**3GPP TSG RAN WG1 #104b-e R1-210xxxx**

**e-Meeting, April 12th – 20th, 2021**

**Agenda Item:** 7.2.5

**Source:** Moderator (LG Electronics)

**Title:** Feature lead summary on other aspects for URLLC/IIoT

**Document for:** Discussion and decision

# Introduction

This document summarizes the topics under AI 7.2.5 based on the contributions submitted to this AI [1-6], especially for related to other aspects for URLLC//IIOT, and provides FL recommendation to organize the subsequent email discussions.

# Issues in RAN1#104b-e

* 1. Issue #1 SPS PDSCH release and SPS receptions with slot aggregation

Issue #1 is already treated as issue #3 in the last meeting. From that discussion, it has been identified that companies had different understanding on how UE handles SPS release and SPS PDSCH reception in the same slot. Since there is no explicit agreement for all number of cases, it could be natural situation. However, current situation is definitely not desirable.

In [1-4,6], companies’ contributions share views on how UE handles SPS release and SPS PDSCH reception with/without slot-aggregation.

Proposals from contributions

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| From [1]:  ***Proposal 1: Do not support the case that SPS release PDCCH is received in a slot where SPS PDSCH is configured to be received for the same SPS configuration corresponding to the SPS release PDCCH if the HARQ-ACK for the SPS release and the SPS reception mapping to different PUCCHs.***  ***Proposal 2: If repetition is configured for SPS PDSCH, the UE can receive SPS release only before the end of the SPS PDSCH in the first slot among all the repetitions and the timeline for single-slot SPS PDSCH is applied in the slot.***  From [2]:  **Observation 2 Existing specification supports HARQ-ACK codebook construction for the cases where HARQ-ACKs for the SPS release and the SPS reception map to different PUCCHs.**  **Proposal 2 Conclude that: when HARQ-ACKs for the SPS release and the SPS PDSCH reception do not map to the same PUCCH, the existing specification supports the SPS release and its HARQ-ACK, regardless of the relative timing between the SPS release PDCCH and the SPS PDSCH in the slot.**  **Proposal 3 Conclude that: if HARQ-ACK for SPS PDSCH is mapped to a slot (or sub-slot) later than the slot (or sub-slot) of HARQ-ACK for its SPS release, the HARQ-ACK for such SPS PDSCH is not to be transmitted in the HARQ-ACK codebook.**  From [3]:  ***Observation 1: For releasing a SPS PDSCH with configured with pdsch-AggregationFactor,*** ***it may not be feasible to ensure same-PUCCH mapping when the SPS PDSCH release needs to be transmitted in the same slot as the first SPS PDSCH repetition.***  **Proposal 1: Support the case that SPS release PDCCH is received in a slot where SPS PDSCH is configured to be received for the same SPS configuration corresponding to the SPS release PDCCH if the HARQ-ACK for the SPS release and the SPS reception map to different PUCCHs.**   * **The UE behaviour/operation is similar as for the same-PUCCH case:**   + **The gNB is not expected to transmit the SPS PDSCH**   + **UE does not receive the SPS PDSCH nor generates HARQ-ACK feedback for SPS PDSCH reception**   + **UE reports HARQ-ACK for SPS release on the PUCCH indicated in the SPS release DCI.**   **If this is not to be supported, changes to TS 38.213 specifications are needed to preclude this case.**  **Proposal 2: In case of SPS PDSCH repetitions, support behaviour 2 (discussed in [104-e-NR-L1enh-URLLC-05]) where UE can only receive SPS release no later than the end of the first corresponding SPS PDSCH occasion.**   * **UE does not receive the SPS PDSCH nor generates HARQ-ACK feedback information for SPS PDSCH reception**   **Note that this is conditioned on also supporting SPS PDSCH reception and SPS release on different PUCCHs**  **Proposal 3: If SPS release to come after the SPS PDSCH in the same slot is to be supported, and the HARQ-ACK feedback of the SPS release and SPS PDSCH are mapped to different PUCCH, then the following UE behaviour could be specified:**   * **The gNB should transmit the SPS PDSCH, and the UE receives the SPS PDSCH and provides the corresponding HARQ-ACK feedback information on the PUCCH corresponding to the SPS PDSCH reception.** * **The UE sends the HARQ-ACK for the SPS release in the indicated PUCCH.**   From [4]:  **Proposal 1: SPS PDSCH and SPS release in the same DL slot mapped to different HARQ-ACK PUCCHs is not supported.**   1. **With (1), how to handle the case of SPS PDSCH repetition**   There is no motivation to send a release DCI in the subsequent slot(s) when slot aggregation is configured for SPS. If it is allowed, then if the release DCI is sent in the subsequent slot(s) of SPS repetition, UE still needs to decode the previous SPS PDSCH repetitions, both HARQ-ACK for SPS release and SPS PDSCH would be mapped to the same HARQ-ACK bit. In this case, if UE missed the release DCI but correctly decoded the SPS PDSCH, UE would send ACK to the gNB and gNB may think that release DCI is correctly received by the UE. A smart gNB would never do such scheduling. Thus, we think it can be avoided by gNB, we are open for specification change to preclude it. We are also fine with no specification change since the UE behaviour is not clear, it should be understood that gNB should not do that.  From [6]:  **Proposal 1: It is not supported that SPS PDSCH and SPS release in the same DL slot mapped to different HARQ-ACK PUCCH in Rel-16**  **Proposal 2: For SPS PDSCH with slot-aggregation, same principle as SPS PDSCH without slot-aggregation are applied. (UE behavior 2)** |

