3GPP TSG RAN WG1 Meeting #106-e R1-210xxxx

e-Meeting, August 16th – 27th, 2021

Agenda Item: 7.1

Source: Moderator (MediaTek Inc.)

Title: Summary of [106-e-NR-7.1CRs-01] Clarification on back-to-back PUSCHs scheduling restriction

Document for: Discussion and Decision

# Introduction

This document provides summary on the following email discussion;

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| [106-e-NR-7.1CRs-01] Issue#1: Clarification on back-to-back PUSCHs scheduling restriction by August 20 –Mohammed (MediaTek)[R1-2106474](file:///C%3A%5CUsers%5CDocs%5CR1-2106474.zip) Clarification on back-to-back PUSCHs scheduling restriction Huawei, HiSilicon[R1-2107313](file:///C%3A%5CUsers%5CDocs%5CR1-2107313.zip) Clarification on back-to-back PUSCHs scheduling restriction Qualcomm Incorporated[R1-2107505](file:///C%3A%5CUsers%5CDocs%5CR1-2107505.zip) On PUSCH scheduling restriction MediaTek Inc. |

Section#2 provides a background on the previous discussions on the back-to-back PUSCH restriction. Section#3 provides description of the issues listed in the contributions. Section#4 is used to collect companies’ views.

Please provide your comments in Section#4 by **17th August 23:59 UTC** (1st check point).

# Background

In NR Rel-15, there is a restriction on scheduling the UE with another dynamic PUSCH before the first PUSCH with the same HARQ process ID has been transmitted. The restriction is captured in Clause 6.1 of TS38.214 (V15.13.0) as follows:

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| The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0 or 0\_1 scrambled by C-RNTI or MCS-C-RNTI for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process. |

The current text of TS38.214 doesn’t properly reflect the intention of the TP agreed in RAN1#94bis. Hence, in RAN1#104-e the ambiguity issue was discussed and the following conclusion was reached [1];

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| **Conclusion (RAN1#104-e)**For the sentence “The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0 or 0\_1 scrambled by C-RNTI or MCS-C-RNTI for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process.” in TS 38.214 Clause 6.1, * The common understanding is that the DCI is expected to be received after the end of the last PUSCH.
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In RAN1#105-e, there was a discussion on adding TC-RNTI and CS-RNTI to the restriction [2], and it was agreed to add TC-RNTI to the restriction as shown below;

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| The UE is not expected to be scheduled to transmit another PUSCH by a DCI format 0\_0 with CRC scrambled by TC-RNTI, for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI format 0\_0 with CRC scrambled by TC-RNTI or by an UL grant in RA Response. |

For adding CS-RNTI to the back-to-back PUSCHs scheduling restriction, there was consensus among companies on adding the CS-RNTI to the resection. However, there was no consensus on the TP for including the CS-RNTI to the resection. The main cause for not achieving the consensus is that there are some cases where the provided TPs (option-1 and option-2 in Proposal#4) could allow (disallow) although there are disallowed (allowed) in the current specs [2].

# Issues highlighted in companies’ contributions

## Issue#1: Adding CS-RNTI to the restriction

This issue raised in R1-2107505 is regarding that CS-RNTIs is used for DG-PUSCH but not included in the mentioned restriction. The description of the issue is as follows:

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| **R1-2107505:**DCI scrambled by CS-RNTI when used for the second (or later) retransmission of the CG-PUSCH, as illustrated in Figure 1. Similar to the first case, the subsequent retransmissions of a CG-PUSCH are considered dynamic PUSCHs. Hence, the mentioned restriction should be applicable to this case as well.Figure 1: Scheduling multiple retransmissions of CG-PUSCH using DCIs scrambled by CS-RNTI. |

This issue is discussed under ***Case-1*** and ***Case-2*** in the next section.

