3GPP TSG RAN WG1 #101 DRAFT R1-2004641

e-Meeting, May 25th – June 5th, 2020

**Agenda item: 7.2.10.6**

**Source: Moderator (Nokia)**

**Title: FL summary #2 on cross-carrier scheduling with different numerology**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution is the RAN1#101 meeting discussion summary.

# 2 Issue to be addressed in RAN1#101-e

Codebook for more than 1 DCI per monitoring occasion, three solution options can be identified in the submitted documents:

1. If the maximum number of unicast DCIs per MO per scheduled cell is increased to larger than one, the PDSCH starting time in addition to the existing MO and Cell index is introduced to order the HARQ-ACK feedback. [1]
2. CCE index is introduced to further determine the Type-2 HARQ-ACK codebook and PUCCH resource. [3], [7]
3. Assuming X>1 DL DCIs scheduling unicast PDSCHs per scheduled cell can be transmitted in a PDCCH MO, C-DAI is used as a third dimension of HARQ-ACK bits ordering in Type2 HARQ-ACK CB [6].

**Q1:** Please provide your company views on the three options

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| **Proposal**  **Company** | **Option 1) [1]** | **Option 2) [3], [7]** | **Option 3) [6]** |
| CATT | None. The current specification works well and nothing is needed. If more than two DCIs per MO is configured, the HARQ-ACK bits can be transmitted in different codebooks.  It should be noted more than one DCIs per MO is not a new issue and has been discussed in Rel-15. The relevant conclusion is quoted below:  **Conclusion**:   * In Rel-15, a UE is not expected to detect two (or more) DCI formats (same or different) in PDCCHs received with a same first symbol in a slot and scheduling PDSCH reception(s) or SPS PDSCH release on a same cell and indicating a same slot for corresponding HARQ-ACK transmission.   + No CR is necessary   The same mechanism can be (actually it should be) applied to the case wherein up to 4 DCIs are transmitted in a same MO. | | |
| ZTE | We support Option 1).  From our perspective, Option 1) is an implementation friendly solution as UE expects to process the HARQ-ACK bits by the order of the receiving time of the corresponding PDSCHs. | The MO is determined via the starting time when UE needs to monitor the PDCCH candidates. If two CORESETs are within the same MO, then CCE index is not applicable to this case as the CCE index in the two CORESETs may be the same. | If the maximum number of DCIs per MO is >= 4, then C-DAI cannot be applied to order the HARQ-ACK. |
| Qualcomm | Our view is none of option 1, 2 or 3 is needed which is aligned with CATT’s views.  We also do not see it necessary to have more than one DCIs per PMO because one slot scheduling multiple slots can be supported based on Case 2 PDCCH monitoring.  Both option 1 to 3 and multiple DCIs per PMO are optimizations that result in unncessary new UE implementation for Rel-16. | | |
| MTK | We think Option 1 is viable. | We think Option 2 is the most straight forward and easy way to order the codebook. However, we expect proponents of Option 2 [3][7] can clarify how to handle the issue mentioned by ZTE (two CORSETs with the same CCE (say 0) mapping to the same PDCCH MO). | We also see the issue as ZTE pointed out. Proponent of Option 3 [6] can clarify how to handle the mentioned scenario (number of DCIs per MO is >= 4). |
| vivo | None of the option is needed.  The proposed option increases the UE complexity (i.e., counting the PDSCH starting time). Moreover each option may have its issue. For example, by option-2 the content of DCI (i.e., DAI) will depend on the mapping location of DCI (i.e., CCE index) which is determined after the generating the coded symbol of DCI. Such kind of change should be avoid. | | |
| Samsung | Option 1. Option 2 has the problem that the same CCE index can exist in different CORESETs (CORESET index needs to also be considered) while Option 3 offers a somewhat reduced protection for missed DCIs.  There was also another proposal from Ericsson that has been missed (use RB index) that we are also OK with.  Although we were OK (actually proposed) to use different slots for HARQ-ACK feedback in Rel-15, this should not be the case now because:   1. The use-case for multi-DCI reception at a same MO did not exist in Rel-15 – the whole discussion occurred only due because of what was an unintended consequence of some FG decisions. This is not the case in Rel-16 and there is actually a very strong use case (schedule FR2 from FR1) 2. The number of DCIs in a same MO is considered to be up to 4 (it was up to 2 in the FG or Rel-15). It would be very difficult to rely on TDM for the HARQ-ACK codebooks in TDD systems and there will be an impact on DL data rates (unlikely that 16 HARQ processes will always suffice) – the whole “schedule FR2 from FR1” feature which was the main reason for cross-cell scheduling with different SCS will be compromised. | | |
