**3GPP TSG RAN WG1 #109-e R1-22nnnnn**

**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 0

**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 1 is intended to prepare the group for the GTW session on Thursday May 12th 03:00 UTC. Please share your inputs by Wednesday May 11th 23:59 UTC.**

# 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** |
| 1.1 | All the MTRP schemes specified in Rel-16/17 are considered/applicable by extension of unified TCI framework, including the followings:* Rel-16 M-DCI based MTRP
* Rel-16 S-DCI based SDM scheme for PDSCH
* Rel-16 S-DCI based PDSCH repetition schemes with FDM and TDM
* Rel-17 S-DCI based PUSCH repetition scheme with TDM
* Rel-17 S-DCI based PDCCH repetition scheme
* Rel-17 S-DCI based PUCCH repetition scheme with TDM
* Rel-17 PDCCH-SFN and PDSCH-SFN
 | Support: Ericsson, Samsung, Docomo, vivo, Qualcomm, ZTE, MTK, CATT, NEC, Lenovo, Intel, HuaweiConcern: Apple (Clarification for R16 mDCI, does it include PDSCH only or not? ) | Given the majority view on this issue, Proposal 1.A is recommended accordingly.Rel-18 MTRP scheme(s) for simultaneous UL transmission can be further discussed once it is agreed |
| 1.2 | Rel-17 inter-cell MTRP is considered/applicable by extension of unified TCI framework | Support: Docomo, MTK, CATT, NEC, Lenovo, Ericsson, Huawei, AppleConcern: | Rel-17 inter-cell MTRP is also captured in Proposal 1.A since it is also one of Rel-17 MTRP schemes, even it was not mentioned by many contributions. |
| 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

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, FujitsuConcern:  | 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, Qualcomm, Ericsson, CATT, Sony, Xiaomi, ITRIConcern: Apple (no use case) |  |
| **Note: On definition of “unified TCI” in this table, for joint DL/UL TCI update, one “unified TCI” comprises one indicated joint TCI state. For separate DL/UL TCI update, one “unified TCI” comprises one indicated DL TCI state and/or one indicated UL TCI state.** |
| 1.6 | TCI state update for S-DCI based MTRP | Use existing (single) TCI field in DCI to update all **unified TCIs**: * Support: Ericsson, Samsung (DCI w/ DLA), Docomo, OPPO (DCI w/ DLA), Apple, Qualcomm, Intel, ZTE, vivo, InterDigital, CATT, TransHold, Futurewei, Spreadtrum, Sony, CEWiT, MTK
* Concern:

More than one TCI fields in DCI w/o DLA and each TCI field can update one respective **unified TCI**: * Support: Samsung, OPPO
* Concern: Apple (DCI overhead)
 | Given the majority view on this issue, Proposal 1.C is recommended accordingly.How to activate TCI states for the multiple unified TCIs 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 **unified TCI** respective to the *CORESETPoolIndex* value* Support: Samsung, Nokia, Docomo, Qualcomm, Intel, ZTE, vivo, MTK, Xiaomi. LGE, Fraunhofer
* Concern: Apple (does it support cross-TRP beam indication?)

Alt2: Use existing (single) TCI field DCI associated with one of *CORESETPoolIndex* values to update the **unified TCIs** respective to both *CORESETPoolIndex* values* Support: Apple, Xiaomi
* Concern:
 | How to activate TCI states for the multiple unified TCIs can be discussed after the update scheme is sufficiently mature |
| 1.8 | DCI format for updating the **unified TCIs** | 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
* 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
* Concern:
 |  |
| 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 can be increased for MTRP)
* 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)
* Concern:
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| 1.10 | Introduction of TRP-ID associated with or included in each TCI state | Support: CMCC, SpreadtrumConcern: Ericsson, MTK, Apple |  |
| 1.11 | Applying/mapping the **unified TCIs** to target channel/signals for S-DCI based MTRP | To inform to the UE at least which **unified TCI(s)** (or which TRP(s)) is mapped to the corresponding channel/signal, an indicator is introduced:* Per CORESET or per search space set: Ericsson, Xiaomi, ZTE, vivo, CATT, Nokia, MTK, Qualcomm, Samsung, Apple (CORESET)
* Per DCI with DL assignment for the scheduled/activated PDSCH: ZTE, vivo, MTK, Qualcomm, CATT
* 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
* Per dedicated PUCCH resource: Ericsson, ZTE, CATT (MAC-CE update), Nokia, MTK, Apple
* Per [P/SP] CSI-RS resource or resource set: Ericsson, ZTE, vivo, MTK, Apple (set)
* Per [P/SP] SRS resource set: Ericsson, OPPO, Nokia, ZTE, vivo, MTK, Apple (set)
* 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
 | If more than one unified TCIs are mapped to a target channel, how to map the unified TCIs to each of repetition occasions (or CDM groups) of the target channel can be further discussed. |
| 1.12 | Applying/mapping the **unified TCIs** to target channels/signals for M-DCI based MTRP | Unified schemes for both S-DCI and M-DCI to apply/map the **unified TCIs** to target channels/signals* Support: Ericsson
* Concern: Nokia, Huawei

