**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 [108-e-R16-UE-features-MIMO-02]

**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-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***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-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***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-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***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.

|  |  |
| --- | --- |
| 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.

|  |  |
| --- | --- |
| 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. |
| Huawei | Although we can understand MTK’s concern and motivation for introducing this feature capability in order to target at low cost UE, we have following concerns:* The scope of introducing maximum number of layers are unclear. It seems to be expanded into multiple FG of 16-2a and 16-2b Families. Some are per band or per FC or per FSPC. How can we deal with different granuraities for low cost UE?
* Even new UE capability (if introduced), it shall be only applied to FR2, rather than FR1.
* RAN2 may have NBC issues so that some proper coordination with RAN2 and RAN2 design are required. Of cause we can assume that new UE capabity (if introduced) would no be understood by pre-RAN1 108 gNB. But given low cost UE, it is unlikely to support this FDMed MTRP-URLLC feature in Rel-16 in FR2 so that there is no under-reporting issue. Low cost UE will not under-report Rel-15 feature for Rel-16 feature.
* The benefit is unclear. Even new UE capability (if introduced) in order to support low cost UE would not be necessary better for the support of MTRP-URLLC in Rel-16. Comparing sTRP with 2 layers and MTRP with 1 layer per TRP, we have scarified polraization diversity to exchange for spatial diversity. Such kind of trade-off was never investigated before in RAN1.

Therefore, we prefer Alt 2.  |
| Ericsson | We agree with Huawei that a UE supporting FDMed Multi-TRP Rel-16 featuers is not likely a low cost UE, and agree that such a low cost UE will not under report rel-15 capabilities in order to support FDMed Multi-TRP Rel-16 featuers.We had very long discussions in Rel-16 on these Multi-TRP URLLC features. Given it is very late now to introduce more rel-16 features, our preference is Alt 2. |
| Moderator (NTT DOCOMO) | Thank you very much for the feedbacks!Based on the feedbacks, companies’ views can be summarized as below.* Support Alt.1 (introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme): MTK, Apple, QC, LGE, OPPO, (ZTE)
	+ Issue is only for FDMSchemeB or for both FDMSchemeA and FDMSchemeB?
	+ The new FG should be limited to FR2?
	+ The new FG can cover both FDM scheme and multi-DCI case (time overlapping) in a unified way?
* Support Alt.2 (do not introduce a new FG): Samsung, ZTE, HW, Ericsson
	+ It is too late to introduce new FG for Rel-16?
	+ How to deal with “type” of the new FG(s)?
	+ The benefit of Alt.1 is still unclear (low cost UE would not support Multi-TRP URLLC features)?

 Therefore, although there are slightly larger number of companies supporting Alt.1, further discussion/clarification are necessary based on above feedbacks.FL would like to ask Alt.1 proponents to provide answers/clarifications to convince Alt.2 supporting companies.FL would also like to ask Alt.2 supporting companies to check the answers/clarifications provided from Alt.1 supporting companies and to reply whether you can live with Alt.1 (with proper coordination with RAN2). |
| NTT DOCOMO | We agree with Huawei, and our preference is Alt.2. The benefit of Alt.1 is obtained only when both UE and gNB can understand the new FG. We have no strong concern on Alt.1, but we think it is too late to discuss. |
| QC | We support Alt1. We think MTK’s request for the low-cost UE in FR2 is reasonable. Just because UE supports mTRP URLLC scheme, it does not mean that 4 digital ports is of trivial cost for the UE in FR2. |
| MTK | Thanks for Moderator’s very nice/clear summary. Let us try to provide replies to Moderator’s summairzed questions:Alt. 1 related questions:* @Samsung: To our understanding, **this issue is for both FDMSchemeA and FDMScheme B**, as also mentioned by **OPPO**:
	+ FDMSchemeA also needs to detect two layers in each panel if UE reports capability of two layers

From our perspective, **for both FDMSchemeA and FDMScheme B**, **UE needs to receive two TRPs with different REs of one PDSCH** (sDCI case) **allocated to each TRP**, while FDMScheme B uses 2 RV values for the two TRPs and FDMScheme A uses the same RV value for the two TRPs.* Yes, as mentioned in our tdoc, the new FG should be limited to FR2.
* If possible, we support to introduce a new FG covering both FDM scheme and multi-DCI case (time overlapping) in a unified way, where we have a proposal in the bottom.

