**3GPP TSG RAN WG1 #110bis-e R1-2210473**

**e-Meeting, October 10th – 19th, 2022**

Agenda Item: 7.1

Source: Moderator (Ericsson)

Title: [110bis-e-NR-R15-02] Discussion on clarification of CSI reporting

Document for: Discussion/Decision

# Introduction

This document provides summary on the following email discussion;

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| [110bis-e-NR-R15-02] Discussion on clarification of CSI reporting by Oct 17 – Mattias (Ericsson) |

This document is created to collect company views on two documents submitted related to the issue:

R1-2208730 Clarification of CSI reporting (Rel-15) Ericsson

R1-2209933 Discussion on even and odd CSI subband index definition Qualcomm Incorporated

RAN1 needs to clarify the intention of the spec during RAN1#110bis-e. Please provide your comments in Section 3 as soon as possible so we can conclude on the issue by **Monday** **17th Oct 23:59 UTC** .

# Background

At least one network vendor observed (from testing of different UE devices) ambiguity in the interpretation and thus implementation of CSI subband indexing when the RRC signalling *csi-ReportingBand* is different from all “111111…”.

A first interpretation counts only the active subbands configured by the gNB, a second counts all the subbands in the BWP with nature order. These two interpretations cause ambiguity in determining even and odd subbands, leading to two different UCI packing orders. Note that the mapping order for CSI part 2 when using subband CQI and PMI follows as (TS 38.212 section 6.3.1.1.2):

1. Subband diff CQI for 2nd TB for all even subbands
2. PMI of all even subbands
3. Subband diff CQI for 2nd TB for all odd subbands
4. PMI of all odd subbands

With mismatched gNB-UE side interpretation respectively, the CSI report contains nonsense unless *csi-ReportingBand* contains all “1”.

* **Interpretation 1**: The CSI subband index count from the first active subband indicated by in the RRC signalling csi-ReportingBand, i.e., the first “1” from the right in the csi-ReportingBand is regarded as subband 0, the second “1” is regarded as subband 1, etc
  + See some examples in the figure below (assuming a total of 8 subbands) together with what values the UE report.



* **Interpretation 2:** The CSI subband index count from the first subband in the BWP, regardless of the RRC signalling csi-ReportingBand. Note that the mapping of subbands is different compared to Interpretation 1 and consequently the UE will report the subbands in a different order.
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# Proposed Resolution

Since there are UE in the field already with implementation of both interpretation 1 and 2, the feature is broken. Hence, gNB may have to always configure subbands patterns without ambiguity (e.g., all “1”s in csi-ReportingBand) since the gNB does not know the UE implementation.

For Rel.17 UE and onwards on the other hand, the feature can be corrected by clarifying the specification to either interpretation 1 or 2.

Hence, the moderator’s proposal is to introduce a Rel.17 CR that clarifies the specification for either 1 and 2. In addition, the gNB need to know whether the UE is supporting the interpretation according to the clarification or not (basically whether it is a Rel.17 UE following the CR).

**Moderator proposal: Introduce a Rel.17 CR that clarifies the specifications to either Interpretation 1 or 2 together with a UE capability for this clarification.**