The **unified TCI** 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
* PDSCH/PUSCH scheduled/activated by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, MTK, vivo, Qualcomm, Samsung, Apple
* PUCCH with HARQ-ACK corresponding to the DCI associated with the *CORESETPoolIndex* value: Nokia, vivo, Qualcomm, Apple
* AP CSI-RS triggered by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, Nokia, ZTE, vivo, Qualcomm, Apple
* 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 at least which **unified TCI** (or which TRP) is associated with the corresponding channel/signal: Nokia, Apple, vivo, Fraunhofer, ZTE, MTK, Xiaomi
 | Whether an explicit association between a unified TCI and an *CORESETPoolIndex* value is needed may depend on the result of sub-issue 1.7, thus can be discussed later. |

**Proposal 1.A:** On unified TCI framework extension, consider at least all the MTPR schemes specified in Rel-16 and Rel-17 as follows:

* Rel-16 M-DCI based MTRP
* Rel-16 S-DCI based PDSCH SDM scheme
* Rel-16 S-DCI based PDSCH repetition schemes with FDM and TDM
* Rel-17 S-DCI based PUSCH repetition schemes with TDM
* Rel-17 S-DCI based PDCCH repetition scheme
* Rel-17 S-DCI based PUCCH repetition schemes with TDM
* Rel-17 PDCCH-SFN and PDSCH-SFN
* Rel-17 inter-cell MTRP

**Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCIs in a CC at least for MTRP operation

* A unified TCI for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* A unified TCI for sperate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* FFS: Details of update and activation for the unified TCIs for S-DCI based MTRP
* FFS: Details of update and activation for the unified TCIs for M-DCI based MTRP
* FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI (i.e., one unified TCI comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state)

**Proposal 1.C**: On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update both unified TCIs at least for single-DCI based MTRP

* FFS: How to map joint/DL/UL TCI states to a TCI field codepoint for both unified TCIs
* FFS: Whether to increase the max number of TCI field codepoints/bits, i.e., more than 8 codepoints/3 bits

Table 2 Additional inputs for Issue 1

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Please check and update your views in Table 1** **2) Share your inputs on the above moderator proposals** |
| QC | For Proposal 1.A, supportFor Proposal 1.B, suggest to add “set”, since each set can include a pair of DL and UL TCIs. Otherwise, it will cause ambiguity in future. Also, each set conceptually corresponds to one TRP. **Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCI~~s~~ sets in a CC at least for MTRP operation* A unified TCI set for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* A unified TCI set for sperate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* FFS: Details of update and activation for the unified TCIs for S-DCI based MTRP
* FFS: Details of update and activation for the unified TCIs for M-DCI based MTRP
* FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI set (i.e., one unified TCI set comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state)

