3GPP TSG-RAN WG1 Meeting #104-e R1-xxxxxxx

e-Meeting, January 25th – February 5th, 2021

Agenda Item: 8.9.2

Source: Moderator (Ericsson)

Title: Feature Lead Summary on [104-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] |

This feature lead summary (FLS) collects companies’ views as described in [2-7], classifies technical areas according with the contents in the contributions, and provides potential agreements.

Annex 1 contains the agreements reached in RAN1 #102-e [8], and RAN1 #103-e [9].

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

## 2.1 PDSCH scheduling delay

Background: In relation to the PDSCH scheduling delay solutions, in RAN1 #104-e the following agreement was reached [9]:

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

In line with the previously cited agreement, companies made the following proposals as described in [2-7]:

|  |  |
| --- | --- |
| **Company** | **Proposed “PDSCH Scheduling delay” solutions according with [2-7].** |
| **Huawei, HiSilicon [2]** | **Proposal 1: Configurable PDSCH scheduling delay is supported, with the range of scheduling delay from 2 to 34 BL/CE downlink subframes.** |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 1:** **When a PDSCH scheduling delay of 7 is signaled, the UE selects between one of the two subframe type sequences:**   * + **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.** |
| **ZTE [4]** | **Proposal 2: The indication of subframe types for the PDSCH scheduling delay of 7 are:**   * **Type 1: 1 BL/CE DL subframe + 1 subframe + 3 BL/CE UL subframes + 1 subframe + 1 BL/CE DL subframe**   **Type 2: 1 subframe + 3 BL/CE UL subframes + 1 subframe + 2 BL/CE DL subframes** |
| **Sierra Wireless [5]** | Proposal 2:  **When a PDSCH Delay of 7 is indicated, one of the two timings is used by the UE:**  **#1 - 1 BL/CE DL subframe + 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 1 BL/CE DL subframe.**  **#2 - 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 2 BL/CE DL subframes**  **FFS how UE determines which of the above to use (e.g. UE implementation, implicit, explicitly signaled)** |
| **Qualcomm Incorporated [6]** | **Proposal 1: For the indication of PDSCH scheduling delay, a DCI field indicates the PDSCH scheduling delay of a number of absolute subframes among *N* possible values, which are RRC configured.**   * **FFS whether the PDSCH scheduling delay is jointly encoded with the HARQ-ACK delay in the same DCI field.** |
| **Ericsson [7]** | Proposal 2: Down-select between the following two alternatives to determine the PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1) in presence of non-BL/CE DL subframes and non-BL/CE UL subframes when PUCCH is not postponed:  Alt 1: The PDSCH scheduling delays are:   * + - 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.   Alt 2: The PDSCH scheduling delays are:   * 2 BL/CE DL subframes. * 7 BL/CE DL subframes – *k* BL/CE DL subframes.   where, *k* = depends on the DL bitmap and refers to one integer value among different integer values in a given set. |

**Comment from the Feature Lead:** Before discussing the “PDSCH scheduling delay” solutions, one thing that has to be clear is that the presence of a non-BL/CE UL subframe (i.e., invalid UL subframe) does not cause a postponement of PUCCH if it uses 1 repetition. This clarification is important because e.g., [2], [4], assumed a postponement of PUCCH even though it uses 1 repetition, which should not be the case. Since there is no postponement of PUCCH when it uses 1 repetition, the solution that expresses the PDSCH scheduling delay of 7 in terms of different subframe types should for the term surrounded by brackets (i.e., “3 [BL/CE UL subframes]”) use absolute subframes (i.e., “3 subframes”), otherwise the term will introduce a postponement. Having said that, the potential agreement 1 list the potential solutions for down-selection, for the case in which there is presence of both non-BL/CE DL subframes and non-BL/CE UL subframes when PUCCH is not postponed (i.e., PUCCH repetitions = 1).

In potential agreement 1, Solution 1 reflects the proposals in [3], [4], [5] and [7], whereas the other proposed solutions rely on similar principle but still they were split into Solution 2 (Alt1: [6], Alt2: [2]) and Solution 3 [7].