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| Company | View |
| Qualcomm | Our 1st preference is to clarify the Rel-15 spec with interpretation 2. If there exists UE implementing other than interpretation 2, we support moderator proposal.  Besides, maybe a new RRC parameter *csi-ReportingBand-r17* is needed also for the clarified spec while leaving the original *csi-ReportingBand* used for legacy UE. |
| ZTE | If our understanding is correct, we should only specify one of interpretation 1 and 2 in Rel-17 (although Rel-15/16 seems better). Then, we still need to introduce a UE capability for what? Since it is just for Rel-17 UE, in our views, the Rel-17 UE should be implemented according to the endorsed CR.  **Moderator**: But how does the network know that the UE is a Rel.17 UE? I don’t think using the *accessStratumRelease* is a good solution, it will create dependencies and may be even more complicated in the future. |
| OPPO | We are fine with the proposal.  For the new RRC parameter *csi-ReportingBand-r17*, is the understanding correct that when it is configured, the UE behavior will follow the new CR, while Rel-15/16 implementation when *csi-ReportingBand* is configured? If that is the intention, we propose to use *csi-ReportingBand* for both Rel-17 UE and legacy UE. |
| Nokia, NSB | We support the proposal in general. We’d be interested in taking the clarification/correction already than Rel-17, but assuming that a new capability is required, Rel-17 maybe the earliest possible alternative. |
| Samsung | After checking, we also recognized the issue on interpretation between 1 and 2 for subband index for CSI.  From our view, clarifying and having a common understanding on one of two interpretations for all releases (Rel-15/16/17) is the best way. However, the problem is, Rel-15/16 UEs are already in the field and some of their interpretations are not aligned.  In order to solve a problem considering Rel-15/16 UEs and networks already in the field, instead of use Rel-15/16 spec with some holes, we believe that introducing a restriction on *csi-ReportingBand* bitmap can be a better way. Our view is that, with a certain restriction, both contiguous and non-contiguous subband configurations are possible by aligning even/odd subbands for both interpretations. We are open to how to capture this restriction whether to capture in RAN1, 2, or else.  For Rel-17, in order to utilize *csi-ReportingBand* bitmap without any restriction, we need to agree one of two interpretations and further study on how gNB distinguishes between Rel-15/16 UEs and Rel-17 UEs.  For this, we don't think Rel-17 UE capability which indicates an interpretation an UE assumes can solve this issue perfectly, since when the UE capability is adopted, gNB should implement both interpretations and manage UEs with different interpretations separately and which would introduce another complexity.  We can discuss further how to support this feature in Rel-17.  **Proposal**: Strive to have a common understanding on one of two interpretations for all releases (Rel-15/16/17).  - For Rel-15/16, clarify spec with restriction on *csi-ReportingBand* only to have common understanding between interpretation 1 and 2.  - For Rel-17, one of two interpretation is supported and clarify in Spec.  Moderator: Note that a UE capability will not be used to indicate either 1 or 2, but to indicate whether UE support the Rel.17 CR of either option 1 or 2, for example the CR can be written so that if UE support *csi-ReportingBand-r17* then option [1 or 2] shall be assumed. |
| Intel | The proposed solution is a good way forward in our view. |
| Qualcomm2 | We don’t think there is a need to change Rel-15/16 spec, the ambiguity exists since first day of Rel-15 and not recognized till now because it has been solved via IODT and offline agreement between vendors.  Besides, as stated by the moderator, for Rel-17, additional UE capability is used to indicate whether UE support the changed spec and csi-ReportingBand-r17. We also echo moderator’s view on not using release version, we think it is a more proper way to support any new feature/parameter with dedicated capability. gNB has the flexibility to reuse the legacy implementation with legacy RRC parameter or change to the new implementation with the new configuration, so does the UE. |
| Samsung2 | Thank Moderator and Qualcomm for the quick reply. We now understand that a new UE capability can indicate whether the UE supports one interpretation implemented by Rel-17 CR. However, based on the summary below, we cannot understand why a new RRC parameter, *csi-ReportingBand-r17*, is needed. gNB can reuse *csi-ReportingBand* without restriction.   * + - For UE not reporting the UE capability (i.e., for Rel-15/16/17 UEs): gNB can give a restricted *csi-ReportingBand* only, for aligning two interpretations.     - For UE reporting the UE capability (i.e., for Rel-17 UEs): gNB can give a full flexible *csi-ReportingBand*, for supporting one of two interpretations if the interpretation can be agreed.   Also, clarifying in Rel-17 is of course important, but we think that the more important problem to be fixed indeed is Rel-15/16, since there are several vendors which have different understanding on subband CSI reporting in Rel-15/16, as mentioned in Ericsson's contribution. Hence, we would like to suggest on clarifying Rel-15/16 spec as well, by using a restricted configuration on *csi-ReportingBand*. |
