**3GPP TSG-RAN WG1 Meeting #117 R1-240xxxx**

**Fukuoka, Japan, May 20th-24th, 2024**

**Agenda Item: 7**

**Source: Moderator (HiSilicon)**

**Title: Summary of discussion on DCI ordering issues**

**Document for: Discussion and Decision**

# Introduction

This document is created to collect company views on the proposals in [1].

# Contacts

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| **Company** | **Contact** | **Email** |
| Huawei, HiSilicon | Yangfan | James.yangfan@huawei.com |
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# Problem description

## Issue 1: Ordering DCI formats to determine PUCCH resource

In the clause 9.2.3 of TS38.213 v16.17.0, (highlighted in Appendix A), the order of DCI formats is summarized as:

- First, index in an ascending order across CORESET indexes within a serving cell for a same PDCCH monitoring occasion;

- Second, index in an ascending order across serving cells indexes for a same PDCCH monitoring occasion;

- Third, index in an ascending order across PDCCH monitoring occasion indexes.

In [1], it explains when multiple CORESETs are enabled, and within a same CORESET, there are still more than one DCI formats and how to order them are not clear in the spec. Refer to the order of DAI values for Type-2 HARQ codebook, PDSCH reception starting time is also considered. Thus, same principle can be applied as well. An example is also provided in contribution [1], in the Figure 1 below, five DCI formats are detected in a same monitoring occasion and belong to two CORESETs, where DCI format {2} is in the first CORESET, and DCI formats {0,1,3,4} are within the second CORESET. In CC0, DCI format 3 should be indexed before DCI format 4, since PDSCH3 starts earlier than PDSCH4. Similarly, the principle is applied to CC1 as well, and the final order of DCI formats is DCI format {3, 4, 2, 0, 1}. The last DCI format is DCI format 1.



Figure . The order of determining last DCI

Based on the online discussion, some companies also think the principle below is also applied when multiple CORESETs are not enabled, we can further discuss it.

## Issue 2: Ordering DAI values in DCI formats to generate Type-2 HARQ-ACK codebook

Another issue is about the order to count counter DAI. In [1], it also explains that in the clause 9.1.3.1 of TS38.213 v16.17.0, (highlighted in Appendix B), when determining the value of the counter DAI field in DCI formats, there is an ordering rule across the DCI formats. The part of spec marked in blue specifies that if more than one PDSCH receptions on a serving cell that are scheduled from a same PDCCH monitoring occasion, the counter DAI is accumulated in increasing order of the PDSCH reception starting time. Similarly, the part of spec marked in purple requires UE count DAI in the first CORESET first and then the second CORESET. However, spec does not state the implementation priority of these two-colored paragraphs, and they may become contradict each other for some cases.

As the example in contribution [1], in the Figure 2 below, four DCI formats are detected in the same PDCCH monitoring occasion and belong to two serving cells, where DCI {2} is in the first CORESET and DCI {1, 3, 4} are within the second CORESET. In CC 1, if the value of the counter DAI is in the order of first the different CORESETs, then the order of DCI format 2 is before DCI format 1 since DCI format 2 is in the first CORESET and DCI format 1 is in the second CORESET. However, this is not consistent with the rule that counter DAI is in the increasing order of PDSCH starting time within the same serving cell and the same PDCCH monitoring occasion, where starting time of PDSCH 1 is earlier than PDSCH 2.

Similarly, if the value of the counter DAI is in the order of first the PDSCH starting times, the order of DCI format 2 is after DCI format 1, since starting time of PDSCH 2 is later than starting time of PDSCH 1. This is not consistent with the rule that counter DAI is in the order of the first CORESETs and then the second CORESETs, since DCI format 2 is in the first CORESET and DCI format 1 is in the second CORESET.



Figure 2. The order of determining counter DAI value in DCI formats

# 1st round Discussion

## Companies’ view

### Issue 1: Ordering DCI formats to determine PUCCH resource

**Q1-1: Do you agree that to determine the last DCI format indicating the PUCCH resource, when multiple CORESETs are ‘enabled’ based on TS38.213, it is not clear how to order the DCI formats when there are multiple DCI formats within a same CORESET of the same serving cell PDCCH for same PDCCH monitoring occasion? If not, please explain why.**

