3GPP TSG-RAN WG1 Meeting #105-e R1-21xxxxx

e-Meeting, May 10th – 27th, 2021

Agenda Item: 8.9.2

Source: Moderator (Ericsson)

Title: Feature Lead Summary [105-e-LTE-Rel17\_NB\_IoT\_eMTC-02]

Document for: Discussion and Decision

# 1 Introduction

In the Work Item (WI) on “Additional enhancements for NB-IoT and LTE-MTC” [1], one of the objectives is to specify the following enhancement for LTE-MTC:

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| * Support additional PDSCH scheduling delay for introduction of 14-HARQ processes in DL, for HD-FDD Cat M1 UEs. [LTE-MTC] [RAN1] |

The update performed on this feature lead summary (FLS) accounts for the most recent agreements made in RAN1# 105-e as to prepare the new potential agreements.

Annex 1 contains the agreements reached in RAN1 #102-e [7], RAN1 #103-e [8], RAN1 #104-e [9], RAN1 #104-bis-e [10] and the one reached until now in RAN1 #105-e [11].

# 2 FLS on 14 HARQ processes in DL in LTE-MTC

## 2.1 DCI Design for PDSCH Scheduling delay and HARQ-ACK delay

Background: In relation with the “HARQ-ACK delay” solution, in RAN1 #105-e the following agreement was recently reached [11]:

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| **Agreement**  In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be supported with multiple solutions: Alt-1 for full flexibility and Alt-2e for support of legacy delay  Alt-1: The HARQ-ACK delay is determined through an expression consisting of different subframe types (Using a similar principle as the PDSCH scheduling delay).   * + Without using more than 6 bits   + FFS: How to minimize the overhead by using joint encoding   Alt-2: The HARQ-ACK delay is determined following the legacy approach. That is, the “HARQ-ACK delay” is kept expressed in terms of “absolute subframes”.   * + The HARQ-ACK delay values and the length of the HARQ-ACK delay set will be based on     - Alt-2e: “3 bits (same as legacy)”     - FFS: Whether HARQ delay set is to use range1 or range2   RRC signaling will be used to configure between Alt-1 and Alt-2e  FFS: Signaling details  FFS: Joint encoding |

In line with the previously cited agreement, below it is described what needs to be considered towards analysing DCI design proposals when the PDSCH Scheduling delay solution is used along with Alt-1 or Alt-2e depending on which of those two alternatives has been configured via RRC as the HARQ-ACK delay solution to be in use:

### 2.1.1 PDSCH Scheduling delay solution used along with Alt-1 configured via RRC as the HARQ-ACK delay solution

Below there are described the elements of the PDSCH Scheduling delay and the HARQ-ACK delay using “Alt-1 for full flexibility”:

* PDSCH scheduling delay:

2 BL/CE DL subframes

1 BL/CE DL subframe + 1 subframe + 3 BL/CE UL subframes + 1 subframe + 1 BL/CE DL subframe.

1 subframe + 3 BL/CE UL subframes + 1 subframe + 2 BL/CE DL subframes.

* HARQ-ACK delay using “Alt-1 for full flexibility”:

(y) BL/CE DL subframe + 1 subframe (any type) + (z) BL/CE UL subframes.

where:

• y = {0,1,2, … ,11}

• z = {1,2,3}

#### 2.1.1.1 Using independent DCI fields: PDSCH Scheduling delay and HARQ-ACK delay using “Alt-1 for full flexibility”

If independent DCI fields were used for the PDSCH Scheduling delay and the HARQ-ACK delay using “Alt-1 for full flexibility”, then the following number of bits would be required:

* PDSCH scheduling delay: 2 bits.
* HARQ-ACK delay using “Alt-1 for full flexibility”: (4-bits for “y” and 2-bits for “z”) 6 bits.
* Total Number of bits if independent DCI fields were used: 8 bits.

#### 2.1.1.2 Using a joint encoding solution: PDSCH Scheduling delay and HARQ-ACK delay using “Alt-1 for full flexibility”

If a joint encoding solution were used for the PDSCH Scheduling delay and the HARQ-ACK delay using “Alt-1 for full flexibility”, then the following number of bits would be required:

* PDSCH scheduling delay: There are 3 different expressions.
* HARQ-ACK delay using “Alt-1 for full flexibility”: There are 12 values for “y” and 3 values for “z”.
* The joint encoding solution will require: 12(3) + 12(3) + 12(3) = 108 states, meaning that we will need 7-bits for a fully flexible joint-encoding solution
* Total Number of bits if a joint encoding solution in DCI were used: 7 bits.

