**3GPP TSG-RAN WG1 Meeting #104-eR1-210xxxx**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda item:** **7.1**

**Source: Moderator (Apple Inc.)**

**Title: Summary of email discussion [104-e-NR-7.1CRs-03] on the clarification of PUSCH scheduling restriction**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution provides the summary for the following email discussion in RAN1#104-e:

[R1-2100580](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2100580.zip) Clarification on back-to-back PUSCHs scheduling restriction in Rel-15 MediaTek Inc.

[R1-2101340](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_104%5CDocs%5CR1-2101340.zip) Clarification on the PUSCH scheduling constraint in Rel-15 Apple

[104-e-NR-7.1CRs-03] Clarification on back-to-back PUSCHs scheduling restriction in Rel-15 – Sigen (Apple) by Jan 29

Section 2 provides the issues being raised in [1] and [2] and the related background information. Section 3 captures the detailed email discussions. Section 4 summarizes the outcome of the email discussion.

# 2 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 (V15.11.0) 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.** |

## Issue #1: Ambiguity in the text

It was pointed out in [1] and [2] that the sentence above is ambiguous, and it can be interpreted in two ways:

* **Interpretation 1**: DCI scheduling another PUSCH for a given HARQ process shall not occur before the end of the last PUSCH.
* **Interpretation 2**: Another PUSCH for a given process shall not occur before the end of the last PUSCH.

The understanding in both [1] and [2] is that interpretation 1 is the original intention.

The related TP was agreed in RAN1#94bis, and captured in the chairman’s notes as follows:

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| Agreements**:*** RAN1 clarifies operation by adopting the TP to 6.1 of 38.214 below, which corresponds to updating a previous agreement (copied below)

A UE shall upon detection of a PDCCH with a configured DCI format 0\_0 or 0\_1 transmit the corresponding PUSCH as indicated by that DCI. For any two HARQ process IDs in a given cell, if the UE is scheduled to start a PUSCH transmission in symbol *j* by a PDCCH in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than symbol *j* by a PDCCH starting later than symbol *i*. 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.**Copy of previous agreements as in RAN1#88:**For UE configured with K repetitions for a TB transmission **with/without grant**, the UE can continue repetitions (FFS can be different RV versions, FFS different MCS) for the TB until one of the following conditions is met* + If an UL grant is successfully received for a slot/mini-slot for the same TB
		- FFS: How to determine the grant is for the same TB
	+ FFS: An acknowledgement/indication of successful receiving of that TB from gNB
	+ The number of repetitions for that TB reaches K
	+ FFS: Whether it is possible to determine if the grant is for the same TB

Note that this does not assume that UL grant is scheduled based on the slot whereas grant free allocation is based on mini-slot (vice versa) |

The feature lead summary [R1-1811891](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_94b/Docs/R1-1811891.zip) [3] provides more detailed information about the discussion as follows, and the intention is to prevent back-to-back PUSCHs for the same HARQ process. More background on the motivation for such restriction can also be found in [4][5].

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| 2.2 Back-to-back uplink transmissionsCurrently in specification, a PDSCH is not expected to be transmitted for the same HARQ process until after the HARQ-ACK has been transmitted. The provides some reasonable constraint on dynamic scheduling that helps simplify implementation and testing. It was noted by [Intel] that the equivalent limitation for the uplink has not been captured in specification but should be this meeting. The following proposal is provided from [Intel].**Proposal (from [Intel]):*** *For each HARQ process ID, the UE is not expected to receive a scheduling DCI for a unicast PUSCH transmission with the same HARQ process ID until*
	+ *The time after the end of the expected transmission of the PUSCH, including any repetition of the PUSCH, of an earlier transmission on the same HARQ process ID.*