Alt. 2 related questions:* To our understanding, it is possible to avoid NBC issue from UEs’ perspective, if the new FG is developed in a way that it does not conflict with old FGs (while we admit that it may have to be considered with coordination with RAN2). Besides, according to the state of art we know for now, R16 multi-TRP features in FR2 are not yet deployed (please correct us if we have outdated information), and it may be good to make the feature applicable to more scenarios for a better future of this feature.
* For the concern on “type” of the new FG(s), to our knowledge *maxNumberMIMO-LayersPDSCH* is reported per FSPC, so following the same logic, the new FG’s type should also be per FSPC. It is noted that the parameter *maxNumberMIMO-LayersPDSCH* is used by both single-TRP and multi-TRP schemes, but these schemes still can have different types.
* We would like to clarify that our aim is to enhance reliability in FR2 for low/medium class UE implementaions. We think there is room for reliability enhancement which can be useful for low/medium class UE implementaions. It is a pity that multi-TRP URLLC features can only target high end UEs.

@ Huawei: Even if the UE includes the new FG, dynamic switching between sTRP with 2 layers and MTRP with 1 layer per TRP can be supported. Depending on channel conditions, gNB can dynamically decide which scheme is better for the UE. **When considering the blockage effect, spatial diversity is more important than polarization diversity**.Considering the comments above, **we further propose the following new FG, which applies to both FDM scheme and multi-DCI case** (time overlapping), so that we may have the chance to save the discussion for m-DCI case in next meeting as mentioned by **Qualcomm**. If this new FG is even harder to achieve consensus, we can hold it and settle the original proposed s-DCI feature first.

| Definitions for parameters | Per | M | FDD-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***maxNumberMIMO-LayersPDSCH-For-mTRP-FDM-r16***If this field is included, for DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in *maxNumberMIMO-LayersPDSCH*. If this field is included, for DL reception of multi-DCI based multi-TRP overlapped in time but non-overlapped in frequency, the maximum number of spatial multiplexing layer(s) per PDSCH supported by the UE is half of the value reported in *maxNumberMIMO-LayersPDSCH*. | FSPC | No | N/A | FR2 only |

Note: **This capability applies to both sDCI and mDCI mTRP**. For the current available *maxMIMO-LayersForMulti-DCI-mTRP-r16*, it targets to reinterpret *maxNumberMIMO-LayersPDSCH* for the case when overlapping happens in RE level, while **the new proposed feature targets** to reinterpret *maxNumberMIMO-LayersPDSCH* for the case when **overlapping happens in time domain level**. Through our initial check, we think this proposed feature can co-exist with current featrues without causing conflicts. |
| Huawei | * Dynamic switching between sTRP with 2 layers and MTRP with 1 layer per TRP is not supported in Rel-16. NW need to choose one semi-statically.
* For Multi-DCI case, new FG will conflict with 16-2a-9, which was agreed a few meeting ago including FR2 and is per band.
* If we take one step back, why gNB need to configure FDM with 1 layer per TRP, instead of SDM with 1 layer per TRP? A low cost UE can support SDM with 1 layer per TRP (i.e. 2 layers NCJT across two TRPs or 2 layers per TRP as Rel-15). With FDM, the gNB will waste half of BW to reduce cross TRP interference. But such loss of BW is so significant that it cannot be compensated back with the benefit of interference mitigation, if with proper BM and NCJT CSI. SDM can address the block effect with two “legs” as FDM in FR2. FDM can be better than SDM/TDM for some NW implementation. It might lose its technical advantage if supported layers of FDM are halved than that of SDM/TDM.
* It is not necessary to support all Rel-16 schemes. A low-cost UE can support Rel-16 SDM/TDM without sacrificing maximal spatial layers and a high-end UE can support all schemes. gNB will take own discretion to configure proper scheme in FR2 for given UE at given channel conditions.
 |
| Ericsson | Our preference is still Alt-2. Note that Rel-16 is already frozen and this is not an essential correction. Agree with NTT DOCOMO that it is too late to discuss this. |
| Moderator (NTT DOCOMO) | Thank you very much for further feedbacks!Based on the feedbacks, although the proposal for Alt.1 is further clarified, there are still multiple companies having concern on Alt.1.FL would like to ask companies to discuss on following alternatives in one more round.If we cannot reach a consensus, we should take Alt.2 as conclusion considering this stage of Rel-16. It may be possible to continue discussing the proposal for Rel-17 if necessary.**Alt.1-1: introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A and B**

