3GPP TSG-RAN WG1 Meeting #110 R1-22xxxxx

Toulouse, France, August 22nd – 26th, 2022

Agenda Item: 9.1.1.2

Source: Moderator (Ericsson)

Title: Moderator Summary on Two TAs for multi-DCI

Document for: Discussion

1 Introduction

During RAN#94e, a new WID for Rel-18 MIMO evolution for DL and UL was agreed [26]. The highlighted Part of objective 7 is relevant for this AI:

1. 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.

In this documents, proposals submitted to Agenda 9.1.1.2 are summarized and discussed.

# 2 Two TAGs vs one TAG

In RAN1#109-e, the following agreement was made with regards to how many TAGs to configure within a serving cell:

Agreement

For multi-DCI based multi-TRP operation, down-select one of the two alternatives:

* Alt 1: configure two TAGs within a serving cell
* Alt 2: consider two TAs within one TAG within a serving cell

The following is a summary of company views:

* Support Alt 1 **(19)**: Huawei/HiSilicon, Qualcomm, ZTE, vivo, FUTUREWEI, MediaTek, Apple, Intel, CATT, Ericsson, Xiaomi, Sharp, NTT Docomo, CMCC, Google, Lenovo, TCL, Spreadtrum, Transsion
* Support Alt 2 **(4)**: Samsung, OPPO, Interdigital, NEC
* Defer Decision **(2)**: Nokia/NSB, LGE

*FL Comment: A large majority of companies prefer to support two TAGs per serving cell. Based on this, FL suggestion is to see if we can agree Alt 1.*

***Proposal 1: For multi-DCI based multi-TRP operation with two TAs, support configuring two TAGs within a serving cell.***

*Companies are asked to provide their views below:*

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Google | We support FL’s proposal.  |
| QC | Support. |
| Apple  | Support  |
| LGE | We think that it is more like RAN2 work. |
| NTT DOCOMO | Support the proposal. |
| MediaTek | Support, we think the decision should be made in RAN1 |
| Lenovo | Support. |
| CATT | Support FL’s proposal |
| OPPO | On Alt.1, i.e. two TAGs within a serving cell, we would like to share and remind some of our concerns. * Each TAG is with one DL timing reference. Two TAGs within a serving cell introduces two potentially different DL timing references for the serving cell. Hopefully the gap between two DL timing references could be kept within a CP, otherwise it will increase the DL processing burden of UE.
* If a serving cell is SpCell, the two TAGs that contain this SpCell would be considered PTAGs. Alt.1 would introduce two PTAGs which seems not aligned with RAN2 Spec.

The following definition on TAG is captured from TS 38.213.**Timing Advance Group:** A group of Serving Cells that is configured by RRC and that, for the cells with a UL configured, using the same timing reference cell and the same Timing Advance value. A Timing Advance Group containing the SpCell of a MAC entity is referred to as Primary Timing Advance Group (PTAG), whereas the term Secondary Timing Advance Group (STAG) refers to other TAGs. |
| Nokia | OK, but this is a RAN2 decision.  |

# 3 Two TACs vs One TAC

In RAN1#109-e, the following agreement was made with regards to how many TACs the network signals:

Agreement

Enhancement on two TAs for UL multi-DCI for multi-TRP operation is supported in Rel-18.

Note 1: whether (1) the network signals two TACs or (2) the network signals one TAC and the UE deriving the second TA can be further studied.

Note 2: evaluations can be considered on as-needed basis.