**Proposal (offline consensus):** *RAN1 clarifies operation by adopting the TP below, which corresponds to updating a previous agreement for a condition associated with grant-based repetition of a TB which was not captured in specification.* -------------------------------------------------------- Start of Text Proposal for 38.214 ----------------------------------------------------< Unchanged parts are omitted >A UE shall upon detection of a PDCCH with a configured DCI format 0\_0 or 0\_1 transmit the corresponding PUSCH as indicated by that DCI. For any two HARQ process IDs in a given cell, if the UE is scheduled to start a PUSCH transmission in symbol *j* by a PDCCH in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than symbol *j* by a PDCCH starting later than symbol *i*. 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.-------------------------------------------------------- End of Text Proposal for 38.214 ----------------------------------------------------The previous agreement is noted below.**RAN1#88****Agreements:**For UE configured with K repetitions for a TB transmission **with/without grant**, the UE can continue repetitions (FFS can be different RV versions, FFS different MCS) for the TB until one of the following conditions is met* + If an UL grant is successfully received for a slot/mini-slot for the same TB
		- FFS: How to determine the grant is for the same TB
	+ FFS: An acknowledgement/indication of successful receiving of that TB from gNB
	+ The number of repetitions for that TB reaches K
	+ FFS: Whether it is possible to determine if the grant is for the same TB

Note that this does not assume that UL grant is scheduled based on the slot whereas grant free allocation is based on mini-slot (vice versa)Also for reference, following wording in specification for the downlink from 38.214 is provided.“The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Subclause 9.2.3 of [6].” |

From these discussions, it seems clear that the agreed TP was intended to capture interpretation 1.

## Issue #2: Conflict with early termination of CG-PUSCH repetitions

It was also pointed out in [1] and [2] that the sentence above conflicts with the supported early termination of CG-PUSCH repetitions.

According to Clause 6.1.2.3.1 in TS38.214 (V15.11.0), the repetitions of CG-PUSCH can be terminated if the UE receives a DCI scheduling a PUSCH with the same HARQ process.

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| **Clause 6.1.2.3.1 in TS38.214 (V15.11.0):**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. |

This implies that the UE can receive a DCI that schedules a PUSCH for a given HARQ process before the end of the expected transmission of the last repetition of the CG-PUSCH for that HARQ process, which conflicts with the above mentioned restriction. The conflict can be summarized as follows:

1. Clause 6.1.2.3.1 says: *a DCI with C-RNTI (scheduling a PUSCH for a given HARQ process)* ***can be received*** *before the end of the last PUSCH for that HARQ process (because the initial PUCH is CG).*
2. Clause 6.1 says: *a DCI with C-RNTI (scheduling a PUSCH for a given HARQ process)* ***cannot be received*** *before the end of the last PUSCH for that HARQ process*.

## Issue #3: Missing types of RNTIs

It was mentioned in [1] that there are some cases that was not covered by the current text:

**Case#1:** DCI scrambled with TC-RNTI, which is used for scheduling the initial transmission and retransmission of Msg3, are not currently included in the restriction. These are dynamically scheduled PUSCHs, and the UE behaviour is identical to PUSCHs scheduled with DCIs scrambled by C-RNTI.

**Case#2:** 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.

To address the issues above, two versions of TPs were provided in [1] and [2].

TP from [1]:

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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 >A UE shall upon detection of a DCI format scheduling a PUSCH transmit the corresponding PUSCH 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*. Upon detection of a DCI format 0\_1 with "UL-SCH indicator" set to "0" and with a non-zero "CSI request" where the associated "reportQuantity" in *CSI-ReportConfig* set to "none" for all CSI report(s) triggered by "CSI request" in this DCI format 0\_1, the UE ignores all fields in this DCI except the "CSI request" and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. The UE is not expected to receive a DCI format 0\_0 scrambled by TC-RNTI schedules a PUSCH for a given HARQ process until after the end of the transmission of the last PUSCH for that HARQ process. If the UE receives a DCI scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI schedules a PUSCH for a given HARQ process, the UE is not expected to receive another DCI scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI scheduling a PUSCH with the same HARQ process until after the end of the transmission of the last PUSCH for that HARQ process.< Unchanged parts are omitted > |

TP from [2] (also propose to adopt a similar TP for Rel-16):

