**3GPP TSG RAN WG1 Meeting #103-e R1-20xxxxx**

**E-meeting, October 26 - November 13, 2020**

**Agenda Item: 7.2.5**

**Source: Moderator (Huawei)**

**Title:** **Feature lead summary#1 on PDCCH enhancements**

**Document for: Discussion and Decision**

# Introduction

This document summarizes the key issues for PDCCH enhancements discussed under agenda item 7.2.5 based on the views in [1][2][3][4][5][6][7][8][9][10][11][12][13][14][14], and aims to identify a set of critical issues for RAN1#103-e email discussion.

# Summary of issues raised for PDCCH enhancements

This section summarize the issues raised by companies on PDCCH enhancements, among which a set of issues can be identified for RAN1#103-e email discussions per the guidance from Chairman. Note that per the guidance from Chairman, only critical issues should be included and no more “nice to have” features.

Recommendation on the email threads and scope are given in section 2.1 and the summary of detailed issues are given in section 2.2.

## Recommendation for the scope of email threads

### Draft recommendation for the scope of email threads (i.e. draft for first round email discussion)

Based on the summary of issues in section 2.2, the following recommendation are made for the scope of email threads. Note that based on the outcome of the preparation discussion in RAN1#102-e, Issue A-2, A-3 and B-2 were postponed to RAN1#103-e.

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**Email discussion #1**

Email discussion/approval on remaining issues on enhanced PDCCH monitoring capability:

* **Issue B-1**: Time variation of “aligned” status for PDCCH spans across DL cells
* **Issue B-2**: Whether to apply M-TRP on the Rel-15 cells for case 3

**Email discussion #2**

Email discussion/approval on remaining issues on DCI format design:

* **Issue A-1**: Type2 HARQ-ACK codebook construction related to DAI bit width
* **Issue A-2**: Correction on missing case of PUSCH release for search space sharing
* **Issue A-3**: Correction on Transmission configuration indication in DCI format 1\_2

**Companies are encouraged to provide views on whether to include the following issues to the scope**.

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| *Company* | *Issue A-4* | *Comments on other issues if any* |
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## Summary of detailed issues

**Issues raised on DCI format design**

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| **Issue #** | **Description** | **Source** | **Recommended handling** |
| A-1 | Type2 HARQ-ACK codebook construction related to DAI bit width | Huawei/HiSilicon  WILUS  Samsung  CATT  Vivo | Included in email discussion #1  **Reason:**   1. *Critical correction, otherwise the spec is not correct* |
| A-2 | Correction on missing case of PUSCH release for search space sharing | Sharp | Included under email discussion #1 *unless there is other issue identified as higher priority*  **Reason:**   1. *Issue is valid. It was postponed to this meeting due to the workload in RAN1#102-e.* |
| A-3 | Correction on Transmission configuration indication in DCI format 1\_2 | ASUSTeK | Included under email discussion #1 *unless there is other issue identified as higher priority*  **Reason:**  *Issue is valid. It was postponed to this meeting due to the workload in RAN1#102-e.* |
| A-4 | Ambiguity of subselection indication for DCI format 0\_1 and DCI format 0\_2 | Sharp | More inputs from companies on whether to include or not. If agreed then will be included under email discussion #2.  **Reason:**  *The issue is valid, but some companies doubt the necessity* |

**Issues raised on enhanced PDCCH monitoring capability**

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| **Issue #** | **Description** | **Source** | **Recommended handling** |
| B-1 | Time variation of “aligned” status for PDCCH spans across DL cells | Apple  Quectel  Intel  Ericsson,  Vivo  Huawei/HiSilicon | Included in email discussion #1  **Reason:**   1. *Remaining issues from RAN1#102-e* |
| B-3 | Whether to apply M-TRP on the Rel-15 cells for case 3 (i.e. both cell(s) with Rel-15 monitoring capability and cell(s) with Rel-16 monitoring capability are configured) | Samsung  ZTE  Quectel  Huawei/HiSilicon | Included in email discussion #1  **Reason:**   1. *Essential correction otherwise the specification is not complete* |

# DCI format scheduling Rel-16 URLLC

Based on the contributions from companies, the following issues related to DCI format design are discussed.