The following is a summary of the proposals from different companies:

* Support network signalling of two TACs **(7)**: Qualcomm, Ericsson, ZTE, CATT, CMCC, NEC, Transsion, Apple, LGE, Lenovo, OPPO, Nokia
* Support network signalling one TAC and UE deriving the second TA **(2)**: Samsung, vivo

*FL Comment: One open question is whether we should study or support the possibility of network signaling one TAC and the UE deriving the second TA. One scenario mentioned by vivo [2] for allowing the UE to derive the second TA is the case where 2nd TRP has associated PUCCH transmission but does not have SRS/PUSCH transmission.*

*This issue depends on the outcome of Proposal 1 and can be discussed once Proposal 1 is resolved.*

# 4 Two vs One reference timing

In RAN1#109-e, the following agreement was made with regards to how many reference timings are to be considered:

Agreement

For multi-DCI multi-TRP operation with two TAs, study the following alternatives:

* Alt 1:  two reference timings are considered
* Alt 2:  one reference timing is considered

Note: reference timing above is the timing of the DL reception

The following is a summary of company views:

* Support Alt 1 **(13)**: Huawei/HiSilicon, Qualcomm, Nokia/NSB, vivo, Futurewei, Apple, Ericsson, Xiaomi, Sharp, CMCC, Interdigital, TCL, Transsion
* Support Alt 2 **(9)**: ZTE, Samsung, MediaTek, OPPO, LGE, CATT, NTT Docomo, NEC, Spreadtrum

*FL Comment: There is no strong majority support for either alternatives. FL would like to ask companies comment on if they have strong concerns on either Alt 1 or Alt 2. Please provide technical reason for your concern.*

***Question: Companies are asked to comment if they have strong concerns on either Alt 1 or Alt 2. Please provide technical reason for your concern.***

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| QC | We do not have strong concern with Alt2 (we think it can also work), but would like to mention the following impact to legacy if Alt2 is adopted:In CA scenario with e.g., 3 CCs, where CC1 is multi-TRP (TAG1 and TAG2), CC2 is configured with TAG1 (sTRP) and CC3 is configured with TAG2 (sTRP), then Alt2 results CC2 and CC3 to also use the same DL reference timing. This is not consistent with existing UL-CA with multiple TAGs. |
| Apple  | We support Alt.1. On Alt.2, it may result in modification of TA value range e.g., support negative values depending on the relative timing difference between two TRPs.  |
| NTT DOCOMO | Our preference is Alt.2. From our perspective, Alt.2, i.e., one reference timing together with per TRP TA, is sufficient to achieve that the UL timing misalignment at TRP is within a CP. With Alt.1, association between DL signal and TRP needs to be studied, which brings more spec. impact. |
| MediaTek | We prefer Alt2. However, we do see both alternatives may cause impact to the definition of reference timing. |
| CATT | We support Alt2. The benefits of Alt1 need to be clarified.  |
| OPPO | We support Alt.2. As mentioned by DOCOMO, one reference timing plus per TRP differential TA would results in less UE complexity when compared with two timing references. For Alt.1, UE may have to prepare two DL/UL processing timelines.  |
| Nokia | Support Alt. 1Alt. 2 does not fully fit with two TACs.  |

# 5 Two vs One Timing Advance Offset

In RAN1#109-e, the following agreement was made with regards to how many *n-TimingAdvanceOffset* values per serving cell are to be considered in Rel-18:

Agreement

For multi-DCI multi-TRP operation with two TAs, study the following alternatives further in Rel-18:

* Alt 1: one *n-TimingAdvanceOffset* value per serving cell
* Alt 2: two *n-TimingAdvanceOffset* value per serving cell

Company views are summarized as follows:

* Support Alt 1 **(13)**: Nokia/NSB, vivo, Samsung, Futurewei, OPPO, LGE, CATT, Ericsson, Xiaomi, Sharp, NTT Docomo, Spreadtrum, MediaTek
* Support Alt 2 **(6)**: Huawei/HiSilicon, Qualcomm, Apple, ZTE, NEC, TCL

*FL comment: Proponents of Alt 1 argue that the same duplex mode and frequency range are expected in a multi-DCI multi-TRP scenario and hence one n-TimingAdvanceOffset* *is sufficient. Some proponents of Alt 2 argue that the duplex mode may be different between the two TRPs involved in multi-DCI multi-TRP operation.*

