**3GPP T****SG-RAN WG2 Meeting #113bis-electronic R2-210xxxx**

**Online, April 12th – April 20th, 2021**

**Agenda item: 6.1.3.1**

**Source: vivo**

**Title:** **[AT113bis-e][015][NR16] Overlapping UCI Data and SR of equal priority and UL skipping (vivo)**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution is aimed at reporting the discussion and results of the following email discussion:

* [AT113bis-e][015][NR16] Overlapping UCI Data and SR of equal priority and UL skipping (vivo)

Scope: Take into account on-line progress, Take into account R2-2102628, R2-2102626, R2-2102724, R2-2102759, R2-2102754, R2-2103381, R2-2103481, R2-2103846, R2-2103847, R2-2102775, R2-2103067, R2-2103426, R2-2103208, R2-2103439, R2-2103440, R2-2102776, R2-2103845, R2-2104054

Determine agreeable parts, make decisions for Reply LS to RAN1. For parts with incomplete conclusions, pave the way for on-line CB

Intended outcome: Report, approved LS out,

Deadline: Monday April 19 (if needed CB April 20)

The discussion scope is to gather understanding on whether the MAC layer is aware of the final PUCCH resource after UCI multiplexing with multiple UCI types in a PUCCH and to check if there is sufficient support to pursue the correction CR [R2-2103381](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113bis-e/Docs/R2-2103381.zip).

Then, the rapporteur would like to point out the specific deadline for this discussion with two phases,

* In phase 1, companies are invited to provide their views by April. 15th (Thursday), 2021, 18:00 UTC.
* In phase 2, the corresponding summary proposals (if consensus can be achieved), draft CR(s), and draft reply LS will be provided. Any comments on the proposals, draft CR(s), and draft reply LS are invited to be provided by April. 19th (Monday), 2021, 18:00 UTC.

# 2 Participants

|  |  |
| --- | --- |
| Participant name | E-mail |
| Yitao Mo (Stephen) | yitao.mo@vivo.com |
| Sangkyu Baek | sangkyu.baek@samsung.com |
| Tao Cai | tao.cai@huawei.com |
| Zhenhua Zou | zhenhua.zou@ericsson.com |
| Fei Dong | Dong.fei@zte.com.cn |
| Zhe Fu | fuzhe@OPPO.com |
| SunYoung LEE | Ssunyoung.lee@lge.com |
| Ping-Heng Wallace Kuo | Ping-Heng.Kuo@nokia.com |
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# 3 Discussion

## 3.1 Visibility of final PUCCH resource in MAC layer

During the online discussion at RAN2#113bis-e meeting, a warm discussion on the RAN1 LS question that whether MAC is aware of UCI multiplexing in PHY or not has been launched [1]. The corresponding discussion records are given as below:

|  |
| --- |
| R2-2102626 Reply LS on overlapped data and SR are of equal L1 priority (R1-2102244; contact: vivo) RAN1 LS in Rel-16 NR\_IIOT-Core To:RAN2  moved from 6.1.1  SR  - vivo think that MAC layer is not aware of the final resource of SR etc.  - Oppo think there is a dependency between L1 and MAC as L1 decides based on MAC decision, e.g. PUCCH format.  - MTK think MAC is written fuzzy e.g. doesn’t say whether info is configured or L1 chosen, e.g. in order to do UL skipping MAC need to be aware of L1, and MAC/L1 are quite tight coupled, MAC can be aware.  - Samsung think that PUCCH PUSCH conflicts are explicit and MAC cannot determine other conflicts. MAC is not aware of PUCCH resource.  - ZTE think MAC is aware, DRX Note about CSI-RS reporting refers to CSI-RS resources co-inciding with DRX active time. ZTE think MAC can be aware. Think we need to consider the chicken egg problem. CATT think there is no chicken-egg issue, and the time-line shows that UCI multiplexing is already known in the UE when MAC intra-UE-prioritzation is done, so the UE can know. Agree with ZTE that MAC is aware of L1 and there are several examples in the TS.  - Huawei don’t think MAC is aware of everything, think we can choose whether MAC need to know.  - Apple are not sure, whether we need to modify the Phy MAC interface. Chair think we never attempted to specify a MAC Phy interface.  - Ericsson think MAC cannot know the final PUCCH resource.  - LG would like the specification to be as simple as possible i.e. independent in this case.  - Lenovo think the interlayer interaction was never specified in detail, and we always left MAC a bit fuzzy. Qc agrees with this, and current MAC design doesn’t rule out.  - Nokia think MAC doesn’t need to know what is the final resource.  - IDT think the understanding 1 gives the least impact, not sure whether there will need to be any change, e.g. for retriggering maybe SR is just delayed.  - CATT think that Understanding 2 is the current behaviour. MTK agrees.  - Samsung think the impact to UE impl is different.  Chair: A TS can refer to a condition where the details are specified in another TS. This is usually done by fuzzy reference, so it seems that both interpretations are possible (without adding L1 specific details in MAC or vice versa).  Chair: Understanding 1: If we assume that MAC just generate SR and let L1 decide if/by what resource to transmit it, if the SR is not transmitted in the end then MAC may need to know this, in order to re-trigger the SR.  Chair: Understanding 2: If we assume that MAC (the UE) can first know whether SR can be transmitted or not, then the current TS works.  Attempt to progress offline, CB on-line if needed |

Thus, there are two options for LCH-based prioritization:

1. **MAC is not aware of the final PUCCH after UCI multiplexing in PHY:**

In contributions [5][8][11][12][13][14] provide an understanding that the terminologies “PUCCH resource with an SR transmission” (in section 5.4.1), “valid PUCCH resource for SR” (in section 5.4.4), and “PUCCH resource for the SR transmission occasion” (in section 5.4.4) are referred to as the PUCCH resource for SR transmission configured within the *MAC-CellGroupConfig*. This is because the MAC layer, for implementation simplicity and layer independence, should not visit/monitor the other PUCCH configurations used for other purposes (e.g. CSI reporting, UCI multiplexing for multiple UCIs in a PUCCH).

Based on this understanding, for case 2-1 depicted in Figure 1, when performing LCH-based prioritization check, the MAC layer takes the SR resource marked with dashed frame and the overlapping PUSCH for prioritization. Then, the MAC layer will checks with PHY that whether these two resources can be used for SR or PUSCH transmission. Consequently, the MAC will only deliver either SR or PUSCH MAC PDU to PHY layer, which leads to unnecessary performance degradation. For case 2-2 depicted in Figure 2, in the same logic, the MAC will deliver both SR and PUSCH MAC PDU to PHY layer. Fortunately, the current PHY spec allows the PHY to multiplex other UCI(s) i.e., HARQ-ACK/CSI in the PUSCH and does not transmit SR. In this sense, this option would not bring any negative impact on UE behavior.



Figure 1: Example of case 2-1 where the final PUCCH resource does not overlap with PUSCH



Figure 2: Example of case 4 where only the final PUCCH resource overlaps with PUSCH

1. **MAC is aware of the final PUCCH after UCI multiplexing in PHY:**

During the online discussion and also in contributions [4][15][18], some companies think that the terminologies “PUCCH resource with an SR transmission” (in section 5.4.1), “valid PUCCH resource for SR” (in section 5.4.4), and “PUCCH resource for the SR transmission occasion” (in section 5.4.4) are not so clear. It might be referred to as the final PUCCH resource after UCI multiplexing in a PUCCH via PHY layer. Besides, it is mentioned that, based on the current MAC spec, the MAC layer firstly will inquire PHy layer whether the SR can be signaled on a PUCCH resource or not, it is quite natural that the PHY layer will take UCI multiplexing into account and informs MAC layer of the final PUCCH resource for further LCH-based prioritization check.

