**3GPP TSG RAN WG1 #108-e R1-2202511**

**e-Meeting, February 21st – March 3rd, 2022**

**Agenda item:** 7.2.11

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** Summary on Rel-16 NR UE features related discussion

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the following email discussion in AI 7.2.11 regarding Rel-16 UE features for eMIMO.

[108-e-R16-UE-features-MIMO-02] Email discussion/approval on UE features for maximum number of layers for single-DCI based multi-TRP – Hiroki (DOCOMO)

* Discuss the necessity of potential new FG(s) for maximum number of layers for single-DCI based multi-TRP based on R1-2202084, with considering potential NBC issue
  + Only if it is deemed necessary, the introduction of new FGs for the maximum number of layers for multi-TRP can be considered with coordination with RAN2.
* First check point: February 24
* Final check point: March 1

1. Discussion on UE features for eMIMO
   1. Maximum number of layers for multi-TRP (a new FG and FG16-2a-9) [3]

Following proposals are made in a contribution in AI7.2.11.

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| [3] | **Single-DCI based FDM in FR2** For single-DCI based multi-TRP schemes, the parameter *maxNumberMIMO-LayersPDSCH* is shared among the multi-TRP schemes and with the conventional single-TRP operations. A low-complexity UE implementation may support multi-TRP operations by using two panels, each with only one receiver unit (RxU). For single-TRP operations, UE can report *maxNumberMIMO-LayersPDSCH* = 2 by using both one-RxU panels for data reception. It also works for the single-DCI based SDM and TDM schemes. However, the single-DCI based FDM schemes cannot support 2 layers since the signals from the two TRPs arrive at the same time and in FR2 it is seldom that one panel can receive signals well from both TRPs simultaneously. Therefore, for single-DCI based FDM schemes, the maximum number of layers should be separately reported from single-TRP and the single-DCI based SDM and TDM schemes. We propose to introduce a new UE capability indicating the maximum number of layers specifically for the single-DCI based FDM schemes. To align with the parameter *maxNumberMIMO-LayersPDSCH*, we propose to report the new UE capability parameter per FSPC.  **Proposal 1**: Introduce the following UE capability for single-DCI based FDM schemes in TS 38.306 with candidate values {1, 2}:   | Definitions for parameters | Per | M | FDD-TDD  DIFF | FR1-FR2  DIFF | | --- | --- | --- | --- | --- | | ***maxMIMO-LayersForSingle-DCI-mTRP-FDM-r16***  Defines the maximum number of spatial multiplexing layer(s) supported by the UE for DL reception of single-DCI based multi-TRP FDM scheme A and scheme B.  The UE that indicates support of this feature shall support *supportFDM-SchemeA-r16* or *supportFDM-SchemeB-r16*. | FSPC | No | N/A | FR2 only |  **Multi-DCI based multi-TRP overlapped in time but not in frequency in FR2** In the TS 38.306 for Release 16 [1], we have the following UE capability   | Definitions for parameters | Per | M | FDD-TDD  DIFF | FR1-FR2  DIFF | | --- | --- | --- | --- | --- | | ***maxMIMO-LayersForMulti-DCI-mTRP-r16***  Indicates the interpretation of *maxNumberMIMO-LayersPDSCH* for multi-DCI based mTRP. If this field is included, *maxNumberMIMO-LayersPDSCH* is interpreted as the maximum number of layers per PDSCH for multi-DCI multi-TRP operation.  If this field is not included, *maxNumberMIMO-LayersPDSCH* is interpreted as the maximum number of layers across two PDSCHs if having at least one RE overlapped, for multi-DCI multi-TRP operation. The UE that indicates support of this feature shall support *overlapPDSCHsFullyFreqTime-r16*.  NOTE 1: For data rate calculation in clause 4.1.2, if this feature is indicated, each multi-DCI based multi-TRP CC is counted two times toward J. | Band | No | N/A | N/A |   Again, let us consider a low-complexity UE implementation where the UE is equipped with two panels, each with only one RxU. In this case, *maxNumberMIMO-LayersPDSCH* = 2 can be supported for single-TRP operations. Also, for the case of fully overlapped in time and frequency, UE can support 1 layer per PDSCH by reporting *maxNumberMIMO-LayersPDSCH* = 2, interpreted as the maximum number of layers across two PDSCHs if having at least one RE overlapped. However, when the two PDSCHs are overlapped in time but non-overlapped in frequency, the UE cannot support 2 layers per PDSCH due to the same reason as the previous section. In this case, generally 2 RxUs per panel is required. Therefore, there is a fundamental discrepancy depending on whether the two PDSCHs are overlapped in frequency or not. With this UE capability signalling, a UE capable of supporting fully overlapped PDSCHs in time and in frequency is forced to report not supporting multi-DCI based multi-TRP as non-overlapped in frequency is a prerequisite of overlapped in frequency. We propose to address the issue by revising the interpretation when including *maxMIMO-LayersForMulti-DCI-mTRP-r16*.  **Proposal 2**: Revise the definition of *maxMIMO-LayersForMulti-DCI-mTRP-r16* as the following:   | Definitions for parameters | Per | M | FDD-TDD  DIFF | FR1-FR2  DIFF | | --- | --- | --- | --- | --- | | ***maxMIMO-LayersForMulti-DCI-mTRP-r16***  Indicates the interpretation of *maxNumberMIMO-LayersPDSCH* for multi-DCI based mTRP. If this field is included, *maxNumberMIMO-LayersPDSCH* is interpreted as the maximum number of layers per PDSCH for multi-DCI multi-TRP operation.  For FR1, i~~I~~f this field is not included, *maxNumberMIMO-LayersPDSCH* is interpreted as the maximum number of layers across two PDSCHs if having at least one RE overlapped, for multi-DCI multi-TRP operation.  For FR2, if this field is not included, *maxNumberMIMO-LayersPDSCH* is interpreted as the maximum number of layers across two PDSCHs if having at least one symbol overlapped, for multi-DCI multi-TRP operation. The UE that indicates support of this feature shall support *overlapPDSCHsFullyFreqTime-r16*.  NOTE 1: For data rate calculation in clause 4.1.2, if this feature is indicated, each multi-DCI based multi-TRP CC is counted two times toward J. | Band | No | N/A | ~~N/A~~ Yes | |