***Question: Companies are asked to provide their view on the following:***

* ***Are there use cases why two n-TimingAdvanceOffset values per serving cell are needed?***

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| QC | One use case is different coexistence, i.e., one TRP is DSS while the other one is not.In addition, Alt1 results in impact to legacy UL-CA scenario. Similar to the example mentioned in the previous section, it results in CC2 and CC3 to be forced to use the same *n-TimingAdvanceOffset* even though they are configured with different TAGs. |
| Apple  | Our motivation to go with Alt.2 is exactly same as what QC said above. Currently, for FR1, network has flexibility to select different n\_TA offset values based on the actual deployment e.g., coexistence with LTE or not, TDD/FDD CA or not. For mTRP case, TRP#1 may be configured with FDD/TDD CA, but only FDD CCs are used for the other TRP. In this case, n\_offset is needed for TRP#1 but is unnecessary for TRP#2. If we go with Alt.1, n\_offset has been forced for TRP#2 once mTRP is enabled.  |
| LGE | We prefer Alt 1 for simple extension of two TAs in addition to rationale as mentioned by FL, that the value is up to frequency range and depends on duplex mode. |
| NTT DOCOMO | Our preference is Alt.1. In our understanding, it may not be a typical case that two TRPs of a same cell have different coexistence/duplex mode. |
| CATT | We share similar view as DOCOMO and support Alt 1.  |
| OPPO | Support Alt.1.For either intra-cell or inter-cell MTRP, two TRPs are configured within one serving cell and operated on the same frequency band. In most of deployment cases, we believe that the same TDD/FDD mode and same frequency resources would be the wise choice for any operator. Therefore, we think Alt.2 is way too flexible and unnecessary according to RAN4’s rule on n-TimingAdvanceOffset configuration.  |
| Nokia | Agree with DCM. |

# 6 Association between TAs and UL channels/signals

In RAN1#109-e, the following agreement was made:

Agreement

**Two TA enhancement for uplink multi-DCI based multi-TRP operation are applicable to** at least**:**

* **TDM based multi-DCI uplink transmission**
* **simultaneous multi-DCI uplink transmission (if simultaneous uplink multi-DCI uplink transmission is supported in Agenda 9.1.4.1)**
* **Note: Whether two TA enhancement is applicable to other schemes is a separate discussion, which is not in the scope of AI 9.1.1.2.**

***FL Comment: One open issue is how to associate each TA to UL channels/signals. Two different options were proposed by multiple companies:***

Option 1: Associate TA to TCI-state/spatial relation **(10 companies)**

 Supported by Huawei/HiSilicon, Samsung, MediaTek, LGE, ZTE, Intel, CATT, Ericsson, Google, Transsion

Option 2: Associate TA to CORESETPoolIndex **(8 companies)**

Supported by Qualcomm, ZTE, vivo, Apple, Xiaomi, Lenovo, Spreadtrum, Transsion, OPPO, Nokia/NSB

*Taking into account the above input, the following is proposed:*

***Proposal 2: For associating TAs to UL channels/signals for multi-DCI based multi-TRP operation, downselect one of the options:***

* ***Option 1: Associate TA to TCI-state/spatial relation***
* ***Option 2: Associate TA to CORESETPoolIndex***

