3GPP TSG RAN WG1 #102-e R1-20xxxxx

e-Meeting, August 17th – 28th, 2020

Source: vivo

Title: Summary of email discussion [102-e-NR-7.1CRs-11]

Agenda Item: 7.1

Document for: Discussion and Decision

# Introduction

The document provides a summary for email discussion thread [102-e-NR-7.1CRs-11]. **Note that the deadline for the discussion/agreement for the email thread is set to be 8/19. Please provide the first round of comments by 8/18 UTC 11:59 pm.**

* [102-e-NR-7.1CRs-11] Maintenance on PUSCH skipping with overlapping UCI on PUCCH – **Xiaohang (vivo)**
	+ For Rel-16, Issue#29 (including R1-2006837) in R1-2006958
	+ Discussion/Agreements by 8/19, TPs by 8/24

# Discussions

In Rel.15, UL skipping for following cases was concluded.

* Case 1: PUSCH skipping without overlapping CSI/HARQ-ACK on PUCCH (LTE behavior)
* Case 2: PUSCH skipping with overlapping CSI/HARQ-ACK on PUCCH (UE behavior undefined)

For case 1, it was agreed that when a UL grant without UL-SCH field or UL-SCH =1 (if present) is detected by a UE configured with *skipUplinkTxDynamic*, the corresponding PUSCH transmission is skipped by the UE if no transport block for the PUSCH transmission is generated by MAC and there is no CSI/HARQ-ACK on PUCCH overlapping with the PUSCH, which is same as LTE behavior.

For case 2, following CR and conclusion were made, i.e. UE behavior if there would be a PUCCH with CSI/HARQ-ACK overlapping in time with a PUSCH scheduled by a DCI format is not defined. UE behavior for case 2 can be addressed in Rel.16.

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| 6.1 UE procedure for transmitting the physical uplink shared channelA UE shall upon detection of a DCI format scheduling a PUSCH ~~PDCCH with a configured DCI format 0\_0 or 0\_1~~ transmit the corresponding PUSCH ~~as indicated by that DCI.~~ unless the UE does not generate a transport block as described in [10, TS38.321] and there is no PUCCH with CSI/HARQ-ACK that overlaps in time with the PUSCH. In this release of the specification, the UE behavior is undefined if there would be a PUCCH with CSI/HARQ-ACK overlapping in time with a PUSCH scheduled by a DCI format and if the UE does not generate a transport block as described in [10, TS38.321] when *skipUplinkTxDynamic* provided by higher layers is set to *true*.  |
| ConclusionIn case a UL grant without UL-SCH field or UL-SCH =1 (if present) is detected by a UE configured withskipUplinkTxDynamic, Case 2 can be addressed for Rel-16. |

Given the current status, UL skipping for DG-PUSCH is not implementable in Rel.15. UE behavior needs to be defined in Rel.16 if there would be a PUCCH with CSI/HARQ-ACK overlapping in time with a PUSCH scheduled by a DCI. Otherwise, UL skipping feature cannot be implemented.

Moreover, during the previous discussions it was pointed out that CA case should be taken into account. In Rel.15, in CA case, when there are multiple PUSCHs scheduled on multiple serving cells that are overlapping with a PUCCH carrying UCI on a serving cell, the UCI will be multiplexed on the PUSCH overlapping with the PUCCH on the serving cell with lowest cell index, according to the existing multiplexing rules.

When UL skipping is enabled for these serving cells, for example, there are 5 CCs where there are scheduled PUSCH transmission on each CC of CC#2~CC#4 and there is a PUCCH transmission on CC#1 that is overlapping with the PUSCHs on CC#2~CC#4. If UL skipping is not enabled for CC#2~#4, UCI will be multiplexed on the PUSCH transmission on CC#2. If UL skipping is enabled for CC #2~CC #4, UE may skip the PUSCH on CC#2 and multiplex the UCI on the PUSCH on the CC with data. However, for gNB, blind detection for PUSCH on each CC with scheduled PUSCH overlapping with UCI should be performed, with hypothesis of UCI multiplexing. It may result in heavy burden for gNB detection. Hence, in CA case, the blind decoding may be an issue due to the uncertainty between gNB and UE on the PUSCH transmission and the resources for UCI transmission.