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| **TP for TS 38.214 Clause 6.1**6 Physical uplink shared channel related procedure6.1 UE procedure for transmitting the physical uplink shared channel<unchanged text omitted>A UE shall upon detection of a DCI format scheduling a PUSCH transmit the corresponding PUSCH 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*. Upon detection of a DCI format 0\_1 with "UL-SCH indicator" set to "0" and with a non-zero "CSI request" where the associated "reportQuantity" in *CSI-ReportConfig* set to "none" for all CSI report(s) triggered by "CSI request" in this DCI format 0\_1, the UE ignores all fields in this DCI except the "CSI request" and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. ~~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.~~ Unless specified otherwise, the UE is not expected to receive a DCI scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1 until after the end of the expected transmission of the PUSCH for a given HARQ process, if the DCI schedules another PUSCH for that HARQ process.<unchanged text omitted> |

# 3 Email Discussions

## 3.1 First Round of Email Discussion

It seems that all the 3 issues raised in Section 2 are valid. The main differences (other than the fact that the exact text being used is different) between the two versions of the TPs are:

* TP from [1] also addresses issue #3.
* TP from [1] excludes all the cases where the previous PUSCH transmission for the same HARQ process is CG-PUSCH, while TP from [2] only excludes the cases where the previous PUSCH transmission for the same HARQ process is CG-PUSCH with repetitions (using “Unless specified otherwise” to resolve the conflict with TS 38.214 Clause 6.1.2.3.1).

Based on the previous RAN1 agreements and the corresponding feature lead summary, it does not seem to the moderator that the agreements were intended to only apply to the case where the previous PUSCH transmission is a DG-PUSCH. Therefore, the proposed TP below uses the TP from [2] as the baseline, and it is modified accordingly to address issue #3.

### Proposal 1: Adopt the following TP for TS 38.214 Clause 6.1:

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| **TP for TS 38.214 Clause 6.1**6 Physical uplink shared channel related procedure6.1 UE procedure for transmitting the physical uplink shared channel<unchanged text omitted>A UE shall upon detection of a DCI format scheduling a PUSCH transmit the corresponding PUSCH 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*. Upon detection of a DCI format 0\_1 with "UL-SCH indicator" set to "0" and with a non-zero "CSI request" where the associated "reportQuantity" in *CSI-ReportConfig* set to "none" for all CSI report(s) triggered by "CSI request" in this DCI format 0\_1, the UE ignores all fields in this DCI except the "CSI request" and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. ~~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.~~ Unless specified otherwise, the UE is not expected to receive a DCI scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1 until after the end of the expected transmission of the PUSCH for a given HARQ process if the DCI schedules another PUSCH for that HARQ process.<unchanged text omitted> |

**Companies please indicate if you support the intention of the TP.**

|  |  |
| --- | --- |
| **Yes** | Apple  |
| **No** |  |

**Companies please provide detailed comments if any.**

If you do not agree with the intention of the TP, please explain why and the alternative TP if possible.

If you agree with the intention of the TP, please provide detailed comments on the TP if any.

