3GPP TSG RAN WG1 Meeting #105-e R1-210xxxx

e-Meeting, May 10th – 27th, 2021

Agenda Item: 7.1

Source: Moderator (MediaTek Inc.)

Title: Summary of [105-e-NR-7.1CRs-07] 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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| **Issue#17**  [R1-2105741](file:///C:\\Users\\wanshic\\OneDrive%20-%20Qualcomm\\Documents\\Standards\\3GPP%20Standards\\Meeting%20Documents\\TSGR1_105\\Docs\\R1-2105741.zip) Clarification on back-to-back PUSCHs scheduling restriction in Rel-15 MediaTek Inc.  [105-e-NR-7.1CRs-07] Issue#17: Clarification on back-to-back PUSCHs scheduling restriction – Delegate (MediaTek) by May 25 |

Section#2 provides a background on the back-to-back PUSCH restriction. Section#3 provides description of the issue with the current specs. Section#4 is used to collect companies’ views.

Please provide your comments in Section#4.2 by **24th May 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 (V15.12.0) 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 TP relevant to the above restriction was agreed in RAN1#94bis:

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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) |

As it can been seen from the feature lead summary [1], the intention of the restriction is to simplify the UE implementation by excluding a “back-to-back” PUSCHs scheduling with the same HARQ process ID. By back-to-back scheduling, it meant that the UE doesn’t expect another DCI scheduling a PUSCH for a given HARQ process ID unless the last PUSCH of that HARQ process has been transmitted. The relevant section from the feature lead summary [1] is copied below. More background on the motivation for the restriction can be found in [2][3] as well.

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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].” |

## RAN1#104-e discussion

The current text of TS38.214 doesn’t properly reflect the intention of the TP agreed in RAN1#94bis. In RAN1#104-e, the ambiguity issue was discussed and the following conclusion was reached [5];

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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. |

# Issue#1: Other cases of dynamic PUSCH scheduling

This issue raised in [4] is regarding some of the RNTIs that are used for DG-PUSCH but not included in the mentioned restriction. The description of the issue is as follows:

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| **R1-2105741:**  It can noticed from the FL summary [1] that the TP meant to cover the dynamic PUSCH scheduling case (referred to it as “*grant-based*”). However, the existing text of the restriction didn’t include all the cases of dynamic PUSCH scheduling, it listed only the PUSCHs that are scheduled with DCIs scrambled by C-RNTI or MCS-C-RNTI. The following two cases should be included in the restriction:  **Case#1:** DCI scrambled with TC-RNTI, which is used for scheduling Msg3 as illustrated in Figure 1, 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/MCS-C-RNTI.    Figure 1: Scheduling multiple retransmissions of Msg3 using DCIs scrambled by TC-RNTI.  **Case#2:** DCI scrambled by CS-RNTI when used for the second (or later) retransmission of the CG-PUSCH, as illustrated in Figure 2. 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 2: Scheduling multiple retransmissions of CG-PUSCH using DCIs scrambled by CS-RNTI. |

# Email discussion

## First round of discussion

Based on the issue description above and the companies’ views from the email discussion in RAN1#104-e [5], it seems there is a general consensus on including the CS-RNTI and TC-RNTI to the back-to-back PUSCH scheduling restriction

***Question#1: Do you agree with the following: as CS-RNTI and TC-RNTI are used for DG-PUSCH scheduling, they should be included in the back-to-back PUSCHs scheduling restriction (in addition to the already included C-RNTI/MCS-C-RNTI)?***

