3GPP TSG RAN WG1 #104-e R1-2102169

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

**Agenda item: 7.1**

**Source: Moderator (Nokia)**

**Title:** **Moderator summary of [104-e-NR-7.1CRs-17]  
38.213 CR on DCI ordering in a search space**

**Document for: Discussion and Decision**

# 1 Introduction

Draft CR [R1-2101134](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101134.zip) 38.213 CR on DCI ordering in a search space set, Nokia, Nokia Shanghai Bell noted that there are two possible interpretations in two parts of 38.213 related to how the DCI ordering is counted.

1. When the UE is e.g. configured with 1-symbol CORESET with the fist 3 symbols in a slot as a search space set, and the UE scheduled with a PUSCH in a DCI on an earlier symbol and a PDSCH in a later symbol in the same search space set, the current specification could be interpreted as if the UE may drop the DCI scheduling the PDSCH according to the yellow highlighted text of clause 9.

A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.

1. When a UE configured with two CCs, it is not clear how the cDAI/tDAI are counted as the yellow highlighted in the paragraph in subclause 9.1.3.1 can be interpreted in two ways when e.g. 1 symbol CORESET with first 3 symbols of the slot are configured to contain a search space. This is because it is not clear what constitutes as a start of a search space set.

The set of PDCCH monitoring occasions for DCI format 1\_0 or DCI format 1\_1 for scheduling PDSCH receptions or SPS PDSCH release is defined as the union of PDCCH monitoring occasions across active DL BWPs of configured serving cells, ordered in ascending order of start time of the search space set associated with a PDCCH monitoring occasion. The cardinality of the set of PDCCH monitoring occasions defines a total number  of PDCCH monitoring occasions.

**Interpretation 1: Even tough there are 3 symbols where PDCCH could be transmitted, they are all part of just one search space set, so the “start time of the search space set” is symbol 0 regardless of where DCI is actually transmitted**



**Interpretation 2: The start time of the search space set is the symbol of the search space in which DCI is transmitted**



# 2 Discussion

# 2.1 Issue #1

Possible interpretation 1: The word ‘previously’ refers to a previous set of search spaces (not counting symbol-wise), and the UE is expected to process both DCIs regardless of their order in time if they are in the same group of search spaces.

Possible interpretation 2: The word ‘previously’ refers to any previous symbol, and the UE may drop the DCI scheduling the PDSCH unless gNB ensures that the PUSCH-scheduling DCI is in an overlapping or in a later symbol than the PDSCH-scheduling DCI.

Possible actions:

1. Draft a CR
2. Capture a RAN1 conclusion in the chairman’s notes

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| **Company** | **Comment** |
| Nokia, NSB | **Interpretation 1:** The previously should refer to an earlier set of search spaces.  **Action a):** a CR should be drafted and agreed together with issue #2 |
| CATT | We have a different understanding on the definition of search space set. For the case when UE is configured with a search space associated with 1-symbol CORESET and configured to monitor PDCCH in the first 3 symbols in a slot, they are three search space sets instead of one according to our understanding. With this understanding, we do not see any issue here. |
| Apple | **Interpretation 2.**  We do not see the need of CR.  Note that, this sentence is precisely captured in the following agreement made in RAN1 90bis meeting after long debating. At the end, none of alt.1/Alt.2 was agreed and hence last bullet was converted to agreement, which was captured in specification. At that time, main concern from infra-vendors is that Alt.2 results in predication of DL grant for the future and is not assumed in scheduler alogirthm design.   |  | | --- | | Agreements:   * Regarding hanlding the possibility of DL assignments later than UL grant, to down-select between:   + Alt 1: Limit to up to X ACK bits for later DL assignments. ACK bits for later DL assignments puncture PUSCH     - X=2 for slot-based scheduling     - FFS X for non-slot based scheduling   + Alt 2: Uplink grant indicates number of ACK/NACK bits including past and estimated future DL assignments. UE computes ACK/NACK resources based on indicated number of ACK/NACK bits     - FFS other details * If no consensus can be achieved by the end of this week, the following will be agreed:   + In Rel-15, do not support the case when DL assignments are later than UL grant mapped to the same time instance for HARQ-ACK transmission on PUSCH |   Referring to the agreement and taking into the debating point, Interpretation #2 should be the intended behavior regardless of later DL grant comes from a same or different search space set. |
| ZTE | **Interpretation 2. No CR is needed.**  Interpretation 1 would require gNB to predict the subsequent DL scheduling, and would also cause UE to count UL DAI kind of out of order in some cases.  Regarding the definition of search space set, our understanding is a search space set contains all the associated MOs in one slot. For the example given by CATT, our understanding is there is only one search space set which contains three MOs. It’s good to hear other companies view on this. |
| Spreadtrum | **Interpretation 2. Agree with Apple.**  **For three MOs of a SS set, our understanding is same as ZTE.** |
| Huawei | **Interpretation 2.**  No CR is required and the interpretation 1 would require the gNB to do prediction which is ruled out according to previous discussion as quoted by Apple. |
| Intel | **Interpretation 2.**  On issue 1, agree with Apple that interpretation 2 was indeed the intention, and we do not think a CR is needed. |
| QC | **Interpretation 1.**  Interpretation 1 just says DL grant has to arrive in earlier set of search spaces, which aligned with the agreements well. We don’t see how this would require gNB to do prediction of DL grants. |
| vivo | **Interpretation 2.**  No CR is required. The current spec reflect the intention of the agreement of RAN1#90b. |
| MediaTek | **Interpretation 2.**  We agree with Apple that Interpretation 2 is the intention and no CR is needed. |
| DOCOMO | **Interpretation 2.**  Agree with Apple and other companies that Interpretation 2 is the intention and no CR is needed. |
| Samsung | “Previously” is just a time concept and is not associated with “Interpretation 1” or “Interpretation 2”.  We do not see any “issue” with Issue#1 and no action is needed. |
| Ericsson | We have the same understanding that “previously” is a time concept. Hence, our view is aligned with interpretation 2 and CR is not needed. |