During the preparation phase email discussion, following feedbacks were provided.

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| Company | Comment |
| Apple | We are open to discuss the following proposals in R1-2202084, namely   * Introdue per FSPC maximum number of PDSCH layers for FDMSchemeA and FDMSchemeB   For the proposal to revise the definition of FG16-2a-9, we do not prefer to revise the existing FG. We can consider introducing new FG if necessary |
| ZTE | We prefer not to introduce the new FGs at such late stage of Rel-16 because of NBC issue. Especially for the second issue for MDCI based MTRP, it was discussed very long time by email. |
| OPPO | We support a new feature for single DCI based mTRP transmission for FDM only.  For FG16-2a-9, we support to maintain existing FG which is outcome of long discussion. |
| Samsung | Basically we have similar view with ZTE that we do not prefer to introduce a new FG. Further, we fail to understand what the issue is on the 1st bullet. If this is an issue, is it only for sDCI mTRP FDM, but also for sDCI mTRP SDM? Regarding 2nd bullet, we have same view with ZTE and OPPO which has been already discussed. |
| Nokia, NSB | We do not support the proposal. This issue was debated extensively in Rel-16 already, and the current FG structure reflects the outcome of the compromise achieved then. We do not see a reason to reopen the discussion. |
| NTT DOCOMO | We don’t prefer to introduce the new FGs at late stage, because it would course potential NBC issue. We are open to discuss further clarification of existing FGs. |
| Intel | We are supportive of discussing this issue |
| QC | Our preference is similar to Apple, OPPO, and Intel.  To address the issue for multi-DCI, we suggest adding a new FG specific to FR2, instead of revising the definition of FG 16-2a-9 (the change is related to the case when FG 16-2a-9 is not reported). |
| Ericsson | Do not support introducing new FGs at this very late stage of Rel-16. |
| Moderator (NTT DOCOMO) | Thanks for the feedbacks!  Companies’ views can be summarized as below.   * For the 1st bullet proposal,   + Support discussing the introduction of new FG     - Apple, OPPO, Intel, Qualcomm   + Not support the introduction of new FG     - ZTE, Samsung, Nokia/NSB, NTT DOCOMO, Intel, Qualcomm, Ericsson * For the 2nd bullet proposal,   + Support discussing the revision of FG16-2a-9 or the introduction of new FG     - Apple(new FG), Intel, Qualcomm(new FG)   + Not support discussing it     - ZTE, OPPO, Samsung, Nokia/NSB, NTT DOCOMO, Ericsson   There is a larger number of companies arguing that the introduction of new FG is not necessary/preferable while there are several companies preferring to discuss the issue. Regarding the 2nd bullet proposal, there is a clear majority opposing to discuss the definition of FG16-2a-9 again as it was outcome of long discussion.  Therefore, FL proposal can be updated as below.  **Updated FL proposal #2 of email discussion/approval:**  **[108-e-AI7.2.11-NR-UEFeature-eMIMO-02] Email discussion/approval on UE features for maximum number of layers for multi-TRP**   * **Discuss the necessity of potential new FG(s) for maximum number of layers for multi-TRP based on R1-2202084, with considering potential NBC issue**   + **Only if it is deemed necessary, the introduction of new FGs for the maximum number of layers for multi-TRP can be considered.**   + **The definition of FG16-2a-9 should be maintained** |
