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:\Users\Docs\R1-2106474.zip) Clarification on back-to-back PUSCHs scheduling restriction Huawei, HiSilicon  [R1-2107313](file:///C:\Users\Docs\R1-2107313.zip) Clarification on back-to-back PUSCHs scheduling restriction Qualcomm Incorporated  [R1-2107505](file:///C:\Users\Docs\R1-2107505.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#5** by **19th August 17:00 UTC** (2nd 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. |

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.

# First round of 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 |
| Ericsson | Agree |
| MediaTek | Agree |
| Intel | Agree. |
| Sharp | Agree |
| Lenovo, Motorola Mobility | Agree |
| Apple | 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 |
| Nokia, NSB | Agree |
| Ericsson | Agree |
| MediaTek | Agree |
| Intel | Agree. |
| Sharp | Agree |
| Lenovo, Motorola Mobility | Agree |
| Apple | 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 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 after symbol, and if the gap between the end of PDCCH and the beginning of symbol is less than symbols. The value in symbols is determined according to the UE processing capability defined in Clause 6.4, and 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.** |
| Nokia, NSB | No. We have exactly the same understanding as Vivo. |
| Ericsson | Thanks for the explanation and discussion. We prefer to not revise the spec for this issue. |
| MediaTek | Yes. In our view, TS38.214 section 6.1.2.3.1 is misleading and conflicts with the conclusion from RAN1#101-e. Below we explain the scenarios where TS38.214 section 6.1.2.3.1 is not aligned with RAN2 specs & the conclusion from RAN1#101-e.   * **Scenario#1:** CGT is running, DG overlaps with CG:   Section 6.1.2.3.1 says the UE should terminate “*from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process*”, while RAN2 specs (aligned with RAN1#101-e conclusion) says to terminate after the end of PDCCH reception. So, clearly these are two different behaviours as illustrated in the figure below. However, we may assume that the UE will terminate after PDCCH because this is the “earliest” termination point.     * **Scenario#2:** CGT is running, DG does not overlap with CG   Section 6.1.2.3.1 does not address this case, while RAN2 (aligned with RAN1#101-e conclusion) defines the termination after the PDCCH.     * **Scenario#3:** CGT is not configured, DG overlaps with CG   No UE behaviour defined in RAN2 specs. Section 6.1.2.3.1 says the UE should terminate “*from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process*”, which contradicts with RAN1#101-e conclusion.     * **Scenario#4:** CGT is not configured, DG does not overlap with CG   No UE behaviour defined in RAN1 or RAN2 specs. However, RAN1#101-e conclusion defines such UE behaviour.    So, for the cases where CGT is running (Scenario#1 & 2), the UE will follow RAN2 specs, and the mentioned UE behaviour in Section 6.1.2.3.1 **is not needed**. Similarly, for the cases where CGT is not running (Scenario#3 & 4), the UE should follow RAN1#101-e conclusion rather than the mentioned UE behaviour in Section 6.1.2.3.1.  Hence, TS38.214 section 6.1.2.3.1 need to be revised to capture RAN1#101-e conclusion. |
| Intel | No spec change needed.  The concern spec text has been there since Rel-15 and there is no conflict between PHY and MAC specs whatsoever. The quoted conclusion was made much later (likely during Rel-16 maintenance for URLLC), and the fact that a \*conclusion\* was made based on reading of the specs, trying to again align specs to such a conclusion would be counter-productive. If there is a serious issue (which we do not quite see), then the conclusion from RAN1 #101-e can be updated/clarified. However, such clarification would not be needed either since the conclusion from RAN1 #101-e was made in view of both RAN1 specs in 38.214 and MAC specs in 38.321 and summarizes both possibilities.  To summarize, no conflict between PHY and MAC specs (they specify two different methods), and neither is there a conflict between RAN1 #101-e conclusion and current specs. |
| Sharp | No. We agree with vivo that the concluded behaviour already exists when the configuredGrantTimer is configured. |
| Lenovo, Motorola Mobility | In our understanding, we think CG-PUSCH repetition termination in TS38.214 Section 6.1.2.3.1 has a bit conflicting with the conclusion from RAN1#101-e.  If comments from vivo is common understanding in the group, no spec change is preferred from us. |
| Apple | Strictly speaking, we think there is some conflict/unclarity in the specs not consistent with the conclusion, as what CATT/MediaTek explained in detail.  For the case when configuredGrantTimer is configured, we could live with the view that the conclusion intends to explain the unclear part in the specs as long as it is the common understanding. It can be argued the conclusion explains how we should interpret MAC and PHY specs together. (Ideally it is always better to have clear specs.)  However, the case when configuredGrantTimer is not configured (scenario #3/#4 in MediaTek’s response) is still unclear, and the PHY spec conflicts with RAN1#101-e conclusion. |

