**3GPP TSG RAN WG1 #101 R1-2003880**

**e-Meeting, May 25th – June 5th, 2020**

**Agenda item:** 7.2.6.1

**Source:** Moderator (Samsung)

**Title:** Feature lead summary for MU-MIMO CSI

**Document for:** Discussion and Decision

# Introduction

The FL summary of the proposals in the submitted contributions ([1]-[11]) for Rel.16 NR\_eMIMO MU-CSI maintenance is given below and categorized under the following sections:

* *H*igh priority (essential)
* *E*ditorial
* *L*ow priority (non-essential)

Proposals on Rel.16 draft shadow CRs are not summarized here since they are to be discussed as a part of Rel.15 maintenance.

Summary

## High priority (essential)

The following issues pertain to some ambiguity in the current description of the specs and may have some significant impact on spec completeness and/or UE implementation.

In this meeting, no essential issue has been identified.

## Editorial

The following issues pertain to relative simple editorial corrections which are valid and not expected to be contentious. Some textual refinement may be fitting and can be discussed.

Table 1 Editorial

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| **Issue #** | **Description/Proposal** | **Companies** |
| E.1: typographical correction (missing dash sign in RRC parameter name) | < Start TP for TS 38.214 V16.1.0>  5.2.2.2.5 Enhanced Type II Codebook  < Unchanged parts are omitted >  The parameter is configured with the higher-layer parameter *numberOfPMI-SubbandsPerCQI-Subband-r16*.  < End TP for TS 38.214 V16.1.0> | Support: Huawei/HiSi, Apple, Nokia/NSB, Samsung, LGE, ZTE, OPPO |
| E.2: typographical correction (correction on clause #) | < Start TP for TS 38.212 V16.1.0> 6.3.2.1.2 CSI --------------- Unchanged parts omitted -------------  Table 6.3.2.1.2-2A: PMI of *codebookType=* *typeII-PortSelection-r16*  Note: the bitwidth for , and shown in Table 6.3.2.1.2-2A is the total bitwidth of , and up to Rank = , respectively, and the corresponding per layer bitwidths are , , and 4, (i.e., 1, 3, and 4 bits for each respective indicator elements , , and , respectively), where as defined in Clause 5.2.2.2.5 in [6, TS 38.214] is the number of nonzero coefficients for layer such that  < End TP for TS 38.212 V16.1.0> | Support: LGE, Apple, Nokia/NSB, Huawei/HiSi, Samsung, ZTE, OPPO |

## Non-essential

The following issues pertain to non-essential proposals with some potential specification impact which are not intended to address incomplete or faulty functions. Therefore, they will not be discussed during the eMeeting.

Table 2 Low-priority (non-essential)

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| **Issue #** | **Proposal(s)** | **Companies** |
| N.1: R=2 for BWP size < 24 PRBs | *Proposal 1: UE is not expected to be configured with R =2 for BWP size less than 24 PRBs.*  FL assessment: unclear if this proposal is relevant at all since there is no support for Rel.16 eTypeII when BWP size < 24 PRBs. | Support: vivo  Concern: ZTE, Nokia/NSN, LGE |
| N.2: SCI payload for rank 1 | *Proposal 1: bits are used to indicate the strongest coefficients for RI=1, where*  FL assessment: optimization and requiring change in previous agreement | Support: CATT  Concern: Samsung, ZTE, Nokia/NSN, LGE |
| N.3: Parameter combination | *Proposal 1: For Rel-16 Type II CSI reporting, the minimum number of CSI subbands can be summarized as the following, where the number of CSI subbands is defined as the number of 1’s in csi-ReportingBand.*   * *For parameter setting 1*   + *To support up to rank 2 CSI reporting, the minimum number of CSI subbands is 5*   + *To support up to rank 3 CSI reporting, the minimum number of CSI subbands is 9*   + *To support up to rank 4 CSI reporting, the minimum number of CSI subbands is 13* * *For parameter setting 2*   + *To support up to rank 3 CSI reporting, the minimum number of CSI subbands is 5*   + *To support up to rank 4 CSI reporting, the minimum number of CSI subbands is 5* * *For parameter setting 3*   + *To support up to rank 3 CSI reporting, the minimum number of CSI subbands is 5*   + *To support up to rank 4 CSI reporting, the minimum number of CSI subbands is 5*   FL assessment: optimization | Support: Apple  Concern: ZTE, Nokia/NSN, LGE |
| N.4: K0 | *Text Proposal 1. Modify the definition of , by introducing a minimum value, , from one of the following alternatives*  *1a. , to ensure that a UE can report one NZC per polarisation for rank*  *1b. , to ensure that a UE can report one NZC per polarisation for rank*  *2a. , to ensure that a UE can report one NZC for each selected beam for rank*  *2b. , to ensure that a UE can report one NZC for each selected beam for rank for*  FL assessment: optimization (2a/b) and requiring change in previous agreement | Support: Nokia/NSB, Huawei/HiSi (1a and 1b)  Concern: Samsung (2a, 2b), ZTE, LGE |
| N.5: CBSR | ---------------------------- Start of proposed TP for TS38.214 ----  **5.2.2.2.5 Enhanced Type II Codebook**  --- Unchanged text omitted ---------  The bitmap parameter *n1-n2‑codebookSubsetRestriction-r16* forms the bit sequence and configures the vector group indices as in clause 5.2.2.2.3. Bits indicate the maximum allowed average amplitude, (), with , of the coefficients associated with the vector in group indexed by , where the maximum amplitudes are given in Table 5.2.2.2.5-6 and the average coefficient amplitude is restricted as follows    for , and . is the set of indices of the selected beams that are not associated with any of the sets of group indices g(k) for *k*=0,1,2,3 described in 5.2.2.3. A UE that does not report the parameter *amplitudeSubsetRestriction*='supported' in its capability signaling is not expected to be configured with or .  --- Unchanged text omitted ---------  ----------------------------End of proposed TP for TS38.214 ----  FL assessment: optimization | Support: MotM/Lenovo, NTT Docomo  Concern: ZTE, LGE, Nokia/NSN, Samsung |
| N.6: size of InS | *Proposal: When , the size of the intermediate set is give by for RI={1,2,3,4}, where is the number of FD bases selected for RI={1,2}.*  FL assessment: optimization | Support: Qualcomm  Concern: ZTE, LGE, Nokia/NSN |
| N.7: additional restriction for | *Proposal: : For eType II and eType II port-selection, support if .*  FL assessment: optimization | Support: Qualcomm  Concern: ZTE, LGE, Nokia/NSN |