**Issue A-1**: Type2 HARQ-ACK codebook construction related to DAI bit width

In RAN1#101-e meeting, type 2 HARQ-ACK codebook construction related to DAI bit width was discussed under PDCCH enhancements, and the following agreement was achieved:

Agreement

If UE is configured to monitor DCI format 1\_2/0\_2, the HARQ-ACK codebook size for type-2 HARQ-ACK codebook is determined by



Further, the pseudo-code related to the agreement was also specified in section 9.1.3 of TS38.213 v16.2.0:

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel  […]  If the UE transmits HARQ-ACK information in a PUCCH in slot and for any PUCCH format, the UE determines the , for a total number of HARQ-ACK information bits, according to the following pseudo-code:  Set  – PDCCH with DCI format scheduling PDSCH reception or SPS PDSCH release monitoring occasion index: lower index corresponds to earlier PDCCH monitoring occasion  Set  Set  Set  Set  Set  to the number of serving cells configured by higher layers for the UE  […]  Set  to the number of PDCCH monitoring occasion(s)  while  […]  end while  if    end if  if *harq-ACK-SpatialBundlingPUCCH* is not provided to the UE and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for at least one configured DL BWP of a serving cell,  else  end if  for any |

However, as discussed in RAN1#102-e, some error exists with the pseudo highlight in yellow as explained below:

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| Take the case shown in Table 1 as an example, where the gNB sends 3 DL DCIs with 1-bit counter DAI in three monitoring occasions and one UL grant with 2-bit UL DAI=3. If there is no missed DCI in the given example, then both gNB and the UE will have the same understanding about the codebook size, i.e. OAck = 3. However, if the DL DCI in MO#3 is missed, based on the value in Table 1 and the pseudo code highlighted in yellow above, the value of j is still equal to 0, which will result in OAck = 1 according to the equation for type 2 HARQ-ACK codebook construction. The reason for this problem is that the yellow-marked pseudo-code “” will not update the value of in this case, because is not smaller than in this case because of the different number of bits that are used for counter DAI and total DAI.  Table 1 - Last DCI is missed (2-bits UL DAI and 1-bit counter DAI)   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | MO#1 | MO#2 | MO#3 | UL grant | |  | cDAI=1 | cDAI=2 | cDAI=1 | UL DAI=3 | | Correct value of assuming no missed DCI | 0 | 0 | **1** |  | | Value of j according to the pseudo code in the spec if DCI in MO#3 is missed | 0 | **0** |  |  |   Note that when no DCI is missed or one DCI but not the last one is missed, then there is no problem as shown in table 2 below.  Table 2 - No DCI or one DCI but not the last one is missed (2-bits UL DAI and 1-bit counter DAI)   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | MO#1 | MO#2 | MO#3 | UL grant | |  | cDAI=1 | cDAI=2 | cDAI=1 | UL DAI=3 | | Correct value of assuming no missed DCI | 0 | 0 | **1** |  | | Value of j according to pseudo code in the spec if DCI in MO#1 is missed |  | 0 | **1** |  | | Value of j according to pseudo code in the spec if DCI in MO#2 is missed | 0 |  | **1** |  | |

The issues was discussed in RAN1#102-e, however it was not agreed since it was identified that the proposal for RAN1#102-e cannot solve the case of missing 3 DCIs case. Some companies provided further views on this issue with the candidate options summarized as below:

* ***Option 1****: Endorse the text proposal in R1-2xxxxxx for TS 38.213 Section 9.1.3.1.*

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel **\*\*\*Unchanged text is omitted\*\*\***  if    end if  **\*\*\*Unchanged text is omitted\*\*\*** |

* + ***Support****: Huawei/HiSilicon, WILUS, CATT*
  + ***Reasons:*** 
    - *There is no need to optimize for missing 3 DCIs case, since even we make it to get the number of missed DCIs,* ***the UE still cannot retrieve the correct location in the codebook using 1-bit counter DAI based on the pseudo for Vs****.*
    - *The principle for option 1 here is aligned with the original spirit of the agreements in RAN1#101-e we made for fixing 1 bit counter DAI in new DCI formats. .*
* ***Option 2****: It is up to gNB implementation to handle the bit size misalignment between counter DAI and UL DAI, e.g. by omitting the MSB bit of UL DAI.*
  + ***Support****: Vivo*
  + ***Cons:*** 
    - *More specification needed compared to option 1.It needs to add another table in which “(X-1) mod 4” in table 9.1.3.2 is changed to “(X-1) mod 2” so that both the gNB and the UE would align with the value of X, and define the rule to pick the table to use based on the configuration of counter DAI. In addition, the type 2 HARQ-ACK codebook size needs also to change to the legacy number .*
* ***Option 3****: Endorse the text proposal in R1-2xxxxxx for TS 38.213 Section 9.1.3.1.*

