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) continues from what was discussed and agreed until now in RAN1 #104-e, prioritizing the down-selection of the PDSCH scheduling delay solution since the decisions on other topics highly depend on its frameworks.

Annex 1 contains the agreements reached in RAN1 #102-e [8], RAN1 #103-e [9] and the agreement reached until now in RAN1# 104-e.

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

## 2.1 Down-selection of the PDSCH scheduling delay

Background: In RAN1 #104-e the following agreement was reached:

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| Agreement  The PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1) will be selected from one of 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). |

Below it is compared how Solution 1, Solution 2 (Alt1 and Alt2), and Solution 3 handle respectively the scenario discussed in RAN1#103-e having only presence of non-BL/CE DL subframes (i.e., invalid subframes), and one other scenario depicted in [7] which has the presence of non-BL/CE DL subframes, non-BL/CE UL subframes and Measurement Gaps.

* **Scenario 1: Presence of non-BL/CE DL subframes (i.e., invalid subframes)**

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| Non-BL/CE DL subframes are illustrated using “0”. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| subframe No | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| MPDCCH | 0 | 1 | 2 | 3 | 4 | 5 | 6 |  |  | 7 | 8 | 9 | 10 | 11 |  |  |  |  |  | 0 | 1 | 2 |
| PDSCH | 12 | 13 | 0 | 1 | 2 | 3 | 4 |  |  | 5 | 6 | 7 | 8 | 9 |  |  |  |  |  | 10 | 11 | 0 |
| ACK/NACK (Bundling)  0: (12, 13, 0, 1)  1: (2, 3, 4, 5)  2: (6, 7, 8, 9) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0 | 1 | 2 |  |  |  |  |

* **Scenario 2: Presence of non-BL/CE DL subframes, non-BL/CE UL subframes and Measurement Gaps**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| MGL |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Non-BL/CE UL subframes are illustrated using “0”. | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| Non-BL/CE DL subframes are illustrated using “0”. | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| subframe No | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| MPDCCH | 0 | 1 | 2 |  |  | 3 | 4 | 5 | 6 |  | 7 | 8 | 9 |  |  | 10 |
| PDSCH |  |  | 0 |  |  | 1 | 2 | 3 | 4 |  | 5 | 6 | 7 |  |  | 8 |
| ACK/NACK |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

The time progression of the diagram continues below

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| MGL | MGL+1 subframes with no UL transmission | | | | | | |  |  |  |  |  |  |  |  |
|  | Measurement Gap Length | | | | | |  |  |  |  |  |  |  |  |  |
| Non-BL/CE UL subframes are illustrated using “0”. | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| Non-BL/CE DL subframes are illustrated using “0”. | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| subframe No | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| MPDCCH |  |  |  |  |  |  | 11 |  |  |  |  |  | 0 |  | 1 |
| PDSCH |  |  |  |  |  |  | 9 |  |  |  |  |  | 10 |  | 11 |
| ACK/NACK |  |  |  |  |  |  |  |  | 0 | 1 | 2 |  |  |  |  |

Comparison of the PDSCH Scheduling delay solutions, when PUCCH uses 1 repetition and the presence of a non-BL/CE UL subframe (i.e., invalid UL subframe) does not cause a postponement:

**Table 1: Comparison of the PDSCH Scheduling delay solutions**

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|  | Solution 1 |
| General description | 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. |
| Comparison | As in RAN1#103-e, for illustration purposes we will focus on HARQ-Process # 10 which is in subframe No 12 for Scenario 1, and in subframe No 15 for Scenario 2. |
| * Scenario 1: As illustrated in RAN1 #103-e, focusing on HARQ-Process # 10, if we count the delay of 7 using 1 BL/CE DL subframe + 1 subframe + 3 subframes + 1 subframe + 1 BL/CE DL subframe, this take us to have the PDSCH corresponding to HARQ process #10 scheduled on subframe No 19. Please note, that due that Scenario 1 does not have presence of non-BL/CE UL subframes (i.e., invalid UL subframes), on the terms surrounded by brackets we could have used either “3 subframes” or “3 BL/CE UL subframes”. * Scenario 2: Solution 1 cannot handle this scenario because none of its equations used to describe the delay of 7 match what is required by Scenario 2. |
| Number of bits that are foreseen to be required to indicate the PDSCH scheduling delay | * DCI bits: 2-bits   For example:  PDSCH scheduling delay:  00 → 2 BL/CE DL subframes.  01 → 1 BL/CE DL subframe + 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 1 BL/CE DL subframe.  10 → 1 subframe + 3 [BL/CE UL subframes] + 1 subframe + 2 BL/CE DL subframes.  11 → Not used/Reserved.   * RRC bits: None   Note: Solution 1 can handle the presence of non-BL/CE DL subframes, and the presence of non-BL/CE UL subframes applying on the terms surrounded by brackets either “3 subframes” or “3 BL/CE UL subframes” depending on whether the no postponement rule when PUCCH uses 1 repetition is followed or not.  **Total:**  2-bits in DCI  None in RRC |

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|  | Solution 2: Alt1 | Solution 2: Alt2 | Solution 3 |
| Assuming all three solutions use a 3-bit set from which the configurable variable takes its value. | | |
| General description | The PDSCH scheduling delays are:   * *x* subframes   where, *x* = e.g., {2, 3, 4, 5, 6, 7, 8, 9}. | The PDSCH scheduling delays are:   * *x* BL/CE DL subframes   where, *x* = e.g., {2, 3, 4, 5, 6, 7, 8, 9}. | The PDSCH scheduling delays are:   * *2* BL/CE DL subframes * *7* BL/CE DL subframes - *k* BL/CE DL subframes   where, *k* = e.g., {-3, -2, -1, 0, 1, 2, 3, 4}. |
| Comparison | As in RAN1#103-e, for illustration purposes we will focus on HARQ-Process # 10 which is in subframe No 12 for Scenario 1, and in subframe No 15 for Scenario 2. | | |
| * Scenario 1: Requires a PDSCH scheduling delay of 7 subframes as to avoid an unnecessary waste of subframes (NOTE: If the PDSCH scheduling delay is given in terms of absolute subframes longer delays are needed), Solution 2 Alt1 can handle it with *x* = 7 as to directly signal 7 subframes. * Scenario 2: Requires a PDSCH scheduling delay of 13 subframes as to avoid an unnecessary waste of subframes (NOTE: If the PDSCH scheduling delay is given in terms of absolute subframes longer delays are needed), Solution 2 Alt-1 cannot handle Scenario 2 with a 3-bit set since the largest value that *x* can take is 9. Please note that values in the set of *x* start from 2 since this is the minimum delay that must be signaled. | * Scenario 1: Requires a PDSCH scheduling delay of 5 BL/CE DL subframes as to avoid an unnecessary waste of subframes, Solution 2 Alt2 can handle it with *x* = 5 as to directly signal 5 BL/CE DL subframes. * Scenario 2: Requires a PDSCH scheduling delay of 10 BL/CE DL subframes as to avoid an unnecessary waste of subframes, Solution 2 Alt2 cannot handle it with a 3-bit set since the largest value that *x* can take is 9. Please note that values in the set of *x* start from 2 since this is the minimum delay that must be signaled. | * Scenario 1: Requires a PDSCH scheduling delay of 5 BL/CE DL subframes as to avoid an unnecessary waste of subframes, Solution 3 can handle it with *k* = 2, since  7 BL/CE DL subframes – 2 BL/CE DL subframes = 5 BL/CE DL subframes. * Scenario 2: Requires a PDSCH scheduling delay of 10 BL/CE DL subframes as to avoid an unnecessary waste of subframes, Solution 3 can handle it with *k* = -3, since 7 BL/CE DL subframes + 3 BL/CE DL subframes = 10 BL/CE DL subframes. |
| Number of bits that are foreseen to be required to indicate the PDSCH scheduling delay | * DCI bits: 3-bits or more   For example:  PDSCH scheduling delay:  000 → 2 subframes  001 → 3 subframes  010 → 4 subframes  011 → 5 subframes  100 → 6 subframes  101 → 7 subframes  110 → 8 subframes  111 → 9 subframes  Note: The support of a large enough set of delay values makes possible to handle a number of scenarios.  Note 2: Recall that Solution 2 Alt-1 cannot handle Scenario 2 with a 3-bit set.   * RRC bits: None   **Total:**  4-bits (To handle Scenario 2) or more in DCI  None in RRC. | * DCI bits: 3-bits or more   For example:  PDSCH scheduling delay:  000 → 2 BL/CE DL subframes  001 → 3 BL/CE DL subframes  010 → 4 BL/CE DL subframes  011 → 5 BL/CE DL subframes  100 → 6 BL/CE DL subframes  101 → 7 BL/CE DL subframes  110 → 8 BL/CE DL subframes  111 → 9 BL/CE DL subframes  Note: The support of a large enough set of delay values makes possible to handle a number of scenarios.  Note 2: Recall that Solution 2 Alt-2 cannot handle Scenario 2 with a 3-bit set.   * RRC bits: None   **Total:**  4-bits (To handle Scenario 2) or more in DCI  None in RRC. | * DCI bits: 1-bit or 2-bits   1-bit example:  PDSCH scheduling delay:  0 → 2 BL/CE DL subframes.  1 → *7* BL/CE DL subframes - *k* BL/CE DL subframes  2-bits example (For saving signaling reconfiguration in the most complex scenarios which may require two values of *k*, *k1* and *k1* are obtained from the same set and re-configured when needed via RRC signaling):  PDSCH scheduling delay:  00 → 2 BL/CE DL subframes.  01 → *7* BL/CE DL subframes - *k1* BL/CE DL subframes  10 → *7* BL/CE DL subframes - *k2* BL/CE DL subframes  11 → Reserved   * RRC bits: e.g., 3-bits or more   For example:  *k* = e.g., {-3, -2, -1, 0, 1, 2, 3, 4}.  Note: The support of a large enough set of delay values makes possible to handle a number of scenarios.  Note 2: Solution 3 can handle Scenario 2 with a 3-bit set.  **Total:**  1 or 2-bits in DCI  3 or more bits in RRC. |