| MTK | Our understanding for current spec (R15/R16/R17) is interpretation 1. For the moderator proposal, a Rel-17 CR with UE reported capability is fine by us; however, we would prefer to also define that the default behavior when UE does not report this capability is interpretation 1. |
| Huawei, HiSilicon | We don’t think a new UE capability is needed, we prefer to have a unified interpretation through releases. |
| vivo | Thanks for the discussion. We think current spec has addressed this issue clearly in subclause 5.2.3 in 38.214 as following which should be interpretation 1.  When CSI reporting on PUSCH comprises two parts, the UE may omit a portion of the Part 2 CSI. Omission of Part 2 CSI is according to the priority order shown in Table 5.2.3-1, where  is the number of CSI reports configured to be carried on the PUSCH. Priority 0 is the highest priority and priority  is the lowest priority and the CSI report *n* corresponds to the CSI report with the *n*th smallest Prii,CSI(*y,k,c,s*) value among the  CSI reports as defined in clause 5.2.5. The subbands for a given CSI report *n* indicated by the higher layer parameter *csi-ReportingBand* are numbered continuously in increasing order with the lowest subband of *csi-ReportingBand* as subband 0. When omitting Part 2 CSI information for a particular priority level, the UE shall omit all of the information at that priority level. |
| Qualcomm3 | @Samsung, I am afraid clarifying the subband restriction in Rel-15/16 may also have backward compatibility issue. Some Rel-15/16 gNB may implement subband restriction without causing ambiguity, but also there is possibility that some other gNB may implement both with blind decoding or follow offline agreement.  @MediaTek and @Huawei, we understand your preference, but the fact is that there are two implementations already in the field. It seems not possible to define a default behavior in the spec without causing backward compatibility issue.  As mentioned by many companies, adding UE capability is the proper way to address the ambiguity. Otherwise, we might have to leave Rel-17 spec broken and all gNB/UE vendors would keep whatever they are implementing which does not seem problematic in the past 3 years. |
| Samsung | @Qualcomm:  As you mentioned, now all companies can be noticed that there are two different implementations already in the field no matter what was actually agreed. Hence, if we leave Rel-15/16 as is, anyway the functionality of subband CSI reporting is broken. For us, we cannot leave this feature as broken, and fixing this broken feature is very important.  In addition, it is unclear how gNB utilizes a subband CSI reported from a UE by doing blind decoding for both interpretations. Although gNB implements both interpretations, gNB cannot know which one is the actual interpretation for the UE. Similarly, if a certain gNB implements based on offline agreement, there are some UEs which have implementation with different interpretation. Hence, anyway misunderstanding would be there.  Therefore, in order to utilize at least some of the functionality of subband CSI reporting, the only way we can do in Rel-15/16 is configuring csi-ReportingBand to UE with restriction that same outcome can be achieved based on both interpretation 1 and 2.  Regarding NBC issue, we don't think the restriction causes NBC since the restricted configuration is already included in all the possible combinations expressed by csi-ReportingBand bitmap.  If restricted configuration on csi-ReportingBand in Rel-15/16 is not acceptable, the possible wayforward is agreeing interpretation 1 for all releases (Rel-15/16/17) since it was actually agreed in Rel-15 based on the reference provided by Apple. |
| Qualcomm4 | @Samsung:  This is maintenance phase and avoiding NBC is the top priority. Avoiding NBC means none of the UE or gNB in the field has to change their implementation. If offline agreement is made, it means that gNB knows either interpretation 1 or 2 a UE could have implemented, so the gNB can configure subband without restriction. However, your suggestion enforces those gNB to change their implementation, thus having NBC issue. We would like to hear more voices from infra vendors.  Regarding agreeing interpretation 1 in Rel-15/16, it is also not a way forward, as there are UEs implementing interpretation 2. RAN1 #94b agrees a TP, but the text is ambiguous which is the source of issue. |
| LG | As commented by many companies, interpretation 1 seems common understanding in RAN1, so the CR is not needed. But, if majority companies wants to clarify, we could be flexible for introducing CR. |