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| **Company** | **Comments** |
| vivo | Following can be found in [**R1-1811891**](file:///E%3A%5Claptop%5CRAN_1_meeting%5C94bis%5CDocs%5CR1-1811891.zip)**Proposal (offline consensus):** *RAN1 clarifies operation by adopting the TP below, which corresponds to updating a previous agreement for a condition associated with* ***grant-based repetition of a TB*** *which was not captured in specification.* As shown in above highlighted parts, the back-to-back uplink transmission restrictions proposed by Intel in RAN1#94bis were only apply to the case where the previous PUSCH transmission is a DG-PUSCH. Therefore, we think CG initial transmission case should be excluded from the restriction. Following should be the correct intention:“If the UE receives a DCI scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI with NDI=1 schedules a PUSCH for a given HARQ process, the UE is not expected to receive another DCI scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI with NDI=1 scheduling a PUSCH with the same HARQ process until after the end of the transmission of the last PUSCH for that HARQ process.”About to preclude the case of TC-RNTI, we are not sure about whether it is necessary or possible. Since for UEs in RRC-connected state, it can still perform the contention based RACH and it may not be possible for NW to avoid such scheduling. |
| Spreadtrum | Issue 1: we agree Interpretation 1 is original intention.Issue 2: Agree. Issue 3: We don’t agree with Case 1. Because HARQ process in DCI 0\_0 scrambled by TC-RNTI is reserved. It cannot indicate the HARQ process information. We agree with Case 2.In summary, we support the proposed TP, because it does not include TC-RNTI case.Clarification: The proposed TP by moderator do not have TC-RNTI, however, it is in TP2. Unclear it is intention or not. |
| Qualcomm | First of all, we agree that the Issue #1 is the problem that needs to be resolved. CR is necessary.The proposed TP is a good starting point. However, fine tuning on the text would be necessary. * The TP of proposal 1 misses “TC-RNTI”, which seems an error (since TP from [2] includes it).
	+ The UE should be able to know that the back-to-back scheduling is restricted before PDCCH decoding. Hence, TC-RNTI should be included as part of the restriction.
* We recommend not to use “Unless specified otherwise” – it is unclear where/how it is specified. In addition, this condition will be unclear when the specs are updated in the future releases. We can consider for example “Except for the case where …, as specified in Clause 6.1.2.3.1 of TS38.214, the UE is not expected to …”.
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| CATT | We agree with issue #1 that there is ambiguity in the current specification and agree that CR is needed to clarify that interpretation 1 is intended.For issue #2, in addition to CG PUSCH with repetition, for CG w/o repetition, it is our understanding that UE can be scheduled to transmit a DG PUSCH which overrides the CG PUSCH.For issue #3, we agree with case #2 but share the same view as vivo that TC-RNTI (case #1) should not be included considering the CBRA for a UE in RRC\_CONNECTED state. |
| ZTE | On issue#1, we agree with the intended behavior is Interpretation 1. On issue#2, we share with CATT that a DG PUSCH can override CG PUSCH (w/ or w/o repetition). Thus, the CG initial transmission case should not be included here.On issue#3, agree with above companies that Case 1 should not be included here.  |
| OPPO | On issue#1, we agree interpretation 1 is original intention.On issue#2, we share view with CATT.On issue#3, we agree with that Case 1 should not be included. |
| MediaTek | * We don’t recommend the use of “*Unless specified otherwise*”, because it is unclear where/how it is specified. The TP should fully explain the cases where the restriction apply. Otherwise, we may have to come back later to discuss what is excluded by “*specified otherwise*”.
* We would like to highlight that the TP we provided in [2] allows DG-PUSCH overrides CG-PUSCH (*w/ or w/o repetition*), which is aligned with what some of the companies mentioned above.
* We can’t accept the TP in proposal-1 because it excludes TC-RNTI:
	1. From UE perspective, PUSCHs scheduled by DCI scrambled with TC-RNTI and PUSCHs scheduled by DCI scrambled with C-RNTI (MCS-C-RNTI, etc.) require the same implementation. If the UE can support the “back-to-back” PUSCHs scheduling with TC-RNTI, the UE will be able to support this case for other RNTIs. Hence, it doesn’t make sense to exclude any of the RNTIs used for DG-PUSCH (i.e. either have the restriction or not). We hope this addresses the comments from vivo and others about the *necessity* of including TC-RNTI.
	2. Regarding Spreadtrum’s comment “*Because HARQ process in DCI 0\_0 scrambled by TC-RNTI is reserved. It cannot indicate the HARQ process information*”, it is not clear to us why this considered as a reason for excluding TC-RNTI from the restriction. It is the same implementation/behaviour if the HARQ process is indicated (as in C-RNTI, CS-RNTI, etc.) or the HARQ process is predefined (as in TC-RNTI).