## Preparatory email discussion (04/21-24):

In addition to the captured comments in the above subsections, some additional comments can be summarized below. Some of the comments below are also relevant for the second phase of the eMeeting discussion.

Table 3 Additional comments

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| **Company** | **Comment** |
| Samsung | N.2: non-essential since spec is not broken and the overhead saving is insignificant when compared with the total CSI payload  N.4: addressing a corner case (when small parameter values for N\_SB values, beta etc. are configured) which is a not target use case of R16 eType2. Also, a proper gNB implementation can handle this. [Alternatively,] one way to address concern from the proponents of N.4 is to restrict (not allowed) such strange parameter combinations for small N\_SB values. Since M1=1 happens for paramCombination-r16=1 and N\_SB=3,4, we can restrict (not allowed) this configuration.  **Alternative proposal**: the UE is not expected to be configured with paramCombination-r16 = 1 when N\_SB = 3,4  N.5: non-essential, the proposal in N.5 is trying to address a weird UE implementation of CBSR. A reasonable UE implementation can avoid the issue mentioned in N.5 |
| Qualcomm | Open to discuss N.2-N.6 if possible (N.1 seems not applicable because we don’t support eType II for BWP < 24).  N.4: the idea is to introduce a minimum value for K0 in case is small. This spirit seems align with our proposal 2 (please see proposal 2 in N.6), in which we introduce a minimum value for when number of subbands is small. So, we kindly suggest move our proposal 2 to N.4   * FL assessment: Proposal 2 (in the original N.6) from Qualcomm does not seem to fall within the category of N.4 although it is related. For now, proposal of N.6 is separated and categorized as N.7 so it stands by its own.   (Later comment) N.7 intends to address the issue of small K0 values when number of subbands is small (Please note that when , e.g., 2 CQI subbands, we have and . Since beta <= ¾, the number of NZC is smaller than 2L, which can be worse than Type II, so we simply set and in this case). So, we see the goal is same as N.2 as it aims at optimizing K0 value (saying , but with different x value and condition, i.e., if ).  (Later comment) Responding to ZTE/Nokia/Huawei latest proposal for x: If the intention is to ensure UE can report one NZC per pol per layer, we should have total 8 NZCs considering rank-4, which results in . Considering different minimum value for different max rank seems redundant. Besides, if UE would report rank-1 (due to the bad channel condition), the number of NZCs should be dependent on the channel, not the max allowable rank. We fail to see the reason why we need to restrict if max allowable rank is 2 and if max allowable rank is 4. It would make more technical sense if minimum is independent of max allowable rank. Lastly, having two “max” in equation makes the spec a bit difficult to read. |
| ZTE | OK not to discuss N1 - N3 and N5 - N6 since the specification still works without them.  N.4/N.7: we agree for some cases (e.g., small bandwidth) gNB cannot acquire good CSI for them as there is only one coefficient reported, and it's not possible to achieve high-rank transmission even the wireless channel allows.   * However, it's not clear to us whether these are typical cases requiring high data rate transmission. * Further, the proposals from proponents are divergent, so it seems hard to achieve consensus in email on this issue. * N.4 is easier than N.7 as N.7 would let UE to calculate more coefficients for these corner cases.   (Later comment) If the majority wants to optimize this case, we think we should target a complete solution to achieve the benefit from high rank for restricting K0 values. Considering this perspective, 1a (Alt a) is not a complete solution in our view. If we want to take N.4 in thread 2, what we can accept is to limit the scope to 1b, i.e., Alt b. Further, we think the issue is from small K0 values, and it is not related to whether to ensure UE can report one NZC per polarization, which has been discussed before.  (Commenting on Samsung’s alternative proposal for N.4) The proposal is a part of N.3 which has been concluded as non-essential. |
| LGE | For any of the non-essential issues, prefer not to discuss them unless a majority is formed |
| Nokia/NSN | N.1: out of scope for the reason pointed out by the FL  N.2: this is a very small optimisation that does not address any critical issue so it does not warrant revisiting an existing agreement.  N.3: we do not support introducing network restrictions on the minimum number of configurable subbands.  N.4: in our view,   * case 1 (a and b) addresses a more significant issue, i.e. when no NZC can be reported for some or all the layers because K0 is too small, such that the bitmap and reference amplitudes are not used but they are still reported. This happens for a non-negligible number of cases, i.e., the first 3 parameter combinations for . * case 2 (a and b) is more of an optimisation   N.5 and N.6: unnecessary optimisations  N.7: in our view, the goal is the same as case 2 of N.4, although the solution is different.  In conclusion of all the N issues, in our view only N.4-case 1 addresses a more significant issue and can be discussed in phase 2 if there is consensus to do so. |
| NTT Docomo | N.5: with the current normalization, for a given, if   , the chance of failure of the CBSR test increases, since the term added to the numerator is smaller than the term added to the denominator. Further, with the given quantization, there is a high probability that the term is smaller than 1 while is always 1 (for a reported NZC). As per our understanding, the normalization factor should not depend on the number of NZCs associated with the beam under consideration and rather should be a fixed reference value |
| MotM/Lenovo | N.5: The issue is related to the behavior of the CBSR equation rather than UE implementation; in words, the current CBSR equation may reject a beam although it would pass another beam with higher wideband power. Our concern is that this undesired behavior is straightforwardly tied to the number of non-zero coefficients in the restricted beam on which the UE has full control, so I’m not sure how this qualifies as a corner case. |
| Apple | N.3/N.4: Based on our contribution [7], if the goal is to ensure for each layer, there is at least one none-zero coefficient for each polarization, [Table 1] is the minimum number of subbands. A few parameter combinations do not have the issue such as 4/5/6. The reason of the issue is due to NW configuring too aggressive compression and/or smaller number of L=2, while at the same time, configuring small number of subbands. It is an issue chosen by the NW, not the specification to certain extent. |