Based on this understanding, for case 2-1 depicted in Figure 1, when performing LCH-based prioritization check, in practice, the MAC layer has to firstly indicate PHY that a SR would be transmitted and then the PHY assumes that UCI multiplexing should be performed. Then, if UCI multiplexing condition is fulfilled (e.g. processing timeline and PUCCH format can support the UCI multiplexing), the PHY can tell MAC the final PUCCH resource. Otherwise, the PHY just checks whether the initial SR resource can be used for SR transmission or not. Further, if the SR is considered as a prioritized SR transmission and the SR transmission is instructed by the MAC layer, the PHY layer has really performed the UCI multiplexing procedure for final PUCCH transmission with SR. Obviously, the PHY layer has to at first assume the UCI multiplexing hypothesis and again recall the UCI multiplexing procedure in reality if SR is delivered.

The potential UE implementation for both Understanding 1 and Understanding 2 are given in the following Figure 3. And Table 1 summarizes the pros and cons of these two understandings, based on contribution [20].



Figure 3: UE implementation via Understanding 1/2

**Table 1: Summary of pros and cons of Understanding 1 and Understanding 2**

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| --- | --- | --- |
| **Cases** | **Understanding 1:**  **MAC is not aware of the final PUCCH resource** | **Understanding 2:**  **MAC is aware of the final PUCCH resource** |
| Case 2-1 | **Pros:**   * Simple UE implementation; * No MAC spec impact.   **Cons:**   * Performancedegradation since either SR or PUSCH will be unnecessarily dropped by MAC. | **Pro:**   * Both SR and PUSCH can be transmitted.   **Con:**   * Complex interaction between PHY and MAC; * NBC change might be needed. |
| cid:image001.png@01D6FBC1.DD0FD2F0  Case 4 | **Pros:**   * Simple UE implementation; * No MAC spec impact.   **Con:**   * PHY should drop the SR. | **Pro:**   * PHY doesn’t need to drop SR.   **Con:**   * Complex interaction between PHY and MAC; * NBC change might be needed. |

Anyway, the rapporteur thinks a decision is needed for the way forward although it is really hard to select either option since they are all feasible and have their advantages.