| Samsung | @Qualcomm  The solution we mentioned does not make NBC.  The solution is based on RRC configuration, i.e., using *csi-ReportingBand*.  We think that bitmap such as 11111111, 11111100, or 00111100 for contiguous subbands, 00110011 or 11001100 for non-contiguous subbands can make same understanding on both interpretation 1 and 2, and gNB just can do RRC (re)configuration like these. We don't think RRC (re)configuration means that gNB and UE should change implementation, i.e., no NBC issue.  The reason why we suggested the restriction is that although gNB doesn’t know whether a certain UE is based on either interpretation 1 or 2, it is beneficial for UEs implemented different ways by assisting from gNB side based on appropriate RRC configuration to have same outcome on interpretation 1 and 2.  BTW, when we go through the inputs from other companies, we realize that all companies, except Qualcomm, have same understanding as interpretation 1. Also, since this was already discussed as CR in RAN1#94b in 2018, which means companies already discussed the issue, therefore current spec (from Rel-15) is not broken and no ambiguity issue, so we don't even need a conclusion or further discussion.  Having said that, since the spec is clear as interpretation 1, we think that restricted *csi-ReportingBand* to align interpretation 1 and 2, which was our proposal, and Rel-17 UE capability proposed by moderator are not needed, and interpretation 1 is only option for all Releases (Rel-15/16/17). |
| Qualcomm5 | @Samsung, vivo, Huawei, LG:  No matter how many companies implement interpretation 1, and how many implement interpretation 2, the key issue now is that currently there are two implementations in the field (two kinds of UEs and two kinds of gNBs), and the Moderator proposal is the only way to align the two implementations in future releases. If we don’t take any action, it means that we will keep these two implementations in the future.  Moreover, repeat our reason that why interpretation 2 is valid: 331 spec describes the rightmost bit represent the lowest subband, while 214 spec describes the lowest subband is subband 0 – these means the rightmost bit represent subband 0. |
| Mod | Thanks for the discussion, I think if reading 214 or 212 solely, it gives interpretation 1 while if reading 214/212 together with 331, it becomes Interpretation 2.  It’s clear that both interpretation 1 and 2 are present in the field and that only one UE side vendor in this discussion used interpretation 2. Also, it is clear from Samsung input that there are other bitmaps than “1111…” that doesn’t case the ambiguity issue and can be used by gNB when the UE interpretation (1 or 2) is now known to the gNB.  This leads me to two alternative conclusions here depending in whether one believes the spec is clear (A) or not (B). Going for B is a safer route.  ***Proposed Conclusion A***  ***RAN1 understanding is that Interpretation 1 shall be assumed.***  ***RAN1 acknowledge that the issue can be partially avoided by some restricted configurations of csi-ReportingBand***  ***Proposed Conclusion B***  ***RAN1 understanding is that Interpretation 1 shall be assumed.***  ***RAN1 acknowledge that the issue can be partially avoided by some restricted configurations of csi-ReportingBand***  ***Introduce a Rel-17 CR that Resolve ambiguity in the specifications to clarify interpretation 1***  ***Introduce a Rel-17 UE capability related to the Rel.17 CR*** |
| Qualcomm | Given that there are UEs implementing interpretation 2, we cannot share the understanding “***RAN1 understanding is that Interpretation 1 shall be assumed***” in either conclusion. But we acknowledge the rest of both conclusions. In the second sentence, RAN1 ack there is ambiguity, but first sentence say interpretation 1 is assumed which sounds conflict.  Regarding the two conclusions, our understanding is that,   * in conclusion A, we keep the two implementations and acknowledge that the ambiguity can be solved by subband restriction. * In conclusion B, we align the implementation in Rel-17, keep the two implementations in Rel-15/16.   If the above understandings are correct, conclusion B is better and we are also fine we conclusion A (but first sentence to be removed). |
| Apple | First of all, we are fine with either proposed conclusion A or B just to respect the other UE vendor as much as possible.  However, we are puzzled by the justification of conclusion B. From the design perspective, interpretation 1 is the right choice based on the past discussion. The whole purpose of even and odd subband is to split the CSI roughly in half between CSI part 1 and CSI part 2 for UCI omission. Interpretation 1 can achieve this goal regardless of how csi-ReportingBand is configured, however, interpretation 2 cannot. In the worst case, interpretation 2 will put all the CSI in either part 1 or part 2, defeating the purpose of the design. In the past RAN1 technical discussion, we do not think any company prefer interpretation 2 as documented in the discussion of Huawei CR including the company who implemented interpretation 2.  We cannot solve the issue for Rel-15/16 since those UEs are in market. For Rel-17. UE anyhow needs to change some implementation, for example, to support the new csi-ReportingBand-r17 and/or new capability. Why cannot that UE implement the interpretation 1? UE will report its release to the NW anyway.  Again, we would be fine with Conclusion B. But for conclusion B, we would prefer to check a complete proposal to make sure companies who implemented interpretation 1 do not get penalized unnecessarily. In our view, the only thing needed is a new [Rel-17] UE capability.   * If the new capability is reported, the UE uses interpretation 2 * If the new capability is not reported , the UE uses interpretation 1   We do not know why we need csi-ReportingBand-r17 sine it is configured per UE anyway after NW receives UE capability reporting. Why a UE who implements interpretation 1 correctly needs to handle a new csi-ReportingBand-r17? Or we need two csi-ReportingBand for the same NW and the same UE? |