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel **\*\*\*Unchanged text is omitted\*\*\***  Set  – PDCCH with DCI format scheduling PDSCH reception or SPS PDSCH release monitoring occasion index: lower index corresponds to earlier PDCCH monitoring occasion  Set  Set  Set  Set  Set  to the number of serving cells configured by higher layers for the UE  - 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 = JointFeedback,* the serving cell is counted two times where the first time corresponds to the first CORESETs and the second time corresponds to the second CORESETs  - if the UE indicates *PDSCH-Number-perMOperCell*, a serving cell is counted times where is the number of PDSCH receptions that can be scheduled for the serving cell by DCI formats in PDCCH receptions at a same PDCCH monitoring occasion based on the reported value of *PDSCH-Number-perMOperCell*  Set  to the number of PDCCH monitoring occasion(s)  while  Set  – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cell  while  if PDCCH monitoring occasion  is before an active DL BWP change on serving cell  or an active UL BWP change on the PCell and an active DL BWP change is not triggered in PDCCH monitoring occasion  ;  else  if there is a PDSCH on serving cell  associated with PDCCH in PDCCH monitoring occasion , or there is a PDCCH indicating SPS PDSCH release on serving cell  if    end if    if    else    end if  if *harq-ACK-SpatialBundlingPUCCH* is not provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for at least one configured DL BWP of at least one serving cell,  = HARQ-ACK information bit corresponding to the first transport block of this cell  = HARQ-ACK information bit corresponding to the second transport block of this cell  elseif *harq-ACK-SpatialBundlingPUCCH* is provided to the UE and  is a monitoring occasion for PDCCH with a DCI format that supports PDSCH reception with two transport blocks and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks in at least one configured DL BWP of a serving cell,  = binary AND operation of the HARQ-ACK information bits corresponding to the first and second transport blocks of this cell  else  = HARQ-ACK information bit of this cell  end if  end if    end if  end while    end while  if UE does not set and  end if  if    end if  if *harq-ACK-SpatialBundlingPUCCH* is not provided to the UE and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for at least one configured DL BWP of a serving cell,  else  end if  for any  **\*\*\*Unchanged text is omitted\*\*\*** |

* + ***Support****: Samsung*
  + ***Reasons:*** 
    - *Can correct the number of HARQ-ACK bit for 3 missing DCI case.* 
      * ***Feature lead****: It was argued from some company that there is no point to do the optimization here since UE still cannot retrieve the correct location in the codebook using 1-bit counter DAI based on the pseudo for Vs.*
* ***Option 4****: Endorse the text proposal in R1-2xxxxxx for TS 38.213 Section 9.1.3.1.*

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| 9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel **\*\*\*Unchanged text is omitted\*\*\***  If the UE transmits HARQ-ACK information in a PUCCH in slot and for any PUCCH format, the UE determines the , for a total number of HARQ-ACK information bits, according to the following pseudo-code:  […]  if    end if  if *harq-ACK-SpatialBundlingPUCCH* is not provided to the UE and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for at least one configured DL BWP of a serving cell,  else  end if  for any  **\*\*\*Unchanged text is omitted\*\*\*** |

* + ***Support****: WILUS*
  + ***Reasons:*** 
    - *Can correct the number of HARQ-ACK bit for 3 missing DCI case.* 
      * ***Feature lead****: It was argued from some company that there is no point to do the optimization here since UE still cannot retrieve the correct location in the codebook using 1-bit counter DAI based on the pseudo for Vs.*

**Please provide your views on the above options. If you have other solutions, please indicate here also.**

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## Issue A-2: Missing case of PUSCH release for search space sharing

In Rel-15, DCI format 0\_1 is used for search space sharing. Note that although DCI format 0\_1 cannot be used for release of type 2 PUSCH but can be used for release of semi-persistent CSI transmission on PUSCH.

In Rel-16, the DCI format 0\_1 and 0\_2 are further agreed to support release of type 2 PUSCH transmission. However, the above description of search space sharing captures the DCI format scheduling PDSCH reception, SPS PDSCH release, DCI format scheduling PUSCH transmission but miss capturing the PUSCH release. Therefore, PUSCH release should be captured to make the description of search space sharing correct and precise.

Sharp (R1-2008392) proposes to adopt the following TP for section 10.1 in TS 38.213 to compensate for a missing case of PUSCH release for search space sharing.