| Definitions for parameters | Per | M | FDD-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***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 |

**Alt.1-2: introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A/B and multi-DCI based multi-TRP overlapped in time**

| Definitions for parameters | Per | M | FDD-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***maxNumberMIMO-LayersPDSCH-For-mTRP-FDM-r16***If this field is included, for DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in *maxNumberMIMO-LayersPDSCH*. If this field is included, for DL reception of multi-DCI based multi-TRP overlapped in time but non-overlapped in frequency, the maximum number of spatial multiplexing layer(s) per PDSCH supported by the UE is half of the value reported in *maxNumberMIMO-LayersPDSCH*. | FSPC | No | N/A | FR2 only |

**Alt.2: no new FG is introduced, i.e., *maxNumberMIMO-LayersPDSCH* is applied also for single-DCI based multi-TRP FDM scheme A and B** |
| MTK | Thanks for the further input.Considering the interaction between multi-DCI proposal and FG 16-2a-9 may need further discussion, **we suggest to focus on sDCI case for now**.* However, it would be appreciated if Huawei can **elaborate the conflict between Alt. 1-2 and FG 16-2a-9 (which seems not obvious to us)**, so we can have a more aligned understanding

Then, **for sDCI case**, we would like to try to address Huawei’s concern as below* To our understanding, **dynamic switching** between single-TRP and multi-TRP is **supported in Rel-16** through the DCI field “***Transmission Configuration Indication***”, ex. in **38.214 5.1** shown below
	+
* About “**FDM with 1 layer per TRP**” v.s. “**SDM with 1 layer per TRP**”
	+ **FDM schemes** are suitable for **URLLC** applications **with low data rate (thus 2x BW in FDM is still small)**
		- In this case, **single-layer FDM transmission is sufficient** for this kind of applications
	+ **SDM is more complicated than FDM** as UE needs to **tackle cross TRP interference (not fitted for low-cost UE)**
		- For **NCJT CSI calculation**, which is supported only from Rel-17, it **may involve complicated computations** and **not favourable for lost cost UEs**.
* Thefefore, we still see technical merit for **FDM with 1 layer per TRP**

With the reasons above, we would be grateful for companies to consider the following possible proposal for sDCI case:**Alt.1-3: introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A and B**

| Definitions for parameters | Per | M | FDD-TDDDIFF | FR1-FR2DIFF |
| --- | --- | --- | --- | --- |
| ***maxMIMO-LayersForSingle-DCI-mTRP-FDM-r16***If this field is included, for DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in *maxNumberMIMO-LayersPDSCH*. | FSPC | No | N/A | FR2 only |