## 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 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 after symbol, and if the gap between the end of PDCCH and the beginning of symbol is less than symbols. The value in symbols is determined according to the UE processing capability defined in Clause 6.4, and 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. |
| Nokia, NSB | The current spec is clear and defines all the cases as error cases. This maybe somewhat unintentional and the cases 4b and 4c (if not matching to a first transmission occasion of a CG-PUSCH) could have perhaps been allowed, but as it now stands they are all error cases according to the spec. |
| Ericsson | We are fine to accept the 3 cases as error cases. |
| MediaTek | In our view, all these are error cases. We believe a conclusion to highlight this common understanding would be sufficient. |
| Intel | Fine to consider these as error cases as explained by vivo. |
| Sharp | Spec is clear that all the 3 cases are error cases. |
| Lenovo, Motorola Mobility | We can accept the three above cases are error cases. |
| Apple | Agree that all the 3 cases are error cases. |

## 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. |
| 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,  @vivo  We 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)?  @QC  You 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.** |
| Nokia, NSB | We agree with many that the case, even though is a valid one, doesn’t seem like a practical one as at the time of issuing the DCI the gNB doesn’t know if there is going to be a CG-PUSCH and thus it should not make a decision that that CG-PUSCH cannot be retransmitted. That said, as mentioned by Huawei, we don’t see a practical issue for the UE supporting this even if it is not practical to use. |
| Ericsson | No. We share same understanding with VIVO. |
| MediaTek | We agree that the specification does not define UE behaviour for the case when CGT is not configured. In our view, RAN1 or RAN2 could adopt one of the following options:   * Option#1: An error case (as mentioned in Question#5). * Option#2: Define an invalidation behaviour (most likely in RAN2 specs) similar to the case where CGT is running. * Option#3: Leave it up to UE implementation whether (or not) to transmit the CG-PUSCH(s) that occur between the DCI and the corresponding DG-PUSCH.   All the above options should be sufficient as the gNB can easily avoid this case by using different HARQ process ID. However, one of the options need to be adopted. |
| Intel | Agree that this particular case when CGT is not configured is not explicitly covered in the specs. However, also agree with others that the scenario can be seen as rather atypical.  At this point, the most reasonable option would be to leave it up to UE implementation in case of such a scenario on whether it may transmit the CG PUSCH or not. |
| Sharp | Agree. The UE behaviour is not specified for the case where the configuredGrantTimer is not configured. We prefer to make it up to UE implementation. |
| Apple | Agree.  We also agree this is not a typical case, so we would be fine with any easy solution . |

## Other cases?

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

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| ***Company*** | ***View*** |
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# Second round of email discussion

## Adding CS-RNTI to the restriction

Based on the inputs in the first round of discussion on Case-1 and Case-2, all the companies 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.
* 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.

Accordingly, the following TP can be proposed to capture the above restrictions.

***Proposal#1: Adopt the following TP for TS38.214 in R15 (similar CR will be also provided for R16 if this TP is agreed);***

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| **6 Physical uplink shared channel related procedure**  **6.1 UE procedure for transmitting the physical uplink shared channel**  < Unchanged parts are omitted >  …. 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. 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 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, CS-RNTI or MCS-C-RNTI.  < Unchanged parts are omitted > |