***FFS: detailed association (e.g., whether implicit association or explicit association)***

*Companies are asked to provide their views below:*

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Google | We support Option 1. It’s not clear to us how Option 2 can work for some preconfigured UL channels/RSs (i.e., those not scheduled/triggered by CORESETs). Regarding detailed association, we believe it falls into RAN2’s expertise no matter which option is agreed finally.  |
| QC | Support Option 2. We have a concern with Option 1 as it requires two different frameworks (the association would be needed for both unified TCI framework as well as Rel-15/16 spatial relation info). In addition, it is not clear how option 1 can work for FR1 for a UE not supporting unified TCI. In this case, spatial relation info does not even exist. However, in the previous meeting, we agreed the TA enhancements are applicable to both FR1 and FR2. Regarding Google’s comment on Option 2, configuration of associated TAG is anyway needed. Actually, the situation is the other way around as Option 2 is already supported for dynamically scheduled signals/channels (which is not the case in Option 1), and the required enhancements are limited to configured UL signals/channels. |
| Apple  | In previous release with single TRP and multiple beams, the TA is always maintained on a per CC/serving cell level, instead of beam-level. Of course, gNB can use TAC MAC-CE to update TA value for a given TAG in case of Beam Switching. For Rel-18 with multiple TRPs, the TA framework is naturally extended to two TAGs towards two TRPs, but it should be still kept as CC or serving cell level. With Opt.1, it seems different TAs are associated with different UL TCI states. If there are multiple UL TCI states are activated for a TRP by MAC-CE, does it mean UE needs to maintain multiple TAGs with each for a UL TCI-state even for a TRP? We do not see the justification for this. With Opt.2, different UL TCI states are associated with two CORESETPoolIndex values for two TRPs, which is simple and sufficient design for TA maintenance.   |
| LGE | We support both option 1 and 2.In Rel-18 unified TCI enhancement, N>1 of TCI states could be naturally associated with CORESETPoolIndex for M-DCI based M-TRP operation. For a UE with capable of Rel-18 extension of unified TCI, option 1 is simple solution without much specification impact. For a UE without capable of unified TCI(e.g., Rel-15/16 spatialRelationInfo or FR1 UE), option 2 can be used as QC mentioned. |
| NTT DOCOMO | Support the proposal and prefer option2. We share similar concern as Qualcomm for option1.  |
| MediaTek | We prefer Option 1 due to forward compatibility, e.g., Rel-18 mobility where M-DCI may not be configured. On the other hand, for SRS/PUCCH transmission that may not have association with a *coresetPoolIndex* value, how/whether to provide such association for Option 2 has to be discussed. For option 1, every UL Tx will be naturally provided with a TCI state/spatial relation at least in FR2. Regarding FR1, support it based on unified TCI should be okay.On the wording of the proposal, since one alternative for providing two TAs is based on two TAGs, we prefer to include the possibility in this proposal, for example:***Proposal 2: For associating TAs or TAGs to UL channels/signals for multi-DCI based multi-TRP operation, downselect one of the options:**** ***Option 1: Associate TA or TAG to TCI-state/spatial relation***
* ***Option 2: Associate TA or TAG to CORESETPoolIndex***
 |
| Lenovo | OK with the proposal and we support Option 2. |
| CATT  | Support Opt1 and Opt2. For opt1, each TA can be associated with TCI state/Spatial Relation info for the PUSCH/PUCCH transmission. In the implementation, a TASG (TA sub group) can be introduced to represent a CC group that can be used for one TRP, each TAG consists of several TASGs, UE maintains one TA for each TASG. When two TCI states/Spatial Relation infos are indicated for PUSCH/PUCCH transmission to two TRPs, the associated TA can be used accordingly.For opt2, each TA can be associated with the CORESETPoolIndex of the CORESET dynamically scheduling the PUSCH/PUCCH, for the periodic/semi-persistent PUCCH transmission, the association can be defined by RRC configuration.  |
| OPPO | Support Option 2. As for Option 1, i.e. association TA to TCI state/spatial relation, the UL channels/signals may apply different TCI states/spatial relations, even for unified TCI states (SRS with UTCI #1, PUCCH/PUSCH with UTCI #2). That will result in different TAs in UL for the same TRP, which is clearly out the scope of the WID. 1. 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.
 |
| Nokia | Support Option 2. We do not think Option 1 is in the scope of the WI objective. This discussion option 1 is not needed as WI is about mDCI and simultaneously transmitted TRPs are represented by CORESETPoolIndex.  |