Hence, we propose to adopt the TP in [2]:“The UE is not expected to receive a DCI format 0\_0 scrambled by TC-RNTI schedules a PUSCH for a given HARQ process until after the end of the transmission of the last PUSCH for that HARQ process. If the UE receives a DCI scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI schedules a PUSCH for a given HARQ process, the UE is not expected to receive another DCI scrambled by C-RNTI, MCS-C-RNTI or CS-RNTI scheduling a PUSCH with the same HARQ process until after the end of the transmission of the last PUSCH for that HARQ process.” |
| Huawei, HiSilicon | 1. For dynamic grant case, Interpretatoin-1 is OK.
2. Issue 2 itself is incorrect. Clause 6.1.2.3.1 is only about CS-RNTI while 6.1 is about C-/MCS-C- RNTI. There is no conflict.
3. For Issue-3, strictly speaking, case 1 does not require CRs but the effect is probably the same, as the gNB does not know which UE is sending PUSCH, it will anyway do conservative scheduling without causing issues. So no strong view on case 1.
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| Nokia, NSB | * Issue #1: Agree that for dynamic grant the interpretation 1 is according to the original intent and could be clarified. Agree with other comments on not using “unless specified otherwise”.
* Issue #2: DG-PUSCH pre-empting or early terminating a CG-PUSCH should be allowed.
* Issue #3: TC-RNTI seems to be a non-issue. If a CR is to be done, we don’t oppose inclusion of TC-RNTI, but don’t see the case as relevant.
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| DOCOMO | Issue #1: we agree that the intended behavior is Interpretation 1.Issue #2: DG overriding CG should be precluded from the restriction and it should be clarified in 6.1 to avoid the same discussion in the future. However, we don’t recommend the use of “Unless specified otherwise”. The description suggested by QC look better.Issue #3: share the same view with other companies. Only Case 2 should be included in the restriction. |
| Intel | Similar views as expressed by some of the companies above:* Issue #1: fine to clarify it as Interpretation #1.
* Issue #2: DG-PUSCH can definitely cancel CG-PUSCH, with or without repetitions; and thus, this part is better reflected in the TP from MTK.
* Issue #3: Only case #2 would be accurate to capture. On TC-RNTI, the issue is not regarding UE, but that it would not be possible for gNB to enforce this in case of contention-based RA in connected mode. Thus, gNB would anyway schedule conservatively by avoiding reusing same HARQ PID. Thus, TC-RNTI need not be captured in specs.
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| Samsung | * Issue#1: Agree interpretation-1. We still think that current specification is somewhat clear since it should be “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.” if interpretation-2 is right. However, if we are only one company to think this way, we are okay to have better wording. We are okay to use “unless specified otherwise” since 214 already have used this word in other paragraph.
* Issue#2: Agree with the intention. There exists some conflict. If we use “unless specified otherwise” in the proposal 1, we think that there is no more TP for this issue.
* Issue#3: We understand motivation since anyhow UE would control HARQ buffer according to HARQ process number regardless of RNTI. But, from gNB side, is it make a scheduling limitation since gNB is not sure when UE falls into RACH-procedure? Actually, it is noted that current specification there is no limitation on TC-RNTI. In this sense, adding TC-RNTI could be seen as NBC issue.
 |
| Ericsson | * Issue#1: Agree clarification is needed - interpretation 1 is OK for dynamic grant. We prefer to avoid usage of “unless specified otherwise” and provide explicit reference to any exception.
* Issue#2: early termination of CG-PUSCH should be allowed.
* Issue#3: Regarding TC-RNTI, and also the case of PUSCH transmission scheduled by RAR grant/MSGA, the issue to consider is whether such transmissions are subject to the PUSCH scheduling restriction or not (Note that according to 38.321, “*For UL transmission with UL grant in RA Response or for UL transmission for MSGA payload, HARQ process identifier 0 is used.*”).
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## 3.2 Second Round of Email Discussion

Based on the comments during the first round of email discussion, we can break it into a few discussion points.

**It seems to be the common understanding that interpretation 1 is the correct understanding at least for DG.**

**Companies please provide comments if this is not your understanding.**

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| --- | --- |
| **Company** | **Comments** |
|  |  |

However, companies have different understanding on whether interpretation 1 also applies to CG (with the exception of DG early terminating CG repetitions as described in 6.1.2.3.1).