## Issue#2: CG-PUSCH repetition termination

In R1-2106474, a conflict between a conclusion from RAN1#101-e and current specs on CG-PUSCH repetition termination was discussed. In addition, it was highlighted that there is an ambiguity on the expected behavior when the scheduling DCI does not meet the processing timeline of a CG-PUSCH repetition but it meets the processing timeline of the subsequent repetition(s).

This issue is discussed under ***Case-3*** and ***Case-4*** in the next section.

## Issue#3: *configuredGrantTimer* is not running

In R1-2107313, it was highlighted that the UE behavior is not defined for the case when a DCI received before CG-PUSCH occasion for a HARQ process and scheduling a DG-PUSCH with the same HARQ process to be transmitted after the CG-PUSCH occasion.

This issue is discussed under ***Case-5*** in the next section.

# Email discussion

The main reason for not being able to achieve consensus on a CR in previous RAN1 meetings is that there is no common understanding on the expected behaviour for each scenario/case. Hence, for this email discussion, the aim is to build a common understanding on the scenarios/cases before drafting the TP. Once there is consensus on a case (or cases), a TP (or several TPs) can be proposed to be adopted in the specs.

## Case-1: Back-to-back DCIs with CS-RNTI

In this case, there are back-to-back DCIs scrambled with CS-RNTI that schedule DG-PUSCHs as illustrated in the figure below.



Figure 1: Illustration example for back-to-back DCIs scrambled with CS-RNTI.

***Question#1: Do you agree with the following: “The UE is not expected to be scheduled to transmit another PUSCH by a DCI with CRC scrambled by CS-RNTI for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI with CRC scrambled by CS-RNTI”? If not, please provide information on the reasoning and the expected UE behaviour.***

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| ***Company*** | ***View*** |
| vivo | Agree |
| Qualcomm | Agree.Just for confirmation – NDI value is not the matter of this case. |
| ZTE | Agree |
| OPPO | Agree |
| CATT | Agree |
| Samsung | Agree |
| Huawei, HiSilicon | Agree  |

## Case-2: Back-to-back DCIs with CS-RNTI & MCS/C-RNTI

In this case, a DCI scrambled with C-RNTI or MCS-C-RNTI (scheduling a DG-PUSCH) followed by DCI scrambled with CS-RNTI scheduling DG-PUSCH. It is worth mentioning that the DCI scrambled with CS-RNTI will be “activating DCI” and the first CG-PUSCH transmission considered as DG-PUSCH.



Figure 2: Illustration example for DCI with C-RNTI followed by DCI with CS-RNTI.

***Question#2: Do you agree with the following: “The UE is not expected to be scheduled to transmit another PUSCH by a DCI with CRC scrambled by CS-RNTI for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI with CRC scrambled by C-RNTI or MCS-C-RNTI”? If not, please provide information on the reasoning and the expected UE behaviour.***

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| ***Company*** | ***View*** |
| vivo | Agree  |
| Qualcomm | Agree.Just for confirmation – NDI value is not the matter of this case. |
| ZTE | Agree |
| OPPO | Agree |
| CATT | Agree |
| Samsung | Agree |
| Huawei, HiSilicon | Agree  |

## Case-3: CG-PUSCH repetition termination (timeline satisfied)

In R1-2106474, a conflict between a conclusion from RAN1#101-e and current specs on CG-PUSCH repetition termination was discussed as highlighted below.

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| **Conclusion (RAN1#101-e):**In Rel.15, for a DG PUSCH scheduled by a DCI overriding a CG PUSCH configured with repetition factor K>1,* If the HARQ process is the same between the DG and the CG, DG overrides all remaining repetition occasions after the end of **PDCCH reception**, under the timeline specified in TS 38.214 section 6.1.
* Otherwise, DG overrides only the CG repetition overlapped with DG, under the timeline specified in TS 38.214 section 6.1.
 |
| **TS38.214, Section 6.1.2.3.1:**For any RV sequence, the repetitions shall be terminated after transmitting *K* repetitions, or at the last transmission occasion among the *K* repetitions within the period *P*, or from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process scheduled by DCI format 0\_0 or 0\_1, whichever is reached first. |

As it is clear from the conclusion, for the same HARQ process, a DG-PUSCH can override a CG-PUSCH configured with repetition factor K>1, where the overriding is performed a) relative to the PDCCH ending position and b) regardless of whether CG-PUSCH and DG-PUSCH overlap or not.