**Potential Agreement 1:**

The PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1) in presence of non-BL/CE DL subframes and non-BL/CE UL subframes when PUCCH is not postponed, will be down-selected from among the following solutions:

Solution 1: The PDSCH scheduling delays are:

* + - 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.

Solution 2: The PDSCH scheduling delays are:

* Alt1: *x* subframes/Alt2: *x* BL/CE DL subframes

**where, *x* = is signalled (FFS: signalling details) and refers to one integer value among different integer values in a given set (FFS: The values and length of the set).**

Solution 3: The PDSCH scheduling delays are:

* 2 BL/CE DL subframes.
* 7 BL/CE DL subframes – *k* BL/CE DL subframes.

**where, *k* = is signalled (FFS: signalling details), depends on the DL bitmap and refers to one integer value among different integer values in a given set (FFS: The values and length of the set).**

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| **Company** | **Agree?** | **Comments** |
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## 2.2 Support of the PUCCH repetition case

Background: In relation to the support of the PUCCH repetition case, companies made the following observations and proposals as described in [2-7]:

|  |  |
| --- | --- |
| **Company** | **Support of the PUCCH repetition case according with [2-7].** |
| **Huawei, HiSilicon [2]** | **Proposal 3: The 14 HARQ processes feature is not supported in PUCCH repetition case.** |
| **Nokia, Nokia Shanghai Bell [3]** | **N/A** |
| **ZTE [4]** | ***Proposal 7: For 14-HARQ processes, there is no need to consider the case of PUCCH repetition.*** |
| **Sierra Wireless [5]** | Proposal 1: The 14 HARQ processes feature shall NOT be supported when PUCCH or PDSCH repeats are used. |
| **Qualcomm Incorporated [6]** | **Observation 2: Configurable delays (for PDSCH scheduling delay and HARQ-ACK delay) allow for increased flexibility in scheduling at the eNB side, and in dealing with a larger set of situations (e.g. measurement gaps, PUCCH repetition) without explicit handling in the specification** |
| **Ericsson [7]** | Proposal 3: Incorporate the PUCCH repetition case into the framework of the selected solution used to determine the PDSCH scheduling delay in presence of non-BL/CE subframes |

**Comment from the Feature Lead:** There is no clear majority, 3 companies do not want to support the PUCCH repetition case, 2 companies think that the case can be supported using the framework of the PUCCH non-repetition case, and 1 company stayed neutral.

**Recommendation 1: The Support of the PUCCH repetition case is discussed once the PDSCH scheduling delay solution has been down-selected.**

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| **Company** | **OK?** | **Comments** |
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## 2.3 HARQ-ACK delay

Background: In relation to the PDSCH scheduling delay solutions, in RAN1 #104-e the following agreement was reached [9]:

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

In line with the previously cited agreement, companies made the following observations and proposals as described in [2-7]:

|  |  |
| --- | --- |
| **Company** | **HARQ-ACK delay according with [2-7].** |
| **Huawei, HiSilicon [2]** | **Observation 3: Current HARQ-ACK delays are not enough to use all the BL/CE downlink subframes.** |
| **Nokia, Nokia Shanghai Bell [3]** | **Proposal 3: RAN1 support the use of joint encoded DCI fields for the 14-HARQ process support, to expand the range of delay and offset options.**  **FFS: Details of joint encoding.**  **“** **Using these 8 bits together, will allow a far wider range HARQ-process-ID, PDSCH-offset and HARQ-ACK delay permutations to be supported as illustrated by Table 5 below. With this wider range of HARQ-ACK delays, we can now include a HARQ-ACK delay value of “8”, which resolves the issues summarized by Observations 1 and 2”** |
| **ZTE [4]** | ***Proposal 5: For 14 HARQ processes,***   * ***The corresponding HARQ-ACK delay value range is 4~17 for PDSCH scheduling delay of 2.*** * ***The corresponding HARQ-ACK delay value range is 12~19 for PDSCH scheduling delay of 7.*** |
| **Sierra Wireless [5]** | “When no invalid SFs are configured, the above ranges of ACK delays is sufficient, but when invalid SF are configured the range needs to be expanded. The more invalid SFs that are configured, the more dynamic the range needs to be.”  Proposal 4: The Ack delay values for the *HARQ-ACK* field can be RRC configured.  **FFS: number of ranges and values in each range** |
| **Qualcomm Incorporated [6]** | **Proposal 2: For UEs configured with 14 HARQ processes, RAN1 to discuss whether to introduce new values of HARQ-ACK delays, or whether the values in Table 7.3.1-2 in TS 36.213 are sufficient.** |
| **Ericsson [7]** | Proposal 4: The “HARQ-ACK delay” field in DCI Format 6-1A is increased by 1-bit (i.e., to use 4 bits) as to include the legacy set of HARQ-ACK delay values, delay values equal to 13 and 15 needed for ideal scenarios, and six other delay values to be chosen depending on the assumed percentage of presence of non-BL/CE DL subframes and if PUCCH repetitions are supported or not. |