There is another proposal on SPS PDSCH release not supported. According to [2], the described SPS release in the agreement below is not supported but not yet captured in the specification.

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| **Agreement (RAN1#101e)**  It is not supported that a SPS release PDCCH in a slot is received after the end of the SPS PDSCH reception in the slot for the same SPS configuration corresponding to the SPS release PDCCH if HARQ-ACKs for the SPS release and the SPS reception would map to the same PUCCH.   * FFS: if HARQ-ACKs for the SPS release and the SPS reception mapping to different PUCCHs |

Text proposal and from [2]

**Proposal 1 Adopt the text proposal to capture the agreement on SPS release that is not supported.**

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| ---------------------------------Start of Text Proposal to TS 38.213 v16.5.0----------------------- 9.1 HARQ-ACK codebook determination ...  If a UE is configured to receive SPS PDSCHs in a slot for SPS configurations that are indicated to be released by a DCI format, and if the UE receives the PDCCH providing the DCI format in the slot where the end of a last symbol of the PDCCH reception is not after the end of a last symbol of any of the SPS PDSCH receptions, and if HARQ-ACK information for the SPS PDSCH release and the SPS PDSCH receptions would be multiplexed in a same PUCCH, the UE does not expect to receive the SPS PDSCHs, does not generate HARQ-ACK information for the SPS PDSCH receptions, and generates a HARQ-ACK information bit for the SPS PDSCH release.  < Unchanged parts are omitted >  If a UE is configured to receive SPS PDSCH(s) in a slot for SPS configuration(s), the UE does not expect to receive a PDCCH providing a DCI format in the slot to indicate SPS PDSCH release of the these SPS configuration(s), where the end of a last symbol of the PDCCH reception is after the end of a last symbol of any of the SPS PDSCH reception(s), if HARQ-ACK information for the SPS PDSCH release and the SPS PDSCH receptions would be multiplexed in a same PUCCH.  < Unchanged parts are omitted >  --------------------------------- End of Text Proposal to TS 38.213 v16.5.0----------------------- |

**From FL:**

This issue has been discussed for a long time. It is clear that we should finalize this issue until this meeting.

**FL recommendation: Discuss issue #1**

* 1. Issue #2 PUCCH resource for SPS PDSCH HARQ-ACK and CSI

In [4], the issues of PUCCH resource for SPS PDSCH HARQ-ACK and CSI was raised and related text proposal is also provided. In short, the proposal is to modify description on PUCCH resource selection in order to include the case of multiple SPS configuration.

In [5], there is also proposal related to multiplexing of CSI and HARQ-ACK of more than one SPS PDSCH.

