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

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

**Agenda Item:** 7.2.5

**Source:** Moderator (LG Electronics)

**Title:** Summary #1 of [104b-e-NR-L1enh-URLLC-05] on other aspects for URLLC and IIoT

**Document for:** Discussion and decision

# Introduction

According to discussion at the preparation phase, the following email thread is allocated by Chairman for further discussion:

[104b-e-NR-L1enh-URLLC-05] Email discussion/approval on remaining issues on SPS enhancements – Duckhyun (LG):

* Issue #1: SPS PDSCH release and SPS receptions with slot aggregation
* Issue #2: PUCCH resource for SPS PDSCH HARQ-ACK and CSI
* Issue #3: CSI-PUCCH-ResourceList where SPS HARQ-ACK multiplexed
* Discussion/decision by April 15 and TP(s) by April 20

To address the identified issues of the above email thread, suggestions and questions for the issues are provided in Section 2. In section [3 and 4], the outcome from [104b-e-NR-L1enh-URLLC-05] are provided including all the agreements and all the endorsed TPs.

Other submitted issues are listed up in the summary in preparation phase [7]. It would be appreciated that companies can provide input/feedback in the next meeting in order to facilitate the discussion.

# 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. Detailed roposals from companies’ contribution can be found in [7]

From contributions and the summary of the last discussion, it has been suggested to discuss on whether to support **“the case that SPS release is received in a slot where SPS PDSCH is configured to be received for the SPS configuration corresponding to the SPS release if the HARQ-ACK for the SPS release and the SPS reception mapping to different PUCCHs”** of single SPS configuration first. This case will be referred to as "**different PUCCH case**" for convenience. As pointed out by a few contributions, it is true that the proposal to support different PUCCH case was discussed in RAN1#102-e, however, there was no outcome for this issue. At least, it can imply that we need any kind of agreements in order to support different PUCCH case. On the other hand, current specification text seems not preclude different PUCCH case explicitly. Either way could have impacts on UE implementation and specification.

Since there is no strong majority view, It would be necessary to collect more views on this before to make proposal from FL as a first step. Here is a summary of contributions and Question for the discussion.

* **Alt. 1: Support “different PUCCH case”**
	+ Existing specification doesn’t support “different PUCCH case” since there is no clear UE behavior.
	+ Different PUCCH case are not aligned with 38.321. [1]
		- Based on the description in 38.321, when the UE receives the SPS release, it clears the SPS PDSCH assignment, which means that the UE is not required anymore to receive SPS PDSCH with the same SPS configuration corresponding to the SPS release PDCCH. As the UE is not required to receive the SPS PDSCH, it makes no sense to send the HARQ-ACK for this SPS PDSCH in a different PUCCH.
	+ It would make additional discussion on UE behavior following the case [4]
	+ There is no necessity to support the case [1, 4]
	+ It could have UE implementation impact [6]
* **Alt. 1: Do not support “different PUCCH case”**
	+ Existing specification already supports different PUCCH case so that no specification changes are necessary.[2]
	+ There is no misalignment issue if UE doesn’t does not generate HARQ-ACK information for corresponding SPS PDSCH receptions where SPS release is received not after the end of a last symbol of any of the SPS PDSCH receptions[2]
		- This feature doesn’t require nor significant specification effort nor resulting in different UE operation or additional UE complexity [3]
	+ Easier to cover the case with slot-aggregation. [3]

**Questions from FL:**

Q1: Except for the above, are there any more discussion point for this issue?

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According to summary above, it is common understanding that we should aim less impact on UE and specification. Ambiguous text on specification is quite critical and no UE implementation impact should be desired at this late stage. At glance, either way cannot avoid adding text to specification to make specification crystal clear. On the other hands, from the summary, companies seem having different opinions on impact on UE behavior.

Q2: Between two alternatives, which alternatives has less impact on UE behavior and its implementation?

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Q3: If different PUCCH case are not supported (Alt. 1), what are specification impacts envisioned? (Especially except for impacts from precluding different PUCCH case)

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Q4: If different PUCCH case are supported (Alt. 2), what is proper UE behavior when SPS release is received not after the end of a last symbol of any of the SPS PDSCH receptions? And what would be specification impact by the proper UE behavior? (Especially for HARQ-ACK generation for the SPS PDSCH receptions)

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Q5: Please share any other views on this issue, in any.

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

Q6: Companies please indicate if you support the intention of the TP. It would be appreciate if you provide your views with detailed reason.

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* 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:

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| 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.**

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| 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 … |

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**From FL:**

The intention of TP seems clear, also there seems no big difference between two TPs. I tried to modify two TP to have similar expression of other parts in 9.2.5.2. Please check TP below.

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| 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(s), if any, are in response to PDSCH reception(s) 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 … |

Proposal 2-1 from FL: Take TP above to solve issue #2

**Companies please indicate if you support the intention of the TP. Please also share your suggestion on text, if any, with detailed reason.**

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* 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.

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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 |

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. Proposal in [5] are to limit the PUCCH resources in CSI-PUCCH-ResourceList into one sub-slot. To solve this problem and to align with our principle, it should be ensured that PUCCHs that overlap in time in a sub-slot should multiplexed into a PUCCH transmission in the same sub-slot. It would be good to have straight solution as long as possible.

Proposal 3-1 from FL: UE does not expect to transmit a PUCCH in a sub-slot where the PUCCH is a result of UL multiplexing among PUCCHs in a different sub-slot.

**Companies please indicate if you support the intention of the TP. Please also share your suggestion on text, if any, with detailed reason.**

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One thing related to this issue is current specification text on PUCCH resource for HARQ-ACK. According to the text below, UE take different interpretation of *startingSymbolIndex* in *PUCCH-resource* if HARQ-ACK information bit are multiplexed in the PUCCH resource.

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| **From TS 38.213 Section 9:**If a UE is provided *subslotLengthForPUCCH* in a *PUCCH-Config*, the first symbol of a PUCCH resource in *PUCCH-Config* for multiplexing HARQ-ACK in a PUCCH transmission is relative to the first symbol of the *subslotLengthForPUCCH* symbols [12, TS 38.331]. For the remaining cases, the first symbol of a PUCCH resource is relative to the first symbol of a slot with $N\_{sym}^{slot}$ symbols [4, TS 38.211].  |

Q1: if HARQ-ACK information bit are multiplexed in a PUCCH resource in *multi-CSI-PUCCH-ResourceList*, above specification is also applied to the PUCCH in *multi-CSI-PUCCH-ResourceList*?

**Please indicate your views in the table below. It would be appreciate if you provide your views with detailed reason.**

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# Final outcome from [104b-e-NR-L1enh-URLLC-05]

From the discussion in [104b-e-NR-L1enh-URLLC-05],

# Text proposals

From the discussion in [104b-e-NR-L1enh-URLLC-05], following has been agreed:

# 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
7. R1-210xxxx, Feature lead summary on other aspects for URLLC and IIoT, Moderator (LG Electronics)