# 2.2 Issue #2

Possible interpretation 1: The start of a search space set is understood as the first symbol of any CORESET in the search space configuration. See the 1st figure in the introduction.

Possible interpretation 2: The start of a search space set is understood as the first symbol of that CORESET in which the DCI is in. See the 2nd figure in the introduction.

Possible actions:

1. Draft a CR
2. Capture a RAN1 conclusion in the chairman’s notes

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| **Company** | **Comment** |
| Nokia, NSB | **Interpretation1:** The previously should refer to any CORESET so that the location of the DCI does not alter the cDAI/tDAI ordering.  **Action a):** a CR should be drafted and agreed together with issue #1 |
| CATT | Same as comments to Issue #1. The DAI ordering should be as shown for interpretation 2. |
| Apple | **Interpretation 2.**  It is based on the complete sentence of ‘start time of the search space set associated with a PDCCH monitoring occasion’, instead of ‘start time of the search space set’.  Note that, in our view, MO is a pure time-domain concept in symbol granularity across CCs. That’s the reason why C-DAI/T-DAI in TS 38.213 is defined using two-dimension parameters i.e., <serving cell, MO>, instead of MO only.  As pointed out by Aris in email discussion, interpretation #1 would require gNB to implement prediction on lower CC for setting the C-DAI/T-DAI in CC with higher CC index.  With interpretation 2, we think ACTION b) is sufficient. |
| ZTE | **Interpretation 2**  DAI counting is performed per MO basis in the time domain according to the pseudo-code. Thus, Interpretation 2 should be the original intention. In addition, as commented above, Interpretation 1 would require gNB to predict the subsequent DL scheduling, and would also cause UE to count UL DAI kind of out of order in some cases. |
| Spreadtrum | **Interpretation 2. Agree with Apple.** |
| Huawei | **Interpretation 2.**  DAI counting is based on the starting time of PDCCH monitoring occasions instead of the starting time of search space sets in a slot. Interpretation 1 would require a change to the definition of C/T-DAI since the starting time of the three MOs have the same starting time  A value of the counter downlink assignment indicator (DAI) field in DCI format 1\_0 or DCI format 1\_1 denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s) or SPS PDSCH release associated with DCI format 1\_0 or DCI format 1\_1 is present, up to the current serving cell and current PDCCH monitoring occasion, first in ascending order of serving cell index and then in ascending order of PDCCH monitoring occasion index , where .  The value of the total DAI, when present [5, TS 38.212], in DCI format 1\_1 denotes the total number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s) or SPS PDSCH release associated with DCI format 1\_0 or DCI format 1\_1 is present, up to the current PDCCH monitoring occasion  and is updated from PDCCH monitoring occasion to PDCCH monitoring occasion. |
| Intel | **Interpretation 2.**  On issue 2, we agree with explanations from Apple and Huawei.  While a CR is again not essential, but we would be open to considering some clarifications to the phrase “start time of the search space set associated with a PDCCH monitoring occasion” (similar to the suggestion from Samsung during the preparation phase, e.g., “start time of the ~~search space set associated with a~~ PDCCH monitoring occasions”) if deemed useful.    As others have pointed out, with Interpretation 1, the gNB would be expected to predict future scheduling decisions, and this would be problematic even when restricting to within a slot duration. For instance, UE features involving multiple PDCCH MOs distributed within a slot duration (e.g., FGs 3-5, 3-5a, 3-5b, Rel-16 span-based PDCCH monitoring) would all be rendered practically ineffective in addressing low latency use-cases and requirements. |