 |
| Nokia, NSB | We have strong concern on modifying Rel-16 FGs at this stage, and the bar should be very high to allow that. Unfortunately we do not see this request as fulfilling that requirement and hence we support Alt.2 only. Please note also that such modifications on handling of single DCI mTRP imply modifications to gNB handling, i.e. it is likely to imply higher cost on the network side to support such hypothetical “low-cost MTRP-URLLC-capable” UE.  |
| Huawei | We still have concerns to introduce new UE capability at the very late stage for FDM scheme A and B.  As far as I recall, there is no restriction to apply URLLC/low data rate to SDM scheme, ie.16-2b-1. With regarding to SDM is more complicated due to cross-TRP interference, cross-layer interference in Rel-15 with 2 layer transmission has similar issues. I doubt that a low-cost UE will optimize cross-TRP or cross-layer interference differently. Then all burden is up to gNB discretion to mitigate cross-TRP interference as much as possible. Of cause we can keep discussing what is the baseline for low-cost UE, i.e. it will not support 16-2b-1 but only rel-15. Then we are running circle that why we need to discuss at late stage for particular low-cost UE without clear understanding pros and cons among schemes, whilst it can support TDM at least. Note I used SDM as comparison because it is more straightforward.  With halving maximal layer as 1, I doubt that it will be even worse than TDM schemes A and B. |
| Moderator (NTT DOCOMO) | Thank you very much for further discussion!Since there is still concern to any of Alt.1-x and the bar for Rel-16 should be very high at this stage, FL suggests following conclusion for Rel-16 and would like to ask companies to stop the discussion for Rel-16 at this first check point.**Conclusion:*** **no new FG is introduced, i.e., *maxNumberMIMO-LayersPDSCH* is applied also for single-DCI based multi-TRP FDM scheme A and B**

If the proponents want to discuss the proposal for Rel-17, we can continue the discussion towards final check point. Note that RAN1 will send a “stable version” of Rel-17 RAN1 UE features list at the end of RAN1#108-e meeting.**Alt.1-1: introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A and B for Rel-17**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| X. NR Others | [X-Y] | [maximum number of layers for single-DCI based multi-TRP FDM scheme A and B] | [For DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH} | [supportFDM-SchemeA-r16 or supportFDM-SchemeB-r16] | Yes | N/A |  | Per FSPC | N/A | FR2 only | N/A |  | Optional with capability signalling |

**Alt.1-2: introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A/B and multi-DCI based multi-TRP overlapped in time for Rel-17**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| X. NR Others | [X-Y] | [maximum number of layers for single-DCI based multi-TRP FDM scheme A and B and multi-DCI based multi-TRP overlapped in time] | 1.[For DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH}2.[For DL reception of multi-DCI based multi-TRP overlapped in time but non-overlapped in frequency, the maximum number of spatial multiplexing layer(s) per PDSCH supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH] | [supportFDM-SchemeA-r16 or supportFDM-SchemeB-r16 or multiDCI-MultiTRP-r16] | Yes | N/A |  | Per FSPC | N/A | FR2 only | N/A |  | Optional with capability signalling |

**Alt.2: no new FG is introduced for Rel-17** |
| MTK | Thanks moderator for the nice organization. Considering both **HW**/**Nokia** have concern on modifying Rel-16 FGs at this stage, we would like to continue to discuss the possibility of introducing the same FGs for **Rel-17**.Considering **RAN1 will send a “stable version” of Rel-17 RAN1 UE features list** at the **end of RAN1#108-e meeting**, our first preference is Alt. 1-2, followed by Alt. 1-1.Regarding Huawei’s comment, it seems to say SDM/TDM is more useful than FDM.However, we want to further provide our understanding that* + It is **not** straightforward for the **SDM** scheme to tackle the blockage effect, since it is **not** guaranteed that each spatial layer is self-decodable
		- While **FDM scheme B** can be more robust in this scenario, as gNB can make the two RVs for the two TRPs self-decodable
	+ As for the **TDM** scheme, its **latency is worse** than that of the FDM schemes, which is not desirable for URLLC application

