**3GPP TSG RAN WG1 #109-e R1-220nnnn**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.1.1.1

**Source:** Moderator (MediaTek)

**Title:** Moderator summary on extension of unified TCI framework for MTRP (Round 3)

**Document for:** Discussion and Decision

# Introduction

In RAN#94e, the Rel-18 WID of MIMO evolution for downlink and uplink is approved [1]. In the approved WID, extension of unified TCI framework is a part of the RAN1 objectives, and the detailed scope of this agenda item (Item 1A) includes the following highlighted objectives:

|  |
| --- |
| **RAN1:**1. …
2. Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states focusing on multi-TRP use case, using Rel-17 unified TCI framework.
3. …
4. …
5. …
6. Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, focusing on FR2 and multi-TRP, assuming up to 2 TRPs and up to 2 panels, targeting CPE/FWA/vehicle/industrial devices (if applicable)
	* UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission
		+ The total number of layers is up to four across all panels and total number of codewords is up to two across all panels, considering single DCI and multi-DCI based multi-TRP operation.
	* UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation
		+ For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, or PUCCH+PUCCH is transmitted across two panels in a same CC.
7. Study, and if justified, specify the following
	* Two TAs for UL multi-DCI for multi-TRP operation
	* Power control for UL single DCI for multi-TRP operation where unified TCI framework extension in objective 2 is assumed.

For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 6 scenarios. |

Based on the contributions from companies [2]-[31], the followings are provided in this document:

* Summary of companies’ views on each of open issues raised by interested companies
* Observation and recommended proposal based on the summary of companies’ views

**Round 3 is intended to prepare the group for the GTW discussion on Friday May 20th 03:00 UTC.**

**Share your inputs before Thursday May 19th 23:59 UTC, would be appreciated.**

# Issue 1 – Extension of Unified TCI Framework

Open issues on unified TCI framework extension and company views are summarized below.

Table 1 Summary for Issue 1

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 1.3 | Max number of indicated joint TCI states (M1) for joint DL/UL TCI update Max number of indicated DL TCI states (M2) for separate DL/UL TCI updateMax number of indicated UL TCI states (N2) for separate DL/UL TCI update  | Atl1: M1 = 2, M2 = 2, N2 = 2* Support: Samsung, Docomo, OPPO, Apple, Qualcomm, Intel, Nokia, ZTE, MTK, InterDigital, CATT, Spreadtrum, Sony, LGE, ITRI, TransHold, Fraunhofer, Fujitsu, Huawei, FGI, AT&T

Atl2: M1 > 2, M2 > 2, N2 > 2* Support: Ericsson (up to 4 indicated joint, DL, and/or UL TCI states)
 | From moderator’s observation, {M1, M2, N2} = {2, 2, 2} is sufficient to support MTRP operation, which is the use case that should be focused on according to the WID. Another potential use case (separate control and data beams) has been proposed in one contribution, however, {M1, M2, N2} = {2, 2, 2} doesn't prevent that use case. {M1, M2, N2} = {2, 2, 2} is incapable only when both use cases work at the same time (i.e., MTRP + separate control and data beams per TRP-link), but whether such direction is still within the scope defined in the WID is doubtful. Since these max numbers could impact the later designs a lot, moderator suggests concluding them as early as possible. Given the majority view, Proposal 1.B is recommended.How to configure/determine the exact number of indicated joint/DL/UL TCI states can be further discussed |
| 1.4 | The multiple indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation (analogous to Rel-17 procedure) | Support: Ericsson, Samsung, Docomo, OPPO, ZTE, vivo, Apple, Qualcomm, MTK, InterDigital, CATT, Futurewei, Spreadtrum, Sony, Xiaomi, LGE, Lenovo, CMCC, TransHold, Fraunhofer, Fujitsu, Nokia (s-DCI mode), FGI, AT&T, Intel Concern:  | Given the majority view on this issue, Proposal 1.B is recommended accordingly.Details of TCI state update and activation are discussed in the following sub-issues |
| 1.5 | Individual TCI update mode (joint or separate DL/UL TCI update) for each TRP, i.e., one TRP with joint DL/UL TCI update and another with separate DL/UL TCI update | Support: Nokia (m-DCI mode), Qualcomm, , CATT, Sony, Xiaomi, ITRI, FGI, Intel, InterDigitalConcern: Apple (no use case), ZTE, OPPO |  |
| 1.6 | TCI state update for S-DCI based MTRP | Use existing (single) TCI field in DCI to update all or subset of indicated TCI states: * Support: Ericsson, Samsung (DCI w/ DLA), Docomo, OPPO (DCI w/ DLA), Apple, Qualcomm, Intel, ZTE, vivo, InterDigital, CATT, TransHold, Futurewei, Spreadtrum, Sony, CEWiT, MTK, Nokia, Fujitsu, LG, AT&T
* Concern:

More than one TCI fields in DCI w/o DLA and each TCI field can update indicated TCIs respective to one of the TPRs: * Support: Samsung, FGI, LG
* Concern: Apple (DCI overhead), Intel
 | Given the majority view on this issue, Proposal 1.C is recommended accordingly.How to activate TCI states for indicated TCIs states can be discussed after the update scheme is sufficiently matureIf single TCI field in DCI is agreed, whether to increase the max number of codepoints/bits can be further discussedIf single TCI field in DCI is agreed, whether the switching between S-TRP and M-TRP is determined from the number of TCI states associated with the indicated codepoint can be further discussed |
| 1.7 | TCI state update for M-DCI based MTRP | Alt1: Use existing (single) TCI field in DCI associated with one of *CORESETPoolIndex* values to update the indicated TCI states respective to the *CORESETPoolIndex* value (i.e., no cross-TRP beam indication)* Support: Samsung, Nokia, Docomo, Qualcomm, Intel, ZTE, vivo, MTK, Xiaomi. LGE, Fraunhofer, FGI, OPPO, Fujitsu, TransHold
* Concern: Apple, Ericsson

Alt2: Use existing (single) TCI field DCI associated with one of *CORESETPoolIndex* values to update the indicated TCI states respective to both *CORESETPoolIndex* values (i.e., cross-TRP beam indication can be supported)* Support: Apple, Xiaomi
* Concern: Docomo (not good in non-ideal backhaul), Ericsson, InterDigital, Intel
 | Two alternativities for potential down-selection are provided by Proposal 1.DHow to activate TCI states for the indicated TCI states can be discussed after the update scheme is sufficiently mature |
| 1.8 | DCI format for updating the indicated TCI stares | Alt1: Reuse the same DCI formats as in Rel-17 (i.e., DCI formats 1\_1/1\_2 with or without DLA), and no additional DCI format is introduced* Support: ZTE, vivo, CATT, Apple, OPPO Docomo, Nokia, Ericsson, Fujitsu, LG
* Concern:

Atl2: In addition to the DCI formats used in Rel-17, introduce DCI formats 0\_1/0\_2 for updating at least the indicated UL TCI states: * Support: Xiaomi, Intel, FGI, LG
* Concern: Docomo, Ericsson, Spreadtrum
 |  |
| 1.9 | RRC-configured TCI state lists  | Alt1: Reuse Rel-17 design (i.e., one TCI state list for joint/DL TCI states and one TCI state list for UL TCI states)* Support: Ericsson, MTK, Docomo (if the max # of configured TCI states is not increased for MTRP), Nokia, Fraunhofer, Xiaomi, OPPO, Fujitsu, Intel
* Concern: Apple (not good for TCI pool sharing for CCs with different sTRP/mTRP operation)

Atl2: TRP-specific TCI state list(s)* Support: ZTE, Apple, vivo (if individual TCI update mode is allowed for each TRP), Docomo (if the max # of configured TCI states is increased for MTRP), FGI
* Concern: Ericsson