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| ***Company*** | ***View*** |
| vivo | We are fine with above TP. |
| CATT | Instead of adding a separate sentence, we would like to modify the existing sentence to cover CS-RNTI. The proposal in R1-2107313 (copied below) can be a starting point.  The UE is not expected to be scheduled to transmit another PUSCH by a DCI format with CRC scrambled by TC-RNTI, CS-RNTI, C-RNTI or MCS-C-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 or by an UL grant in RA Response. |
| **Moderator** | **@CATT: Thank you for your suggestion. I understand your good intention, but your proposed TP based on modifying the existing sentence was not acceptable by several companies according to last RAN1 meetings [1][2]. We intentionally separated the CR for TC-RNTI to avoid any “interactions” between TC-RNTI and MCS/C-RNTI (the gNB is not aware if there is another PUSCH with C-RNTI when scheduling the UE with TC-RNTI). Please refer to the discussion in last meeting for more information [1].**  **Given that the TP in Proposal#1 reflects exactly what all the companies agreed on in the first round of discussion (Case-1 and Case-2), it is safer to not make changes that may touch other cases we didn’t discuss.**  **Thus, if there is no technical objection to the TP in Proposal#1, I would like to encourage you to accept it.** |
| Qualcomm | We agree with CATT.  Single sentence covering all the cases is cleaner and easier for future maintenance, compared to having three similar sequential sentences covering different cases. So if there is no technical problem, we prefer to the CATT’s suggestion. |
| CATT | Thanks moderator for the comments. It is a valid point. Then we would like to propose the following TP in order to avoid the problem.  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. The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0 or 0\_1 scrambled by C-RNTI, CS-RNTI or MCS-C-RNTI for a given HARQ process ~~until after~~ 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, CS-RNTI or MCS-C-RNTI. |
| ZTE | Fine with both the TP from moderator and the TP from CATT. |
| Apple | We support the original TP from the moderator. The issue with CATT’s TP is that it does not cover the case where the earlier PUSCH is CG. |
| Ericsson | We prefer original TP from moderator. Still, thank you CATT for the good intension. |
| Intel | Either moderator’s or CATT’s updated versions are fine.  @Apple, per our reading, the earlier PUSCH is scheduled by DCI format in both versions, which is the intention here. |
| Huawei, HiSilicon | Better not to mix the different RNTIs with TC-RNTI. Thus, the moderator original version and the second (not first) suggestion from CATT is preferred. |

## CG-PUSCH repetition termination (timeline satisfied)

On Case-3, there was a mix of responses regarding if there is conflict between RAN1 specs and the conclusion from RAN1#101-e. Some companies think that the conclusion from RAN1#101-e is already covered in RAN2 specs (TS38.321, section 5.4, when *configuredGrantTimer* is configured*,* it invalidates the CG resource(s) for a given HARQ process once the UL grant is received for the same HARQ process). Other companies think there is a conflict and the specs need to be clarified. However, from the scenarios listed below it seems we have the following:

1. When CGT is running, the UE will terminate the CG-PUSCH repetition after receiving the UL grant following RAN2 specs (aligned with RAN1#101-e conclusion). For this case, it seems there is no need to define (“additional”) termination behavior in RAN1 specs given that MAC will invalidate the CG-PUSCH occasions (hence no TB will delivered to RAN1).
2. When CGT is not configured, there is no UE behaviour defined in RAN2 and;
   1. if there is overlap between CG and DG, there is a conflict between TS38.214 section 6.1.2.3.1 and RAN1#101-e conclusion,
   2. if there is no overlap between CG and DG, there is no UE behaviour defined in RAN1 specs although RAN1#101-e conclusion defines such UE behavior.

**Note: the scenarios discussed in this section is for the case when CG and DG have the same HARQ ID and the timeline is satisfied.**

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| **Scenario#1:** CGT is running, DG overlaps with CG:  Section 6.1.2.3.1 says the UE should terminate “*from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process*”, while RAN2 specs (aligned with RAN1#101-e conclusion) says to terminate after the end of PDCCH reception. So, clearly these are two different behaviours as illustrated in the figure below. However, we may assume that the UE will terminate after PDCCH because this is the “earliest” termination point.    **Scenario#2:** CGT is running, DG does not overlap with CG  Section 6.1.2.3.1 does not address this case, while RAN2 (aligned with RAN1#101-e conclusion) defines the termination after the PDCCH.    **Scenario#3:** CGT is not configured, DG overlaps with CG  No UE behaviour defined in RAN2 specs. Section 6.1.2.3.1 says the UE should terminate “*from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process*”, which contradicts with RAN1#101-e conclusion.    **Scenario#4:** CGT is not configured, DG does not overlap with CG  No UE behaviour defined in RAN1 or RAN2 specs. However, RAN1#101-e conclusion defines such UE behaviour. |

So, in the following set of questions, Case-3 is divided into several scenarios to see at what scenario there could be conflict between TS38.214 Section 6.1.2.3.1 and RAN1#101-e conclusion.

***Question#7:*** ***Do you agree with the following: “For the case when CGT is configured, the CG-PUSCH repetition termination follows the behaviour defined in TS38.321, Section 5.4 (i.e. the CGT invalidates the CG occasion(s) for a given HARQ process once the UL grant is received for the same HARQ process).”?***

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| ***Company*** | ***View*** |
| vivo | Yes, we agree. |
| CATT | Yes |
| Qualcomm | Intention is OK but not accurate. “For the case when CGT is configured” should be “For the case when CGT is configured and is running at an occasion for a CG PUSCH repetition”. Even if CGT is configured, if it is expired, then the situation is same as no CGT configured. |
| ZTE | Yes |
| Apple | Agree.  But we also wonder about the following scenario when configuredGrantTimer is configured to be 1 periodicity. In this case, the CG PUSCH occasion 1 is invalidated, but not the CG PUSCH occasion 2. However, it is equally challenging for the UE to handle CG PUSCH occasion 2 and the DG. |
| Ericsson | Agree. |
| Intel | Agree. |
| Huawei, HiSilicon | Agree |