| LG | Option 2 is preferred, and regarding the case with multiple CORESETs, gNB might be able to handle the collision by using different CCE index between different CORESETs.  But, Option 1 is also acceptable if such gNB’s handling would be considered as some restriction.  On this issue, basically, we share the same view with Samsung that the support of scheduling from FR1 to FR2 was the main motivation of this WI for cross-CC scheduling between different SCSs.  In this context, the feature of supporting up to 4 DCIs in a same MO should be considered as a facilitator to maximally utilize this scheduling from FR1 to FR2, and the potential involved issue is also willing to be handled.  According to our observations, at least, the DAI counting rule (used for Type-2 dynamic HARQ-ACK codebook) needs to be handled with consideration of up to 4 DCIs in a same MO, in order to avoid potential misalignment/ambiguity on the ordering of HARQ-ACK bits in the HARQ-ACK payload between UE and gNB (the example provided in R1-2004037 is captured below for the understanding).  For example, considering the case that gNB actually schedules total 5 DCIs where the first DCI with DAI = 1 is transmitted in MO#1 and other later 4 DCIs are transmitted in MO#2 but UE misses the first DCI, it would be ambiguous for the UE on which one between the first DCI with DAI = 1 and the last DCI with DAI = 1 is missed by the UE.  Therefore, in order to address the above potential ambiguity, the values of the DAI should be determined by CCE index (by Option 2) or PDSCH starting (by Option 1). | | |
| Intel | We are OK with Option 1. Option 2 has the problem on CCE numbering if there are multiple CORESETs in a MO. | | |
| Huawei | Option 2 is preferred while option 1 is acceptable.  However we’d like to clarify that the issue mentioned from ZTE does not exist. The CCE index is the index of time-frequency resources such that for the overlapping CORESETs where each of the CORESET is also comprised by physical control resources the DCI has to be sent on resources at least with different time or different frequency resource. If the CCE index is also the same it means the two DCIs are received on the identical time-frequency resources, so no way to decode at all.  Using the PDSCH starting time also has the risk that different PDSCHs from different cells has the same starting time. Using CCE index factually differentiate DCIs from both time and frequency dimensions, that has better chance to properly schedule PUCCH and conduct the PUCCH codebook. | | |
| Ericsson | Our preference is to use lowest absolute frequency of the PDCCH as it is clear and simple; however main priority for us is to ensure support of more than one DCI and if another option can help progress and address the issue at hand, we are open for it. Regarding the comment by CATT, the need for supporting more than one DCI with HARQ feedback in same codebook has been discussed in this WI since beginning and is important for cross-carrier scheduling with mixed numerologies (including FR1-FR2 CA. | | |
| Huawei02 | Update of our previous comments. After further checking, the CCE index may overlap when the associated CORESETs are overlapping. In such case, CCE index+CORESET index can resolve the issue.  As also already replied, option 1 is also acceptable. But option 1 solely may also suffer some ambiguity cases thus needs gNB handling.  So, overall, Option2 with modifications (CCE index+CORESET index) can be a complete solution while option2/option1 solely is also workable/acceptable in most cases as gNB can ensure different CCE index when overlapping CORESETs or ensure different PDSCH starting time across CCs.  As Ericsson/Samsung/LG commented, this issue should be resolved to allow better scheduling flexibility than in Rel-15 without penalty on PDCCH capacity. As previously concluded, the issue can be discussed when UE feature discussion starts, thus we do not see any reason procedure-wise to preclude solutions that are already on the table. A new UE capability can be considered to resolve QC concern. | | |

# 3 Conclusion on the scope of the RAN1#101

To be written

# References

1. R1-2003328, Remaining Issues on Cross-carrier Scheduling with Mixed Numerologies, ZTE
2. R1-2003414, Remaining issues on cross-carrier scheduling with mix numerologies, vivo
3. R1-2003508, Remaing issues on cross-carrier scheduling with different numerology, Huawei, HiSilicon
4. R1-2003602, Discussion on HARQ-ACK feedback for SPS PDSCH release with cross-carrier scheduling, CATT
5. R1-2003675, Remaining issues on cross-carrier scheduling with different numerology, MediaTek Inc.
6. R1-2003751, Remaining issues on cross-carrier scheduling with different numerology, Intel Corporation
7. R1-2004037, Remaining issue on cross-carrier scheduling with different numerology, LG Electronics
8. R1-2004366, Remaining issues for cross-carrier scheduling with different numerologies, Ericsson
9. R1-2004639, FL summary on cross-carrier scheduling with different numerology, Moderator (Nokia)