsson] that the “scheduling restriction” should be described using a proper terminology in terms of “BL/CE DL subframes” as to be consistent with the subframe types used for transmitting in DL (e.g., …. UE is not expected to receive another MPDCCH …. 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.). From the moderator’s understanding, if the subframe of X=3ms after the end of the reception of the last PDSCH for that HARQ process is not a BL/CE DL subframe, it is obvious that UE will not receive any DCI in that subframe, since the subframes where UE is expected to receive

MPDCCH have been specified in TS36.213 Section 9.1.5. Based on that there is no need to update the original proposal and do duplicated specification/scheduling restriction.

TS36.213 Section 9.1.5

For MPDCCH UE-specific search space, Type0-MPDCCH common search space, Type1A-MPDCCH common search space, Type2-MPDCCH common search space and Type2A-MPDCCH common search space locations of starting subframe  are given by where is the th consecutive BL/CE DL subframe from subframe , and , and , and , where

- subframe  is a subframe satisfying the condition , where 

The minimum gap between the end of PDSCH and the start of corresponding HARQ-ACK is 3ms for eMTC defined in 36.213, which accounts for PDSCH decoding time and corresponding uplink data preparation at the devices. Furthermore, eMTC UE has the ability to decode MPDCCH and PDSCH in the same subframe and there is NO MPDCCH monitoring restriction in legacy eMTC shown in Figure 1 (e.g., UE has the ability to decode PDSCH and monitor/decode MPDCCH simultanously even for the PDSCH with HARQ enabling/disabling, as subframe #2 in Figure 3-1).





Figure 3-1 Minimal gap between PDSCH and PUSCH

**TS36.213 Section 10.2**

For FDD, a BL/CE UE shall upon detection of a PDSCH intended for the UE and for which an HARQ-ACK shall be provided, transmit the HARQ-ACK response using the same  derived according to Clause 10.1.2.1 in subframe(s) *n+ki* with *i =0,1, …, N-1*, where

- subframe *n-k-K*offset is the last subframe in which the PDSCH is transmitted, where

- if the UE is in half-duplex FDD operation and is not configured with higher layer parameter *ce-PDSCH-14HARQ-Config* and is configured with CEModeA and higher layer parameter *ce-HARQ-AckBundling* and the 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1, or if the UE is configured with higher layer parameter *ce-SchedulingEnhancement*

- is given by the 'HARQ-ACK delay' field in the corresponding DCI, and the HARQ-ACK delay value is determined based on the higher layer parameters according to Table 7.3.1-2;

- if the UE is in half-duplex FDD operation and is configured with higher layer parameter *ce-PDSCH-14HARQ-Config* and is configured with CEModeA, and 'PDSCH scheduling delay and HARQ-ACK delay for 14 HARQ' field is present in the corresponding DCI,

- is given by the HARQ-ACK delay value as defined in [4], in the corresponding DCI,

- otherwise

-

*- 0≤k0<k1<…,kN-1* and the value of and  is provided by higher layer parameter *pucch-NumRepetitionCE-format1,* if configured, otherwise it is provided by higher layer parameter *pucch-NumRepetitionCE*-*Msg4-Level0-r13, pucch-NumRepetitionCE-Msg4-Level1-r13, pucch-NumRepetitionCE-Msg4-Level2-r13* or *pucch-NumRepetitionCE-Msg4-Level3-r13* depending on whether the most recent PRACH coverage enhancement level for the UE is 0, 1, 2 or 3, respectively; and

In NR NTN HARQ disabling, the gap of PDSCH scheduling restriction for HARQ disabling is defined as subframes between previous PDSCH and next PDCCH of scheduling the same HARQ process for dynamic PDSCH transmission, and subframes between previous PDSCH and next PDSCH of the same HARQ process for SPS PDSCH. In order to reuse NR design, unified minimal gap of PDSCH scheduling restriction can be considered for dynamic PDSCH and SPS PDSCH (including FDD and HD-FDD case) for eMTC, the minimal gap is used for UE PDSCH decoding.