### **Q1: Which option do companies prefer for the LCH-based prioritization procedure?**

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| --- | --- | --- |
| **Company** | **Preference (Understanding 1 or Understanding 2)** | **Detailed comments** |
| vivo | Understanding 1 | In our understanding, the terminology “valid PUCCH resource for SR” in the MAC spec, which has been used since V8.4.0, is intended to link to the PUCCH resource configured within MAC configuration with a specific PUCCH format for single SR transmission. In this sense, the current MAC spec text is quite clear and Understanding 1 aligns with the current MAC behavior. From the technical point of view, Understanding 1 can work well without performance degradation in all the cases given by RAN1 except case 2-1 (which might be a very corner case). We don’t think any enhancement (e.g. Understanding 2) is needed for Rel-16 which has been frozen. Also, to get rid of potential impacts on UE implementation and MAC spec clarification, we should stick with Understanding 1. |
| Samsung | Understanding 1 | In Rel-15, MAC specification does not mandate the MAC entity (implementation) to know the final PUCCH resource.  For instance, referring to a NOTE in 5.7 of TS 38.321:  NOTE 4: If a UE multiplexes a CSI configured on PUCCH with other overlapping UCI(s) according to the procedure specified in TS 38.213 [6] clause 9.2.5 and this CSI multiplexed with other UCI(s) would be reported on a PUCCH resource either outside DRX Active Time of the DRX group in which this PUCCH is configured or outside the on-duration period of the DRX group in which this PUCCH is configured if CSI masking is setup by upper layers, it is up to UE implementation whether to report this CSI multiplexed with other UCI(s).  This NOTE let UE implementation decide to transmission of CSI reporting when PUCCH resource is shifted by UCI multiplexing. The reason for this change is that it is not desirable to mandate UE always understand the final PUCCH resource after the UCI multiplexing.  We do not see any critical reason to mandate the new complicated UE implementation between PHY and MAC. For either way, one NOTE or simple text would be sufficient. But the consequence of Understanding 2 is that UE has to check PHY and the final PUCCH resource at every time before the LCH-based Prioritization, which RAN2 should avoid. |
| Huawei, HiSilicon | Understanding 1 | We understand that the said PUCCH resource in MAC spec for SR transmission is assumed as potential or initially possible PUCCH resource, not the actual/final PUCCH resource after PHY level multiplexing. From this perspective, MAC layer needs not to be aware of the UCI multiplexing in PHY during such procedure.  If RAN1 wants MAC layer to be aware of such multiplexing, then for each pending SR, before MAC layer actually delivers the SR to PHY layer, MAC layer needs to interact with PHY layer to check whether a valid PUCCH resource for SR overlaps with other UCI(s) and to acquire the actual position of the final PUCCH resource after considering all possible ways of multiplexing. After that, the MAC layer can judge whether the final PUCCH resource overlaps with a PUSCH. Such interaction incurs additional complexities for both MAC layer and PHY layer and would cause circular (chicken–egg) dependency between PHY and MAC. For example, MAC needs to check on the PHY multiplexing before delivering SR/MAC PDU and PHY needs input from MAC (whether or not there will be SR transmission) to decide on how to multiplex.  We propose for this case, RAN2 can confirm the understanding that MAC layer is not aware of the UCI multiplexing in PHY. MAC will decide to deliver the SR or MAC PDU for the PUSCH to PHY only based on LCH-based prioritization if SR and MAC PDU have the same L1 priority. |
| Ericsson | Understanding 1 | The main concern for the understanding 2 is the circular dependency between PHY and MAC on the decision making. PHY needs to know if SR/PUSCH is delivered from the MAC layer to perform the UCI multiplexing , but MAC needs to know the UCI multiplexing outcome to decide whether to deliver the SR/PUSCH. Since the behaviours would be specified in two different TSs, it is simply too complicated to write down detailed interactions. It is okay/acceptable in our view for the MAC spec to “break the loop”. |
| ZTE | Understanding 2 | We can understanding all the comments from above companies. However, according to the current specification, MAC shall be aware of the UCI multiplexing, otherwise, the MAC spec will be broken and we need re-open the discussion again to correct the MAC spec. For example:  -------------------------- From 38.321-----------------------------------  When the MAC entity is configured with *lch-basedPrioritization*, for each uplink grant whose associated PUSCH can be transmitted by lower layers, the MAC entity shall:  1> if this uplink grant is received in a Random Access Response (i.e. in a MAC RAR or fallback RAR), or addressed to Temporary C-RNTI, or is determined as specified in clause 5.1.2a for the transmission of the MSGA payload:  2> consider this uplink grant as a prioritized uplink grant.  -------------------------- From 38.321-----------------------------------  The sentence highlighted with yellow definitely implies the MAC shall be always aware of the PHY layer behavior on the PUSCH transmission , with the same logic, also ware of the PHY layer behavior on the PUCCH transmission.Assuming MAC cannot be aware of the final PUCCH resources for UCI multiplexing, how the MAC layer can be realize of the transmission status of the PUSCH transmission?  For example:    According to the current spec, we understand the PUSCH#1 shall be prioritized and the corresponding MAC PDU shall be generated. But assuming that the understanding 1 is correct.. We are really confused to interpret the “ for each uplink grant whose associated PUSCH can be transmitted by lower layers,” since the sentence explicitly indicate that the final resources of UCI multiplexing shall be taken into account.  If we really want to go for simplest one, understanding 2 is the simplest and no any other part will be broken. Otherwise, too many collision cases will be raised and the discussion will be endless. |
| OPPO | Understanding 1 | If we use the final PUCCH, it requires the circular dependency between PHY and MAC. For PUCCH format 0/2, PHY knows the final PUCCH for the SR only when the SR is already delivered from MAC to PHY after the overlapping check, but MAC needs to know the final PUCCH for the SR when performing the overlapping check before the SR delivery. Even if MAC can know the final PUCCH before the overlapping check, MAC still uses the configured PUCCH for the SR, since the final PUCCH is for other UCI not for the SR (PHY does not consider the SR when deciding this UCI multiplexing/final PUCCH since the SR has not been received at that time). After MAC delivers the SR to PHY, there is no need for MAC to know the final PUCCH for the SR since the SR has already been delivered.  On the other hand, the function of the UCI multiplexing is introduced in Rel-15, and MAC is not explictly required to be known of the location of the final PUCCH for the SR. Also, there is no exact timeline specified for MAC obtaining the UCI multiplexing. Thus, in one UE implementation, the UCI multiplexing is known by the MAC layer after the end of the intra-UE prioritization procedure. |
| LG | Understanding 1 | We should avoid complicated MAC/PHY interaction unless it is deemed essential. Understanding 1 is well aligned with the design principle which has been kept for a long time and causes no critical problem. |
| Nokia | Understanding 1 | We share the similar view with most of the companies above.  For the example brought up by ZTE, in our understanding the sentence “ for each uplink grant whose associated PUSCH can be transmitted by lower layers,” simply says that PHY may indicate whether a PUSCH can be or cannot be transmitted for whatever reasons (e.g. cannot be transmitted because it is infeasible to stop an on-going transmission) – NOT necessarily exact information about where the final PUCCH resource is.  Hence we think this is a bit over-interpretation to say that MAC should be aware of the final resource of PUCCH in this case because of this sentence. Therefore, based on the current spec. MAC should still only consider validity of configured SR-PUCCH when performing intra-UE prioritization, because PHY’s final decision on UCI multiplexing may not be readily available when MAC is selecting the prioritized grant, due to circular-dependency issues pointed out by other companies. |

