3GPP TSG RAN WG1 #107-e R1-210XXXX

e-Meeting, November 11th – 19th, 2021

**Agenda item: 7.2.5**

**Source: Moderator (Nokia)**

**Title:** **[107-e-NR-L1enh-URLLC-06] Discussion on PUCCH multiplexing with SPS HARQ-ACK within a sub-slot**

**Document for: Discussion and Decision**

# Introduction

This document is created to facilitate the email discussion of

* [107-e-NR-L1enh-URLLC-06] Discussion on PUCCH multiplexing with SPS HARQ-ACK within a sub-slot by Nov 17 - Klaus (Nokia)

This email thread is triggered by the following discussion documents.

1. [R1-2111187](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_107-e/Docs/R1-2111187.zip) (Draft CR) PUCCH Multiplexing with SPS HARQ-ACK within a Sub-slot, Ericsson
2. [R1-2111362](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_107-e/Docs/R1-2111362.zip) Draft CR on UL multiplexing with SPS HARQ-ACK or SR in one sub-slot, ZTE
3. [R1-2111679](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_107-e/Docs/R1-2111679.zip) [Draft CR] Clarification on Inter-sub-slot multiplexing of low-priority UCIs, Nokia, Nokia Shanghai Bell

The discussion should focus on the needed specification changes resulting from the following agreement from RAN1#106-e (part of [106-e-NR-L1enh-URLLC-10]):

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| **Agreement**For the multiplexing among overlapping PUCCH channels with a given priority index, if a UE is provided *subslotLengthForPUCCH* for the HARQ-ACK codebook of the given priority, UE does not expect that the HARQ-ACK corresponding only to SPS PDSCH(s) or SR of the given priority index in one sub-slot is moved to a different sub-slot after multiplexing.* Note: the UE behavior for UL multiplexing with SR and CSI in a slot is maintained if there is no HARQ-ACK in the slot
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# Email discussions

**Option 1: The following changes are proposed by Ericsson [1]:**

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| 9.2.5.2 UE procedure for multiplexing HARQ-ACK/SR/CSI in a PUCCH<Unchanged parts are 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 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 If a UE is provided with *subslotLengthForPUCCH* in a given *PUCCH-Config*, in a slot with any HARQ-ACK and consisting of $N\_{symb}^{slot}$ symbols as defined in [4, TS 38.211], for multiplexing overlapping PUCCH(s) with PUCCH resources provided by the given *PUCCH-Config*, the UE does not expect that the HARQ-ACK (if any) or SR (if any) within one set of *subslotLengthForPUCCH* symbols is moved to a different set of *subslotLengthForPUCCH* symbols after multiplexing, where the HARQ-ACK to be multiplexed is in response to PDSCH reception(s) without a corresponding PDCCH.If a UE has HARQ-ACK, SR and wideband or sub-band CSI reports to transmit and the UE determines a PUCCH resource with PUCCH format 2, or the UE has HARQ-ACK, SR and wideband CSI reports [6, TS 38.214] to transmit and the UE determines a PUCCH resource with PUCCH format 3 or PUCCH format 4, where <Unchanged parts are omitted> |

**Option 2: The following changes are proposed by ZTE [2]:**

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| 9 UE procedure for reporting control information< Unchanged part is omitted >If a UE is provided one *PUCCH-Config*- if the UE is provided *subslotLengthForPUCCH* in the *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 0 or any CSI report configuration in the *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the *PUCCH-Config*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 *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*For the multiplexing among overlapping PUCCH channels with a given priority index, if a UE is provided one or two *PUCCH-Config* and provided *subslotLengthForPUCCH* for the HARQ-ACK codebook of the given priority, UE does not expect that the HARQ-ACK corresponding only to SPS PDSCH(s) or SR of the given priority index in one sub-slot is moved to a different sub-slot after multiplexing.< Unchanged part is omitted > |

**Option 3: The following changes are proposed by Nokia/NSB [3]:**

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| 9 UE procedure for reporting control information< Unchanged parts are omitted >If a UE is provided one *PUCCH-Config*- if the UE is provided *subslotLengthForPUCCH* in the *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 0 or any CSI report configuration in the *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the *PUCCH-Config*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 *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*If a UE is provided *subslotLengthForPUCCH* in a *PUCCH-Config* of a given priority index, the UE does not expect that at least one of a HARQ-ACK corresponding to PDSCH reception without a corresponding PDCCH or an SR of the given priority index in one UL slot for PUCCH transmission is moved to a different slot after the UE multiplexes UCIs, including HARQ-ACK, SR and/or CSI, on PUCCH. < Unchanged parts are omitted > |