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| ***Company*** | ***View*** |
| Qualcomm | Yes |
| vivo | We are fine to include the CS-RNTI.  About adding the TC-RNTI and an UL grant in RA Response in the proposed TP shown in proposal 1, we have concerns about the scheduling restriction at gNB side, since it basically means gNB cannot use HARQ ID=0 for the dynamic scheduling for UEs in RRC-connected state since gNB cannot differentiate the UEs until the random access is successfully completed. |
| CATT | Similar as vivo, we are fine to include CS-RNTI but we do not agree to include TC-RNTI for the same reason as explained by vivo. |
| ZTE | Similar view as vivo and CATT, we are fine to include CS-RNTI while not TC-RNTI. |
| Huawei | Fine for CS-RNTI, although we think this already breaks the previous agreements that for DG based PUSCH the repetition can also be terminated…  For TC-RNTI, not needed. |
| DOCOMO | We are fine to include only CS-RNTI, while not fine for adding TC-RNTI. |
| Samsung | We are fine with CS-RNTI. |
| Apple | We agree with the proposal. |

***Proposal#1: Adopt the following TP for TS38.214;***

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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 >  …. 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 a DCI format 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.  < Unchanged parts are omitted > |

The above TP aims to;

1. Include the TC-RNTI and CS-RNTI into the restriction.
2. Include the conclusion from RAN1#104-e [5].
3. Have a single TP for R15 and R16 specs.

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| ***Company*** | ***View*** |
| Qualcomm | We support this part. For this part, we suggest starting from making a common understanding on what exactly the “if conditions” are.  The UE is not expected to be scheduled to transmit another PUSCH by a DCI format 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.  We agree “if the latter is scheduled by a DCI format or by an UL grant in RA response”, the UE is not expected to be as such.  In addition, our understanding is following. The exceptional cases from “the UE is not expected to be..” are the cases highlighted by blue.  If the end of DCI scheduling the DG PUSCH is earlier than the start of the CG PUSCH by > N2 symbols,   * If the CG PUSCH is overlapped with the DG PUSCH for the same HARQ process, the CG PUSCH is not transmitted (specified in the other part of the spec).   + For CG PUSCH with *repK* > 1, this applies to a transmission occasion of the *repK* transmission occasions of a CG PUSCH. * If the CG PUSCH is not overlapped with the DG PUSCH,   + If the *configuredGrantTimer* is configured, the timer invalidates the CG PUSCH (specified in 38.321).   + If the *configuredGrantTimer* is not configured, the UE does not expect this case.   If the end of DCI scheduling the DG PUSCH is not earlier than the start of the CG PUSCH by > N2 symbols,   * Regardless of whether or not the CG PUSCH is overlapped with the DG PUSCH, for the HARQ process, the UE does not expect this case (specified in the other part of the spec). |
| vivo | We are fine to include the CS-RNTI. As mentioned in Question#1, we have concerns on adding the TC-RNTI and UL grant in RAR.  In addition, thanks QC for the explanation. But it seems the above TP is to address the error case for dynamic scheduling vs. dynamic scheduling for the same HARQ process?  About the configured grant transmission vs. dynamic scheduling, we are generally share the QC’s views, for the same HARQ process between the CG and DG, since the configuredGrantTimer starts when receiving the UL grant, the timer will invalidate the CG PUSCH, if the CG PUSCH CG is configured with repK > 1, then the CG transmission occasions will be cancelled from the one after the UL grant scheduling the DG. |
| CATT | We are fine with the TP without TC-RNTI as commented for Q1. |
| ZTE | As commented in Q1, we are fine with the TP with adding CS-RNTI only. |
| Huawei | As above. |
| DOCOMO | Same as CATT and ZTE. |
| Ericsson | Clarification/potential wording update may be needed on the TP.  We think the text "transmit another PUSCH by a DCI format scrambled by TC-RNTI, CS-RNTI, C-RNTI or MCS-C-RNTI" can be interpreted as it is ok to transmit back to back if the original transmission was for another RNTI, e.g. RA-RNTI. "another" is then read as the previous transmission was also made with same RNTI. |
| Samsung | As commented above, we are fine to add CS-RNTI. |
| Intel | We can support the TP. Also, we have the same understanding as vivo on the applicability of this TP to dynamic vs. dynamic cases. |
| Apple | We are fine with adding CS-RNTI and TC-RNTI, but the TP is unclear to us because we are not sure what “the latter” refers to in “if the latter is scheduled by a DCI format or by an UL grant in RA Response”. |

## Second round of discussion

Based on the first round of discussion, the following is observed;