Therefore, we need to discuss the behaviours for case 2 in both CA case and non-CA case.

* **Q-1: For CA case, when there is PUCCH carrying UCI overlapping with a set of PUSCHs, whether a PUSCH from the set can be skipped or not if there would be UCI to be multiplexed on the PUSCH?**
	+ **Option 1:**
		- **the UE first determines which PUSCH from the set of PUSCHs would carry the UCI, PUSCH\_0**
		- **the PUSCH with UCI multiplexing cannot be skipped and MAC generates MAC PDU for the PUSCH\_0, and UCI is multiplexed on PUSCH\_0**
	+ **Option 2:**
		- **the UE determines which PUSCH/PUCCH would carry the UCI based on MAC PDU generation:**
			* **If MAC generates data for all or a subset of PUSCHs from the set, UCI will be multiplexed on one of the PUSCH(s) with data based on the existing multiplexing rules.**
			* **If MAC generates data for none of the PUSCHs, none of the PUSCHs in the set will be transmitted and UCI will be transmitted in the PUCCH.**
	+ **Option 3:**
		- **the UE first determines which PUSCH from the set of PUSCHs would carry the UCI, PUSCH\_0**
		- **If MAC generates data for all PUSCHs, all PUSCH will be transmitted and UCI is multiplexed in PUSCH\_0**
		- **If MAC generates data only for a subset of the PUSCHs, that subset will be transmitted, and UCI will be multiplexed in PUSCH\_0. MAC always generates a PDU for PUSCH\_0, whether it is with padding or not.**
		- **If MAC generates data for none of the PUSCHs, none of the PUSCHs will be transmitted and UCI will be transmitted in the PUCCH**

*(Moderator’s understanding): regarding option 3, if there are data for any PUSCH(s) from the set of PUSCHs, outcome of option 3 is equivalent to option 1; if there are data for none of the PUSCHs from the set of PUSCHs, outcome of option 3 is equivalent to option 2.*