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| **TP2**  TS 38.213 V16.1.0 (2020-03) 10.1 UE procedure for determining physical downlink control channel assignment < Unchanged parts are omitted >  A UE that  - is configured for operation with carrier aggregation, and  - indicates support of search space sharing through *searchSpaceSharingCA-UL* or through *searchSpaceSharingCA-DL*, and  - has a PDCCH candidate with CCE aggregation level  in CORESET  for a first DCI format scheduling PUSCH transmission or releasing PUSCH transmission, other than DCI format 0\_0, or for a second DCI format scheduling PDSCH reception or SPS PDSCH release, other than DCI format 1\_0, having a first size and associated with serving cell ,  can receive a corresponding PDCCH through a PDCCH candidate with CCE aggregation level  in CORESET  for a first DCI format or for a second DCI format, respectively, having a second size and associated with serving cell  if the first size and the second size are same.  < Unchanged parts are omitted > |

**Feature lead view**: The issue is valid. As to the TP, some companies commented that it might have impact on the Rel-15 behavior, e.g. it may give the impression that in Rel-15 DCI format 0\_1 can be used for releasing of type 2 PUSCH. However, if it is an issue then it seems the issue exist for SPS PDSCH release also. Probably ok to have simple correction here since anyway there is other sections in the spec which define the corresponding DCI format (s) for PUSCH release and SPS release.

***Proposal A-2****: Endorse the text proposal in R1-2xxxxxx for TS 38.213 Section 10.1.*

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| 10.1 UE procedure for determining physical downlink control channel assignment < Unchanged parts are omitted >  A UE that  - is configured for operation with carrier aggregation, and  - indicates support of search space sharing through *searchSpaceSharingCA-UL* or through *searchSpaceSharingCA-DL*, and  - has a PDCCH candidate with CCE aggregation level  in CORESET  for a first DCI format scheduling PUSCH transmission or releasing PUSCH transmission, other than DCI format 0\_0, or for a second DCI format scheduling PDSCH reception or SPS PDSCH release, other than DCI format 1\_0, having a first size and associated with serving cell ,  can receive a corresponding PDCCH through a PDCCH candidate with CCE aggregation level  in CORESET  for a first DCI format or for a second DCI format, respectively, having a second size and associated with serving cell  if the first size and the second size are same.  < Unchanged parts are omitted > |

**Please provide your views whether the TP is needed or not.**

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## Issue A-3: Correction on Transmission configuration indication in DCI format 1\_2

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| ASUSTeKR1-2008634  In Rel-15 NR, whether a TCI bitfield is in DCI format 1\_1 is determined based on *TCI-PresentInDCI* in CORESET information element. If *TCI-PresentInDCI* is enabled, size of TCI bitfield is 3 bits in DCI format 1\_1. Otherwise, TCI bitfield is not present (e.g., 0 bits) in DCI format 1\_1. In addition, since *TCI-PresentInDCI* is a CORESET specific parameter rather than a BWP specific parameter, for a DCI indicating BWP switching, UE assumes that size of TCI bitfield (e.g., 0 or 3 bits) in target BWP is the same as scheduling CORESET in current BWP. In other words, in case *TCI-PresentInDCI* is enabled, UE receives scheduled PDSCH in target BWP via a TCI state indicated by the TCI bitfield in scheduling DCI. In case *TCI-PresentInDCI* is disabled, UE receives scheduled PDSCH in target BWP via a TCI state of the scheduling CORESET.  For new DCI format (i.e., DCI format 1\_2) scheduling Rel-16 URLLC, a more compact size of DCI is considered. In RAN1 #99 meeting, size of TCI bitfield in DCI format 1\_2 is agreed to be configured with more candidate values like 1, 2 bits additional to 0, 3 bits. According to current running CR [3], handling TCI bitfield for BWP switching DCI format 1\_2 is similar to DCI format 1\_1 in Rel-15 NR. However, since *TCI-PresentInDCI* could be configured as 1, 2, 3 bits, it’s not clear for the size of TCI bitfield of target BWP according to current running CR that the UE assume TCI bitfield is enabled for all CORESETs in target BWP. It may have impact on whether the UE performs zero padding or truncating on the TCI bitfield. In addition, it may cause problem if different assumption of size of TCI bitfield for all CORESETs in target BWP between UE and gNB. For example, in figure 1, a UE is configured with *tci-PresentInDCI-ForDCIFormat1\_2* as 2 bits for a DCI format 1\_2 in a CORESET. For a received DCI format 1\_2 indicating BWP switching, if spec does not specify how many bits of TCI bitfield the UE assume for all CORESETs in target BWP, it may cause misalignment between gNB and UE when gNB assumes no truncation or zero padding for TCI bitfield “10” while truncated TCI bitfield state “0” is performed by UE (if UE assumes 1 bits of TCI bitfield for all CORESETs in target BWP).   |  |  |  |  |  | | --- | --- | --- | --- | --- | | TCI bitfield value | TCI state |  | TCI bitfield value | TCI state | | 00 | A |  | 0 | A | | 01 | B |  | 1 | B | | 10 | C |  |  |  | | 11 | D |  |  |  | | Current BWP | |  | UE assume 1 bits for TCI bitfield for all CORESETs in target BWP | |   Figure. 1  In our view, since TCI state association or a TCI code-point could be reused after BWP change, it’s not necessary for UE to assume less bits for TCI bitfield. In addition, it may be fine for UE to assume larger bits for TCI bitfield since padding zero does not change the amount of TCI states that DCI format 1\_2 can indicate. However, in our view, it’s simpler to follow similar logic in Rel-15 NR that by assuming same size of TCI bitfield as current CORESET for all CORESETs in target BWP for a BWP switching DCI. In other words, for a DCI format 1\_2 indicating BWP switching and with configured *tci-PresentInDCI-ForDCIFormat1\_2*, the UE assume same size of TCI bitfield in DCI format 1\_2 and enabled for all CORESETs in target BWP. Figure 2 is an example for illustrating the solution.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | TCI bitfield value | TCI state |  | TCI bitfield value | TCI state | | 00 | A |  | 00 | A | | 01 | B |  | 01 | B | | 10 | C |  | 10 | C | | 11 | D |  | 11 | D | | Current BWP | |  | UE assume the same number of bits for TCI bitfield for all CORESETs in target BWP | |   Figure. 2  **Observation: For TCI bitfield with configured *tci-PresentInDCI-ForDCIFormat1\_2* in a DCI format 1\_2 indicating BWP switch, it’s not clear how the UE assume size of TCI bitfield for all CORESETs in target BWP.**  **Proposal: Adopt following TP.** |