* Most of the companies are fine with including CS-RNTI in the back-to-back PUSCHs scheduling restriction.
* Several companies had concerns on including TC-RNTI because the gNB is not aware of which UE initiated a CBRA. To address this concern the back-to-back scheduling restriction can be applied among PUSCHs scheduled with TC-RNTI. Thus, the gNB doesn’t need to worry about the PUSCHs scheduled with other RNTIs for this specific UE.
* Qualcomm discussed some similar restitution that could be applied between CG-PUSCH and DG-PUSCH. However, based on the companies inputs here and the views expressed during RAN1#104-e [5], it seems it is not possible to extend the back-to-back restriction to the CG vs DG case.
* Ericsson highlight that the current wording could be misunderstood as the back-to-back restriction is only applicable between PUSCHs scheduled with the same RNTI. However, it seems the common understating the back-to-back restriction is applicable between PUSCHs scheduled with the different RNTI. It will be good hear more views from the companies on if the wording need to be changed.

According to the above observations, the following TP is proposed which aims to address the concerns on TC-RNTI. The restriction is divided into two parts; one part for PUSCHs scheduled by TC-RNTI, and the second part for PUSCHs scheduled with other RNTIs.

***Proposal#2: Adopt the following TP for TS38.214;***

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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 >  …. 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 a DCI format 0\_0 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 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 a DCI format scrambled by 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.  < Unchanged parts are omitted > |

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| ***Company*** | ***View*** |
| vivo | The first part of the TP should be an error case. So, we are fine with the TP. |
| Qualcomm | The if condition at the very end of the TP “if the latter is scheduled by a DCI format” does not cover all the conditions. What we would like to exclude is the case specified under 38.214 6.1.2.3.1 and 6.1.2.3.2:  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, 0\_1 or 0\_2, whichever is reached first.  So, the second part of the TP should be something like following:  The UE is not expected to be scheduled to transmit another PUSCH by a DCI format scrambled by 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 except for the case where the latter is a PUSCH with a configured grant and the two PUSCHs overlap as specified in Clause 6.1.2.3.1 and 6.1.2.3.2. |
| CATT | We are fine with the TP.  We do not quite understand the comment from Qualcomm. It is our understanding that the TP does not cover the cases specified in 38.214 6.1.2.3.1 and 6.1.2.3.2 since the latter is DG PUSCH. |
| Apple | We are fine with the first part of the TP on TC-RNTI.  For the second part, we agree with the comments from QC.  Our understanding is that the current email thread has not discussed whether the constraint only applies to “the last PUSCH” being dynamic PUSCH, so we do not think it is proper to include this as part of the TP. With this, we could also be fine with the following to capture the RAN1#104-e conclusion:  The UE is not expected to be scheduled to transmit another PUSCH by a DCI format scrambled by 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~~. |
| ZTE | For the second paragraph, it seems it doesn't preclude the latter DCI with CRC scrambled by TC-RNTI. So, we suggest adding ‘with CRC scrambled by CS-RNTI, C-RNTI or MCS-C-RNTI’ to the end of the second paragraph.  In addition, 'scrambled by xx-RNTI' in both paragraphs should be changed to 'with CRC scrambled by xx-RNTI' to align with other parts of the specification.  For the comment from Qualcomm, we have similar understanding with CATT. The current TP already excludes the case for CG. |
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# Outcome of the Email Discussion

To be updated.

# References

1. R1-1811891, “Summary for Rel-15 DL/UL data scheduling and HARQ procedure”, Qualcomm, RAN1#94bis, Oct. 2018.
2. R1-1810756, “Remaining issues on NR scheduling & HARQ”, Intel, RAN1#94bis, Oct. 2018.
3. R1-1807364, “Remaining Issues on DL/UL Scheduling, Processing Time and HARQ management,” Qualcomm, RAN1#93, May 2018.
4. R1-2105741, “Clarification on back-to-back PUSCHs scheduling restriction in Rel-15”, MediaTek, RAN1#105-e, May 2021
5. 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.