**Conclusion:**

**TBD**

## 3.2 R2-2103381 on UL skipping correction

In [R2-2103381](https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_113bis-e/Docs/R2-2103381.zip), it pointed out that CG-UCI is not able to be multiplexed with other UCIs if *cg-UCI-Multiplexing* is not configured in case of CG PUSCH transmission in NR-U. Thus, if *cg-UCI-Multiplexing* is not configured, it is useless for MAC to generate an empty TB. Besides, retransmission of such empty TB is then later prioritized over new transmission, which is rather undesirable.

Therefore, the following correction is proposed:

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| **TS 38.321 sub-clause 5.4.3.1.3 Allocations of resources**  The MAC entity shall:  1> if the MAC entity is configured with *enhancedSkipUplinkTxDynamic* with value *true* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or if the MAC entity is configured with *enhancedSkipUplinkTxConfigured* with value *true* and the grant indicated to the HARQ entity is a configured uplink grant; and  1> if the MAC entity is not configured with *lch-basedPrioritization*; and  1> if there is no UCI to be multiplexed on this PUSCH transmission as specified in TS 38.213 [6] or if there is HARQ-ACK information overlapping with this PUSCH transmission which is a configured uplink grant configured with *cg-RetransmissionTimer* but not *cg-UCI-Multiplexing*; and  1> if there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212 [9]; and  1> if the MAC PDU includes zero MAC SDUs; and  1> if the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR:  2> not generate a MAC PDU for the HARQ entity. |