**Please provide your comments on Q-1.**

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| **Company** | **Comment** |
| CATT | We prefer Option 1.For option 2, in addition to the increased gNB blind detection complexity, there is also timeline issue. To be more specific, it is possible that a PUCCH with CSI/HARQ-ACK overlaps with a PUSCH and the PUSCH starts later than the start of the PUCCH. At the time point of UCI multiplexing determination, it is possible that no MAC PDU is delivered to PHY and a MAC PDU may be delivered from MAC later on. From UE perspective, UE cannot wait since otherwise there may be no sufficient processing time for the PUCCH. Therefore, option 2 does not work in this case in our view.The same issue applies to option 3. |
| ZTE | Option 1 ensures that the UCI is always multiplexed on the PUSCH as defined by Rel-15 rules. No gNB blind detection is required for Option 1, which is therefore preferred.  |
| NTT DOCOMO | Option 1.Many times of gNB blind detections should be avoided. |
| Samsung | Option 2 is preferable. - For gNB perspective, all options have the same complexity due to miss detection. gNB needs to do blindly detection for either PUSCH or PUCCH as it is likely that the UE misses the DCI scheduling PUSCH or PUCCH(e.g., HARQ-ACK with corresponding PDSCH or SP-CSI) regardless of UL skipping. So, we are not sure whether or not option 1 and option 3 are able to reduce gNB blind detection efforts. - For UE perspective, option 2 seems quite simple solution since legacy LTE UE have already supported. Although option 1 and option 3 reuses the concept of MAC padding PDU to transmit PUSCH, it might be necessary to have explicit or implicit signalling exchange between PHY and MAC in order that MAC figures out whether granted PUSCH is overlapped with PUCCH or not. - For specification perspective, option 2 is very simple as LTE does, while it has considerable specification impact as both PHY and MAC specification changes are necessary to support option 1 or 3. Besides, we are not sure whether it would be common understanding to RAN2 group. This is because RAN2 explained “The RAN2 understanding of the desired UE behaviour is that the HARQ feedback is not multiplexed in the PUSCH without MAC PDU and can be transmitted in the PUCCH, i.e. there will be no PUSCH transmission for the case of uplink skipping. RAN2 thinks that there should be no further RAN2 specification impact, even if there would be misalignment between RAN1 specification and RAN2 specification.” in RAN2 LS (R2-1916572).  |
| ASUSTeK | We prefer option 2 in general. However, it is unclear how to achieve the first sub-bullet of option 2, given currently it’s up to UE implementation how to allocate available data to PUSCHs on multiple cell, i.e. the sequence of data allocation may be decoupled from sequence of existing UCI multiplexing rule. If the intent is to specify some constraint on sequence of data allocation, it would also involve RAN2 impact.Note that for option 1/option 3 there would be non-trivial RAN2 impact and given the situation in Rel-15 we are not that confident that it would become acceptable for RAN2. |
| vivo | We prefer option 1, since from gNB blind detection, UE implementation and specification perspectives, option 1 is the simplest one. From gNB blind detection perspective, in case of CA, the complexity is option 2> option 3 > option 1. For option 2, whether on PUSCH or PUCCH, and on which PUSCH, the UCI will be multiplexed is unknown for gNB until gNB does the BD; for option 3, only if all PUSCH transmissions on all CCs are skipped, the UCI will be transmitted on PUCCH; otherwise, the UCI will be multiplexed on PUSCH\_0. The required BD at gNB side is comparable with single CC case. For option 1, no BD due to enabling UL skipping is required at gNB side, the UCI will always be multiplexed on PUSCH\_0. In addition, as discussed in previous meeting, it is understood that the probability of UL skipping when configured could be higher than that of UL grant miss detection, considering the purpose/motivation for UL skipping feature is to allow gNB to do the excessive pre-scheduling. From UE perspective, the complexity is option 2> option 3 > option 1. Different from LTE case that all transmissions are aligned with subframe boundary, NR supports more flexible scheduling so that the starting/ending symbols for the overlapped channels do not need to be aligned. To achieve such flexibility, the UCI multiplexing timeline and rules defined in NR is much more complex than the LTE case. So, even if option 2 is supported for LTE, it cannot be easily supported for NR. Also as commented by CATT, both option 2 and option 3 have timeline issue, and the timeline is more stringent for option 2 compared to option 3. For option 2, whether UCI will be multiplexed on PUSCH and on which PUSCH depends on whether and “when” the MAC PDU will be delivered from MAC layer; for option 3, whether UCI will be multiplexed on PUSCH\_0 depends on whether and “when” any MAC PDU will be delivered from MAC layer. Typically, such timeline “when to deliver MAC PDU” will not be defined in MAC specification.Regarding to the internal exchange between PHY and MAC layer, we do not see any complexity given that such internal exchange is already supported for many cases, like PRACH power ramping suspension, LBT failure indication from Layer 1 to MAC etc. From specification perspective, the complexity is option 2> option 3 > option 1. For option 2, it is very challenging to define new timeline or define new procedure in RAN1 for UCI multiplexing conditioned on MAC PDU generation; Although option 1 and option 3 need modification in MAC spec to generate the MAC PDU for the PUSCH which the UCI will be multiplexed on, option 3 further requires the exchange of information whether a MAC PDU is generated among HARQ entities of different cells on which the allocated PUSCH resources are overlapped in physical layer. In addition, it is noted that RAN2 LS (R2-1916572) is for Rel.15, we understand it is difficult to be corrected for Rel.15. However, for Rel.16, we should try to make alignment between RAN1 and RAN2 specification.Based on above analysis, option 1 is preferred.  |
| Spreadtrum | We prefer Option 1 and totally agree with vivo’s comments. |
| Huawei, HiSilicon | Option 1. We agree with CATT and Vivo about the analysis of timeline and BD issues for option 2 and option 3. In addition, option 2 will introduce another judgement for multiplexing UCI, i.e. the existence of MAC PDU. Actually, gNB is not aware of which PUSCHs would carry UL-SCH, so it cannot find exact PUSCH for multiplexing although current multiplexing rules are applied. For option 3, as the analysis from CATT and Vivo, timeline and BD issues cannot be avoided when all PUSCHs have no data. Therefore, we prefer option 1. |
| MediaTek | We slightly prefer Option 2. (Option 2>Option 1> Option 3)As commented by Samsung, the blind detection complexity is similar in all options due to the DCI miss detection problem. And Option 1/3 will lead to non-trivial RAN2 specification impact, we are also not sure whether it is acceptable to RAN2. In addition, regarding the timeline issue in Option 2/3, we are wondering whether Option 1 has similar issue. E.g., does UE have sufficient time to generate MAC PDU after checking the UCI multiplexing condition?  |
| Nokia, NSB | Strong preference for option 1. The main arguments have been expressed. |
| Ericsson | Our preference is option 3 first, then option 1. We do not support option 2 because of the complexity on PUSCH blind decoding.  |
| Apple | We also have strong preference for Option 1 (which is the cleanest solution). On top of the arguments provided by the supporting companies above, we would like to emphasize:* + - 1. The extent of the BD issues introduced by Option 2 is not on the same level as what is caused by missed DCI. Depending on gNB implementation, the gNB may choose not to handle the error cases caused by missed DCI because the probability is small, or just do a limited number of hypothesis to cover the main error case, but it would have to do all the blind detections caused by Option 2.
			2. For UE, Option 2 is indeed creating issues from timeline perspective because the UE needs to hold on the processing of UCI before getting PDUs from MAC.
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For non-CA case, it could be subset of the CA case. The possible behaviours for case 2 for non-CA case are as below.