From FL perspective, it is beneficial to reach closure on each of the items above as some of them have been proposed for a few meetings. It is quite clear that:

* N.1 is irrelevant
* N.2, N.3, N.4 2a/2b, N.5, N.6, and N.7 are optimization attempts, some of which involving amending previous agreement(s)
* N.4 1a/1b may warrant further discussion since, as pointed out by Nokia, it may result in the UE reporting useless information (bitmap and reference amplitude are reported even if LCC is absent) for 3 out of 8 supported parameter combinations
  + ZTE proposed to focus on alternative 1b since it offers a (more) complete solution. This proposal was also supported by the proponents (Nokia/NSB and Huawei/HiSi)
  + Qualcomm pointed out another alternative with x=4

FL proposal for phase-2 discussion

Based on the above summary and inputs from the participants, the following FL proposals were made.

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| **Proposed conclusion**: There is no consensus in supporting the proposals in N.1, N.2, N.3, N.4 1a/2a/2b, N.5, N.6, and N.7 as summarized in Table 2  **Proposed threads** for phase-2 email discussion for RAN1#101-e eMeeting:   1. Thread #1: Agree and finalize on the TP proposed for E.1 and E.2 in Table 1 2. Thread #2: Discuss the following issue:    1. Examine when the UE reports useless information (bitmap and reference amplitude are reported even if LCC is absent) for 3 out of 8 supported parameter combinations and whether this optimization is significantly beneficial and should be addressed by specification    2. If so, modify the definition of to ensure that a UE can report one NZC per polarization for rank . Two alternatives to be discussed are:       1. Alt 1:       2. Alt 2: |

# References

1. R1-2003396 On remaining issues on MU CSI vivo
2. R1-2003468 Maintenance of CSI enhancement for MU-MIMO ZTE
3. R1-2003530 Remaining issues on MU-CSI in R16 Huawei, HiSilicon
4. R1-2003626 Remaining issues on CSI enhancement for MU-MIMO CATT
5. R1-2003879 On maintenance of Rel.16 MU CSI enhancements Samsung
6. R1-2003927 TP on enhanced Type II port selection codebook LG Electronics
7. R1-2004228 Remaining issues for Rel-16 Type II CSI enhancement Apple
8. R1-2004264 Maintenance on Rel-16 CSI enhancements Nokia, Nokia Shanghai Bell
9. R1-2004372 Maintenance on MU-CSI Enhancements Motorola Mobility, Lenovo
10. R1-2004462 Remaining issues on MU-CSI enhancement Qualcomm Incorporated
11. R1-2004527 Discussion on MU CSI Ericsson