### **Q2: Do companies agree the intention of CR R2-2103381?**

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| **Company** | **Yes/No** | **Detailed comments** |
| vivo | No | In our understanding, the former condition “if there is no UCI to be multiplexed on this PUSCH transmission” has covered the case mentioned in the CR. Specifically, when performing the UL skipping check, the MAC layer will instruct the PHY layer to check whether there is a UCI (e.g. HARQ-ACK) that will be multiplexed on this CG-PUSCH. Then if *cg-UCI-Multiplexing* is not configured, the PHY is aware that the HARQ-ACK will not be multiplexed on the CG PUSCH transmission based on the following highlighted quoted text from 38.213 section 9. As a result, the MAC will consider there is no UCI to be multiplexed on this CG PUSCH transmission, and no padding MAC PDU will be generated.   |  | | --- | | 38.213 section 9  *When a UE would multiplex HARQ-ACK information in a PUSCH transmission that is configured by a ConfiguredGrantConfig, and includes CG-UCI [5, TS 38.212], the UE multiplexes the HARQ-ACK information in the PUSCH transmission if the UE is provided cg-UCI-Multiplexing; otherwise, the UE does not transmit the PUSCH and multiplexes the HARQ-ACK information in a PUCCH transmission or in another PUSCH transmission.* | |
| Samsung | No | Agee with vivo. The case covered by this CR is already covered by the current text, i.e. no UCI is multiplexed. |
| Huawei, HiSilicon | No | We think the change is not needed as the case should be already covered by the first part of the same sentence "if there is no UCI to be multiplexed on this PUSCH transmission". |
| Ericsson | No | Agree with vivo |
| ZTE | No | Agree with vivo |
| OPPO | No | It is already covered by the case that no UCI is to be multiplexed. |
| LG | No | Agree with vivo. |
| Nokia | Yes but | It meant to explicitly cover the case where HARQ-ACK is to be multiplexed on top of CG-UCI when *cg-UCI-Multiplexing* is configured, for the sake of clarity. But we are fine if companies think this is not necessary. |

## 3.3 Other potential impacts/enhancements

Last but not least, companies can provide their comments on the remaining issues of overlapping UCI and PUSCH with Rel-16 PUSCH skipping, if they are not covered by this discussion.

### **Q3: Are there any additional comments on the remaining issues?**

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| **Company** | **Yes/No** | **Detailed comments** |
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**Conclusion:**

**TBD**

# 4 Conclusion

The contribution is summarized with observations and proposals as follows,

**Phase 1:**

# 5 References

1. R2-2102626, Reply LS on overlapped data and SR are of equal L1 priority (R1-2102244; contact: vivo)
2. RAN2 113bis-e Chairman notes 2021-04-12 1600 UTC
3. R2-2102628, LS on UL skipping for PUSCH in Rel-16 (R1-2102249; contact: vivo)
4. R2-2102724, Analysis of RAN1 reply LS on overlapped SR and data, CATT
5. R2-2102759, Remaining issues on overlapped PUSCH and UCI with UL skipping, vivo
6. R2-2102754, Draft reply LS to RAN1 on overlapped data and SR are of equal L1 priority, vivo
7. R2-2103381, Correction to PUSCH skipping with UCI for NR-U, Nokia, Nokia Shanghai Bell
8. R2-2103481, MAC behaviour for overlapped UCI(s), SR and PUSCH with equal L1 priority, Huawei, HiSilicon
9. R2-2103846, Overlapped SR and PUSCH of equal L1 priority, Apple
10. R2-2103847, Treatment of overlapping SR/Data, Apple
11. R2-2102775, Discussion on overlapped data and SR with equal PHY priority, Samsung
12. R2-2103067, LCH based prioritization for SR and PUSCH, Intel Corporation
13. R2-2103426, Remaining corrections for Intra-UE prioritization, Ericsson
14. R2-2103208, Discussion on reply LS on overlapped data and SR are of equal L1 priority, OPPO
15. R2-2103439, Considerations on the intra-UE multiplexing coupled with PUCCH transmission, ZTE Corporation, Sanechips
16. R2-2103440, Correction to 38.321 on intra-UE multipexing involved PUCCH transmission, ZTE Corporation, Sanechips
17. R2-2102776, UL Skipping with LCH-based Prioritization, Samsung
18. R2-2103845, UL skipping and intra-UE prioritization, Apple
19. R2-2104054, RAN2 impact of Case 1-6 for UL skipping, Huawei, HiSilicon
20. R2-2104309, Treatment of overlapping SR/Data, Apple