**Feature lead view**: The issue looks valid. However, during the preparation phase in RAN1#100b-e, some companies commented that the change is not needed. More views are needed. The following proposal is made for further discussion.

***Proposal A-3****: Endorse the text proposal in R1-2xxxxxx for TS 38.212 Section 7.3.1.2.3.*

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| 7.3.1.2.3 Format 1\_2 **\*\*\*Unchanged text is omitted\*\*\***  - Transmission configuration indication – 0 bit if higher layer parameter *tci-PresentForDCI-Format1-2* is not configured; otherwise 1 or 2 or 3 bits determined by higher layer parameter *tci-PresentForDCI-Format1-2* as defined in Clause 5.1.5 of [6, TS38.214].  If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part,  - if the higher layer parameter *tci-PresentForDCI-Format1-2* is not configured for the CORESET used for the PDCCH carrying the DCI format 1\_2,  - the UE assumes *tci-PresentForDCI-Format1-2* is not configured for all CORESETs in the indicated bandwidth part;  - otherwise,  - the UE assumes *tci-PresentForDCI-Format1-2* is configured for all CORESETs in the indicated bandwidth part with the same value configured for the CORESET used for the PDCCH carrying the DCI format 1\_2.  **\*\*\*Unchanged text is omitted\*\*\*** |

**Please provide your views on proposal 3-4, including whether need it or not.**

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## Issue A-4: Ambiguity of subselection indication for DCI format 0\_1 and DCI format 0\_2