Increase the max number of configured joint/DL/UL TCI states for MTRP operation* Support:
* Concern:
 | For this sub-issue, Proposal 1.H is recommended accordingly |
| 1.10 | Introduction of TRP-ID associated with or included in each TCI state | Support: CMCC, Spreadtrum, ZTE (still case-by-case)Concern: Ericsson, MTK, Apple, Docomo, Nokia, CATT, OPPO, LG, Intel |  |
| 1.11 | Applying/mapping the indicated TCI states to channel/signals for S-DCI based MTRP | To inform to the UE at least which one or two indicated TCI states (or which one or two TRPs) is mapped to the corresponding channel(s)/signal(s), an indicator is introduced:* Per CORESET or per search space set: Ericsson, Xiaomi, ZTE, vivo, CATT, Nokia, MTK, Qualcomm, Samsung, Apple (CORESET), Docomo, FGI, OPPO (per CORESET), Fujitsu, LG, Intel (CORESET)
* Per DCI with DL assignment for the scheduled/activated PDSCH: ZTE, vivo, MTK, Qualcomm, CATT, FGI, Fujitsu, LG
* Per TDRA codepoint for scheduled/activated PDSCH/PUSCH: Apple
* Per DCI with UL grant for the scheduled/activated PUSCH: vivo (reinterpret the SRS resource set indicator), Qualcomm, MTK, Xiaomi (reinterpret the SRS resource set indicator), Fujitsu, LG
* Per dedicated PUCCH resource: Ericsson, ZTE, CATT (MAC-CE update), Nokia, MTK, Apple, Docomo, Xiaomi, LG
* Per [P/SP] CSI-RS resource or resource set: Ericsson, ZTE, vivo, MTK, Apple (set), Docomo, Fraunhofer, Xiaomi, LG
* Per [P/SP] SRS resource set: Ericsson, OPPO, Nokia, ZTE, vivo, MTK, Apple (set) , Docomo, Fraunhofer, Xiaomi, LG
* Per DCI with CSI request for the triggered AP CSI-RS: vivo
* Per DCI with SRS request for the triggered AP SRS: vivo
* Per Type-1 CG configuration: Nokia, Fraunhofer, Xiaomi
 | For PDCCH, Proposal 1.E is recommended accordinglyFor PDSCH, Proposal 1.F is recommended accordinglyIf two indicated TCI states are mapped to a channel, how to map the indicated TCI states to each of repetition occasions (or CDM groups) of the channel can be further discussed. |
| 1.12 | Applying/mapping the indicated TCI states to channels/signals for M-DCI based MTRP | Unified schemes for both S-DCI and M-DCI to apply/map the indicated TCI states to channel(s)/signal(s)* Support: Ericsson, Docomo
* Concern: Nokia, Huawei

The indicated TCI state(s) respective to one of *CORESETPoolIndex* values applies to:* PDCCH on the CORESET(s) configured/associated with the *CORESETPoolIndex* value (as in Rel-17): ZTE, Qualcomm, Nokia, vivo, Samsung, MTK, LGE, Xiaomi, Apple, Docomo, Fraunhofer, OPPO, Fujitsu, TransHold, Intel
* PDSCH/PUSCH scheduled/activated by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, MTK, vivo, Qualcomm, Samsung, Apple, Fraunhofer, Fujitsu, TransHold, Intel
* PUCCH with HARQ-ACK corresponding to the DCI associated with the *CORESETPoolIndex* value: Nokia, vivo, Qualcomm, Apple, Fraunhofer, TransHold
* AP CSI-RS triggered by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, Nokia, ZTE, vivo, Qualcomm, Apple, OPPO
* AP SRS triggered by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, Nokia, ZTE, vivo, Qualcomm, Apple

For channels/signals that don't have explicit/implicit association with a *CORESETPoolIndex* value:* Introduce an indicator (reuse *CORESETPoolIndex* or a new one) to indicate which indicated TCI state(s) (or which TRP(s)) is associated with the corresponding channel/signal: Nokia, Apple, vivo, Fraunhofer, ZTE, MTK, Xiaomi, Docomo, FGI, LG
 | For PDCCH, Proposal 1.G is recommended accordinglyWhether an explicit association between indicated TCI state(s) and an *CORESETPoolIndex* value is needed may depend on the result of sub-issue 1.7, thus can be further studied |

## Proposal 1.F: On unified TCI framework extension for S-DCI based MTRP, consider at least the following alternatives to indicate the mapping/association between one or two indicated joint/DL TCI states and PDSCH reception(s):

* Atl1: Introduce a field (other than the existing TCI field) in a scheduling DCI to indicate the mapping/association
* Alt2: Use the TDRA in a scheduling DCI to indicate the mapping/association
* Alt3: Use the existing TCI field to indicate the mapping/association
* Note: Other alternatives are not precluded

Study the mapping between the indicated joint/DL TCI states and PDSCH Tx occasions, non-overlapping FDRAs, and CDM groups when two indicated joint/DL TCI states are mapped/associated to the corresponding PDSCH reception, and it is not precluded to reuse the Rel-16 mapping rule

## Proposal 1.G: On unified TCI framework extension for M-DCI based MTRP, consider at least the following alternatives to map/associate a joint/DL TCI state to PDCCH reception(s) on a CORESET that shares the indicated joint/DL TCI state(s):

* Alt1: For a CORESET configured/associated with one of *CORESETPoolIndex* values, the UE should apply the indicated joint/DL TCI state corresponding to the *CORESETPoolIndex* value to PDCCH reception(s) on the CORESET
* Alt2: Use RRC configuration other than *CORESETPoolIndex* to inform the mapping/association between a configured or indicated joint/DL TCI state and a CORESET or a CORESET group
* Alt3: Use RRC configuration other than *CORESETPoolIndex* to inform the mapping/association between a configured or indicated joint/DL TCI state and a search space set