However, for the case of same HARQ process between CG-DG PUSCHs, the starting position for overriding defined in the current specification is relative to the PUSCH instead of the scheduling PDCCH, and is restricted to overlapped PUSCH only, which is not consistent with the conclusion in terms of condition a) and b) and thus needs to be revised.

***Question#3: Do you agree with the following: “The current specs on CG-PUSCH repetition termination in TS38.214 Section 6.1.2.3.1 conflict with the conclusion from RAN1#101-e, hence the specs need to be revised (to align with the conclusion from RAN1#101-e)”? If not, please provide information on the reasoning and the expected UE behaviour.***

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| ***Company*** | ***View*** |
| vivo | No. By combining specification TS 38.214 and TS 38.321, there is no conflict. From the conclusion made in RAN1#101-e meeting, yes, it covers both cases where there is resource overlapping and there is no resource overlapping for the same HARQ process. The timeline for both cases is the timeline specified in TS 38.214 section 6.1, namely the gap between the end of PDCCH scheduling the DG and the beginning of symbol j for CG is not less than N\_2 symbols. In spec 38.214, Section 6.1.2.3.1, it specifies the starting position for CG termination, but the termination timeline still needs to be met based on TS 38.214 section 6.1. TS 38.214, Section 6.1.2.3.1 specifies only the case of resource overlapped PUSCH. However, in TS 38.321, section 5.4, by *configuredGrantTimer,* it can invalidate the CG resource(s) for a given HARQ process once the UL grant is received for the same HARQ process, see below. Such invalidation by *configuredGrantTimer* covers both resource overlapped and resource not overlapped cases for the same HARQ process, and the timeline (gap between the UL grant and beginning of symbol j for CG) needs to be satisfied based on TS 38.214 section 6.1.2> if the uplink grant is for MAC entity's C-RNTI, and the identified HARQ process is configured for a configured uplink grant:3> start or restart the *configuredGrantTimer* for the corresponding HARQ process, if configured.So combine the specifications TS 38.214 and TS 38.321, there is no conflict per pour understanding.  |
| Qualcomm | No.The above spec text includes multiple conditions that the repetitions shall be terminated. If we just focus on the DG overriding case, it can be read as following.*For any RV sequence, the repetitions shall be terminated from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process scheduled by DCI format 0\_0 or 0\_1.*The above is aligned with the conclusion and hence no spec change is necessary. |
| ZTE | We agree that the current specs on CG-PUSCH repetition termination in TS38.214 Section 6.1.2.3.1 conflict with the conclusion from RAN1#101-e, and the conclusion should be respected. As for whether to revise the current specification for this case, we have no strong preference considering there would be no ambiguity as commented by vivo.  |
| OPPO | The current wording of TS 38.214 seems not perfect. Considering vivo’s explanation, we have no strong view on whether to revise TS 38.214 or not  |
| CATT | Yes. We think the texts in TS 38.214 section 6.1.2.3.1 is misleading and conflict with the conclusion and MAC specification quoted by vivo. As explained by vivo, if CGT is configured for a HARQ process, an UL grant with C-RNTI for the HARQ process would invalidate the CG resource(s) for the HARQ process so that UE should terminate the transmission after the end of PDCCH reception, which is aligned with the conclusion but conflict with TS 38.214 section 6.1.2.3.1 where UE terminates the transmission from the start of the repetition of CG overlapping with the DG PUSCH. Even if we read TS 38.214 and TS 38.321 together, it is not clear whether UE behaviour defined in 38.321 or 38.214 should be followed. |
| Samsung | No.Agree with the vivo’s view. |
| Huawei, HiSilicon | Let us understand the issue with RAN2 spec together.As RAN1 spec/conclusion till now does not state anything about the CGT, it should/could be understood that the PUSCH is allowed to be transmitted in the occasion throughout RAN1 spec and RAN1 conclusion, i.e. the below also applies to the case that either CGT is not configured, or not running.***TS38.214, Section 6.1.2.3.1:****For any RV sequence, the repetitions shall be terminated from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process scheduled by DCI format 0\_0 or 0\_1.*This is logical since there is other place specifying this (also recited in Case-5)***TS38.214, Section 6.1:****A UE is not expected to be scheduled by a PDCCH ending in symbol* $i$ *to transmit a PUSCH on a given serving cell for a given HARQ process, if there is a transmission occasion where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321] with the same HARQ process on the same serving cell starting in a symbol* $j$ *after symbol*$ i$*, and if the gap between the end of PDCCH and the beginning of symbol* $j$ *is less than* $N\_{2}$ *symbols. The value* $N\_{2}$ *in symbols is determined according to the UE processing capability defined in Clause 6.4, and* $N\_{2} $*and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH.*@vivo, QC In this case what vivo stated about invalidation by CGT does not matter. However, then still, the early termination procedure in 6.1.2.3.1 only cover the overlapping case while the conclusion also additionally include non-overlapping case; The other difference is that the timing for early termination in spec concerns overlapped PUSCH, while the timing per the RAN1 conclusion concerns the end of PDCCH reception. The difference can be shown using the below example: according to RAN1 conclusion, PUSCHs from Rep#N will be dropped while according to RAN1 spec, PUSCHs will be terminated from Rep#N+1. If the DG is in between two Rep of CG-PUSCH without overlapping, it is Case-5 and you can also easily see the issue: according to RAN1 conclusion, there will be overriding; while no spec specifies that yet.On the other hand if we want to take CGT into account, then some clarification is needed for: How the previous RAN1 conclusion interacts with CGT and how the early termination interacts with CGT? Perhaps related to Case-5. I feel this would too much complicate the RAN1 behavior, thus **our preference is that in RAN1 we assume all cases are for PUSCH is allowed to transmit.** |