| QC | **Interpretation 1.**  The spec is very clear, it says: “ordered in ascending order of start time of the search space set associated with a PDCCH monitoring occasion.” Based on spec, for a PDCCH MO, what matters is the starting time of the associated “search space set”, not the starting time of the MO. It is QC view but we don’t see how the spec can be interpret as interpretation 2.  We acknowledge that interpretation 2 might be the original design principle in RAN1. But the spec is implemented as in the above quoted sentence and have been there for a long time. What Intel proposed is an NBC change to spec and we reject it. |
| vivo | **Interpretation 2.**  Interpretation 2 is the design intention, i.e., DAI counting is performed per MO basis in the time domain. This is also reflected in the pseudo-code of codebook. We are open to either a conclusion or a CR (either R15 or R16) for clarification. |
| MediaTek | **Interpretation 2.**  We have the same understanding as Apple that MO is the time domain concept in symbol granularity across CCs. The corresponding spec is quoted below.  “The set of PDCCH monitoring occasions for DCI format 1\_0 or DCI format 1\_1 for scheduling PDSCH receptions or SPS PDSCH release is defined as the union of PDCCH monitoring occasions across active DL BWPs of configured serving cells, ordered in ascending order of start time of the search space set associated with a PDCCH monitoring occasion. The cardinality of the set of PDCCH monitoring occasions defines a total number  of PDCCH monitoring occasions.”  And according to the following spec, we think Interpretation #2 is correct and no CR is needed.  “A value of the counter downlink assignment indicator (DAI) field in DCI format 1\_0 or DCI format 1\_1 denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s) or SPS PDSCH release associated with DCI format 1\_0 or DCI format 1\_1 is present, up to the current serving cell and current PDCCH monitoring occasion, first in ascending order of serving cell index and then in ascending order of PDCCH monitoring occasion index , where .  The value of the total DAI, when present [5, TS 38.212], in DCI format 1\_1 denotes the total number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s) or SPS PDSCH release associated with DCI format 1\_0 or DCI format 1\_1 is present, up to the current PDCCH monitoring occasion  and is updated from PDCCH monitoring occasion to PDCCH monitoring occasion. ” |
| DOCOMO | **Interpretation 2**  Agree with Apple and MTK that PDCCH monitoring occasion is the reference point for DAI counting. |
| Samsung | **Interpretation 2 and CR to clarify**  Interpretation 1 is not functional and would like to understand how an implementation according to Interpretation 1 was done.  A search space set starts at say slot#0 of the drxOnDuration and can continue as long as the timer is running. How is it possible for a gNB to set the DAI at slot#0 of CC1 based on the DAI at slot#4 of CC0?  Whether the change is NBC or not can be discussed but a different interpretation than the RAN1 agreement (Interpretation 2) does not seem pragmatic. |
| Ericsson | **Our understanding is Interpretation 2**. But we would like to share our view on some aspects:  From our point of view, RAN1 intention was Interpretation 2 and the pseudo code also reflects interpretation 2. However, **we sympathize with QC that the text under discussion actually leads toward interpretation 1. On the other hand, the pseudo code as described by other reflects interpretation 2.**  The fact is that irrespective of RAN1 design intention and technical arguments that mentioned above, different UE vendors have implemented differently and as NW vendor, this is the important issue that we hope that we can somehow resolve. |

# 3 Discussion round 2

# 3.1 Issue #1

Two interpretations have been presented, one where the UE is not expected to process the PDSCH-scheduling-DCI placed on a symbol after the PUSCH-scheduling-DCI (a majority interpretation), and another where the processing takes place. The interpretations are not in conflict in the sense that the latter works in a network designed for the former. A large number of companies indicate that there is no need for a CR.