### 2.1.2 PDSCH Scheduling delay solution used along with Alt-2e configured via RRC as the HARQ-ACK delay solution

Below there are described the elements of the PDSCH Scheduling delay and the HARQ-ACK delay using Alt-2e: “3 bits (same as legacy)”:

* PDSCH scheduling delay:

2 BL/CE DL subframes

1 BL/CE DL subframe + 1 subframe + 3 BL/CE UL subframes + 1 subframe + 1 BL/CE DL subframe.

1 subframe + 3 BL/CE UL subframes + 1 subframe + 2 BL/CE DL subframes.

* HARQ-ACK delay using Alt-2e: “3 bits (same as legacy)”:

3-bits HARQ-ACK delay set = {a, b, c, d, e, f, g, h}.

Note: The delay values in the HARQ-ACK delay set dependent on the resolution of the following “*FFS: Whether HARQ delay set is to use range1 or range2*”.

#### 2.1.2.1 Using independent DCI fields: PDSCH Scheduling delay and HARQ-ACK delay using “Alt-2-e”

If independent DCI fields were used for the PDSCH Scheduling delay and the HARQ-ACK delay using Alt-2e: “3 bits (same as legacy)”, then the following number of bits would be required:

* PDSCH scheduling delay: 2 bits.
* HARQ-ACK delay using Alt-2e: “3 bits (same as legacy)”: 3 bits.
* Total Number of bits if independent DCI fields were used: 5 bits.

#### 2.1.2.2 Using a joint encoding solution: PDSCH Scheduling delay and HARQ-ACK delay using “Alt-2-e”

If a joint encoding solution were used for the PDSCH Scheduling delay and the HARQ-ACK delay using Alt-2e: “3 bits (same as legacy)”, then the following number of bits would be required:

* PDSCH scheduling delay: There are 3 different expressions.
* HARQ-ACK delay using Alt-2e: The HARQ-ACK delay e.g., would aim to get most of the 5-bits used by the joint encoding solution as to provide 10 delays values instead of 8 delay values for the HARQ-ACK delay set with the same 5-bits. That is, the HARQ-ACK delay set would become = {a, b, c, d, e, f, g, h, i, j}.
* The joint encoding solution will require: 10 + 10 + 10 = 30 states, meaning that we will need 5-bits for a fully flexible joint-encoding solution
* Total Number of bits if a joint encoding solution in DCI were used: 5 bits.

**Comment from the Feature Lead:** Based on the received feedback, two possible approaches have been considered as to select the approach that will become the Potential Agreement 1:

* **Potential Agreement 1a**, refers to a set of considerations towards deciding on the DCI design in RAN1#106-e (includes the possibility of using either independent DCI fields or a joint encoding solution).
* **Potential Agreement 1b**, refers to progressing further on the DCI design through deciding on using a joint encoding solution based on the bit saving (for Alt-1) and extra-delay values (for Alt-2) that it will provide over a solution based on independent DCI fields.
* Please note that the Potential Agreement 1b refers to Alt-1, however the expression it uses to determine the HARQ-ACK delay has not been described therefore a note has been added to described it.

Below the “**Potential Agreement 1a**” and “**Potential Agreement 1b**” are shown, being expected that companies can provide their views on which of those two approaches should be taken as the **Potential Agreement 1.**

**Potential Agreement 1a:**

**The following aspects will be considered towards selecting in RAN1# 106-e the DCI designs for the PDSCH Scheduling delay and HARQ-ACK delay solutions:**

* **For the PDSCH Scheduling delay solution used along with “Alt-1 for full flexibility” configured via RRC as the HARQ-ACK delay solution:**
  + **DCI designs for the “PDSCH Scheduling delay” and the “HARQ-ACK delay”** **using independent DCI fields and joint encoding are considered.**
    - **PDSCH scheduling delay: The 3 different expressions as agreed in RAN1# 104-e shall be considered.**
    - **HARQ-ACK delay using “Alt-1 for full flexibility”:** **The structure of the expression is (y) BL/CE DL subframe + 1 subframe + (z) BL/CE UL subframes, where there are 12 values (i.e., y = {0, 1, 2, … 11}) for the variable associated to the term BL/CE DL subframe and 3 values (i.e., z = {1, 2, 3}) for the variable associated to the term BL/CE UL subframe, which shall be considered.**
* **For the PDSCH Scheduling delay solution used along with Alt-2e configured via RRC as the HARQ-ACK delay solution:**
  + **DCI designs for the “PDSCH Scheduling delay” and the “HARQ-ACK delay” using independent DCI fields and joint encoding of are considered.**
    - **PDSCH scheduling delay: The 3 different expressions as agreed in RAN1# 104-e shall be considered.**
    - **HARQ-ACK delay using “Alt-2-e”: The minimum of 8 delay values in the HARQ-ACK delay set provided by Alt-2e: “3 bits (same as legacy)” can be increased (e.g., to 10 or more delay values) depending on the total number of bits used in case of a joint encoding solution.**