Regarding the minimal gap value proposed by majority companies: X=3ms. Following gives some illustration of the scheduling restriction for different scenarios.

* For FDD eMTC of dynamic PDSCH transmission, due to the cross subframe scheduling of eMTC, the minimal gap of PDSCH scheduling restriction between previous PDSCH and next PDCCH of scheduling the same HARQ process is 3ms (e.g., subframe 3 4 5 for HARQ process #0 as shown in Figure 3-2), the corresponding gap between previous PDSCH and next PDSCH for the same HARQ process is 5ms (e.g., subframe 3 4 5 6 7 for HARQ process #0 as shown in Figure 3-2), and 5ms gap for PDSCH-to-PDSCH is enough for UE PDSCH decoding.
* For FDD eMTC SPS PDSCH, due to SPS without DCI scheduling, the minimal gap of PDSCH scheduling restriction between previous PDSCH and next PDSCH of the same HARQ process is 3ms, and 3ms gap for PDSCH-to-PDSCH is enough for UE PDSCH decoding as shown in Figure 3-3(e.g., assuming the HARQ process number of #0, #1, #2, #3 is determined by subframe index).
* For HD-FDD eMTC without HARQ bundling or without HARQ delay enhancement (e.g., HARQ feedback delay of 4ms), due to the cross subframe scheduling of eMTC, the minimal gap of PDSCH scheduling restriction between previous PDSCH and next PDCCH of scheduling the same HARQ process is 3ms, the corresponding gap between previous PDSCH and next PDSCH for the same HARQ process is 5ms, and 5ms gap for PDSCH-to-PDSCH is enough for UE PDSCH decoding as shown in Figure 3-4. (e.g. if there is uplink subframe scheduled between two DL transmission, the gap between previous PDSCH and next PDCCH of scheduling the same HARQ process may be longer due to switching subframes and uplink transmission in half-duplex FDD)
* For HD-FDD eMTC HARQ bundling or HARQ delay enhancement (e.g., HARQ feedback delay dynamically indicated), due to the cross subframe scheduling of eMTC, the minimal gap of PDSCH scheduling restriction between previous PDSCH and next PDCCH of scheduling the same HARQ process is 3ms, the corresponding gap between previous PDSCH and next PDSCH for the same HARQ process is 5ms, and 5ms gap for PDSCH-to-PDSCH is enough for UE PDSCH decoding as shown in Figure 3-5.



Figure 3-2 Minimal gap for PDSCH scheduling restriction



Figure 3-3 Minimal gap for PDSCH scheduling restriction



Figure 3-4 Minimal gap for PDSCH scheduling restriction



Figure 3-5 Minimal gap for PDSCH scheduling restriction

However, [Qualcomm] proposes that in one case of HD-FDD timeline, the earliest an eMTC UE expects to receive a retransmission for the same HARQ process is in subframe N+6 due to UL-to-DL switching, which is X=5ms after the end of last PDSCH for the same HARQ process.

* UE receives a PDSCH in subframe *N*
* UE transmits HARQ-ACK in subframe *N+4*
* UE retunes to downlink in subframe *N+5*
* UE starts monitoring for MPDCCH in subframe *N+6*

From moderator’s understanding, the minimal gap period is used for UE PDSCH decoding for a particular HARQ process as Tproc,1 in NR, not related to the potential MPDCCH monitoring subframe, where 3ms is enough for PDSCH decoding both HD-FDD and FDD in eMTC. After the 3ms period of PDSCH scheduling restriction, whether the gNB transmits PDCCH scheduling the PDSCH with the same HARQ process is up to eNB implementation. There may be UL-to-DL switching subframes and invalid DL subframe after the 3ms period, eNB and UE have the common understanding on these subframes, and eNB will not transmit any DCI in these subframes. Furthermore, besides the HD-FDD timeline illustrated by [Qualcomm], there is another HD-FDD timeline in Figure 3-5 where the UE is expected to receive the transmission/retransmission for the same HARQ process after a period of 3ms instead of 5ms. Based on that, the minimal gap period is designed for UE PDSCH decoding, X= 3ms can cover “all” cases to balance the PDCCH monitoring power saving and UE decoding capability and we don’t need to set an “infinite” value of minimal gap period to cover “corner” case for UE power saving consideration.