# 7 Overlap Handling

Several companies discuss the issue of how to handle overlapping of two consecutive UL slots when two different TA values are used in multi-DCI multi-TRP operation:

* Huawei/HiSilicon [9] propose to introduce scheduling constraint in time domain to avoid overlap of two consecutive UL slots with different TA values
* Qualcomm [5] proposes to study further how to address the case when two different UL signals/channels overlap in time due to multi-TRP operation with two TAs.
* ZTE [1] proposes to introduce scheduling restriction gap in which UE does not expect to transmit any UL signals/channels
* ZTE [1] further proposes to reduce the transmission duration of one of the slots rather than shortening the later slot as in legacy.
* vivo [2] proposes to study how to handle overlapped channels/signals due to two TAs applied to different TRPs
* CATT [3] proposes similar dropping rule as legacy when the UE supports TDM multi-DCI based PUSCH transmission. CATT proposes to allow overlapped transmission in case the UE supports NR Rel-18 STxMP transmission.
* NEC [19] supports a time gap between consecutive PUSCH transmission occasions applying different TAs.

*Based on the input, the following is proposed:*

***Proposal 3: For multi-DCI based multi-TRP operation with two TAs, study how to handle overlapping part in consecutive UL slots, where the study includes:***

* ***whether to introduce scheduling restriction in overlapping part in consecutive UL slots***
* ***whether to introduce dropping rules***
* ***whether specification impact is need, or if the issue can be handled via implementation***
* ***whether to allow overlapped transmission in case the UE supports STxMP transmission (if STxMP feature is agreed in NR Rel-18)***

*Companies are asked to provide their views below.*

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Google | We support FL’s proposal.  |
| QC | Support this proposal in principle to further study the issue, but this is not limited to “consecutive UL slots”. It is equally applicable to UL transmissions within a slot (e.g., PUSCH1 with TAG1 and PUSCH2 with TAG2 scheduled back-to-back in the same slot) |
| Apple  | Agree in principle and share the QC’s comment.  |
| LGE | Support the proposal. |
| NTT DOCOMO | Support the proposal.  |
| MediaTek | Support the proposal. |
| Lenovo | Support the proposal. |
| CATT | Support FL’s proposal.  |
| OPPO | Support the FL proposal. |
| Nokia | Ok  |

# 8 Timing Alignment Timers

Several companies propose to support separate timing alignment timers per TRP when two different TA values are used in multi-DCI multi-TRP operation:

* ZTE [1] proposes support for configuring time alignment timer per TRP for TAGs within a serving cell
* OPPO [23] proposes to support up to 2 TA *TimeAlignmentTimer*’s for multi-TRP within a TAG
* Google [18] proposes two time alignment timers corresponding to two TA values are separately configured for a serving cell

*Based on the input, the following is proposed:*

***Proposal 4: For multi-DCI based multi-TRP operation with two TAs, support two time alignment timers corresponding to the two TAs***

* ***FFS: configuration details***

*Companies are asked to provide their views below.*

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Google | We support FL’s proposal. However, to make it clear, we suggest the following revision. ***Proposal 4: For multi-DCI based multi-TRP operation with two TAs, support two time alignment timers corresponding to the two TAs for a serving cell**** ***FFS: configuration details***
 |
| QC | The proposal may not be needed if proposal 1 is agreed (each TAG has its own configurable timer in current spec) |
| Apple  | Agree in principle.  |
| LGE | Similar view as QC. We can wait for proposal 1. |
| NTT DOCOMO | Support the proposal.  |
| MediaTek | We can wait for conclusion of proposal 1 |
| Lenovo | Similar view with QC. |
| CATT | Support FL’s proposal. *timeAlignmentTimer*(per TAG) is used to control how long the MAC entity considers the Serving Cells belong to the associated TAG to be uplink time aligned. When a new TA is indicated, UE will reset *timeAlignmentTimer*. When the timer expires, UE will perform random access procedure to obtain a new TA and restart *timeAlignmentTimer.* In the case of multi-DCI based multi-TRP operation with two TAs, it’s natural that two timer alignment timers corresponding to the two TAs be supported.  |
| OPPO | Support the FL proposal or the updated version from Google.  |
| Nokia | Support |

# 9 Impact on PDCCH order

Several companies propose studying potential impact of two TAs for multi-DCI multi-TRP scenario on PDCCH order.