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| *Sharp (R1-2008393)*  According to the TS 38.214 [1], aperiodic CSI-RS trigger procedure for DCI format 0\_1 is applied to that for DCI format 0\_2 by applying the higher layer parameter *reportTriggerSize-ForDCIFormat0\_2* instead of *reportTriggerSize*. Furthermore, as described in 5.2.1.5.1 in TS 38.214, when the number of configured CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than , the UE would receive a subselection indication for selection of the configured aperiodic triggering states. For a case where the number of configured CSI triggering states would be larger than the corresponding number indicated by the *reportTriggerSize* and also be larger thanthe corresponding number indicatedthe *reportTriggerSize-ForDCIFormat0\_2*, it would give an impression that the UE 102 would receive two subselection indications. However, the subselection indication is common for the DCI format 0\_1 and 0\_2.  Moreover, the number of selected CSI trigger states in the subselection indication should be a maximum number between the number indicated by the *reportTriggerSize* and the number indicated *the reportTriggerSize-ForDCIFormat0\_2.* That is, the *CSI request* field with less bitwidth in a DCI format is used to map to the first  selected CSI trigger states of the selected CSI trigger states in the subselection indication.  **Proposal 1:** Adopt the following TP in TS 38.214 to precisely describe the subselection indication used for aperiodic CSI-RS trigger procedure for DCI format 0\_1 and DCI format 0\_2.  TS 38.214 V16.2.0 (2020-06) 5.2.1.5.1 Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have the same numerology < Unchanged parts are omitted >  A trigger state is initiated using the *CSI request* field in DCI.  - When all the bits of *CSI request* field in DCI are set to zero, no CSI is requested.  - When the number of configured CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than , where  is the number of bits in the DCI *CSI request* field, the UE receives a subselection indication, as described in clause 6.1.3.13 of [10, TS 38.321], used to map up to first  trigger states to the codepoints of the *CSI request* field in DCI.  is configured by the higher layer parameter *reportTriggerSize* where . When the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the subselection indication, the corresponding action in [10, TS 38.321] and UE assumption on the mapping of the selected CSI trigger state(s) to the codepoint(s) of DCI CSI request field shall be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH. For the case that the number of configured CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than , where  is the number of bits in the DCI *CSI request* field in either of DCI format 0\_1 and DCI format 0\_2, the subselection indication is applied to both DCI format 0\_1 and DCI format 0\_2.  - When the number of CSI triggering states in *CSI-AperiodicTriggerStateList* is less than or equal to , the *CSI request* field in DCI directly indicates the triggering state. |

**Feature lead view**: The issue looks valid. However, more views are needed before making decision on how to correct the specification.

**Please provide your views on the proposed TP above.**

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# Enhanced PDCCH monitoring capability

This section summarize the issues on enhanced PDCCH monitoring capability.

## Issue B-1: Time variation of “aligned” status for PDCCH spans across DL cells

The following text has been captured in section 10 of TS38.213.

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| A UE can indicate a capability to monitor PDCCH according to one or more of the combinations = (2, 2), (4, 3), and (7, 3) per SCS configuration of and . A span is a number of consecutive symbols in a slot where the UE is configured to monitor PDCCH. Each PDCCH monitoring occasion is within one span. If a UE monitors PDCCH on a cell according to combination , the UE supports PDCCH monitoring occasions in any symbol of a slot with minimum time separation of symbols between the first symbol of two consecutive spans, including across slots. A span starts at a first symbol where a PDCCH monitoring occasion starts and ends at a last symbol where a PDCCH monitoring occasion ends, where the number of symbols of the span is up to .  If a UE indicates a capability to monitor PDCCH according to multiple combinations and a configuration of search space sets to the UE for PDCCH monitoring on a cell results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of for one or more of the multiple combinations , the UE monitors PDCCH on the cell according to the combination , from the one or more combinations , that is associated with the largest maximum number of and defined in Table 10.1-2A and Table 10.1-3A. The UE expects to monitor PDCCH according to the same combination in every slot on the active DL BWP of a cell.  …  If a UE is configured only with downlink cells for which the UE is provided *monitoringCapabilityConfig-r16* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell, the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs  - per set of spans on the active DL BWP(s) of all scheduling cell(s) from the downlink cells within every symbols, if the union of PDCCH monitoring occasions on all scheduling cells from the downlink cells results to PDCCH monitoring according to the combination and any pair of spans in the set is within symbols, where first symbols start at a first symbol with a PDCCH monitoring occasion and next symbols start at a first symbol with a PDCCH monitoring occasion that is not included in the first symbols  - per set of spans across the active DL BWP(s) of all scheduling cells from the downlink cells, with at most one span per scheduling cell for each set of spans, otherwise  where is a number of configured cells with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration . If a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig-r16* = *r15monitoringcapability* and *monitoringCapabilityConfig-r16* = *r16monitoringcapability*, is replaced by . |

In the RAN1#102-e meeting, the following proposal was discussed but no consensus was achieved.

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| * *A UE doesn’t expect slot-dependent aligned spans vs. unaligned spans variation, i.e. either aligned spans or unaligned spans for all slots.* |

Some companies provide further views in the contributions for RAN1#103-e, and the related to issues are summarized as below:

**Question 1: Interpretation of the allowed gNB configuration**

Based on the discussion in RAN1#102-e, it seems most companies agree with the principle of the proposal above, however it was not agreed due to different understanding of the allowed gNB configuration.