## Company views

According to the above summary, reusing NR PDSCH scheduling restriction can be a starting point for eMTC. Regarding the value of X, as the minimum gap is defined as 3ms, the PDSCH scheduling restriction duration should be 3ms.

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

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 until X=3 (ms) after the end of the reception of the last PDSCH for that HARQ process.

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | **[Proposal 3-1a]:** We would be ok with the proposal but upon adding the proper terminology:  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.  It has been commented that is “obvious”, but it is not, that is why the spec distinguishes between BL/CE DL subframe, non-BL/CE DL subframe, BL/CE UL subframe, non-BL/CE UL subframe, or simply subframe.  We are already being quite open to adopt the scheduling restriction with X=3 (ms), we are just asking to use a proper terminology. |
| Qualcomm | The timeline (3ms) is based on UE processing requirements, therefore we think it should be based on absolute subframes (not BL/CE DL subframes) |

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

## Background

eMTC HD-FDD HARQ bundling by multiple DCIs is introduced in Rel.14 and enhanced in Rel.17. The design of disablement of HARQ feedback should handle the case where HARQ feedback is bundled, and HARQ feedback is enabled for some HARQ processes and is disabled for others. Similar as enhancement of NR NTN HARQ codebook Type-1, [Lockheed, Speadtrum, CATT, NEC, Apple] proposes that ACK is assumed for a feedback-disabled HARQ process in the logical AND operation.

However, [Lenovo]mentions due to PDSCH number restriction (e.g., 10 PDSCH for each scheduling cycle) and PUCCH feedback resource restriction for each scheduling cycle (e.g., 3 for PUCCH resource for each scheduling cycle), if ACK is assumed for HARQ disabling scenarios (e.g., this HARQ feedback of ACK will occupy a PDSCH number and a PUCCH resource of HARQ bundling), there is no available PDSCH and corresponding PUCCH resource in the scheduling cycle and it is equivalent that HARQ disabling feature is not supported in HD-FDD HARQ bundling.

Similar as enhancement of NR NTN HARQ codebook Type-2, [OPPO, Lenovo, E///, Qualcomm, Sharp] proposes UE only report the HARQ feedback for HARQ process enabled by setting “*HARQ-ACK bundling flag=0*” for HARQ disabled process as shown in Figure 4-1, and further mentions that the legacy HARQ bundling only includes the bundling of HARQ enabled process in legacy TS36.213.

[NEC] proposes that ACK is assumed for the disabled HARQ process when performing a logical AND operation if not all the bundled TB is disabled HARQ feedback, and if all the bundled TB is disabled HARQ feedback, then HARQ bundling function will not apply even it is configured.



Figure 4-1 HARQ disabling in HARQ bundling by multiple DCIs for eMTC HD-FDD

TS36.213 h20

10.2 Uplink HARQ-ACK timing

[……]

For FDD, a BL/CE UE shall upon detection of a PDSCH intended for the UE and for which an HARQ-ACK shall be provided, transmit the HARQ-ACK response using the same  derived according to Clause 10.1.2.1 in subframe(s) *n+ki* with *i =0,1, …, N-1*, where

- subframe *n-k**-**K*offset is the last subframe in which the PDSCH is transmitted, where

- if the UE is in half-duplex FDD operation and is not configured with higher layer parameter *ce-PDSCH-14HARQ-Config* and is configured with CEModeA and higher layer parameter *ce-HARQ-AckBundling* and the 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1, or if the UE is configured with higher layer parameter *ce-SchedulingEnhancement*

- is given by the 'HARQ-ACK delay' field in the corresponding DCI, and the HARQ-ACK delay value is determined based on the higher layer parameters according to Table 7.3.1-2;

- if the UE is in half-duplex FDD operation and is configured with higher layer parameter *ce-PDSCH-14HARQ-Config* and is configured with CEModeA, and 'PDSCH scheduling delay and HARQ-ACK delay for 14 HARQ' field is present in the corresponding DCI,

- is given by the HARQ-ACK delay value as defined in [4], in the corresponding DCI,

- otherwise

-

[….]