**Possible conclusion to be captured in RAN1 chairman’s notes:**

* **UE implementation that does not process a PDSCH-scheduling-DCI in a later symbol than a PUSCH-scheduling-DCI when the HARQ-ACK of that PDSCH would be mapped on that PUSCH (k1=k2) is implemented according to the specification.**
* **gNB needs to ensure that either the PDSCH-scheduling-DCI is never after the PUSCH-scheduling-DCI or k1≠k2 if it wants both to be processed by all UE implementations.**

**Please provide your view on the possible conclusion above**

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| **Company** | **Comment** |
| Apple | On the 1st bullet, we are ok to capture a conclusion in the chairman notes to avoid potential ambiguity, although we believe the existing specification was already clear. However, the condition ‘k1=k2’ is not precise, as explained in the following paragraph.  On the 2nd bullet, we agree with the moderator to rely on gNB implementation constraint in resolving the situation that already have two implementations. However, the condition ‘k1**≠ k2**’ is not precise. The ‘k1’ refers to the time distance between the last symbol PDSCH and the first symbol of HARQ-ACK, independent of DL grant; k2 refers to the time distance between last symbol of UL grant and the first symbol of PUSCH. We are not sure how ‘k1**≠ k2**’ can achieve the purpose of HARQ-ACK associated with later PDSCH does not piggyback on PUSCH scheduled by the earlier UL Grant.  Instead using ‘k1’ and ‘k2’, maybe we can use the similar text as current spec:  gNB needs to ensure that a DCI format scheduling a PDSCH reception or a SPS PDSCH release shall have an ending symbol that is not later than the ending symbol of a DCI format scheduling a PUSCH transmission, if the UE multiplexes the corresponding HARQ-ACK information in the PUSCH transmission. |
| ZTE | We are fine with the first bullet with deleting ‘k1=k2’, which is not accurate as Apple explained.  For the second bullet, we don’t see a need to have a conclusion on gNB’s scheduling behavior. There could be many ways to avoid this, e.g., PDSCH-scheduling-DCI is before PUSCH-scheduling-DCI or the PUCCH carrying HARQ-ACK for the PDSCH doesn’t overlap with the PUSCH in time, or the PUCCH carrying HARQ-ACK for the PDSCH overlaps with a second PUSCH which has earlier symbol and the UCI would be multiplexed on the second PUSCH, etc. |
| QC | On one hand, we don’t see strong necessity to have this conclusion. As some companies mentioned, “previously” is just a time concept and it is not tied with the issue 2. On the other hand, the conclusion seems fine to us if majority see it clarifies specification. The wording can be fine-tuned like Apple pointed out. |
| Huawei | Overall we don’t see a strong need to have a conclusion on this. For the first bullet, we share similar view with Apple and ZTE that “k1=k2” should be removed. For the second bullet, it is not clear whether there is a need to say anything about gNB scheduler, our understanding is that all UE have been implemented according to the specification while the situation for issue #2 might be different. |
| CATT | We share the similar view as others that a conclusion is not needed since the current spec is clear. However, we would not object to the proposal if majority companies see the need.  For the first bullet, we also think “k1=k2” should be removed. We do not think the second bullet is needed. |

# 3.2 Issue #2

Two interpretations have been presented, one where all the CORESETs are part of the same search space set and the start time of the search space set is symbol#0, and another, where each symbol consists of its own search space set (a majority interpretation). The two interpretations lead to different ordering of HARQ-ACK bits. Two possible ways forward can be seen:

**Possible ways forward:**

* **Alt1: Agree that interpretation 2 is the correct one, draft a RAN1 conclusion or a CR accordingly**
* **Alt2: Accept that two implementations exist already, do nothing in RAN1 to ensure that the standard is understood the same way by everyone, and the gNBs must implement a work-around.**

**Please provide your view on the possible way forward**

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| **Company** | **Comment** |
| Apple | We prefer Alt.1 at least for Rel-16 and onwards, i.e., a CR is still needed to avoid different interpretations and confusion in the future.  For Rel-15, considering the existing situation that there are already Rel-15 devices with different implementations on market, a realistic solution is to use Alt.2 for Rel-15. |
| MediaTek | Support Alt 1 at least for Rel-16. And a CR is preferred. |
| ZTE | Support Alt 1. A Rel-16 CR is preferred. |
| QC | We object to Alt 1. As we mentioned before, we acknowledge that interpretation 2 was the original RAN1 intent. However, that’s not what got specified. We have implemented the specification as written and we object to changing it now.  Alt 2 is acceptable to us.  We can consider another alternative (Alt 3).  We can make a compromise to change the Rel-16 specification to reflect interpretation 2. But as for the Rel-15 specification, since there are already deployed devices in the field, we cannot accept changing the requirement and cannot accept Alt 1. |
| Huawei | Support Alt.1 to clarify that interpretation 2 is the correct one. A CR is needed at least for Rel-16. |
| CATT | Alt. 1.  We don’t understand how interpretation 2 works as commented by Samsung. |

# 4 Conclusion

**Issue#1:** No for further RAN1 specification corrections or RAN1 conclusions were agreed.

**Issue#2:** A CR according to interpretation 2 was agreed in R1-2102170.