***Question#8:*** ***For the case when CGT is configured, is there any scenario where the termination procedure defined in TS38.214 Section 6.1.2.3.1 (i.e. “repetition terminated from the starting symbol of the repetition that overlaps with a PUSCH”) is needed in addition to the behaviour defined in TS38.321, Section 5.4 (which is aligned with RAN1#101-e conclusion)?***

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| ***Company*** | ***View*** |
| vivo | No, we did not see additional scenarios need to be captured. |
| CATT | No |
| Ericsson | No. |
| Intel | No. |
| Huawei, HiSilicon | No. Thus, we assume the PHY overriding or early termination is for the case the PUSCH occasion is valid (in RAN1 spec, it is “PUSCH is allowed according to 321”), i.e. CGT is not configured or not running. |

***Question#9:*** ***Do you agree with the following: “For the case when CGT is NOT configured and DG overlaps with CG;***

1. ***There is no UE behaviour defined in RAN2 for this case,***
2. ***The CG-PUSCH repetition termination should follow the RAN1#101-e conclusion rather than the behaviour defined in TS38.214, Section 6.1.2.3.1”***

***If the answer is Yes, please indicate if RAN1#101-e conclusion need to be captured in RAN1 specs.***

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| ***Company*** | ***View*** |
| vivo | For 1), we agree that no UE behaviour defined in RAN2 in case CGT is NOT configured.  For 2), since DG overlaps with CG and this case is covered by TS38.214, Section 6.1.2.3.1, there is no need to change the spec. |
| CATT | Yes for both 1) and 2).  @ vivo, for scenario #3 above, the UE behaviour in TS38.214 is different from the conclusion. |
| Qualcomm | Understand the conflict between the RAN1 spec and the conclusion, but then this appears to be a very minor issue: it is easily resolved by the network by configuring CGT appropriately. If CGT is not appropriately configured, the UE may terminate from different CG PUSCH repetition than the conclusion, but this should not be a critical issue. |
| ZTE | Yes for both 1) and 2).  No strong preference about whether spec update is needed. |
| Apple | Yes for 1).  In terms of how to resolve, we can either go with 2) to update the spec or leave it to UE implementation as commented by some companies in the 1st round. |
| Ericsson | Yes. |
| Intel | Yes to 1). On 2), we do see the mismatch, but in this case, it would be best to leave it up to UE implementation on whether it can transmit any of the CG PUSCH repetitions before overlap or not. |
| Huawei, HiSilicon | Yes to 1), thus, again, we assume the PHY overriding or early termination is for the case the PUSCH occasion is valid (in RAN1 spec, it is “PUSCH is allowed according to 321”), i.e. CGT is not configured or not running.  Yes for 2), and we think relying on proper CGT configuration is not the case – once the PUSCH is invalid, it does not matter any more either it follows the conclusion or follows the spec; the misalignment occurs when PUSCH is possible to be transmitted. However, we can accept for UE implementation – a conclusion is needed in that case. |

***Question#10:*** ***Do you agree with the following: “For the case when CGT is NOT configured and DG doesn’t overlap with CG;***

1. ***There is no UE behaviour defined in RAN2 for this case,***
2. ***There is no UE behaviour defined in RAN1 specs for this case***,
3. ***The CG-PUSCH repetition termination should follow the RAN1#101-e conclusion”***

***If the answer is Yes, please indicate if RAN1#101-e conclusion need to be captured in RAN1 specs.***

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| ***Company*** | ***View*** |
| vivo | For 1), we agree that no UE behaviour defined in RAN2 in case CGT is NOT configured.  For 2), we agree that no UE behaviour is defined in RAN1 specs for the non-overlapping case.  For 3), it would be good to follow RAN1#101-e conclusion. But we also share with other’s views that this case is not typical and prefer no spec change. |
| CATT | Yes to 1) to 3). |
| Qualcomm | Agree with 1) and 2).  For 3), it is not clear whether the conclusion is applicable to non-overlapping case. The conclusion says “for a DG PUSCH scheduled by a DCI overriding a CG PUSCH”. The overriding occurs only if a DG PUSCH and a repetition of a CG PUSCH are overlapped in the RAN1 spec. |
| ZTE | Yes to 1) to 3). No need to update the spec for this corner case. |
| Apple | Yes for 1) and 2).  In terms of how to resolve, we can either go with 3) to update the spec or leave it to UE implementation as commented by some companies in the 1st round. |
| Ericsson | Agree. |
| Intel | Agree with 1) and 2). On 3), we prefer to leave it up to UE implementation. |
| Huawei, HiSilicon | It can be error cases or leave it to UE. |

## CG-PUSCH repetition termination (timeline not satisfied)

Based on the inputs in the first round of discussion on Case-4, all the companies agree that Case-4a, Case-4b & Case-4c are considered as error cases. To avoid visiting this issue any time in the future, the following conclusion is proposed.