**Companies please indicate if you think interpretation 1 also applies to CG.**

|  |  |
| --- | --- |
| **Yes** | Apple |
| **No** | Vivo, Intel, CATT |

**Companies please provide detailed comments if any.**

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| --- | --- |
| **Company** | **Comments** |
| Apple | Regarding vivo’s comments that the following means the agreements only apply to DG, we disagree. **Proposal (offline consensus):** *RAN1 clarifies operation by adopting the TP below, which corresponds to updating a previous agreement for a condition associated with* ***grant-based repetition of a TB*** *which was not captured in specification.* Our understanding of the highlighted text is to override the previous agreement for PUSCH with repetitions as highlighted below. The previous agreement allows a DG to early terminate a previous DG with repetitions, but the later TP overrides/overturns this agreement.**Agreements:**For UE configured with K repetitions for a TB transmission **with/without grant**, the UE can continue repetitions (FFS can be different RV versions, FFS different MCS) for the TB until one of the following conditions is met* + If an UL grant is successfully received for a slot/mini-slot for the same TB
		- FFS: How to determine the grant is for the same TB
	+ FFS: An acknowledgement/indication of successful receiving of that TB from gNB
	+ The number of repetitions for that TB reaches K
	+ FFS: Whether it is possible to determine if the grant is for the same TB

Therefore, we do not think see any evidence that suggests CG is excluded from the agreement.It also seems that there is some misunderstanding that the TP in proposal 1 prevents the case of DG overriding CG (with or without repetition). By “overriding”, I assume companies refer to the case where CG is not transmitted if there is a DG overlapping with CG and the DCI for the DG satisfies the overriding timeline. But this case is not related to the TP here. So I would like to emphasize that **TP in proposal 1 does NOT prevent DG overriding CG**.What this TP intends to exclude is the case where the UE transmits a CG PUSCH, and may need to immediately transmit another DG PUSCH for the same HARQ process. From UE implementation point of view (or at least for some UE implementation), back-to-back CG+DG transmissions and back-to-back DG+DG transmissions have the same impact.In addition, we do not see the practical use case where the gNB would want/need to transmit the DCI for the DG PUSCH before the end of CG transmission. It would make sense for the gNB to wait and see if the CG is transmitted, and if yes, whether it can be successfully decoded. Therefore, we do not see the need to increase UE complexity for a non-practical use case.We also think the current specification text should be kept as much as possible (i.e. if there is no ambiguity or error) to avoid any NBC issue. If we change the text to exclude CG, that would change the R15 behavior. |
| vivo | Different companies may have different interpretations on the cited **Proposal (offline consensus)**. But we can see the agreements in RAN1#88 above include that the early termination is supported for configured grant (For UE configured with K repetitions for a TB transmission with/without grant) and the further updated agreements in RAN1#94bis was only *updating a previous agreement for a condition associated with* ***grant-based repetition of a TB****.* So, in Rel-15 CG repetition can be terminated by an UL grant.With this understanding and we further clarified in RAN1#101-e meeting, making following conclusion:

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| **Conclusion**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.
 |

As can be seen above, when HARQ process is the same between the DG and the CG, regardless of whether there is resource overlapping between the DG and CG, the DG overrides CG **on the remaining repetitions as long as the timeline is satisfied.** When HARQ process is different between the DG and the CG and only the CG repetition overlapped with DG, the overriding is per repetition under the timeline restriction. From our understanding, Rel-15 support early termination of the CG by an UL grant. If back-to-back transmission restriction is added to CG, it may cause NBC.  |
| Intel | The original intention for the CR during RAN1 #94bis was intended for DG PUSCH only. As Vivo commented, this can be seen from the highlighted description of the change to “***grant-based repetition of a TB***”. This can be further observed in the following from **R1-1814125** (FL summary on R15 maintenance for scheduling/HARQ) where the FL had clarified the above-mentioned agreement as below. Note the clarification at top (“**with amendment from RAN1 #94bis**”) and striking out “**~~with~~**” in “with/without grant”. Thus, it can be seen that the decision from RAN1 #94bis was indeed intended for DG PUSCH.