## Case-4: CG-PUSCH repetition termination (timeline not satisfied)

According to the scheduling restriction specified in 6.1 of TS38.214, for CG-DG back-to-back scheduling with the same HARQ process ID, the case that the timeline is not satisfied is an error case. For a CG PUSCH without repetition, the specification is clear. However, for the CG PUSCH with repetition, (as shown in the figures below), the timeline does not satisfy the *Nth* CG repetition, but satisfied for the *(N+1)th* CG repetition. In RAN1#105-e, there was some controversy as to whether the above cases would be allowed.

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| **TS38.214, Section 6.1:**A UE is not expected to be scheduled by a PDCCH ending in symbol $i$ to transmit a PUSCH on a given serving cell for a given HARQ process, if there is a transmission occasion where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321] with the same HARQ process on the same serving cell starting in a symbol $j$ after symbol$ i$, and if the gap between the end of PDCCH and the beginning of symbol $j$ is less than $N\_{2}$ symbols. The value $N\_{2}$ in symbols is determined according to the UE processing capability defined in Clause 6.4, and $N\_{2} $and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH. |

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| **Case-4a: DG overlaps with CG repetition# N.****Case-4b: DG does not overlap with CG repetition.****Case-4c: DG overlaps with CG repetition# (N+1).** |

***Question#4: Please provide your view on whether the above cases (Case-4a, Case-4b & Case-4c) are considered as error cases or not? If not an error case, please provide information on the reasoning and the expected UE behaviour.***

