**3GPP TSG RAN WG1 #101 R1-2004713**

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

**Agenda item:** 7.2.6.1

**Source:** Moderator (Samsung)

**Title:** Feature lead summary for MU-MIMO CSI thread #2

**Document for:** Discussion and Decision

1. Introduction

Based on the discussion during the preparation phase summarized in [1] and the Phase-2 instruction from the MIMO chairman, the following issue is to be discussed in thread #2 for MU CSI:

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| *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:*
3. *Possible conclusion*
	1. *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 [of [1]]*
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Issue 3 (“possible conclusion”) has been discussed at length in Phase-1 and the content has been agreeable to the group. Therefore, the group is to focus on issues 1 and 2 which are pertinent to N.4-1b.

It is quite apparent that issue 1 and 2 are inter-dependent. Whether issue 2 needs to be discussed depends on whether the problem raised in issue 1 requires spec-based solution(s). Conversely, the need for spec-based solution(s) in issue 1 should be based on the assessment of the two alternatives given in issue 2 (Alt1 and Alt2 for the value of *x*) since only such alternatives are to be considered if a spec-based solution is to be adopted. Therefore, issue 1 and 2 cannot be decoupled and should be decided jointly.

In addition, given that proposal N.4-1b is non-essential and an optimization, more stringent assessment based on a properly identified core issue should be made. In this case, the core issue is precisely *the absence of LCC with the presence of bitmap and reference amplitude in an instant of eType-II CSI reporting*. To assess the seriousness of this core issue, each interested company is encouraged to:

1. state the scenarios in which the core issue occurs,
2. assess the importance of each of those scenarios,
3. assess the benefit of the two alternatives, and
4. state whether a spec-based solution is justified and, if so, which one
5. Summary

Interested companies are to provide their abridged views in the following table.

Table 1 Abridged views

|  |  |
| --- | --- |
| **Company** | **Position** |
| **Spec-based solution not needed** | **Spec-based solution needed: Alt 1** | **Spec-based solution needed: Alt 2** |
| Samsung | Support |  |  |
| Apple | Support |  |  |
| Qualcomm |  |  | Support |
| Huawei/HiSi |  | Support (1st preference) | Support (2nd preference) |
| Nokia/NSB | Support (2nd preference) | Support (1st preference) |  |
| ZTE |  | Support (1st preference) | Support (2nd preference) |
| OPPO | Support (1st preference) |  | Support (2nd) |
| Intel | Support (1st preference) |  | Support (2nd preference) |
| LG | Support |  |  |
| vivo | Support |  |  |
| Fraunhofer/HHI | Support |  |  |
| Ericsson | Support |  |  |
| MotM/Lenovo |  |  | Support |
| CATT | Support (1st preference) |  | Support (2nd preference) |
| Spreadtrum | Support |  |  |
|  |  |  |  |
| **TOTAL** | 13 | 5 | 9 |

In the table below, interested companies are to provide more detailed views based on the four points in section 1.

Table 2 More detailed views

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Samsung | 1. The issue exists with small #SBs (e.g. 3,4), which however is not a target use case of eT2.
	1. The main use case of eT2 is MU-MIMO with frequency-selective MU scheduling – which requires sufficiently large number of SBs.
2. Optimization of a corner case
	1. Optimization since the current spec is not broken, and the proposal (Alt 1 and Alt 2) targets performance improvement (when compared with Type I CSI)
	2. Corner case (cf. point 1. above) since the probability of being configured with small #SBs for MU-MIMO is extremely small.
3. The issue is only with certain value(s) of ParamCombination-r16 (e.g. 1). The gNB however is free to configure other ParamCombination-r16 values (e.g. 2). Hence, there is already spec-support to avoid this.
	1. Note: a larger ParamCombination-r16 value implies a larger K0 value. And Alt 1 and Alt 2 essentially propose to increase K0 value. But, the same (a large K0 value) can be achieve by configuring a large ParamCombination-r16 value.
4. If the concern is performance loss when compared with Type I, then gNB is free to configure Type I codebook (or R15 T2 CB). Note that a small K0 value (e.g. K0=1) implies lower-resolution, hence such a codebook is any way closer to Type I. If K0 is too small (e.g. 1), the gNB might as well configure Type I.
5. Regarding higher rank (e.g. rank 3-4), if gNB allows (expects) higher rank CSI, then it should configure reasonable/appropriate value for codebook parameters (such as ParamCombination-r16 and number of SBs). It is strange to configure ParamCombination-r16=1 and small #SBs, and expect a UE to report high rank CSI. In our view, there is no technical motivation behind such weird configurations.
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| Apple | Based on our check, for any CSI subband configuration, we don’t see an issue for parameter combination 4/5/6 (and 7/8). The issue seems to exist only in parameter combination 1/2/, as shown below. There are many cases that NW can configure something that UE cannot do, such as measuring a non-active BWP or deactivated SP-CSI-RS. The handling of the specification is either to explicitly or to implicitly clarify that UE is not expected to perform the corresponding action, which we think is real missing part.  |
| Qualcomm | As explained earlier, *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.We originally propose (equivalently,) as the minimum so that eType II would have no less NZC than Type II, so considering x=4 has been a compromise. |
| Huawei/HiSi | For parameter combination 1~3 with small #SBs, no coefficient may be reported for some layer. For *ParamCombination-r16*=1, relatively large number of SBs still cannot be ensure that . For example, only 3 coefficients can be reported at most when #SBs<13 for *ParamCombination-r16*=1 and *v*=4. Moreover, for *ParamCombination-r16*=1~2, rank 3-4 cannot be supported for *L*=2 when #SBs<5, because the #SBs should be larger than 4 to ensure.Alt 1 is a simple method to guarantee the system performance of eT2 codebook and expand the application scenarios for *ParamCombination-r16*=1~3. WB-like PMI with single beam can be reported for each polarization/layer even for extreme parameters with small #SBs. Alt 2 is also relatively straightforward.  |
| Nokia/NSB | Here is our assessment, following the FL guidance:1. The problem occurs when for reported rank , or for rank . In these cases, some or all layers have no reported LCC, hence the reference amplitudes and (for ) the bitmap are unused but still reported.