Therefore, we still deem **FDM with 1 layer per TRP** a useful scenario for URLLC low data rate application.To us, it would be a pity that a low complexity FR2 UE can only under-report its *maxNumberMIMO-LayersPDSCH* to be 1 if the UE wants to support both SDM and FDM cases. |
| Moderator (NTT DOCOMO) | Thank you very much for further inputs!FL would like to ask companies to check above MTK’s proposal for Rel-17 and provide feedback if any by 23:59 UTC 28th February. |
| MTK | Thanks moderator for the nice organization. As we tried to state before:* To us, it would be a pity that a low complexity FR2 UE can only under-report its *maxNumberMIMO-LayersPDSCH* to be 1 if the UE wants to support both SDM and FDM cases
* To us, it is **kind of like a spec hole** RAN1 did not have the chance to consider in R15, and **we should fix a spec hole at least for releases which has not be deployed**.

Hence, for Rel-17, our preference is still Alt. 1-2, followed by Alt. 1-1. |
| Moderator (NTT DOCOMO) | Thanks for further explanation!As there seems no concern on either Alt.1-2 or Alt.1-1, the following is the updated FL proposal for final checking towards final check point.**Updated FL proposal #1****Introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A/B and multi-DCI based multi-TRP overlapped in time for Rel-17**

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| X. NR Others | [X-Y] | [maximum number of layers for single-DCI based multi-TRP FDM scheme A and B and multi-DCI based multi-TRP overlapped in time] | 1.[For DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH}2.[For DL reception of multi-DCI based multi-TRP overlapped in time but non-overlapped in frequency, the maximum number of spatial multiplexing layer(s) per PDSCH supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH] | [supportFDM-SchemeA-r16 or supportFDM-SchemeB-r16 or multiDCI-MultiTRP-r16] | Yes | N/A |  | Per FSPC | N/A | FR2 only | N/A |  | Optional with capability signalling |

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### **Updated FL proposal #1**

**Introduce a new FG for maximum number of layers for single-DCI based multi-TRP FDM scheme A/B and multi-DCI based multi-TRP overlapped in time for Rel-17**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| X. NR Others | [X-Y] | Maximum number of layers for single-DCI based multi-TRP FDM scheme A and B and multi-DCI based multi-TRP overlapped in time | 1.For DL reception of single-DCI based multi-TRP FDM scheme A and scheme B, the maximum number of spatial multiplexing layer(s) supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH2.For DL reception of multi-DCI based multi-TRP overlapped in time but non-overlapped in frequency, the maximum number of spatial multiplexing layer(s) per PDSCH supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH | supportFDM-SchemeA-r16 or supportFDM-SchemeB-r16 or multiDCI-MultiTRP-r16 | Yes | N/A |  | Per FSPC | N/A | FR2 only | N/A |  | Optional with capability signalling |

Companies are encouraged to check above FL proposal and to provide feedback if there is a concern in below.

|  |  |
| --- | --- |
| Company | Comment |
| MTK | Thanks moderator for the nice organization. We support the Updated FL proposal #1. |
| Ericsson | Note that the above FG does not directly provide the maximum number of layers. It only provides if the maximum number of PDSCH layers is half that of the number reported in *maxNumberMIMO-LayersPDSCH* FG. So, we are not sure if this needs to be ‘Per FSPC’. May be ‘Per UE’ may be sufficient since this is considered a low-cost implementation. |
| QC | We support the proposal. Regarding Type, our suggestion is at least “per band”. In FR2, there are different bands (also we have both FR2-1 and FR2-2 in Rel-17), and this low-cost implementation may be true only for some of the bands in FR2.Furthermore, for component 2, do we need “but non-overlapped in frequency”? This description should be applicable as long as the two PDSCHs are overlapped in time. For the case of overlapping in both time and freq, one may argue to rely on the description of FG16-2a9 as “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”, but this decription is not exactly the same the description in the new FG. Hence, we think component 2 can be modified as:2.For DL reception of multi-DCI based multi-TRP overlapped in time ~~but non-overlapped in frequency~~, the maximum number of spatial multiplexing layer(s) per PDSCH supported by the UE is half of the value reported in maxNumberMIMO-LayersPDSCH |

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