**Question: Which interpretation (1 or 2) is should be the Rel.17 clarification in specification?**

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| Company | View |
| Qualcomm | We believe interpretation 2 is the correct understanding. As stated in our contribution R1-2209933, there are two reasons:   1. **Interpretation 2 reflects the original intention of UCI packing principle, in the sense of, keeping the subbands as close to each other as possible when UCI omission occurs**    1. For instance, with subband configuration 1110001000111, when CSI omission occurs, the orphan subband in the middle will be dropped if following interpretation 1, but will be kept if following interpretation 2. So interpretation 2 will make it much easier for the gNB to perform CQI/PMI interpolation. 2. **Interpretation 2 is described in current 331 and 214 spec.**   When CSI reporting on PUSCH comprises two parts, the UE may omit a portion of the Part 2 CSI. Omission of Part 2 CSI is according to the priority order shown in Table 5.2.3-1, where  is the number of CSI reports configured to be carried on the PUSCH. Priority 0 is the highest priority and priority  is the lowest priority and the CSI report *n* corresponds to the CSI report with the *n*th smallest Prii,CSI(*y,k,c,s*) value among the  CSI reports as defined in Clause 5.2.5. The subbands for a given CSI report *n* indicated by the higher layer parameter *csi-ReportingBand* are numbered continuously in increasing order with the lowest subband of *csi-ReportingBand* as subband 0. When omitting Part 2 CSI information for a particular priority level, the UE shall omit all of the information at that priority level.  ***csi-ReportingBand***  Indicates a contiguous or non-contiguous subset of subbands in the bandwidth part which CSI shall be reported for. Each bit in the bit-string represents one subband. The right-most bit in the bit string represents the lowest subband in the BWP. The choice determines the number of subbands (subbands3 for 3 subbands, subbands4 for 4 subbands, and so on) (see TS 38.214 [19], clause 5.2.1.4). This field is absent if there are less than 24 PRBs (no sub band) and present otherwise, the number of sub bands can be from 3 (24 PRBs, sub band size 8) to 18 (72 PRBs, sub band size 4). |
| ZTE | Technically speaking, we also think that Interpretation-1 looks much more reasonable, considering that we may have almost equal number of odd and even active subbands. It seems that only suband(s) with the corresponding bit set to '1' in csi-ReportingBand may be numbered continuously (some further clarification is needed?). Otherwise, if going with Interpretation-2, in a worst case, all active subbands for reporting (i.e., odd bands by csi-ReportingBand:'01010101'B) may be omitted. It seems to betray the motivation of this omission rule. |
| OPPO | We think Interpretation-1 is the better way and can be applied for Rel-17. Interpretation-1 would avoid the case mentioned by ZTE, where all the subbands would be omitted/maintained. With Interpretation 1 at least half of the subbands can always be reported. Also, we think Interpretation-1 is easier to be implemented for UE, where only the active bands need to be processed. |
| Apple | After checking the issue, what we found is that this issue was clarified as interpretation 1 in RAN1#94b in 10/2018. The sentence "*The subbands for given CSI report n indicated by the higher layer parameter csi-ReportingBand are numbered continuously in the increasing order with the lowest subband of csi-ReportingBand as subband 0*” was endorsed as CR and show up in TS38.214 in RAN1#94b in 10/2018.   * The reason why this sentence was introduced was to clarify the different interpretation as raised by Huawei in "R1-1810099”.   + The proposal from Huawei is to clarify, exactly, that the understanding is only for the indicated subband, which is clear from their contribution. * The proposal from Huawei was also agreed in the same meeting, with FL summary in R1-1812015 and the Chairman note |
| Nokia, NSB | Our understanding is that Interpretation-1 is the original intent of the specification, and Apple’s reference to Huawei R1-1810099 further underlines the point and makes it very difficult for RAN1 to 4 years later revert course and say that interpretation-2 is the correct interpretation. |
| LG | Our understanding is also Interpretation-1. |
| Samsung | We think a common understanding of either interpretation 1 or 2 for gNB and UEs should be needed in Rel-17. |
| MTK | Our understanding is Interpretation-1. Same reason as ZTE/OPPO/Apple/Nokia. It seems clear from Apple’s reference. |
| Huawei, HiSilicon | As mentioned by Apple, this issue has been discussed previously, and the understanding is interpretation 1 with corresponding CR approved, as rule (c) in R1-1810099.   * (c) using the first subband in CSI reporting band   The reason of interpretation 1 is simple that the intention of UCI omission is to omit half the subband reporting to reduce UCI size. With interpretation 2, if all even PRB is configured, there will be no omission. On the contrary, if all odd PRB configured, all reporting will be omitted. |
| vivo | We think current spec has addressed this issue clearly in subclause 5.2.3 in 38.214 as following which should be interpretation 1. |

# Outcome of the Email discussion

To be updated