* ***Interpretation 1****: All three cases below allowed assuming both case 2 and case 3 belongs to unaligned span case*

Chart

Description automatically generated

* + ***Support****: Intel, Ericsson, Vivo*
  + ***Pros****:* 
    - *No limitation of network configuration*
  + ***Cons:*** 
    - *Slot-dependent aligned spans vs. unaligned spans variation may happen at the UE side, which is not desirable from UE implementation perspective*
* ***Interpretation 2****: Only case 1 and case 2 are allowed*

A picture containing diagram

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* + ***Pros****:* 
    - *Ensure no slot-dependent aligned spans vs. unaligned spans variation at the UE side*
  + ***Cons:*** 
    - *Limitation of network configuration*

**Feature lead**: It seems most companies agree that interpretation 1 is better from the configuration flexibility perspective, unless we cannot achieve consensus on how to address the UE complexity concern at the UE side, I would suggest not consider interpretation 2 at this stage.

**Question 2: Solutions to allow interpretation 1 above while address the complexity concern at the UE side**

To leave the flexibility on configuration and also address the UE complexity on determining aligned span and unaligned span, the following options are considered:

* ***Option 1****: Network sends RRC signaling concerning the CCs at the same numerology and (X,Y) indicates “aligned span” or “unaligned span” designation to a UE*
  + ***Support****: Apple*
  + ***Feature lead:*** 
    - *Pros: Reduced UE complexity and relaxing the limitation of gNB configuration*
    - *Cons: The RRC signaling structure (e.g. the groups of cells needs to be indicated) may depend on the search space configuration on the cells*
* ***Option 2****: define a small set of reference slot(s) (e.g., N slots) to determine whether the spans are aligned or unaligned for CA, where N is less than the maximum PDCCH monitoring periodicity in the configured search space sets, e.g., N=1 or 2*
  + ***Support****: Ericsson, Vivo,*
  + ***Feature lead:*** 
    - *Pros: Reduced UE complexity and relaxing the limitation of gNB configuration to some extent*
    - *Cons: gNB still needs to ensure unaligned case within the reference slots, therefore still some limitation at the gNB side*
* ***Option 3****: Determine the combination (X, Y) using* ***synthetic*** *monitoring occasions* 
  + ***Support****:*
  + *Endorse the following text proposal for TS 38.213 Section 10.*

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| 10 UE procedure for receiving control information **\*\*\* Unchanged text is omitted \*\*\***  A UE can indicate a capability to monitor PDCCH according to one or more of the combinations = (2, 2), (4, 3), and (7, 3) per SCS configuration of and . A span is a number of consecutive symbols in a slot where the UE is configured to monitor PDCCH. Each PDCCH monitoring occasion is within one span. If a UE monitors PDCCH on a cell according to combination , the UE supports PDCCH monitoring occasions in any symbol of a slot with minimum time separation of X symbols between the first symbol of two consecutive spans, including across slots. A span starts at a first symbol where a PDCCH monitoring occasion starts and ends at a last symbol where a PDCCH monitoring occasion ends assuming a PDCCH monitoring occasion exists in all slots if it exist in any slot, where the number of symbols of the span is up to Y.  If a UE indicates a capability to monitor PDCCH according to multiple combinations and a configuration of search space sets to the UE for PDCCH monitoring on a cell results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of for one or more of the multiple combinations , the UE monitors PDCCH on the cell according to the combination , from the one or more combinations , that is associated with the largest maximum number of and defined in Table 10.1-2A and Table 10.1-3A. The UE expects to monitor PDCCH according to the same combination in every slot on the active DL BWP of a cell.  **\*\*\* Unchanged text is omitted \*\*\*** |

* + *Endorse the following text proposal for TS 38.213 Section 10.1.*

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| 10.1 UE procedure for determining physical downlink control channel assignment <Unchanged parts are omitted>  If a UE is configured only with downlink cells for which the UE is provided *monitoringCapabilityConfig-r16* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cell(s) using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell, the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs  - per set of spans on the active DL BWP(s) of all scheduling cell(s) from the downlink cells within every symbols, if the union of PDCCH monitoring occasions on all scheduling cells from the downlink cells results to PDCCH monitoring according to the combination and any pair of spans in the set is within symbols assuming a PDCCH monitoring occasion exists in all slots on a scheduling cell if it exist in any slot on the scheduling cell, where first symbols start at a first symbol with a PDCCH monitoring occasion and next symbols start at a first symbol with a PDCCH monitoring occasion that is not included in the first symbols  - per set of spans across the active DL BWP(s) of all scheduling cells from the downlink cells, with at most one span per scheduling cell for each set of spans, otherwise  where is a number of configured cells with SCS configuration . If a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig-r16* = *r15monitoringcapability* and *monitoringCapabilityConfig-r16* = *r16monitoringcapability*, is replaced by .  <Unchanged parts are omitted> |

**Please provide your views on the above options. If you have other solutions, please indicate here also.**

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**Question 3: Whether/how to set a time window for which a set of spans is considered for unaligned span case**

For the non-aligned case, as no time window is defined for the span set construction, a span set including two spans which are sufficiently separated in time domain (e.g., tens of slots) still needs to be checked. The number of span sets to be checked will be exponentially increased as the span pattern cannot repeat in a long time.