| Huawei, HiSilicon | Similar to the above, our preference is new FGs that affect ASN.1 should be coordinated with RAN2 to see if still possible. For the mentioned issue, we are also not certain the target of new FG for single-DCI FDM scheme. If a low-complexity UE can receive two layers by using two panels (ie. with one RxU per panel) simultaneously by using single-DCI SDM scheme in FR2, we assume that it can receive two layers simultaneously in a FDM manner, whereas each panel receive one group of PRBs with one layer transmission.  With regarding to revise FG 16-2a-9, we have similar concerns as above. |
| MTK | We are fine with the “Updated FL proposal #2 of email discussion/approval”.  The proposed new UE capability for single DCI based FDM scheme in R1-2202084 is to **extend sDCI muti-TRP usage to an FR2 UE with 2 panels and one RxU per panel**. Otherwise, **two FDMed 2-layer PDSCH in multi-TRP** would require UE to **process 4 layers at one time**, which **exceeds the FR2 UE’s maximum capability**.  For FG16-2a-9, we are fine to either adding a new FG specific to FR2, or revising the current, definition of FG 16-2a-9  @Samsung: To our understanding, the sDCI issue is **only for sDCI mTRP FDM**, but **not for sDCI mTRP SDM**. Take an FR2 UE with 2 panels and one RxU per panel as example, if the FR2 UE reports *maxNumberMIMO-LayersPDSCH* = 2, then for SDM case, to us it means UE can receive at most 2 spatial layers by SDM at one time, where each panel can receive at most one spatial layer. |
| vivo | We are fine with the updated FL proposal #2. |
| ZTE | Regarding the updated proposal#2, it is not crystal for me if the discussion includes the multi-DCI based mTRP case or not.  As several companies pointed it out, the issues on introducing a new FG related to maximum layer for multi-DCI based MTRP was discussed before, the current 16-2a-9 is the outcome. I don't think we need to repeat the discussion again. Hence, I suggest we make the proposal to only focus on single-DCI based multi-TRP. |
| Moderator (NTT DOCOMO) | Thanks for further feedbacks!  Based on the feedbacks, we can discuss potential new FG for single-DCI based multi-TRP, i.e., first bullet issue of original proposal. For multi-DCI based mutli-TRP, majority of companies argued that it was concluded with 16-2a-9 after long discussion and hence we should not reopen the discussion.  For potential new FG, it can be clarified same as for FL proposal #1 that any new FG to be introduced at this late stage should be coordinated with RAN2.  Therefore, the final updated FL proposal #2 is below.  **Updated FL proposal #2 of email discussion/approval:**  **[108-e-AI7.2.11-NR-UEFeature-eMIMO-02] Email discussion/approval on UE features for maximum number of layers for single-DCI based multi-TRP**   * **Discuss the necessity of potential new FG(s) for maximum number of layers for single-DCI based multi-TRP based on R1-2202084, with considering potential NBC issue**   + **Only if it is deemed necessary, the introduction of new FGs for the maximum number of layers for multi-TRP can be considered with coordination with RAN2.**   + **~~The definition of FG16-2a-9 should be maintained~~** |

Based on the above, FL suggests discussing whether potential new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme is necessary or not.