**Comment from the Feature Lead:** From the analysis in Table 1, the preliminary conclusion is as follows:

* If the PDSCH scheduling delay solution is intended to only handle the presence of non-BL/CE DL subframes and non-BL/CE UL subframes, then Solution 1 seems to be the best choice since it was tailored-made for it and it only requires 2-bits in DCI.
* If the PDSCH scheduling delay solution is intended to handle a number of scenarios (e.g., non-BL/CE DL subframes, non-BL/CE UL subframes and Measurement Gaps) as a function of length of the set from which the configurable variable is picked-up, then Solution 2 and Solution 3 seem to be better choices. Between Solution 2 Alt1 and Solution 2 Alt2, Alt1 will require longer delays and the length of the set will be longer than the one required for Alt2 to provide the same result, hence Solution 2 Alt2 would be preferred. Solution Alt2 and Solution 3 are similar, but it seems that because of the use of RRC signaling Solution 3 will require less bits in DCI than Solution Alt2.

**Potential Agreement 1:**

**For the support of 14 HARQ processes, the PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1) is determined according with Solution [].**

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| **Company** | **Solution []?** | **Comments** |
| Lenovo,MotoM | Solution 2: Alt 2  Solution 3(?) | The solutions seems more clear now.  For solution 1, as moderator mentioned, save the DCI size but only handle limited/ideal scenarios.  For solution 2 (Alt 2) and solution 3, they are very similar. If solution 3 can directly use K BL/CE DL subframes, it can be our preference.  e.g., eNB RRC-configure one of the delay set from {set 1:{2 6 7 8}, set 2{2 5 7 9}, set 3(2, x,x,x)....... } based on the DL-UL valid subframe configuration, DCI use 2 bit to select one of the scheduling delay. We need to cover the most scenarios not all cases, so 2-bit scheduing delay field in DCI is enough. |
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# 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.

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

Agreement

The PDSCH scheduling delay for the PUCCH non-repetition case (i.e., PUCCH repetitions = 1) will be selected from one of 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).