For Proposal 1.C, same comment as for Proposal 1.B**Proposal 1.C**: On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update both unified TCI sets at least for single-DCI based MTRP* FFS: How to map joint/DL/UL TCI states to a TCI field codepoint for both unified TCI sets
* FFS: Whether to increase the max number of TCI field codepoints/bits, i.e., more than 8 codepoints/3 bits
 |
| Apple | Proposal 1.A: We suggest we clarify whether R16 mDCI only includes PDSCH?Proposal 1.B: Suggest the following revision, since UE may support mTRP operation for a particular channel instead of all channels.**Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCIs in a CC for the channel(s) configured with MTRP operation* A unified TCI for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* A unified TCI for sperate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* FFS: Details of update and activation for the unified TCIs for S-DCI based MTRP
* FFS: Details of update and activation for the unified TCIs for M-DCI based MTRP
* FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI (i.e., one unified TCI comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state)

Proposal 1.C: OK with QC’s revision |
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# Issue 2 – UL Power Control for UL MTRP

Open issues on UL PC for UL MTRP and company views are summarized below.

Table 3 Summary for Issue 2

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 2.1 | Discussion on Issue 2 should start after simultaneous UL　transmission schemes are determined in AI 9.1.4.1 | Support: Samsung, ZTEConcern:  | From moderator perspective, sub-issue 2.2 still can be discussed first, at least for Rel-17 UL MTRP  |
| 2.2 | Reuse Rel-17 TCI-specific UL PC parameter setting (including PLRS, and per-PUSCH/PUCCH/SRS P0, alpha, CL index) to support per panel/TRP power control | Support: Ericsson, Docomo, OPPO, vivo, Futurewei, Xiaomi, Lenovo, MTK, LGE, Fujitsu, CATT, Apple Concern: | Given the majority view on this issue, Proposal 2.A is recommended at least for Rel-17 UL MTRP.How to handle the case if the indicated joint or UL TCI states for S-DCI based UL MTRP are not associated with power control settings can be further discussed |
| 2.4 | Tx power limitation for simultaneous UL transmission | Study per-panel power limit* Support: Nokia, OPPO, Docomo, Huawei, ZTE, Qualcomm (per-TRP), vivo (LS to RAN4), CATT, Spreadtrum, LGE, Lenovo, CMCC, Apple
* Concern:

Study total power limit shared by two panels* Support: Huawei, CATT, CMCC, Spreadtrum, Apple ~~(?)~~, Intel
* Concern:
 |  |

**Proposal 2.A:** 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, closed loop index, and PL-RS), the UE should apply the UL PC parameter setting for the PUSCH/PUCCH transmission occasion.

* FFS: If the indicated joint or UL TCI state is not associated with an UL PC parameter setting for PUCCH/PUSCH
* FFS: Extend to other Rel-18 MTRP scheme(s), if supported

Table 4 Additional inputs for Issue 2

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| **Company** | **Input** |
| Mod V0 | **1) Please check and update your views in Table 3****2) Share your inputs on the above moderator proposal** |
| QC | For Proposal 2.A, support |
| Apple  | Support Proposal 2.A. In addition, added our position on different aspects listed in Table 3 for Issue 2. On the scheme 2.4, we are open for both schemes, i.e., defining per-TRP power limitation or limiting per serving cell with sharing across two panels. However, for per-TRP power limitation option, we need to send LS to RAN4 to check the feasibility of defining the per-panel max power as it is specified in RAN4 spec. Otherwise, there is risk that RAN1 develops solutions assuming per-panel max power would be introduced, but RAN4 decides to not introduce it for FR2. This happens for FR2-FR2 NR-DC already.  |
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# 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

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 3.1 | Enhance group-based reporting to support simultaneous UL transmission | Support: Qualcomm, Samsung, vivo, MTKConcern: Apple | This issue can be discussed once any Rel-18 MTRP scheme for simultaneous UL transmission is agreed |
| 3.2 | Extend Rel-17 UE capability correspondence reporting to support simultaneous UL transmission | Support: Samsung, Nokia, CATT, LGE, MTK, AT&T, QC, AppleConcern:  | 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, QualcommConcern: |  |

Table 6 Additional inputs for Issue 3

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| **Company** | **Input** |
| Mod V0 | **Please check and update your views in Table 5** |
| QC | We are also fine for 3.2 with table updated |
| Apple | For beam report, in our view, current group based beam report cannot be reused, as it cannot provide enough information for simultaneous transmission. |
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# 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** |
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# Appendix A: Agreements in RAN1#109-e

Void

# 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