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| **Company** | **Agree or not?** | **Comment** |
| Qualcomm | No | We think identifying the last DCI format for PUCCH resource identification is based on the understanding that gNB may want to indicate different PUCCH resource across DCI formats in different PDCCH monitoring occasions. Within the same monitoring occasion, gNB can indicate the same PUCCH resource and hence there is no issue identified for this. |
| ZTE | No | We once proposed a CR in R1-2007736 to clarify this. While companies didn’t think this is a critical issue, and gNB should ensure the same PUCCH resource for different DCIs within a same MO. We don’t think we need to re-discuss again.  |
| CATT | No | This CR related issue was also discussed in Rel-18 MCE, and finally companies achieve common understanding that gNB should send same PRI across the DCIs in the same serving cell and same MO. Based on this situation, we prefer to keep current spec.  |
| Ericsson | No | Tend to agree with previous comments that the gNB shall indicate the same PUCCH resource for DCIs in the same monitoring occasion. With the understanding that this can be handled by proper gNB implmentation, then it seems the issue doesn’t need further discussion. |
| vivo | comment | This issue is not just about the final DCI for PUCCH determination; it also involves how the UE organizes the HARQ-ack bits. Multiple DCIs for a cell in the same slot and m-TRP with two coreset indexes have not been jointly considered before, making the prioritization of ordering rules unclear. However, we wonder if this is a corner case. It should be noted that multiple DCI for a same cell in a slot is allowed only when the scheduling cell SCS is lower than the scheduled cell SCS and the corresponding capability is reported. This implies that if the cell with m-TRP is self-scheduled or scheduled by a cell with the same SCS, only one unicast DCI scheduling DL per slot per scheduled CC is allowed. In other words, this ambiguity can be avoided by the network.***crossCarrierSchedulingProcessing-DiffSCS-r16***Indicates the UE cross carrier scheduling processing capability for DL carrier aggregation processing up to X unicast DCI scheduling for DL per scheduled CC. X is based on pair of (scheduling CC SCS, scheduled CC SCS) where a pair of (15,120), (15,60), (30,120) kHz SCS can have X = {1,2,4} while a pair of (15,30), (30,60), (60,120) kHz SCS can have X = {2}, and X applies per slot of scheduling CC. |
| Apple | comments | Seems all companies stand on the same understanding that PRI from all DCIs in a given MO for a given serving cell should indicate the same PUCCH resource. At some scenarios, even if we keep PRI to be the same, resultantant pucch can change. If we don’t want to take this ordering (which is preferred to us), let’s make a Conclusion that UE does not expect different PUCCH resources to be indicated by DCIs in a MO for a serving cell |
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**Q1-2: If your answer is ‘yes’ for Q1-1, do you agree the following proposal provided in [1] and/or TP in [2], which include PDSCH reception starting time for DCI formats ordering? If not, please provide the suggested proposal/spec change.**

***Proposal 1: The PDSCH starting time is included in ordering the detected DCI*** ***formats and determining the last DCI*** ***format, where DCI formats are indexed in an increasing order of the PDSCH reception starting time within the CORESET(s) with same index within a serving cell for a same PDCCH monitoring occasion.***

***TP #1:***

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| 9.2.3 UE procedure for reporting HARQ-ACK<Unchanged Text Omitted>For a PUCCH transmission with HARQ-ACK information, a UE determines a PUCCH resource after determining a set of PUCCH resources for  HARQ-ACK information bits, as described in clause 9.2.1. The PUCCH resource determination is based on a PUCCH resource indicator field [5, TS 38.212], if present, in a last DCI format, excluding the SPS activation DCI, among the DCI formats that have a value of a PDSCH-to-HARQ\_feedback timing indicator field, if present, or a value of *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, indicating a same slot for the PUCCH transmission, that the UE detects and for which the UE transmits corresponding HARQ-ACK information in the PUCCH where, for PUCCH resource determination, detected DCI formats are first indexed in an ascending order across serving cells indexes for a same PDCCH monitoring occasion and are then indexed in an ascending order across PDCCH monitoring occasion indexes. For indexing DCI formats within a serving cell for a same PDCCH monitoring occasion, if the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs on an active DL BWP of a serving cell, and with *ackNackFeedbackMode* = *joint* for the active UL BWP, detected DCI formats from PDCCH receptions in the first CORESETs are indexed prior to detected DCI formats from PDCCH receptions in the second CORESETs. If the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH receptions associated with detected DCI formats within CORESET(s) with the same index on a serving cell that are scheduled from a same PDCCH monitoring occasion, detected DCI formats are indexed in increasing order of the PDSCH reception starting time.<Unchanged Text Omitted> |

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| **Company** | **Agree or not?** | **Comment** |
| Company Name | Proposal: Agree or notTP: Agree or not |  |
| Qualcomm | No | gNB should be able to handle the PUCCH resource indication and hence there is no issue on this. |
| ZTE | No | Similar comment as above.  |
| CATT | No  | This case can be avoided by gNB implementation. |
| Ericsson | No | Can be handled by gNB implementation. |
| Apple | No | That should be already the gNB procedure, otherwise we may end up Out of order harq which is avoided by spec.  |
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**Q1-3: Do you agree when multiple CORESETs are NOT ‘enabled’, it is still possible to have multiple DCI formats within a same serving cell for the same PDCCH monitoring occasion? If yes, whether PDSCH reception starting time can be used for DCI formats ordering similar as Q1-2 or not? If not, please explain why.**

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| **Company** | **Agree or not?** | **Comment** |
| Qualcomm | No | Same as above |
| CATT | No |  |
| Ericsson | No | Similar comments as above. |
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### Issue 2: Ordering DAI values in DCI formats to generate Type-2 HARQ-ACK codebook

**Q2-1: Do you agree that when to determine the order of DAI values in DCI formats, the order of PDSCH starting time and different CORESETs is not clear enough? If not, what is your understanding of the order?**