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| ***Company*** | ***View*** |
| vivo | All above cases are error case based on the timeline requirement defined in current specification. To be specific, the timeline needs to be satisfied for the “first” CG repetition (or any repetition) **starting after the DCI scheduling the DG**. So, following cases in Figure A-1 and A-2 are allowed and the CG repeitition#2 can be terminated by DG.cid:image001.png@01D752D4.4DCFD710 |
| Qualcomm | According to the spec copied above, for the given HARQ process, the gap between a PDCCH that schedules a PUSCH ending symbol *i* and a transmission occasion for a PUSCH with configured grant with the same HARQ process on the same serving cell starting symbol *j* has to be not less than *N*2 symbols. Simply reading the spec, all the three cases are considered as errors. |
| ZTE | We are fine with treating all three cases as error cases. Also, agree with vivo that the cases in Figure A-1/A-2 are valid cases. The current timeline in section 6.1 is based on each transmission occasion, i.e., each PUSCH repetition. However, as long as the timeline is not satisfied for ‘a transmission occasion’, the scheduling of DG PUSCH for the same HARQ process is not allowed.  |
| OPPO | In our understanding, they are error cases |
| CATT | We share the same understanding with vivo. |
| Samsung | We think all the above cases (Case-4a, Case-4b & Case-4c) are consider as error cases. Above copied specification should apply all remaining repetitions with same HARQ process ID after symbol i. From our perspective, the current spec is clear. |
| Huawei, HiSilicon | Yes. And no spec change needed. |

## Case-5: *configuredGrantTimer* is not running

In R1-2107313, the following issue was raised regarding the expected UE behavior when the *configuredGrantTimer* is not running.

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| For back-to-back DG PUSCH vs DG PUSCH with the same HARQ process ID, approved CR should be extended to cover all other RNTIs. By this, a UE is not required to expect a second DCI for a second PUSCH is before the end of a first PUSCH scheduled by a first DCI. The examples of the timelines are illustrated below.From the UE process point of view, the same problem exists when the DG PUSCH1 in the above figure is a CG PUSCH instead. For a CG, the UE may determine whether to transmit a PUSCH on the CG occasion by N2 symbols earlier than the start of the CG occasion. This is equivalent to the case where a “virtual DCI” that schedules PUSCH on the CG occasion is detected by N2 symbols earlier.However, following are already specified for CG PUSCH and DG PUSCH with the same HARQ process ID.* A UE does not expect the time gap between the end of the DCI scheduling a DG PUSCH and the beginning of the CG PUSCH is less than N2 symbols
* A UE invalidates the CG PUSCH if *configuredGrantTimer* for the HARQ process ID is configured and running at the beginning of the CG PUSCH
* A UE invalidates the CG PUSCH if the DG PUSCH scheduled by a DCI overlaps with the CG PUSCH in time

Therefore, the case in the above figure with *configuredGrantTimer* for the HARQ process ID not running at the CG PUSCH occasion is not clear. Considering the commonality between DG PUSCH vs DG PUSCH and CG PUSCH vs DG PUSCH illustrated earlier above, this should also be the case where a UE does not expect. |

***Question#5: Do you agree with the following: “If the configuredGrantTimer is not configured, a DCI received before CG-PUSCH occasion for a HARQ process can’t schedule a DG-PUSCH with the same HARQ process to be transmitted after the CG-PUSCH occasion.”? If not, please provide information on the reasoning and the expected UE behaviour.***