TS36.213 h20

7.3.1 FDD HARQ-ACK reporting procedure

[….]

For a BL/CE UE in half-duplex FDD operation, if the UE is configured with CEModeA, and if the UE is configured with higher layer parameter *ce-HARQ-AckBundling* and the 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1,

- for HARQ-ACK transmission in subframe *n*, the UE shall generate one HARQ-ACK bit by performing a logical AND operation of HARQ-ACKs across all  BL/CE DL subframes for which subframe *n* is the 'HARQ-ACK transmission subframe'.

- if subframe *n-k1* is the most recent subframe for which subframe *n* is the 'HARQ-ACK transmission subframe', and if the 'Transport blocks in a bundle' field in the corresponding DCI for PDSCH transmission in subframe *n-k1* indicates a number of transport blocks in a bundle other than , the UE shall generate a NACK for HARQ-ACK transmission in subframe *n*.

[…..]

TS36.212 h30

- HARQ-ACK bundling flag – 1 bit, where value 0 indicates HARQ-ACK bundling is not enabled and value 1 indicates HARQ-ACK bundling is enabled as defined in clause 7.3 of [3]. This field is only present when the higher layer parameter *ce-HarqAckBundling-config* is configured and the DCI is mapped onto the UE-specific search space given by the C-RNTI as defined in [3].

## Company views

According to the above summary, in eMTC HD-FDD HARQ bundling by multiple DCI, whether to bundle the HARQ-ACK to single one depends on the DCI field *HARQ-ACK bundling flag* indicationin legacy. To make the discussion simpler, it is possible to specify or schedule HARQ-ACK bundling to the avoid the HARQ bundling between HARQ feedback for downlink transmission with HARQ process disabled and that with HARQ process enabled or with another HARQ process disabled. The following proposals are listed:

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

**Potential 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 as HARQ disabling by RRC signaling.

Please provide your views and comments.

|  |  |
| --- | --- |
| **Company** | **Comments and Views** |
| Ericsson | **[Proposal 4-1a]:** Overall ok, but there seems to be a minor issue with the wording, since instead of “HARQ disabling” I think it should say “HARQ feedback disabled” and probably the statement should end there as follows:  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~~ were configured ~~as~~ with HARQ feedback disabled ~~disabling~~ |
| Spreadtrum | We prefer Ericsson’s version. |
| Qualcomm | We are fine with either the original version or Ericsson’s. |

# [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, corresponding UE behavior and timing relationship as shown in Figure 5-1. 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.



Figure 5-1 HARQ disabling in multiple TB scheduling

## 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:

**[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]:** We are open to discuss, if two TBs are to be scheduled by a single DCI, does “Option 3” mean that if “HARQ process#0 has HARQ feedback disabled” and “HARQ process#1 has HARQ feedback enabled”, then HARQ feedback will be reported? Or what is the meaning of the wording “depending on the other”?      * **[Proposal 5-2a]:** In our understanding, the embedded flexibility in the Multi-TB grant feature will allow the network grouping HARQ processes having the same characteristics (i.e., HARQ processes with HARQ feedback enabled, and HARQ processes with HARQ feedback disabled), hence “Option 2” seems to be suitable. |
| Spreadtrum | For Proposal 5-1a, we prefer Option 1.  For Proposal 5-2a, we prefer Option 1. |

# [Closed]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, [Huawei, 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]. However, as mentioned by [Huawei], no need to enhance link adaptation when dynamic HARQ feedback disabling is introduced.

## 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 (Feb xx)

# 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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