***Proposed conclusion#1:***

***For the scheduling restriction specified in 6.1 of TS38.214 for DG-CG with the same HARQ process ID (quoted text below), the timeline needs to be satisfied for the first CG-PUSCH repetition starting after the DCI scheduling the DG-PUSCH.***

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| ***TS38.214, Section 6.1:***  ***A UE is not expected to be scheduled by a PDCCH ending in symbol 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 after symbol, and if the gap between the end of PDCCH and the beginning of symbol is less than symbols.*** |

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| ***Company*** | ***View*** |
| vivo | We are fine with the proposed conclusion#1. |
| CATT | Fine with the proposal. One question for clarification, for PUSCH repetition type B in Rel-16, is the first CG-PUSCH repetition the first nominal repetition or the first actual repetition? |
| Qualcomm | OK |
| ZTE | Fine with the proposed conclusion. |
| Apple | Agree |
| Ericsson | The conclusion says DG overrides all the remaining repetition occasions. So the example given by vivo is still valid.  **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.  cid:image001.png@01D752D4.4DCFD710 |
| Intel | Fine with the proposed conclusion #1. |
| Huawei, HiSilicon | OK |

## *ConfiguredGrantTimer* is not configured

For Case-5, there was a mix of responses regarding if we define this case as an error case. It seems it was premature to build consensus on defining it as an error case before checking the common understanding on what is the current expected behaviour. Thus, the following questions aim to see if there is a common understanding of the current specs, and provide alternative options for the missing UE behaviour.

***Question#11:*** ***Do you agree with the following: “There is no UE behaviour defined in the specs for the case when: 1) CGT is not configured, 2) both CG and DG have the same HARQ ID, and 3) CG and DG are not overlapped in time.”?***

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| ***Company*** | ***View*** |
| vivo | Yes, we agree if all above 1), 2), 3) conditions happen, the UE behaviour is undefined. |
| CATT | Yes |
| Qualcomm | Yes |
| ZTE | Yes. |
| Apple | Yes. But this seems to overlap with Q10 above? |
| Ericsson | The behaviour is captured in RAN1 spec, but not according to the Conclusion from 101e meeting. |
| Intel | Yes |
| Huawei, HiSilicon | We think generally the spec allows this case (and not possible for spec to describe every case). It is not preferred to always state “undefined” just because one cannot read the texts literally in the spec.  Having said above, same conclusion might be reached given the discussion so far, i.e. further follow the RAN1 conclusion or leave it to UE. |

***Question#12:*** ***If the answer to Question#11 is Yes, do agree with defining one of the following options (please indicate your preferred option if so):***

* ***Option#1: An error case (as mentioned in Question#5).***
* ***Option#2: Define an invalidation behaviour similar to the case where CGT is running.***
* ***Option#3: Leave it up to UE implementation whether (or not) transmit the CG-PUSCH(s) that occur between the DCI and the corresponding DG-PUSCH.***

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| ***Company*** | ***View*** |
| vivo | Given the case is viewed as not typical, we prefer option 3 without spec change. |
| CATT | Either one is fine to us. |
| Qualcomm | We prefer Option 1.  We agree this is not a typical case. And same as for Question 9, appropriate CGT configuration can resolve the issue. However, the difference from Question 9 is that the issue in Question 9 can be left as it is (since network can resolve it easily the real issue is minor), while the issue in Question 12 is that the UE has to be able to be prepared for this scheduling timeline. |
| ZTE | Prefer Option 2, while also ok with other options. |
| Apple | We prefer Option 1 given that it is not a typical case. But still, how is this related to Q10? |
| Ericsson | We are fine with option #3 or #2. |
| Intel | Prefer Option #3. |
| Huawei, HiSilicon | Option 1 and 3 is acceptable. Option 2 is not needed as it is RAN2 spec. Again, we assume the ran1 cases should be assumed that in the PHY layer PUSCH is allowed. |

# 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.