**3GPP TSG RAN WG1 #119 R1-240xxxx**

**Orlando, US, November 18th – 22nd, 2024**

**Agenda item:** **7**

**Source: Moderator (Spreadtrum, UNISOC)**

**Title:** **Summary on PDCCH candidate with larger AL than the REGs in CORESET**

**Document for:** **Discussion and decision**

# Introduction

In this contribution, the discussion on counting and overbooking of PDCCH candidate with larger AL than the REGs in CORESET for Rel-15 is summarized.

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# Discussion

In [1], a contribution is proposed to clarify on PDCCH candidate.

The issue is happened when a PDCCH candidate with an aggregation level is larger than the number of REGs in the CORESET. For example, a candidate of aggregation level configured for a search space set is 16, and the CORESET associated with the search space has only 48 PRB with 1 symbol duration.

There was an agreement in RAN1#92 to allow this type of configuration, and UE is not required to monitor this candidate.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agreements RAN1#92:   * To adopt the TP for TS38.213 Section 10.1 * Also add one sentence in the spec saying “when the number of REGs is not sufficient for a given aggregation level, the UE is not required to monitor candidates of the given aggregation level”   + Up to spec editor for final wording   === Start ===  Table 10.1-1: CCE aggregation levels and max number of candidates per CCE aggregation level for Type0/Type0A/Type2-PDCCH common search space   |  |  | | --- | --- | | CCE Aggregation Level | Number of Candidates | | 4 | 4 | | 8 | 2 | | 16 | 1 |   === End === |

There are some other PDCCH candidates which UE is not required to monitor and they are still counted, such as when PDCCH candidates overlapping with SSB or rate matching pattern of PDSCH, as shown below.

|  |
| --- |
| 38.213 clause 10.1  For monitoring of a PDCCH candidate by a UE, if the UE  - has received *ssb-PositionsInBurst* in *SSB-MTCAdditionalPCI* for a serving cell, and  - at least one RE for a PDCCH candidate overlaps with at least one RE of a candidate SS/PBCH block, after puncturing if applicable, corresponding to a SS/PBCH block index provided by *ssb-PositionsInBurst* in *SSB-MTCAdditionalPCI* with same physical cell identity as the one associated with a RS having same quasi-collocation properties as a CORESET for the PDCCH candidate,  the UE is not required to monitor the PDCCH candidate. |
| If a UE is provided *resourceBlocks* and s*ymbolsInResourceBlock* in *RateMatchPattern*, or if the UE is additionally provided *periodicityAndPattern* in *RateMatchPattern*, the UE can determine a set of RBs in symbols of a slot that are not available for PDSCH reception scheduled by a DCI format as described in [6, TS 38.214]. If a PDCCH candidate that provides a DCI format is mapped to one or more REs that overlap with REs of any RB in the set of RBs in symbols of the slot, the UE does not expect to monitor the PDCCH candidate. |

For a PDCCH candidate with an aggregation level which is larger than the number of REGs in the CORESET, UE is not required to monitor this candidate according to the agreement; however, it is still not clear whether the candidate should be counted or not. It is necessary to clarify the UE behaviour for these PDCCH candidates as it not only will affect BD counting of this search space set, but also will affect other search space sets monitoring if overbooking is configured on the PCell.

There would have two understandings from implementation aspect:

* **Understanding 1**: PDCCH candidates are counted. Because the counting of PDCCH is based on the configuration of search space, same rule also applied when PDCCH candidates are overlapping with SSB/rate matching pattern.
* **Understanding 2**: PDCCH candidates are not counted. These PDCCH candidates are not exist, which can be excluded from the configuration of search space and CORESET. It requires UE to set the number of PDCCH candidates to 0 or ignore these PDCCH candidates.

# Pre-meeting views collection

***Observation 1: When the PDCCH candidates with an aggregation level are larger than the REGs in CORESET, UE is not required to monitor these candidates.***

1. ***Clarify the UE behaviour for the counting of these PDCCH candidates with one of the following understandings.***

* ***Understanding 1: PDCCH candidates are counted.***
* ***Understanding 2: PDCCH candidates are not counted.***

Please share your views to the questions below.

Question 1: Do you agree with Observation 1?

|  |  |  |
| --- | --- | --- |
| Companies | Agree or not | Comments |
| ZTE | Agree |  |
| Qualcomm | Agree |  |
| Nokia | Agree |  |
| Ericsson | Agree |  |
| Samsung | Agree |  |
| Huawei | Agree |  |
| vivo | Agree |  |
| New H3C | Agree |  |

Question 2: For proposal 1, which understanding do you agree?

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| --- | --- | --- |
| Companies | Understanding 1 or Understanding 2 or  other understanding | Comments |
| ZTE | Understanding 2 | For a PDCCH candidate overlaps with SSB or rate match pattern, a UE does not to require to monitor while it is still counted because of the following copied spec text. But, its prerequisite is the PDCCH candidate is within the CORESET, which does not include the concerned case here.  In addition, we don’t see any reason to count such invalid candidate that is caused by PDCCH configuration itself, instead of collision with other signals.   |  | | --- | | A PDCCH candidate with index  for a search space set  using a set of CCEs in a CORESET  on the active DL BWP for serving cell  is not counted for monitoring if there is a PDCCH candidate with index  for a search space set , or if there is a PDCCH candidate with index  and , in the CORESET  on the active DL BWP for serving cell  using a same set of CCEs, the PDCCH candidates have identical scrambling, and the corresponding DCI formats for the PDCCH candidates have a same size; otherwise, the PDCCH candidate with index  is counted for monitoring. | |
| Qualcomm | Understanding 2 |  |
| Nokia | Understanding 2 | While we don’t see any reason why the network would configure an AL that doesn’t fit to the associated CORESET, we do agree with the ZTE description that if this is done, it should be gracefully ignored by the UE and not counted. |
| Ericsson | Understanding 2 |  |
| Samsung | Understanding 2 |  |
| Huawei | Understanding 2 |  |
| vivo | Understanding 1 | According the spec, the PDCCH candidate is counted for search space, according the configured number candidates in the *SearchSpace*:  For each DL BWP configured to a UE in a serving cell, the UE is provided by higher layers with search space sets where, for each search space set from the search space sets, the UE is provided the following by *SearchSpace*:  …  - a number of PDCCH candidates per CCE aggregation level by *aggregationLevel1*, *aggregationLevel2*, *aggregationLevel4*, *aggregationLevel8*, and *aggregationLevel16*, for CCE aggregation level 1, CCE aggregation level 2, CCE aggregation level 4, CCE aggregation level 8, and CCE aggregation level 16, respectively  …  For a search space set associated with CORESET , the CCE indexes for aggregation level corresponding to PDCCH candidate of the search space set in slot for an active DL BWP of a serving cell corresponding to carrier indicator field value , or corresponding to value of *nCI-Value* associated with a set of serving cells *MC-DCI-SetofCells*, are given by  …  , where is the number of PDCCH candidates the UE is configured to monitor for aggregation level of a search space set for a serving cell corresponding to ;  So, unless any exception that defined by the spec, the PDCCH candidate is counted according to the configured number of candidate, even if the UE does not really decode it.  However, we don’t see the reason why NW configure the SS in this way. |
| New H3C | Understanding 2 |  |

# Moderator proposals for online session

TBD

# References

[1] R1-2409624 Discussion on PDCCH candidate larger AL than the REGs in CORESET Spreadtrum, UNISOC