**Potential Agreement 1b:**

**The PDSCH scheduling delay and HARQ-ACK delay are jointly encoded in a single DCI field:**

**• The field is 7 bits if Alt-1 is configured.**

**• The field is 5 bits if Alt-2e is configured.**

**• FFS: Details of the joint encoding.**

**Note: Alt-1 expresses the HARQ-ACK delay as (y) BL/CE DL subframe + 1 subframe + (z) BL/CE UL subframes, where y = {0, 1, 2, … 11} and z = {1, 2, 3}.**

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| **Company** | **Potential Agreement 1a or 1b?** | **Comments** |
| Qualcomm | See note | Thanks to the FL for the detailed analysis. From the analysis above, it seems clear that joint encoding is beneficial in all cases. For Alt-1, it allows to save 1 bit. For Alt-2, it allows to signal 10 combinations instead of 8. Could we agree to it directly, and figure out the details int the next meeting?  **Proposal: The PDSCH scheduling delay and HARQ-ACK delay are jointly encoded in a single DCI field:**   * **The field is 7 bits if Alt-1 is configured.** * **The field is 5 bits if Alt-2e is configured.** * **FFS: Details of the joint encoding.** |
| Lenovo, MotoM |  | Thanks for the discussion. Considering the limited remaining time in this meeting, we can firstly agree the proposal by QC above and give companies more time to design the detail.  For our view, we don’t think it is neccessary to jointly encode all possible conbinations to make the spec complicated, which leads engeneers are not willing to read our spec any more.(e.g., solution in 2.1.2.2) |
| FL | To Lenovo, MotoM | First you mentioned “*we can firstly agree the proposal by QC above and give companies more time to design the detail*”, then you mentioned “*we don’t think it is neccessary to jointly encode all possible conbinations*” which are two contradictory statements. Please note that the 7-bits that you suggest “*we can firstly agree* ” account for the full flexibility that Alt-1 shall have according with the agreements we recently reached: “*Alt-1 for full flexibility*”. |
| Lenovo, MotoM | To FL | Sorry for confusing you. I am missing the “*Alt-1 for full flexibility*” restriction for Alt-1.  For Alt-1, we don’t hope to generate 7bit joint coding table (joint scheudling delay, y and z) to make the specification complicated. So we perfer to use 8 bit as section 2.1.1.1, although we don’t have strong view on that and we don’t like the alternative from the beginning.  For Alt-2, we have no choice, we have to joint code the scheduling delay and HARQ delay, so we are OK to use one single DCI field to indicate the scheduling delay and HARQ delay as section 2.1.2.2  BTW, how can we support 2.1.2.1? For different scheduling delay, is the HARQ delay range the same? E.g., scheduling delay ={2,7,7} HARQ delay={4,5,6,...11}. If not, joint coding is neccesary, right? |

## 2.2 Clarification on PUCCH with R=1: Postponement or No Postponement

Background: In RAN1# 104-bis-e [2], it was discussed whether the legacy behaviour of PUCCH (when Repetition = 1) of no postponing the UL transmission in presence of a non-BL/CE UL subframes will be or not followed.

When the HARQ-ACK delay solution follows Alt-1, the legacy behaviour of PUCCH (when Repetition = 1) is meaningless since Alt-1 overrides it.

When the HARQ-ACK delay solution follows Alt-2, the legacy behaviour of PUCCH (when Repetition = 1) will be overridden when more than 10 HARQ processes will be used, whereas the legacy behaviour of PUCCH (when Repetition = 1) could be followed when 10 or less HARQ processes will be used. This will lead to some sort of postponement/no-postponement changing dynamically via DCI depending on the number of HARQ processes in use.