From [4]:

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| In NR Rel-15, there is only 1-bit HARQ-ACK for SPS PDSCH, and only one PUCCH of format 0/1 is configured for the HARQ-ACK transmission, so when the PUCCH overlaps with a CSI PUCCH, the HARQ-ACK will be multiplexed on CSI PUCCH resources. In NR Rel-16, there can be multiple HARQ-ACK bits for SPS PDSCHs and a UE can be configured with up to 4 PUCCH resources with larger capacity for the HARQ-ACK transmission. The issue of overlapping between multiple HARQ-ACK bits and CSI reports has not been discussed before. Some companies suggested that if the UE is provided *SPS-PUCCH-AN-List,* UE multiplexes the SPS HARQ-ACK and CSI on one of the PUCCH resources configured by *SPS-PUCCH-AN-List* to avoid unnecessary CSI dropping or low coding rate. Some companies thought the current specification can cover the case of multiple HARQ-ACK bits. The current specification for multiplexing of SPS HARQ-ACK and CSI is captured as following:   |  | | --- | | If a UE has one or more CSI reports and zero or more HARQ-ACK/SR information bits to transmit in a PUCCH where the HARQ-ACK, if any, is in response to a PDSCH reception without a corresponding PDCCH  - if any of the CSI reports are overlapping and the UE is provided by *multi-CSI-PUCCH-ResourceList* with  PUCCH resources in a slot, for PUCCH format 2 and/or PUCCH format 3 and/or PUCCH format 4, as described in Clause 9.2.1, where the resources are indexed according to an ascending order for the product of a number of corresponding REs, modulation order , and configured code rate ;  - if , the UE uses PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  - else if  and , , the UE transmits a PUCCH conveying HARQ-ACK information, SR and CSI report(s) in a respective PUCCH where the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  - else the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  and the UE selects  CSI report(s) for transmission together with HARQ-ACK information and SR, when any, in ascending priority value as described in [6, TS 38.214]  - else, the UE transmits the  bits in a PUCCH resource provided by *pucch-CSI-ResourceList* and determined as described in Clause 9.2.5 |   Note that the current specification is captured as “the HARQ-ACK, if any, is in response to a PDSCH reception without a corresponding PDCCH”, it is more like to cover the case of 1-bit SPS HARQ-ACK only.  Therefore, we have following proposal to cover the case of multiplexing SPS HARQ-ACK and CSI on the resource of CSI regardless of number of SPS HARQ-ACK.  **Proposal 2: Adopt the following text proposal for PUCCH resource for SPS HARQ-ACK and CSI in 38.213.**  -------------------------------------------------- Start of text proposal ------------------------------------------------------  9.2.5.2 UE procedure for multiplexing HARQ-ACK/SR/CSI in a PUCCH  \*\*\* Unchanged text is omitted \*\*\*  If a UE has one or more CSI reports and zero or more HARQ-ACK/SR information bits to transmit in a PUCCH where each of the HARQ-ACK(s), if any, is in response to a PDSCH reception without a corresponding PDCCH  - if any of the CSI reports are overlapping and the UE is provided by *multi-CSI-PUCCH-ResourceList* with  PUCCH resources in a slot, for PUCCH format 2 and/or PUCCH format 3 and/or PUCCH format 4, as described in Clause 9.2.1, where the resources are indexed according to an ascending order for the product of a number of corresponding REs, modulation order , and configured code rate ;  - if , the UE uses PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  - else if  and , , the UE transmits a PUCCH conveying HARQ-ACK information, SR and CSI report(s) in a respective PUCCH where the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  - else the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  and the UE selects  CSI report(s) for transmission together with HARQ-ACK information and SR, when any, in ascending priority value as described in [6, TS 38.214]  - else, the UE transmits the  bits in a PUCCH resource provided by *pucch-CSI-ResourceList* and determined as described in Clause 9.2.5  \*\*\* Unchanged text is omitted \*\*\*  ----------------------------------------------------- End of text proposal ------------------------------------------------------ |

From [4]:

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| **Proposal 1: The CSI PUCCH resource is used for multiplexing of CSI and HARQ-ACK of more than one SPS PDSCH. Adopt the following TP.**   |  | | --- | | TS 38.213  9.2.5.2 UE procedure for multiplexing HARQ-ACK/SR/CSI in a PUCCH  …  If a UE has one or more CSI reports and zero or more HARQ-ACK/SR information bits to transmit in a PUCCH where the HARQ-ACK, if any, is in response to PDSCH reception(s) without corresponding PDCCH(s)  - if any of the CSI reports are overlapping and the UE is provided by *multi-CSI-PUCCH-ResourceList* with  PUCCH resources in a slot, for PUCCH format 2 and/or PUCCH format 3 and/or PUCCH format 4, as described in Clause 9.2.1, where the resources are indexed according to an ascending order for the product of a number of corresponding REs, modulation order , and configured code rate ;  - if , the UE uses PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  - else if  and , , the UE transmits a PUCCH conveying HARQ-ACK information, SR and CSI report(s) in a respective PUCCH where the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  - else the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  and the UE selects  CSI report(s) for transmission together with HARQ-ACK information and SR, when any, in ascending priority value as described in [6, TS 38.214]  - else, the UE transmits the  bits in a PUCCH resource provided by *pucch-CSI-ResourceList* and determined as described in Clause 9.2.5  … | |

**From FL:**

If we recall the discussion in the last meeting, it is necessary to fix this issue. The description of PUCCH resource selection has been changed by this AI, it is definitely something we had to do before. Any clarification for multiple SPS configuration seems necessary.

**FL recommendation: Discuss issue #2**

* 1. Issue #3 CSI-PUCCH-ResourceList where SPS HARQ-ACK multiplexed

In [5], an issue related to multiplexing with CSI PUCCH resource has been raised. The=

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| Another issue for multiplexing of CSI and HARQ-ACK of SPS PDSCHs is the configuration of the 2 PUCCH resources in CSI-PUCCH-ResourceList. Figure 1 gives an example to illustrate this issue. CSI PUCCH #0 and CSI PUCCH #1 are configured in CSI-PUCCH-ResourceList and they are configured in sub-slot 0 and sub-slot 1, respectively. CSI PUCCH #0 is used to transmit CSI and it overlaps with HARQ-ACK PUCCH #0. CSI and HARQ-ACK should be multiplexed on a CSI PUCCH resource, in this case, if CSI PUCCH #0 cannot ensure the reliability of UCI, CSI PUCCH #1 will be used as the result PUCCH. In this case, HARQ-ACK in different sub-slot will be multiplexed on a same PUCCH. This case is not specified regarding HARQ-ACK codebook generation. Further, there might be latency issue for the HARQ-ACK in sub-slot 0 if it is multiplexed on CSI PUCCH #1. To avoid this situation, the PUCCH resources in CSI-PUCCH-ResourceList should be configured within a same sub-slot.    Figure 1  ***Proposal 2: The PUCCH resources in CSI-PUCCH-ResourceList should be configured within a same sub-slot. Adopt the following TP.***   |  | | --- | | TS 38.213  **9 UE procedure for reporting control information**  …  If a UE is provided two *PUCCH-Config*  - if the UE is provided *subslotLengthForPUCCH* in the first *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 0 or any CSI report configuration in any *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the first *PUCCH-Config*, if the UE is provided by *multi-CSI-PUCCH-ResourceList*, PUCCH resources in *multi-CSI-PUCCH-ResourceList* should be configured within the same *subslotLengthForPUCCH* symbols.  - if the UE is provided *subslotLengthForPUCCH* in the second *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 1 in any *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the second *PUCCH-Config*  … | |

**From FL:**

In this issue, the reason of problem is that sub-slot PUCCH resource are managed as resource in slot level. According to [5], PUCCH for HARQ-ACK could be multiplexed across sub-slot, which is not our design principle of sub-slot. In this sense, it seems related to both AI, Others and UCI multiplexing. It would be good to discuss first which AI will handle this issue.

**FL recommendation: Discuss which AI will handle this issue in preparation phase.**

# References

1. R1-2102349, Remaining issues on SPS enhancements, Huawei, HiSilicon, SIA
2. R1-2102743, Miscellaneous Issues for Rel-16 NR URLLC, Ericsson
3. R1-2102823, Maintenance of Rel-16 URLLC SPS enhancements Nokia, Nokia Shanghai Bell
4. R1-2102945, Maintenance on SPS enhancements, vivo
5. R1-2103216, Maintanence on SPS PDSCH, Samsung
6. R1-2103338, Remaining issues of other aspects for URLLC/IIOT, LG Electronics