**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:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_104\Docs\R1-2100580.zip) Clarification on back-to-back PUSCHs scheduling restriction in Rel-15 MediaTek Inc.

[R1-2101340](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_104\Docs\R1-2101340.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 transmissions  Currently 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 procedure  6.1 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 TC-RNTI, 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

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 procedure  6.1 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.**

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| **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:\laptop\RAN_1_meeting\94bis\Docs\R1-1811891.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 …”. |
| 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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# 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.