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| **Company** | **Agree or not?** | **Comment** |
| Qualcomm |  | We are not sure yet the concerned ambiguity. The proposed TP is even more confusing since the purple highlighted part is the priority of CORESET pool indexes, while the TP adds priority among CORESETs with different CORESET indexes.  |
| CATT |  | Require more clarification on ‘within CORESET(s) with the same index’. We are not sure it represents same CORESET or same CORESET pool? If the target case is mTRP case, we suggest change the wording of ‘CORESET(s) with the same index’ to ‘CORESET with same coresetPoolIndex ’.  |
| Ericsson |  | The proposed TP has some problems. Note that the modified paragraph is applicable for UEs that don’t support multi-DCI multi-TRP operation also. For UEs that do not support multi-DCI multi-TRP operation, ‘CORESET(s) with the same index’ should not be applicable.  |
| Apple |  | Similar comments as other companies above. We understand the question is different CORESETs with different coresetPoolIndex |
| Samsung | Not  | We think that the proposed TP is already captured in the spec (purple part). the value of the counter DAI is in the order of the first CORESETs and then the second CORESETs for a same serving cell index and a same PDCCH monitoring occasion index.Regarding order, blue part should be general one, and then, purple part should be considered on top of blue part. That is, the principle of blue part is applicable per CORESET as explained in purple part. With this reason, we don’t think that further clarification is not needed. Also, proposed TP has problem of UEs not supporting mTRP. |
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**Q1-2: If your answer is ‘yes’ for Q1-1, do you agree the following proposal provided in [1] and/or TP#2 in [2]? If not, please provide the suggested proposal/spec change.**

***Proposal 2: If more than one PDSCH receptions on a serving cell that are scheduled from a same PDCCH monitoring occasion, DAI values are accumulated within same CORESET pool index first and then accumulated between different CORESETs.***

**TP#2**

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel<Unchanged Text Omitted>A value of the counter downlink assignment indicator (DAI) field in DCI formats denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s), SPS PDSCH release or SCell dormancy indication associated with the DCI formats, excluding the SPS activation DCI, is present up to the current serving cell and current PDCCH monitoring occasion, - first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH receptions associated with detected DCI formats within CORESET(s) with the same index on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair, - second in ascending order of serving cell index, and - third in ascending order of PDCCH monitoring occasion index $m$, where $0\leq m<M$. If, for an active DL BWP of a serving cell, the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode* = *joint*, the value of the counter DAI is in the order of the first CORESETs and then the second CORESETs for a same serving cell index and a same PDCCH monitoring occasion index. |

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| **Company** | **Agree or not?** | **Comment** |
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# Conclusions

To be updated.

# References

1. R1-2405316, Discussion on DCI ordering issues, Huawei, HiSilicon
2. R1-2405317, Correction on DCI ordering issues, Huawei, HiSilicon

# Appendix A. TS38.213 v16.17.0, clause 9.2.3

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| For a PUCCH transmission with HARQ-ACK information, a UE determines a PUCCH resource after determining a set of PUCCH resources for  HARQ-ACK information bits, as described in clause 9.2.1. The PUCCH resource determination is based on a PUCCH resource indicator field [5, TS 38.212], if present, in a last DCI format, excluding the SPS activation DCI, among the DCI formats that have a value of a PDSCH-to-HARQ\_feedback timing indicator field, if present, or a value of *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, indicating a same slot for the PUCCH transmission, that the UE detects and for which the UE transmits corresponding HARQ-ACK information in the PUCCH where, for PUCCH resource determination, detected DCI formats are first indexed in an ascending order across serving cells indexes for a same PDCCH monitoring occasion and are then indexed in an ascending order across PDCCH monitoring occasion indexes. For indexing DCI formats within a serving cell for a same PDCCH monitoring occasion, if the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs on an active DL BWP of a serving cell, and with *ackNackFeedbackMode* = *joint* for the active UL BWP, detected DCI formats from PDCCH receptions in the first CORESETs are indexed prior to detected DCI formats from PDCCH receptions in the second CORESETs. |

# Appendix B. TS38.213 v16.17.0, clause 9.1.3.1

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| A value of the counter DAI field in DCI formats, each scheduling PDSCH receptions on respective more than one serving cells with associated HARQ-ACK information in a same HARQ-ACK codebook, denotes the accumulative number of {serving cell with smallest index from the more than one serving cells, PDCCH monitoring occasion}-pairs in which PDSCH receptions are present up to the current more than one serving cells and current PDCCH monitoring occasion,- first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH receptions on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell with smallest index from the more than one serving cells, PDCCH monitoring occasion} pair,- second in ascending order of the smallest serving cell index from the more than one serving cells, and - third in ascending order of PDCCH monitoring occasion index $m$, where $0\leq m<M$.If, for an active DL BWP of a serving cell, the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode* = *joint*, the value of the counter DAI is in the order of the first CORESETs and then the second CORESETs for a same serving cell index and a same PDCCH monitoring occasion index. |