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| Configured Grant Cancellation Time with Dynamic GrantFor configured grants, it has been agreed that a dynamic scheduling of PUSCH can be used to terminate a repetition which has been initiated with the configured grant. **Agreement from RAN1#88 (with amendment from RAN1 #94bis):**For UE configured with K repetitions for a TB transmission ~~with/~~without grant, the UE can continue repetitions (FFS can be different RV versions, FFS different MCS) for the TB until one of the following conditions is met* + If an UL grant is successfully received for a slot/mini-slot for the same TB
		- FFS: How to determine the grant is for the same TB
	+ FFS: An acknowledgement/indication of successful receiving of that TB from gNB
	+ The number of repetitions for that TB reaches K
	+ FFS: Whether it is possible to determine if the grant is for the same TB

Note that this does not assume that UL grant is scheduled based on the slot whereas grant free allocation is based on mini-slot (vice versa) |

Next, it should be noted that even for the CG PUSCH case, the main problematic scenario for UE implementation is already precluded by the following sentence from Subclause 6.1 of 38.214:

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| 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 𝑁2 symbols. The value 𝑁2 in symbols is determined according to the UE processing capability defined in Clause 6.4, and 𝑁2 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. |

The above restricts that an UL grant with same HARQ PID as a CG PUSCH occasion needs to be at least N2 symbols (cancelation timeline) before start of the CG PUSCH occasion, in which case the DG would cancel the CG as acknowledged by all in this discussion. The main reason for this restriction is due to the handling of configuredGrantTimer in MAC specs. In short, MAC starts the configuredGrantTimer upon reception of a DG PUSCH with HARQ PID corresponding to a CG PUSCH occasion, and a CG PUSCH cannot be transmitted unless the configuredGrantTimer expires, thus, requiring UE to cancel the CG PUSCH in case an UL grant is received prior to CG PUSCH occasion (for details please refer to CR in **R1-1903783**. With the above, we are only left with the possibility that an UL grant is received with same HARQ PID during transmission time for the CG PUSCH occasion (only feasible in FDD). This is precluded for DG per the decision from RAN1 #94bis but it should still be feasible for the UE to handle CG PUSCH case as explained below. The main reason being that this case would be no different from the case wherein the UE receives an UL grant to terminate subsequent repetitions of a CG PUSCH occasion (the “early termination” scenario in Subclause 6.1.2.3.1 in 38.214). In such a case, the UE is expected to cancel repetitions that start at least after the minimum cancelation time from the end of the PDCCH carrying the UL grant, but can very well overlap in time when the UE is transmitting one of the earlier repetitions. To see this, consider the examples below. If the scenario in **Fig a** can be supported by the UE, there is no reason why the same UE cannot support the scenario in **Fig b**. In these figures, the DG PUSCH is scheduled with same HARQ PID as that corresponding to the first of the CG PUSCH repetitions in **Fig a** and the (solitary) CG PUSCH occasion in **Fig b**.In terms of interpretation of “**last PUSCH**” in current specs, in our interpretation this refers to DG PUSCH as should be clear from the use of “**another** PUSCH by DCI format 0\_0, 0\_1 or 0\_2 scrambled by C-RNTI or MCS-C-RNTI”, and not “a PUSCH by DCI format …”. With the use of “another”, the “last PUSCH” should be interpreted as a similar PUSCH as the “(an)other”. In conclusion, we do not think the restriction should apply to CG PUSCH.  |
| CATT | Thanks Apple for the clarification and thanks Intel for the comprehensive analysis.For the concerned back-to-back CG+DG transmissions of the same HARQ process ID, based on the timeline requirement in Subclause 6.1 of 38.214 quoted by Intel, it would not happen since the CG is cancelled by the DCI scheduling the DG PUSCH with the same HARQ process ID. |

For Issue #2 of conflict with early termination of CG-PUSCH repetitions, it seems that companies agree with the issue, and wording can be improved in the next version based on the comments received.

For case 1 in Issue #3, companies have different views on whether TC-RNTI should be included or not. However, it was pointed out by some UE vendors (e.g. QC, MediaTek) that the impact on UE implementation is the same for TC-RNTI also. There are some comments that gNB would need to be conservative in case of CBRA anyway, which also suggests that it is no harm to capture it in the specs to give UE some assurance. With these considerations, the recommendation is to also include TC-RNTI in the restriction.