## 2.1 Round 1

Looking at the three draft CRs in [1], [2] and [3], the first question that comes to mind immediately is, that the needed clarification is either included in Sec. 9.2.6 as proposed by Ericsson [1] or in the main section 9 (below the one & two-PUCCH config clauses) as proposed by ZTE [2] & Nokia/NSB [3]. The chosen section would also have an effect on the needed CR within that section, as in Sec. 9.2.5.2 as seems correctly captured in the Ericsson CR we need to define the ‘PUCCH sub-slot’ in terms of symbols in the condition, whereas if we include this in Sec. 9 directly, we can use the term UL slot for PUCCH transmission or similar there directly (as in the ZTE & Nokia/NSB proposal). Let’s see where companies stand, I plan to use majority input from the first round to define on how to proceed in the 2nd round.

**Question 1: The clarification on the SPS HARQ and SR in 38.213 is to be provided in**

* **Alt. 1: Sec. 9.2.5.2 (as proposed in [1])**
* **Alt. 2: Sec. 9 (as proposed in [2] and [3])**
* **Alt. 3: Other**

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| Alt. 1 – supporting companies | Ericsson |
| Alt. 2 – supporting companies | ZTE, LG,QC,OPPO,vivo, HwHiSi, Nokia/NSB |
| Alt. 3 – supporting companies for other section | Samsung 9.2.5 |

Comments:

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| *Company* | *Comments* |
| ZTE | For the main bullet of the agreement, it doesn’t depend on the existence of CSI. So if the change is under 9.2.5.2, does it imply there should be at least one CSI? |
| LG | The previous agreement is about how to keep sub-slot structure, rather than how to multiplex UCI. We prefer to add the sentence under section 9.  |
| QC | We prefer to put the sentence under section 9, since we don’t need to redefine sub-slot in as FL correctly pointed out.  |
| Ericsson | The agreement was about multiplexing of overlapping PUCCHs. As discussed when the agreement was made, the issue was very specific to the case where (a)-(c) are all true: (a) HARQ-ACK is for SPS PDSCH only; (b) CSI is one of the UCI to be multiplexed, i.e., either {HARQ-ACK, CSI} or {SR, CSI} or {HARQ-ACK, SR, CSI}. It’s not possible to move to a different subslot if only {HARQ-ACK, SR}; I the UE is provided with *multi-CSI-PUCCH-ResourceList*.Thus this agreement should be captured where above case is described, i.e., section 9.2.5.2 “UE procedure for multiplexing HARQ-ACK/SR/CSI in a PUCCH”. |
| Vivo | Agree with Ericsson that the issue was very specific. It can be captured in 9.2.5.2 where above case is described, but we need to define the ‘PUCCH sub-slot’ in terms of symbols in the condition as FL pointed out. It seems simpler to be captured in section 9. |
| HW/HiSi | Prefer to place the TP in Section 9 and agree with LG and QC on the reasons. |
| Nokia/NSB | As most other companies, we prefer to capture this in Sec. 9 of TS 38.213 |
| Samsung | Although the issue is related to multiplexing with CSI, but 9.2.5.2 describes the details of how PRB determination. We think the issue is more related to UCI multiplexing procedure in a PUCCH and should be put under 9.2.5. |

In case we go for Sec. 9.2.5.2, what changes to the Ericsson proposal do you see as needed:

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| **Ericsson in [1] for Sec. 9.2.5.2 of TS 38.213:**If a UE is provided with *subslotLengthForPUCCH* in a given *PUCCH-Config*, in a slot with any HARQ-ACK and consisting of $N\_{symb}^{slot}$ symbols as defined in [4, TS 38.211], for multiplexing overlapping PUCCH(s) with PUCCH resources provided by the given *PUCCH-Config*, the UE does not expect that the HARQ-ACK (if any) or SR (if any) within one set of *subslotLengthForPUCCH* symbols is moved to a different set of *subslotLengthForPUCCH* symbols after multiplexing, where the HARQ-ACK to be multiplexed is in response to PDSCH reception(s) without a corresponding PDCCH. |

**Question 2: In case the clarification is to be provided in Sec. 9.2.5.2, what changes to the Ericsson proposed text above do you think would be needed?**

Comments:

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| *Company* | *Comments* |
| Samsung | “one set of subslotLengthForPUCCH symbols” is not accurate, it does not equal to the symbols in a sub-slot.We think “slot” should be clear as we already clarified in Clause 9 as following,In the remaining of this clause, if a UE is provided *subslotLengthForPUCCH*, a slot for an associated PUCCH resource of a PUCCH transmission with HARQ-ACK information includes a number of symbols indicated by *subslotLengthForPUCCH*, unless stated otherwise. |
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**When looking at the proposed changes for Sec. 9 of 38.213 in ZTE [2] and Nokia/NSB [3],**

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| **ZTE in [2]**For the multiplexing among overlapping PUCCH channels with a given priority index, if a UE is provided one or two *PUCCH-Config* and provided *subslotLengthForPUCCH* for the HARQ-ACK codebook of the given priority, UE does not expect that the HARQ-ACK corresponding only to SPS PDSCH(s) or SR of the given priority index in one sub-slot is moved to a different sub-slot after multiplexing.**Nokia/NSB in [3]**If a UE is provided *subslotLengthForPUCCH* in a *PUCCH-Config* of a given priority index, the UE does not expect that at least one of a HARQ-ACK corresponding to PDSCH reception without a corresponding PDCCH or an SR of the given priority index in one UL slot for PUCCH transmission is moved to a different slot after the UE multiplexes UCIs, including HARQ-ACK, SR and/or CSI, on PUCCH.  |

they clearly address the same with partially even the same wording with some minor differences:

* ZTE spelling out the one or two PUCCH config cases again whereas Nokia only referring directly to a PUCCH config (marked in yellow).
* Nokia uses the wording ‘*at least one of*’ (in magenta) SPS HARQ or SR (which include the case of SPS HARQ & SR), whereas ZTE does not use this (which seems to imply either SPS HARQ or SR)
* ZTE using the wording of ‘*HARQ-ACK corresponding only to SPS PDSCH(s)*’ whereas Nokia using the formulation of ‘*HARQ-ACK corresponding to PDSCH reception without a corresponding PDCCH*’ to differentiate activation / release operation (in blue)
* ZTE uses the wording of ‘*sub-slot*’ not defined in 38.213 whereas Nokia/NSB uses the term ‘*UL slot for PUCCH transmission*’ (in green)

**Question 3: If the clarification is provided in Sec. 9 of 38.213, which type of formulation do you prefer:**

* **Alt. 1: ZTE in [2]**
* **Alt. 2: Nokia in [3]**
* **Alt. 3: Other (e.g., combination)**

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| Alt. 1 – supporting companies |  |
| Alt. 2 – supporting companies |  |
| Alt. 3 – none / other | LG; QC,OPPO, vivo, HW/HiSi |

Comments on either ZTE and/or Nokia wording, addressing e.g., also some of the differences marked in yellow, magenta, blue, green above:

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| *Company* | *Comments* |
| ZTE | Thanks for the detailed comparison. For the last three wording comparisons, the wording from Nokia is more accurate and closer to the common sense of last meeting. We can accept the main architecture from Nokia. But for one or two PUCCH config, can we hear more companies view. In my understanding, some companies show the support for one or two PUCCH config. Or this need further clarification. |
| LG | We have a few comments for changes. For yellow part, we can accept both version, but we slightly prefer Nokia’s version since it is more aligned with other sentence in section 9.For magenta part, we would like to suggest to use “any of …” just for simplicity. Also, we are fine to remove as well. For blue part, we are fine with both version. If there is no way to determine, we would like to use “HARQ-ACK only for the SPS PDSCH reception(s)” as like in 9.1.1 (the term for type-1 codebook only for SPS) For green part, we think both could make problem. * For ZTE’s version, it uses a terminology of ”sub-slot”, however, there is no description for that in the specification.
* For Nokia’s version, it uses UL slot. However, the symbol length of a slot is depending on PUCCH resource and corresponding UCI. Thus, it is hard to be read as sub-slot in the given proposed changes, especially when PUCCH for SR and CSI is used for the transmission.

We suggest to borrow the following description for “sub-slot” in section 9.