### **FL proposal #1**

* **Discuss the necessity of potential new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme**
  + **Only if it is deemed necessary, the introduction of new FGs for the maximum number of layers for multi-TRP can be considered with coordination with RAN2.**

Based on [3] and comments from the proponent, the assumed case is as below.

* A low-complexity UE implementation with two panels, each with only one receiver unit (RxU) in FR2
* The UE can report *maxNumberMIMO-LayersPDSCH* = 2 for single TRP operation and single-DCI based multi-TRP SDM/TDM schemes since at most 2 layers can be processed by the UE, where each panel receives one spatial layer
* However, the UE may not be able to support 2 layers per PDSCH for single-DCI based multi-TRP FDM scheme since it may require processing 4 layers at one time (2 layers per panel assuming different FDMed PDSCHs are received by different panels)

Assuming above assumption is valid, following alternatives may be considered.

* Alt.1: introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme as proposed in [3]
* Alt.2: no new FG is introduced, i.e., *maxNumberMIMO-LayersPDSCH* is applied also for single-DCI based multi-TRP FDM scheme so that the low complexity UE may under-report its capability
* Alt.3: any other solution?

Companies are encouraged to check above FL proposal and to provide feedback if any in below.

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| Company | Comment |
| Apple | We are fine with Alt 1 if it suits the need of MTK. |
| MTK | Thanks for FL’s nice and clear summary, and Apple’s kind reply. We support Alt. 1.  As stated before, the prupose is to **extend sDCI muti-TRP usage** to an **FR2 UE with 2 panels and one RxU per panel**.  Since there is a **total of 2 RxUs**, the **maximum supportable rank is 2**, and **so is the maximum supportable layer ay one time**.  Without this new feature, **two FDMed 2-layer PDSCH in multi-TRP** would require the FR2 UE to **process 4 layers at one time**, which **exceeds the FR2 UE’s physical capability**.  In this case (without Alt. 1), UE may only choose to under-report its capability. |
| QC | We support Alt1 in principle.  Even though the scope here is limited to single-DCI based FDM scheme, we think similar issue (assuming the implementation in FR2 mentioned by MTK) can be addressed for multi-DCI, and companies will likely bring it up in future meetings. Hence, if this new FG can cover both FDM scheme and multi-DCI case (time overlapping) in a unified way, it would be preferred from our point of view. This new FG should be limited to FR2. Anyway, if companies wish to not discuss multi-DCI case in this meeting, that is also fine given the scope. |
| Samsung | Thank you MTK for further clarification. Now we can have much better understanding on the issue. We would like to clarify our view more.  First, we think that the issue is only for FDMSchemeB (receiving two repetitive PDSCHs and up to 2 layers per PDSCH), since FDMSchemeA supports a single PDSCH reception and up to 2 layers per PDSCH. Hence, if the UE wants to operate as FDM but 4 layers at one time cannot be supported due to the low-complexity UE implementation, then the UE can report FDMSchemeA capability, instead of FDMSchemeB.  Second, similar with other companies, we don’t want to introduce new FGs at this very late stage of Rel-16.  Therefore, we support Alt.2. |
| ZTE | We slightly prefer Alt 2.  Alt 1is also acceptable if it is majority. |
| LGE | We prefer Alt1 for a low-complexity UE implementation. |
| OPPO | Alt 1 is preferred, and we think it is necessary even for FDMSchemeA, since FDMSchemeA also needs to detect two layers in each panel if UE reports capability of two layers. |

1. Conclusion

**TBD**

Reference

[1] R1-2201462 Correction on UE feature list for NR positioning and eMIMO NTT DOCOMO, INC.

[2] R1-2201757 Rel-16 UE feature remaining issue Apple

[3] R1-2202084 On UE capability of maximum number of layers for multi-TRP MediaTek Inc.

[4] R1-2202180 Rel-16 UL MIMO coherence capability Qualcomm Incorporated