**Companies please indicate if you are OK with applying interpretation 1 to DCI scrambled with TC-RNTI.**

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| **Yes** | Apple, Intel, MediaTek |
| **No** | vivo (may cause NBC), CATT |

For case 2 in Issue #3, it seems that companies agree that CS-RNTI should be included in the restriction.

**Companies please provide comments if you do not agree.**

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| **Company** | **Comments** |
| Intel | Based on further discussions here and offline, we now agree with the issue at UE side, and would be open to address it, preferably including some workaround for potential R15 NBC issues. |
| CATT | Although we understand the motivation from UE perspective, it is not clear to us how gNB can ensure that. |
| MediaTek | Regarding the issue of how the gNB can ensure the restriction for TC-RNTI, based on offline discussions, our understanding the companies refer to the following case (illustrated in the figure below as well):* The UE scheduled to transmit a PUSCH with HARQ PID=0
* The UE triggers CBRA (e.g. because *timeAlignmentTimer* has expired) before the transmission of the DG-PUSCH.
* Given that the gNB doesn’t know which UE trigged the CBRA, it might schedule Msg3 before the transmission of the early-scheduled DG-PUSCH.

In our view, this scenario should be a problem to the UE because the PUSCH (that was scheduled by C-RNTI) will not be transmitted by the UE. For example, if the CBRA was triggered because the *timeAlignmentTimer* has expired, the MAC entity will not perform the PUSCH transmission.

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| **TS 38.321, Clause 5.2:**“The MAC entity shall not perform any uplink transmission on a Serving Cell except the Random Access Preamble and MSGA transmission when the *timeAlignmentTimer* associated with the TAG to which this Serving Cell belongs is not running. Furthermore, when the *timeAlignmentTimer* associated with the PTAG is not running, the MAC entity shall not perform any uplink transmission on any Serving Cell except the Random Access Preamble and MSGA transmission on the SpCell.” |

Thus, when it comes to TC-RNTI, the restriction should be applied only on PUSCHs that scheduled by RAR or TC-RNTI, as illustrated in the figure below.  |

## 3.3 Third Round of Email Discussion

### Proposal conclusion:

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.

### Proposal 3: Adopt the following TP for TS 38.214 Clause 6.1:

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| **TP for TS 38.214 Clause 6.1**6 Physical uplink shared channel related procedure6.1 UE procedure for transmitting the physical uplink shared channel<unchanged text omitted>A UE shall upon detection of a DCI format scheduling a PUSCH transmit the corresponding PUSCH 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*. Upon detection of a DCI format 0\_1 with "UL-SCH indicator" set to "0" and with a non-zero "CSI request" where the associated "reportQuantity" in *CSI-ReportConfig* set to "none" for all CSI report(s) triggered by "CSI request" in this DCI format 0\_1, the UE ignores all fields in this DCI except the "CSI request" and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i*, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i*. Except for the case where a UE may receive a DCI format scheduling PUSCH that terminates one or more repetitions of a PUSCH with configured grant with repetitions (as specified in Clause 6.1.2.3 of TS38.214), the UE is not expected to receive a DCI format 0\_0 or 0\_1 scrambled by C-RNTI or MCS-C-RNTI or CS-RNTI for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process if the DCI schedules another PUSCH for that HARQ process. <unchanged text omitted> |

# 4 Outcome of the Email Discussion

# References

1. R1-2100580, Clarification on back-to-back PUSCHs scheduling restriction in Rel-15, MediaTek Inc., RAN1#104-e, Jan. 2021.
2. R1-2101340, Clarification on the PUSCH scheduling constraint in Rel-15, Apple, RAN1#104-e, Jan. 2021.
3. R1-1811891, Summary for Rel-15 DL/UL data scheduling and HARQ procedure, Qualcomm, RAN1#94bis, Oct. 2018.
4. R1-1810756, Remaining issues on NR scheduling & HARQ, Intel, RAN1#94bis, Oct. 2018.
5. R1-1807364, Remaining Issues on DL/UL Scheduling, Processing Time and HARQ management, Qualcomm, RAN1#93, May 2018.