## Proposal 1.H: On unified TCI framework extension, study the followings for RRC-configured TCI state list(s)

* Whether to introduce TCI state list(s) per each TRP
* Whether to increase the max number of configured TCI states in the joint/DL TCI state list and the UL TCI state list

Table 2 Additional inputs for Issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Please check Proposal 1.F and 1.G**
2. **Please check new Proposal 1.H**
 |
| QC | For Proposal 1.F, is the intention to dynamically down select one from the two indicated TCIs for a particular PDSCH, i.e. NW indicates two sticky TCIs but wants either one or both of them to be used for a particular PDSCH, e.g. the PDSCH scheduled by the same TCI updating TCI? From the summary table above, it seems the case. If so, may I suggest the following wording? This is to emphasize: * Such dynamic selection is only needed when 2 sticky TCIs are indicated;
* The selection of 1 or 2 TCIs for a particular PDSCH is from the 2 indicated sticky TCIs;
* The TCI down selection is signaled in the scheduling or activation DCI

Proposal 1.F: On unified TCI framework extension for S-DCI based MTRP, if two joint/DL TCI states are indicated, consider at least the following alternatives to dynamically select ~~indicate the~~ ~~mapping/association between~~ one or two TCI states ~~indicated joint/DL TCI states~~ ~~and~~ for PDSCH reception(s) from the two indicated joint/DL TCI states:* Atl1: Introduce a field (other than the existing TCI field) in a scheduling/activation DCI to indicate the ~~mapping/association~~ one or two selected TCI states
* Alt2: Use the TDRA in a scheduling/activation DCI to indicate the ~~mapping/association~~ one or two selected TCI states
* Alt3: Use the existing TCI field to indicate the ~~mapping/association~~ one or two selected TCI states
* Note: Other alternatives are not precluded

Study, the mapping between the two selected ~~indicated~~ joint/DL TCI states and PDSCH Tx occasions, non-overlapping FDRAs, and CDM groups when two indicated joint/DL TCI states are ~~mapped/associated to~~ selected for the corresponding PDSCH reception, and it is not precluded to reuse the Rel-16 mapping ruleFor 1.G, support Alt1. Seems no need to introduce new RRC if we have CORESETPoolIndexFor 1.H, fine to study |
| Lenovo | Proposal 1.F: Support. It is good to discuss multiple proposals at this stage.Proposal 1.G: For M-DCI based MTRP, when more than one 1 joint/DL TCI state is indicated in a DCI, will there be any CORESETPoolIndex configured for the CORESETs? This needs to be clarified for Alt 2 and 3.Proposal 1.H: The maximal number of configured TCI states may be increased for MTRP, but how to configure the TCI state lists can be left for gNB implementation.  |
|  |  |

# Issue 2 – UL Power Control for UL MTRP

Void

# Issue 3 – Beam reporting and beam failure recovery

Open issues on beam reporting and BFR enhancements and company views are summarized below.

Table 5 Summary for Issue 3

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 3.1 | Enhance/extend group-based reporting to support simultaneous UL transmission | Support: Qualcomm, Samsung, vivo, MTK, Nokia, Xiaomi, ZTE, HuaweiConcern: Apple, Ericsson, OPPO | This issue can be discussed once any Rel-18 MTRP scheme for simultaneous UL transmission is agreed |
| 3.2 | Enhance/extend Rel-17 UE capability index reporting to support simultaneous UL transmission | Support: Samsung, Nokia, CATT, LGE, MTK, AT&T, QC, Apple, Docomo, Lenovo, Xiaomi, OPPO, ZTE, HuaweiConcern: Ericsson | This issue can be discussed once any Rel-18 MTRP scheme for simultaneous UL transmission is agreed |
| 3.3 | Enhancement to TRP-specific BFR under unified TCI framework | Support: InterDigital, vivo, Samsung, Apple, Qualcomm, Docomo, Nokia, NEC, Lenovo, Xiaomi, ZTE, Spreadtrum, TransHold, HuaweiConcern: Ericsson |  |

## Proposal 3.A: If STxMP is supported, study the following:

* Enhancement to group-based reporting (including Rel-17 enhanced group-based reporting) to support STxMP
* Enhancement to Rel-17 UE capability index reporting to support STxMP

Support: Transsion, Xiaomi, ZTE, OPPO, Samsung, Nokia, CATT, IDG, Lenovo, QC, CMCC, vivo, LG, Docomo, MTK