**Comment from the Feature Lead:** The legacy HARQ-ACK delays are {4, 5, 6, 7, 8, 9, 10, 11, 13}, whereas an ideal-scenario has been said to require {13 and 15}, since the handling of invalid subframes has been agreed to be supported, then additional values need to be added to the set. How many additional values are to be added depends on the assumed percentage of presence of invalid subframes and whether the handling of Measurement Gaps and PUCCH repetitions will be supported or not. On this matter, a theoretical analysis on the HARQ-ACK delay has been presented in [7] which can be used as a reference to visualize which delay values are foreseen to be the potential candidates to be added to the HARQ-ACK delay set. In Table 2, “HARQ #n is the farthest HARQ process to a given PUCCH”.

**Table 2: Presence in different percentages of invalid BL/CE DL subframes, invalid BL/CE UL subframes, PUCCH repetitions and their impact on the HARQ-ACK delay.**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | invalid DL subframe | 0 | 30% | 40% | 60% | 60% | 0 | 30% | 40% | 60% | 60% |
| invalid UL subframe | 0 | 20% | 20% | 0 | 60% | 0 | 20% | 20% | 0 | 60% |
| PUCCH repetition | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| Average HARQ-ACK delay for HARQ #n | HARQ-ACK bundle 0 | 13 | 18 | 21 | 30 | 31 | 13 | 18 | 21 | 30 | 31 |
| HARQ-ACK bundle 1 | 14 | 20 | 22 | 31 | 34 | 15 | 21 | 24 | 32 | 36 |
| HARQ-ACK bundle 2 | 15 | 20 | 23 | 32 | 36 | 17 | 23 | 26 | 34 | 41 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | invalid DL subframe | 0 | 30% | 40% | 60% | 60% | 0 | 30% | 40% | 60% | 60% |
| invalid UL subframe | 0 | 20% | 20% | 0 | 60% | 0 | 20% | 20% | 0 | 60% |
| PUCCH repetition | 4 | 4 | 4 | 4 | 4 | 8 | 8 | 8 | 8 | 8 |
| Average HARQ-ACK delay for HARQ #n | HARQ-ACK bundle 0 | 13 | 18 | 21 | 30 | 31 | 13 | 18 | 21 | 30 | 31 |
| HARQ-ACK bundle 1 | 17 | 23 | 26 | 34 | 41 | 21 | 28 | 31 | 38 | 51 |
| HARQ-ACK bundle 2 | 21 | 28 | 31 | 38 | 51 | 29 | 38 | 41 | 46 | 71 |

**Potential Agreement 2:**

**For the support of 14 HARQ processes, the “HARQ-ACK delay” set includes the legacy HARQ-ACK delay values (i.e., {4, 5, 6, 7, 8, 9, 10, 11, 13}), and *N* other delay values to be chosen depending on the assumed percentage of presence of non-BL/CE DL and UL subframes and if PUCCH repetitions and/or Measurement Gaps are supported or not (i.e., FFS: the length and values in the set *N*).**

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| **Company** | **Agree?** | **Comments (Please provide your views on how many and which values should compose the set of *N*)** |
|  |  |  |

## 2.4 Support of the measurement gap case

Background: In relation to the support of the measurement gap case, in RAN1 #103-e the following was noted [9]:

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| **For future meetings:**  Companies to further study on the impact of measurement gaps on the 14 HARQ processes feature. |