* **Q-2: For non-CA case, when there is a PUCCH carrying UCI overlapping with a PUSCH, the PUSCH can be skipped or not if there would be UCI to be multiplexed on the PUSCH?**
	+ **Option 1:**
		- **the PUSCH with UCI multiplexing cannot be skipped and MAC generates MAC PDU for the PUSCH, and UCI is multiplexed on the PUSCH**
	+ **Option 2:**
		- **the UE determines which PUSCH or PUCCH would carry the UCI based on MAC PDU generation:**
			* **If MAC generates data for the PUSCH, UCI will be multiplexed on the PUSCH with data.**
			* **If MAC does not generate data for the PUSCH, the PUSCH will not be transmitted and UCI will be transmitted in the PUCCH.**

**Please provide your comments on Q-2.**

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| **Company** | **Comment** |
| CATT | We prefer Option 1.The same issue mentioned in our response to Q-1 applies to option 2 here. In addition, it is preferable to have a unified solution for CA and non-CA cases. |
| ZTE | Option 1 |
| NTT DOCOMO | Option 1.For commonality between CA-case and non-CA case. |
| Samsung | Option 2 is preferable as reasons we explained in Q-2. |
| ASUSTeK | We prefer option 2. |
| vivo | Prefer option 1 as unified solution for both CA and non-CA case.  |
| Spreadtrum | Option 1. It is preferable to have unified solution for CA and non-CA case. |
| Huawei, HiSilicon | Option 1. Same rule applied for both CA and non-CA case. |
| MediaTek | We prefer unified solution for both CA and non-CA cases. That is, if Option 1 is adopted in Q1, Option 1 should be adopted in Q2. Otherwise, Option 2 should be adopted. |
| Nokia, NSB | Option 1 |
| Ericsson | Option 2 to be our first choice , we can accept option 1 depends on the decision on Q-1. |
| Apple | Option 1. We definitely should go for a unified solution. |

# List of contributions

1. R1-2005327 Disucssion on PUSCH skipping with overlapping UCI on PUCCH vivo

1. R1-2005328 Draft 38.213 CR on PUSCH skipping with overlapping UCI on PUCCH vivo

1. R1-2006331 Discussion on dynamic PUSCH skipping with overlapping UCI on PUCCH in Rel-16 ZTE

1. R1-2006902 UL skipping and overlapping PUSCH/PUCCH Ericsson, Nokia and Nokia Shanghai Bell

1. R1-2006837 Discussion of flexible NR UE bandwidth TEI and UL skipping Qualcomm Incorporated