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| In the remaining of this clause, if a UE is provided *subslotLengthForPUCCH*, a slot for an associated PUCCH resource of a PUCCH transmission with HARQ-ACK information includes a number of symbols indicated by *subslotLengthForPUCCH*, unless stated otherwise. |

In our view, sub-slot in the agreement is meant to be a slot for an associated PUCCH resource of a PUCCH transmission with HARQ-ACK information, which includes a number of symbols indicated by *subslotLengthForPUCCH.* Thus, we may be able to use this description directly for green part. In one slot including a number of symbols indicated by subslotLengthForPUCCH is moved to a different slot If necessary, propose changed can move to below from above description.  |
| QC | For yellow, we prefer Nokia’s formulation.For bule, ZTE’s version seems better, since it emphasizes that the first SPS PDSCH activated by DCI doesn’t not count as PDSCH without corresponding PDCCH, and hence the proposal doesn’t apply. For magenta, we are fine with either way.For green, we think ZTE’s version is OK, and it’s fine to use “subslot” here. But we are open to other suggestions (e.g., the one suggested by LG).  |
| OPPO | For the yellow part, we prefer Nokia’s version.For the blue and magenta part, either way is fine for us. For the green part, LG’s comments make sense and we prefer LG’s modification.  |
| Ericsson | First, Ericsson text proposal is equally valid for section 9 and section 9.2.5.2. Thus Ericsson text proposal should be included in TP discussion as well. The question of where to capture it can be treated separately.Then, regarding ZTE TP and Nokia TP, both are problematic for the green part.* For ZTE text, ’sub-slot’ cannot be used in spec, since it’s never defined in spec;
* For Nokia text, ’slot’ cannot be used to stand in for ’sub-slot’, since:
	+ Nokia TP is placed before the clause below, thus the clause below is not yet applied.
	+ For the multiplexing of {SR, CSI}, the clause below does not apply since the PUCCH is not for HARQ-ACK. But the agreement intend to apply sub-slot restriction to {SR, CSI} multiplexing as well.

Section 9 clause:“In the remaining of this clause, if a UE is provided *subslotLengthForPUCCH*, a slot for an associated PUCCH resource of a PUCCH transmission with HARQ-ACK information includes a number of symbols indicated by *subslotLengthForPUCCH*, unless stated otherwise.” |
| Vivo | For the yellow part, we prefer Nokia’s version.For the bullet part, we prefer to use “HARQ-ACK corresponding to PDSCH reception without a corresponding PDCCH” rather than “HARQ-ACK corresponding to SPS PDSCH(s)”. the former one is more aligned with other sentence in section 9. For the green part, LG’s modification seems better. |
| HW/HiSi | * ZTE spelling out the one or two PUCCH config cases again whereas Nokia only referring directly to a PUCCH config (marked in yellow).
* Prefer Nokia
* Nokia uses the wording ‘*at least one of*’ (in magenta) SPS HARQ or SR (which include the case of SPS HARQ & SR), whereas ZTE does not use this (which seems to imply either SPS HARQ or SR)
* Prefer Nokia or we can use “”HARQ-ACK corresponding to PDSCH reception without a corresponding PDCCH and/or SR

 * ZTE using the wording of ‘*HARQ-ACK corresponding only to SPS PDSCH(s)*’ whereas Nokia using the formulation of ‘*HARQ-ACK corresponding to PDSCH reception without a corresponding PDCCH*’ to differentiate activation / release operation (in blue)
* Prefer ZTE
* ZTE uses the wording of ‘*sub-slot*’ not defined in 38.213 whereas Nokia/NSB uses the term ‘*UL slot for PUCCH transmission*’ (in green)
* We could add the text in blue below to the LG proposal from LG’s suggestion above:

 “in one slot including a number of symbols indicated by subslotLengthForPUCCH is moved to a different slot including a number of symbols indicated by subslotLengthForPUCCH” Or, alternatively, we could keep “slot” in the sentence, and add the following note at the end of this paragraph. “*In this paragraph, the slot includes a number of symbols indicated by subslotLengthForPUCCH*” |
| Nokia / NSB | Good discussion here so far. We would be fine with a mix-and-match of what has been given earlier. * Yellow: as most companies above – prefer Nokia version
* Magenta: Nokia’s ‘at least one of’ or LGE ‘any of’. We don’t usually use and/or in our specifications (based on HW proposal)
* Blue part: no strong views here, if majority thinks we should use the ZTE formulation, fine for us
* Green part: could use LGs suggestion with the HW addition.
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| Samsung | Agree with E/// that we don’t have the wording “sub-slot” in 38.213 and it should be avoided.“at least one” is not necessary.“HARQ-ACK information in response to a SPS PDSCH reception” is used several times, we prefer to align with it.Prefer the green one in Nokia’s version for simplicity. |