Now that it has been agreed that “*In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be supported with multiple solutions: Alt-1 for full flexibility and Alt-2e for support of legacy delay*” it is proposed to down-select one of the following options:

**Potential Agreement 2:**

**In Rel-17, for the 14 HARQ processes feature:**

* **Opt-1: PUCCH using Repetition = 1 is not postponed (legacy behavior).**
* **Opt-2: PUCCH using Repetition = 1 is postponed.**
* **Opt-3: When the HARQ-ACK delay is configured to use Alt-1 PUCCH using Repetition = 1 is postponed, whereas when the HARQ-ACK delay is configured to use Alt-2e PUCCH using Repetition = 1 is not postponed (legacy behavior).**

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| **Company** | **Opt-1/Opt-2/Opt-3** | **Comments** |
| Qualcomm | **Opt-3** | We think no specification change is needed for this, though. Should we make it a conclusion? |
| Lenovo, MotoM | **Opt-3** | We can make it as a conclusion, no specification change is needed. |
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## 2.3 Clarification on the CE Mode applicable for the 14 HARQ processes feature

Background: The intention of this section is to perform a clarification on the CE Mode that is applicable for the 14 HARQ processes feature.

The 14 HARQ processes feature makes use of the HARQ-ACK bundling feature which is applicable for CE Mode A only. Thus, beyond the use-cases foreseen for the 14 HARQ processes feature, the HARQ-ACK bundling which is a fundamental component of the feature already establishes the CE Mode in which the 14 HARQ processes feature is to be used.

**Potential Agreement 3:**

**In Rel-17, the 14 HARQ processes feature is applicable for HD-FDD Cat M1 UEs in CE Mode A only.**

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| **Company** | **Agree?** | **Comments** |
| Lenovo, MotoM | **Agree** | Only support in CE Mode A. |

# 5 References

1. [RP-201306](http://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_88e/Docs/RP-201306.zip), WID: Additional enhancements for NB-IoT and LTE-MTC, RAN #88e, Electronic Meeting, June 29th-3rd, 2020.
2. [R1-2104289](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104289.zip), “Support of 14-HARQ processes in DL for HD-FDD MTC UEs,” Huawei, HiSilicon, RAN1 #105-e, May 10th – 27th, 2021.
3. [R1-2104549](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104549.zip), “Support of 14-HARQ processes in DL for eMTC,” Nokia, Nokia Shanghai Bell, RAN1 #105-e, May 10th – 27th, 2021.
4. [R1-2104717](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104717.zip), “Remaining issues on 14-HARQ processes in DL for eMTC,” ZTE, RAN1 #105-e, May 10th – 27th, 2021.
5. [R1-2104821](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2104821.zip), “Support of 14 HARQ processes and scheduling delay,” Qualcomm Incorporated, RAN1 #105-e, May 10th – 27th, 2021.
6. [R1-2105890](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_105-e/Docs/R1-2105890.zip), “Support of 14 HARQ processes in DL in LTE-MTC,” Ericsson, Verizon, Telefónica, SoftBank, Telstra, RAN1 #105-e, May 10th – 27th, 2021.
7. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #102-e, e-Meeting, August 17th – 28th, 2020.
8. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #103-e, e-Meeting, October 26th – November 13th, 2020.
9. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #104-e, e-Meeting, January 25th – February 5th, 2021.
10. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #104-bis-e, e-Meeting, April 12th – 20th, 2021.
11. Session notes for 8.9 (Rel-17 enhancements for NB-IoT and LTE-MTC), Ad-hoc chair (Samsung), 3GPP TSG RAN WG1 Meeting #105-e, e-Meeting, May 10th – 27th, 2021.

# Annex 1

## A1.1 List of agreements from RAN1 #102-e:

**Agreement**

Introduce a new RRC configuration parameter to enable 14 HARQ processes.

**Agreement**

For a UE configured with 14 HARQ processes, a PDSCH scheduling delay of 2 BL/CE DL subframes and 7 [FFS subframes type(s)] is supported at least in the PUCCH non-repetition case:

* FFS details of signaling.
* FFS other delay values to account for the presence of non-BL/CE subframes in the PUCCH non-repetition case.
* FFS if the 14 HARQ processes feature is supported in PUCCH repetition case.

**Working Assumption**

Introduce a new optional UE capability to support 14 HARQ processes

## A1.2 List of agreements from RAN1 #103-e:

**Agreement**

The following working assumption is confirmed

Introduce a new optional UE capability to support 14 HARQ processes

**Agreement**

The design of the 14 HARQ processes feature accounts for the presence of non-BL/CE UL and DL subframes in the PUCCH non-repetition case.