Concern: Huawei, Ericsson

## Proposal 3.B: Study potential enhancement to TRP-specific BFR under unified TCI framework

Support: Transsion, Xiaomi, ZTE, OPPO, Samsung, Nokia, CATT, IDG, Lenovo, QC, CMCC, vivo, LG, Docomo, MTK

Concern: Ericsson

Table 6 Additional inputs for Issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your views on Proposal 3.A and 3.B, if any** |
| QC | For 3.A, supportFor 3.B, support |
| Lenovo | Proposal 3A: SupportProposal 3B: Support |
|  |  |
|  |  |

# Other potential issues

Table 7 Inputs for other potential issues

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your view if there is any open issue that need to be addressed with high priority but is not captured above** |
|  |  |

# Appendix A: Agreements before/in RAN1#109-e

**Agreement**

On unified TCI framework extension, consider all the intra and inter-cell MTRP schemes specified in Rel-16 and Rel-17

* Consider, if STxMP is supported, Rel-18 MTRP scheme(s) with STxMP

**Agreement**

On unified TCI framework extension, if an indicated joint or UL TCI state applies to a PUSCH /PUCCH transmission occasion at least for S-DCI based PUSCH/PUCCH repetition with TDM and the indicated joint or UL TCI state is associated with an UL PC parameter setting for PUSCH /PUCCH (including P0, alpha for PUSCH , and closed loop index) and a PL-RS, the UE should apply the UL PC parameter setting and the PL-RS for the PUSCH /PUCCH transmission occasion.

* FFS: How to extend to other Rel-18 MTRP scheme(s) with STxMP, if supported
* FFS: UL PC enhancement for CB and non-CB SRS in above case

FFS: The applied UL PC parameter setting if one or both indicated joint or UL TCI state(s) is not associated with an UL PC parameter setting (including P0, alpha for PUSCH, and closed loop index) for PUCCH/PUSCH

# References

1. RP-213598 New WID: MIMO Evolution for Downlink and Uplink Samsung
2. R1-2203887 Views on unified TCI extension focusing on m-TRP xiaomi
3. R1-2203793 Unified TCI framework extension for multi-TRP Sony
4. R1-2203723 Consideration on Unified TCI framework for multi-TRP OPPO
5. R1-2203953 Unified TCI framework extension for multi-TRP Sony
6. R1-2204033 Unified TCI framework extension for multi-TRP Ericsson
7. R1-2204229 Views on unified TCI framework extension for multi-TRP Apple
8. R1-2204367 Discussion on unified TCI framework extension for multi-TRP NTT DOCOMO, INC
9. R1-2204141 Unified TCI framework extension for multi-TRP/panel LG Electronics
10. R1-2204162 Discussion of unified TCI framework for multi-TRP Lenovo
11. R1-2203681 Discussion on unified TCI framework extension for multi-TRP NEC
12. R1-2203541 Views on unified TCI framework extension for multi-TRP vivo
13. R1-2203378 On Extension of Unified TCI Framework InterDigital, Inc.
14. R1-2203441 On unified TCI framework extension for multi-TRP operation CATT
15. R1-2203149 Discussion on unified TCI framework extension for multi-TRP Huawei, HiSilicon
16. R1-2203061 Unified TCI framework extension for multi-TRP FUTUREWEI
17. R1-2203320 Discussion on Unified TCI framework extension for multi-TRP Spreadtrum Communications
18. R1-2203174 Discussion on Unified TCI framework extension for multi-TRP CEWiT
19. R1-2203263 Enhancements on unified TCI framework extension for multi-TRP ZTE
20. R1-2205071 Discussion on unified TCI framework extension for multi-TRP Asia Pacific Telecom co. Ltd
21. R1-2205074 Considerations on unified TCI for mTRP Fujitsu Limited
22. R1-2204785 On Unified TCI framework for mTRP Intel Corporation
23. R1-2204678 Multi-TRP enhancements for the unified TCI framework Fraunhofer IIS, Fraunhofer HHI
24. R1-2204857 Unified TCI framework extension for multi-TRP AT&T
25. R1-2205014 Extension of unified TCI framework for mTRP Qualcomm Incorporated
26. R1-2204584 Enhancement on unified TCI framework for multi-TRP Transsion Holdings
27. R1-2204538 Unified TCI framework extension for multi-TRP Nokia, Nokia Shanghai Bell
28. R1-2204684 Unified TCI framework extension for multi-TRP MediaTek Inc.
29. R1-2204287 Discussion on unified TCI framework extension for multi-TRP CMCC
30. R1-2204506 Unified TCI framework extension for multi-TRP Sharp
31. R1-2204440 Discussion on unified TCI framework extension for multi-TRP ITRI