This problem affects the first 3 parameter combinations, for *csi-ReportingBand* configured with smaller than the values shown in the table reported by Apple.1. The critical configurations described here are not typical, but they occur mostly when , which is a case supported by the specs. Configuring a report on a small number of subbands, such that , may be of interest also for larger BWPs to emulate a wideband report with eType2, because in this case only the SD basis is reported (no FD basis is reported).
2. Alt 1 solves the problem by ensuring that a UE can report at least 1 LCC per layer for all parameter combinations.

As pointed out by Samsung in their comment 3, another solution is for the gNB to avoid the first 3 parameter combinations for and the first one for In fact, in a typical configuration, a gNB would probably choose a parameter configuration such that to ensure that a UE can report at least one LCC for each selected x-pol beam for any reported rank, so in practice the original condition proposed by Qualcomm is also achievable by appropriate choice of configuration (except for and rank 4 for which no combination offers more than =6).1. In conclusion, Alt 1 offers a blanket solution for all configurations. However, no spec change is also acceptable, in the sense that it is left to the gNB to avoid certain critical configurations.
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| ZTE | We tend to agree with the views from Qualcomm, Huawei and Nokia. It does not make sense to limit the possibility of rank 2-4 while the wireless channel allows that. Further, this is just to guarantee the minimum number of NZ coefficients in the CSI report. Hence rank 1 can also benefit from this as there will be more NC coefficients reported for rank 1. It does not mean the design will lean towards rank 3-4.Between the two alternatives, we think Alt 1 is a bit more efficient but Alt 2 is also a simple solution to tackle this issue. Hence both are acceptable to us. |
| OPPO | The issue occurs for combination 1 when Nsb<5 result in K0 = 1. It can be avoided by implementation so spec-based solution are not really needed. Making each combination to support all rank is also fine to us. Regarding Alt1 and Alt2, we slightly prefer x=4 for simplicity. |
| Intel | Our preference is not to change the specification since it is corner case valid only for limited number of configurations which can be avoided by the gNB. However, we are fine to accept small change to the spec i.e. Alt. 2 since it looks simpler. |
| LG | While the problem on NZC happens with the small number of SBs, there are several ways to handle the issue for supporting MU-MIMO scenario based on appropriate configuration of parameter combination and/or different CB types, which are supportive in the current spec already. Hence, modifying the definition of K0 is regarded as a kind of optimization because the current K0 still works in spec perspective. |
| vivo | As explained by Samsung, we don’t see necessity for this optimization of corner case |
| Fraunhofer/HHI | The problem can be handled by an appropriate configuration of the parameter configuration by gNB. Therefore, this issue can be considered as an optimization. Modifying the definition of K0 is therefore not required.  |
| Ericsson | Non-essential / optimization |
| MotM/Lenovo | The necessity of having at least one LCC per polarization per layer is well justified, and Alt 2 provides a clean, simple solution to the problem without the need of adding a lot of text or introducing new variables to the spec. However, we acknowledge it is an optimization issue and that the cases in which this solution is triggered are not the main use cases for eType-II.  |
| CATT | Our view is similar to that of Samsung, i.e., the corner cases (e.g., Mv=1) could be avoid by gNB implementation. Further optimization for the corner case is not necessary.For future proof, Alt2 is also fine to us. |
| Spreadtrum | Similar view as Samsung, this issue is not critical since the current spec works. |

From FL perspective, the following can be observed.

First, the main issue that Alt1/2 addresses is the lack of LCC coefficients in the CSI reporting when ParamCombination-r16 = 1 and the number of CSI subbands NSB is small. It is argued that this results in performance degradation for small NSB which can be important for both SU-MIMO and MU-MIMO scenarios. From FL perspective, the performance for smaller NSB (configured via RRC) can be considered of importance. On the other hand, as demonstrated by several companies this issue can be avoided altogether since the gNB can opt for different ParamCombination-r16 setting (also configured via RRC) for the same (small) values of NSB. Therefore, Alt1/2 should be considered optimization at best since the current spec is sufficient for addressing the issue with smaller configured values of NSB. In other words, changing the previous agreement only for increasing the possible number of LCCs for the combination of RRC-configured ParamCombination-r16 = 1 and small values of RRC-configured NSB is in fact –as previously stated by several companies – an optimization for a corner case.

Second, not supporting Alt1/2 (i.e. not changing the previous agreement on K0) represents the majority view. Therefore, it can be concluded that there is no consensus in changing the previous agreement to address the issue raised in relation to N.4-1b as summarized in Table 2 of [1] (R1-2003880).

1. Conclusion

Based on the above inputs and discussion, the following **FL proposals** are made:

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| The following is to be captured as a conclusion: 1. There is no consensus in supporting the proposals in N.1, N.2, N.3, N.4, N.5, N.6, and N.7 as summarized in Table 2 of [1] (R1-2003880)
	1. There is no consensus in changing the previous agreement on K0 to address the lack of LCCs in CSI reporting for a certain combination of ParamCombination-r16 and small values of NSB
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# References

1. R1-2003880 Feature lead summary for MU-MIMO CSI Moderator (Samsung)