* FFS: PDSCH scheduling delays
* FFS: HARQ-ACK delays
* FFS: Configurable/dynamic set of PDSCH delays/HARQ-ACK delays

**For future meetings:**

Companies to further study on the impact of measurement gaps on the 14 HARQ processes feature.

**Agreement**

For the support of 14 HARQ processes, the solution to assign PDSCH scheduling delays should be able to minimize unnecessary waste of subframes derived from the presence of non-BL/CE DL subframes and non-BL/CE UL subframes.

* The following solutions will be further investigated:
  + The indication of subframe types for the PDSCH scheduling delay of 7 are:
    - 1 BL/CE DL subframe + 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 1 BL/CE DL subframe.
    - 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 2 BL/CE DL subframes.
  + Configurable delays including other values than 2 and 7.
* Other solutions are not precluded.

**Agreement**

For the support of 14 HARQ processes, the solution to assign HARQ-ACK delays should aim to maximize the number of HARQ processes that can be scheduled in presence of non-BL/CE DL subframes and non-BL/CE UL subframes.

* Different percentages of presence of non-BL/CE subframes can be analyzed as to represent typical scenarios and determine which HARQ-ACK delays should be included.

## A1.3 List of agreements from RAN1 #104-e:

**Agreement**

The PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1):

* 2 BL/CE DL subframes.
* The PDSCH scheduling delay of 7 is expressed as:
  + 1 BL/CE DL subframe + 1 subframe + [3 subframes] + 1 subframe + 1 BL/CE DL subframe.
  + 1 subframe + [3 subframes] + 1 subframe + 2 BL/CE DL subframes.

**Agreement**

For the 14 HARQ processes feature, when PUCCH is used with 1 repetition and there is presence of non-BL/CE UL subframes (i.e., invalid UL subframes):

* The term surrounded by brackets in Solution 1 is resolved as 3 BL/CE UL subframes.

## A1.4 List of agreements from RAN1 #104-bis-e:

**Agreement**

In Rel-17, for the 14 HARQ processes feature, PUCCH repetition is not supported with HARQ-ACK bundling.

**Conclusion**

In Rel-17, the 14 HARQ processes feature is not supported when the multi-TB grant feature is enabled.

**R1-2103860** Feature Lead Summary [104b-e-LTE-Rel17\_NB\_IoT\_eMTC-02]: 2nd check point Moderator (Ericsson)

**Agreement**

In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be down-selected in RAN1#105-e from:

* Alt-1: The HARQ-ACK delay is determined through an expression consisting of different subframe types (Using a similar principle as the PDSCH scheduling delay).
  + FFS: The expression consisting of different subframe types.
  + FFS: Signaling Details.
* Alt-2: The HARQ-ACK delay is determined following the legacy approach. That is, the “HARQ-ACK delay” is kept expressed in terms of “absolute subframes”.
  + FFS: The percentage of presence of non-BL/CE DL subframes and non-BL/CE UL subframes to be handled.
  + FFS: HARQ-ACK delay values and length of the HARQ-ACK delay set.
  + FFS: Signaling Details.

The following aspects will be considered towards the down-selection of one of the two alternatives (i.e., Alt-1 or Alt-2) for the HARQ-ACK delay solution:

1. Total number of bits required in DCI
2. Scenarios that can be handled, including:

(a) different numbers of scheduled HARQ processes per burst (including dynamically switching between more than 10 HARQ processes and 10 or less HARQ processes)

(b) different % of invalid subframes for both 10 and 40 SF long bitmaps

1. Robustness against loss of DCIs
2. Flexibility
3. RRC signaling overhead

## A1.5 List of agreements from RAN1 #105-bis-e until Week 1:

**Agreement**

In Rel-17, for the 14 HARQ process feature the HARQ-ACK delay solution will be supported with multiple solutions: Alt-1 for full flexibility and Alt-2e for support of legacy delay

Alt-1: The HARQ-ACK delay is determined through an expression consisting of different subframe types (Using a similar principle as the PDSCH scheduling delay).

* + Without using more than 6 bits
  + FFS: How to minimize the overhead by using joint encoding

Alt-2: The HARQ-ACK delay is determined following the legacy approach. That is, the “HARQ-ACK delay” is kept expressed in terms of “absolute subframes”.

* + The HARQ-ACK delay values and the length of the HARQ-ACK delay set will be based on
    - Alt-2e: “3 bits (same as legacy)”
    - FFS: Whether HARQ delay set is to use range1 or range2

RRC signaling will be used to configure between Alt-1 and Alt-2e

FFS: Signaling details

FFS: Joint encoding