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| ***Company*** | ***View*** |
| vivo | No. From technical perspective, even if the CGT is not configured, as long as the timeline (gap between the between the end of PDCCH scheduling the DG and the beginning of symbol j for CG is not less than N\_2 symbols) is met, the DG can cancel the CG for the same HARQ process regardless whether there is resource overlapping or not. We do not understand what is the difference/complexity for the different UE behaviour, e.g. DG can cancel the CG when their resource is overlapping, but it becomes error case if there is no resource overlapping between the DG and CG even if the timeline is satisfied.  |
| Qualcomm | Agree. According to the RAN1 spec, a DG PUSCH overrides a CG PUSCH only if they are overlapped. According to the RAN2 spec, a CG PUSCH is invalidated only if the *configuredGrantTimer* is running. The case that neither condition is satisfied is not clear from the specs.Note that the proposed change does not cause a burden to the network side – by configuring *configuredGrantTimer* properly, the network can achieve the expected UE behavior, i.e., a DG PUSCH (DCI or PUSCH) invalidates a CG PUSCH occasion even when they are not overlapped. |
| ZTE | No.We share with vivo that there is no much difference compared to the overlapping case. On the other hand, we are not sure whether such corner case deserve more time to discuss, considering 1. It is not the typical case without configuring the configured grant timer for CG.
2. If gNB wants to override the CG PUSCH by DG PUSCH, the DG PUSCH can be scheduled with overlapping resources with CG when the timeline can be met.
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| CATT | We think it is a valid case and agree that it is not a typical case at the same time. Our understanding is that there is no problem if the CG PUSCH is invalidated by the DG PUSCH even if CGT is not configured for the HARQ process. However, it seems that such UE behaviour is not specified in the current specification. So an alternative solution is to define the UE behaviour to invalidate the CG PUSCH transmission when *configuredGrantTimer* is not configured.If we cannot reach a consensus, we are also fine to leave it as it is considering that it is not a typical case. |
| Samsung | We don’t think that this is general case since many conditions are involved jointly here: 1) CG timer is not configured and 2) both CG and DG have same HARQ ID and 3) both CG and DG are not overlapped in time. |
| Huawei, HiSilicon | Intention is OK. Error case is fine but some wording improvement is needed, after fixing the issue in Case-3.Actually, @vivoWe understand why vivo consider this is not reasonable – i.e. it is strange that DG can cancel the CG when their resource is overlapping, but it becomes error case if there is no resource overlapping between the DG and CG even if the timeline is satisfied. However, isn't it the RAN1 conclusion says (quoted in Case-3)?@QCYou mentioned that :1. *According to the RAN1 spec, a DG PUSCH overrides a CG PUSCH only if they are overlapped.*
2. *According to the RAN2 spec, a CG PUSCH is invalidated only if the configuredGrantTimer is running.*
3. *The case that neither condition is satisfied is not clear from the specs.*

 The case you are concerning is actually Case-3 where there is non-overlapping PUSCH (anti-A) and the PUSCH is allowed (anti-B), i.e. neither condition is met.Overall, We don’t see UE complexity issue for this case – there is no out-of-order for CG since the UE does not need to handle a DCI in between a DCI->PUSCH.**However, we don't see a practical use case for the scenario: if it is for early termination, then, all remaining repetitions are preferred to be terminated (after fixing the ambiguity Rep#N or Rep#N+1, as questioned in Case-3); otherwise,** * **If there is no repetition for CG PUSCH, the network can easily allocate DCI2 later for scheduling a PUSCH 2 with the same HARQ ID;**
* **If there are repetitions after CG PUSCH1, it is not clear why the network schedule the same TB/ HARQ ID without overriding later on CG PUSCH repetitions. Network shall just wait till all repetitions for the same TB are performed;**
* **The DCI-based re-transmission for DCI2->PUSCH2 will further complicate the scheduling.**
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## Other cases?

***Question#6: Please indicate if there is any other case that should be considered part of this discussion.***

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# Outcome of the Email Discussion

To be updated.

# References

1. R1-2102225, “Summary of email discussion [104-e-NR-7.1CRs-03] on the clarification of PUSCH scheduling restriction”, Moderator (Apple Inc.), RAN1#104e, Jan. 2021.
2. R1-2106268, “Summary of [105-e-NR-7.1CRs-07] Clarification on back-to-back PUSCHs scheduling restriction”, Moderator (MediaTek), RAN1#105e, May 2021.