In [2-7], companies made the following observations and proposals in relation the support of the Measurement Gap case:

|  |  |
| --- | --- |
| **Company** | **Support of the Measurement gap case according with [2-7].** |
| **Huawei, HiSilicon [2]** | **N/A** |
| **Nokia, Nokia Shanghai Bell [3]** | **N/A** |
| **ZTE [4]** | **N/A** |
| **Sierra Wireless [5]** | **N/A** |
| **Qualcomm Incorporated [6]** | **Observation 2: Configurable delays (for PDSCH scheduling delay and HARQ-ACK delay) allow for increased flexibility in scheduling at the eNB side, and in dealing with a larger set of situations (e.g. measurement gaps, PUCCH repetition) without explicit handling in the specification.** |
| **Ericsson [7]** | Proposal 5: The support for handling the presence of measurement gaps is kept open until the PDSCH scheduling delays and HARQ-ACK delays solutions are selected.   * The handling of measurement gaps may be supported only if it can use the same framework as the selected solutions with minor updates (e.g., minor DCI impacts). |

**Comment from the Feature Lead:** The majority of companies have not expressed their views yet about the “further study on the impact of measurement gaps on the 14 HARQ processes feature”.

**Recommendation 2: The Support of the Measurement Gap case is discussed once the PDSCH scheduling delay solution has been down-selected.**

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| **Company** | **OK?** | **Comments** |
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## 2.5 Multi-TB grant

Background: In [5], it has been proposed that “The 14 HARQ processes feature shall be supported when the multi-TB grant feature is enabled”.

In [2-7], companies made the following observations and proposals in relation the support of the Measurement Gap case:

|  |  |
| --- | --- |
| **Company** | **Views on Multi-TB grant according with [2-7].** |
| **Huawei, HiSilicon [2]** | **N/A** |
| **Nokia, Nokia Shanghai Bell [3]** | **N/A** |
| **ZTE [4]** | **N/A** |
| **Sierra Wireless [5]** | **Proposal 5: The 14 HARQ processes feature shall be supported when the multi-TB grant feature is enabled.** |
| **Qualcomm Incorporated [6]** | **N/A** |
| **Ericsson [7]** | Observation 8: The support of 14 HARQ processes along with the Multi-TB grant seems to bring gains only to the Multi-TB grant feature by equalling its achievable peak data rate with respect to the one achieved by the 14 HARQ processes feature on its own.  Proposal 6: The support of the Multi-TB grant is kept open until the PDSCH scheduling delays and HARQ-ACK delays solutions are selected.   * Multi-TB grant may be supported only if it can use the same framework as the selected solutions with minor updates (e.g., with no or only minor DCI impacts). |

**Comment from the Feature Lead:** The majority of companies have not expressed their views on adding support for Multi-TB grant.

**Recommendation 3: Adding support for Multi-TB grant is discussed once the PDSCH scheduling delay solution has been down-selected.**

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| **Company** | **OK?** | **Comments** |
|  |  |  |

# 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. [R1-2100254](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100254.zip), “Support of 14-HARQ processes in DL for HD-FDD MTC UEs,” Huawei, HiSilicon, RAN1 #104-e, January 25th – February 5th, 2021.
3. [R1-2100508](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100508.zip), “Support of 14-HARQ processes in DL for eMTC,” Nokia, Nokia Shanghai Bell, RAN1 #104-e, January 25th – February 5th, 2021.
4. [R1-2100568](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100568.zip), “Support additional PDSCH scheduling delay for introduction of 14-HARQ processes in DL for eMTC,” ZTE, RAN1 #104-e, January 25th – February 5th, 2021.
5. [R1-2101325](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101325.zip), “Design considerations to support 14-HARQ Feature for LTE-M,” Sierra Wireless, S.A., RAN1 #104-e, January 25th – February 5th, 2021.
6. [R1-2101510](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101510.zip), “Support of 14 HARQ processes and scheduling delay,” Qualcomm Incorporated, RAN1 #104-e, January 25th – February 5th, 2021.
7. [R1-2101699](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101699.zip), “Support of 14 HARQ processes in DL in LTE-MTC,” Ericsson, AT&T, SoftBank, Telefónica, Verizon, RAN1 #104-e, January 25th – February 5th, 2021.
8. 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.
9. 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.

# 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.