* ***Option 1****: Limit the time window to one slot*
  + ***Support****: Ericsson*

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| ---------------------------------Start of Text Proposal on TS 38.213 v16.3.0----------------------- 10.1 UE procedure for determining physical downlink control channel assignment <Unchanged parts are omitted>  If a UE is configured only with downlink cells for which the UE is provided *monitoringCapabilityConfig-r16* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell, the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs  - per set of spans on the active DL BWP(s) of all scheduling cell(s) from the downlink cells within every symbols, if the union of PDCCH monitoring occasions on all scheduling cells from the downlink cells results to PDCCH monitoring according to the combination and any pair of spans in the set is within symbols, where first symbols start at a first symbol with a PDCCH monitoring occasion and next symbols start at a first symbol with a PDCCH monitoring occasion that is not included in the first symbols  - per set of spans within a slot across the active DL BWP(s) of all scheduling cells from the downlink cells, with at most one span per scheduling cell for each set of spans, otherwise  where is a number of configured cells with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration .  <Unchanged parts are omitted>  --------------------------------------End of Text Proposal on TS 38.213 v16.3.0------------------ |

* ***Option 2****: Limit the time window to all spans that have overlapped symbols with a same X-symbol window*
  + ***Support****: Quectel*

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| < Unchanged parts are omitted >  If a UE is configured only with downlink cells for which the UE is provided *monitoringCapabilityConfig-r16* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell, the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs  - per set of spans on the active DL BWP(s) of all scheduling cell(s) from the downlink cells within every symbols, if the union of PDCCH monitoring occasions on all scheduling cells from the downlink cells results to PDCCH monitoring according to the combination and any pair of spans in the set is within symbols, where first symbols start at a first symbol with a PDCCH monitoring occasion and next symbols start at a first symbol with a PDCCH monitoring occasion that is not included in the first symbols  - per set of spans across the active DL BWP(s) of all scheduling cells from the downlink cells fully or partially overlapped with a same X symbols， with at most one span per scheduling cell for each set of spans, otherwise  where is a number of configured cells with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration . If a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig-r16* = *r15monitoringcapability* and *monitoringCapabilityConfig-r16* = *r16monitoringcapability*, is replaced by .  < Unchanged parts are omitted > |

**Please provide your views on the above options. If you have other solutions, please indicate here also.**

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## Issue B-2: Whether/how to extend Rel-16 PDCCH monitoring capability to multi-TRP case whether to apply M-TRP on the Rel-15 cells for case 3 (i.e. both cell(s) with Rel-15 monitoring capability and cell(s) with Rel-16 monitoring capability are configured)

A common understanding in the RAN1 #101 email discussion is that there is no need to extend the M-TPR in Rel-16 MIMO with Rel-16 PDCCH monitoring capability [4] because all enhancements for reliability (URLLC) are through single-DCI based operations (assuming ideal backhaul) in M-TRP operation, which does not require any modification of Rel-15 spec on monitoring capability. However whether the M-TPR in Rel-16 MIMO can be extended to only the Rel-15 cells in CA case 3 (mixed Rel-15 and Rel-16 monitoring capabilities) is not clear.

* **Interpretation 1**: M-TPR in Rel-16 MIMO can be extended to only the Rel-15 cells in CA case 3.
  + *Support: ZTE, Samsung, Quectel*
* **Interpretation 2**: M-TPR in Rel-16 MIMO cannot be extended to the Rel-15 cells in CA case 3.
  + *Support: Quectel (ok), Huawei/HiSilicon, ZTE (can accept)*

**From feature view**: It seems we need to discuss this issue in order to make the specification clear. However, more views are needed before making any proposal here.

**Please indicate which interpretation do you prefer and please also provide your reasons also.**

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9. [R1-2008435](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008435.zip) Maintenance of PDCCH design in Physical Layer Enhancements for NR URLLC Apple
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11. [R1-2008634](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2008634.zip) Remaining issue for TCI field ASUSTeK
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