* Qualcomm [5] proposes to study the impact of two TAs per CC to RACH triggered by PDCCH order
* Nokia/NSB [4] mention two possibilities for multi-TRP multi-DCI with two TAs:
	1. Allowing a PDCCH order from a first TRP to trigger PRACHs towards the two TRPs at a time
	2. Allowing TRP specific PDCCH order where each TRP can send a corresponding PDCCH order to trigger PRACH transmission towards that TRP
* ZTE [1] proposes to support PDCCH order based random access as starting point
* vivo [2] proposes to support TRP-specific RACH triggered by PDCCH order for both intra-cell and inter-cell mTRP
* NTT Docomo [15] proposes that PDCCH ordered RACH can be triggered to obtain per TRP TA
* Futurewei [8] proposes to support PDCCH order triggering PRACH transmission to obtain second TA
* OPPO [23] proposes to support updating TA per TRP in CFRA procedure where TRP is indicated implicitly through CORESETPoolIndex that transmits PDCCH order
* CATT [3] proposes PDCCH order triggering to acquire 2nd TA corresponding to 2nd TRP

*Based on the input, the following is proposed:*

***Proposal 5: For multi-DCI based multi-TRP operation with two TAs, study impact of two TAs per serving cell to RACH triggered by PDCCH order.***

* ***Further details of enhancements needed (if any)***

*Companies are asked to provide their views below.*

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Google | We support FL’s proposal.  |
| QC | Support. |
| Apple  | Support  |
| LGE | Support. |
| MediaTek | Support |
| CATT | Support FL’s proposal.  |
| OPPO | Support to study. |
| Nokia  | Support |

# 10 Other Issues

If there are other issues which are not captured in the previous sections, companies are welcome to propose them in the following table. Based on interest and time-permitting, we can try to discuss a subset of the issues during meeting week.

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| QC | Issues related to inter-cell mTRP can be also discussed. At least a high-level proposal on the issues would help companies to study the details further. |
| Apple  | Support to list issues related to inter-cell mTRP to facilitate future discussions. |
|  |  |
|  |  |
|  |  |

# 11 References

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[3] R1-2206376, CATT, “Discussion on two TAs for UL multi-DCI for multi-TRP operation”, RAN1#110, August 2022.

[4] R1-2207545, Nokia, Nokia Shanghai Bell, “Two TAs for UL multi-DCI multi-TRP operation”, RAN1#110, August 2022.

[5] R1-2207216, Qualcomm Incorporated, “Supporting two TAs for multi-DCI based mTRP”, RAN1#110, August 2022.

[6] R1-2206867, LG Electronics, “Two TAs for multi-TRP panel”, RAN1#110, August 2022.

[7] R1-2206811, Samsung, “Views on two TAs for m-DCI”, RAN1#110, August 2022.

[8] R1-2205748, FUTUREWEI, “Enhancements to support two TAs for multi-DCI”, RAN1#110, August 2022.

[9] R1-2205880, Huawei, HiSilicon, ”Study on TA enhancement for UL M-TRP transmission”, RAN1#110, August 2022.

[10] R1-2206996, MediaTek Inc., “UL Tx Timing Management for MTRP Operation”, RAN1#110, August 2022.

[11] R1-2207321, Apple, “Views on two TAs for multi-DCI Uplink Transmissions”, RAN1#110, August 2022.

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[13] R1-2206621, Xiaomi, “Discussion on two TAs for multi-TRP operation”, RAN1#110, August 2022.

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[16] R1-2206895, CMCC, “Discussion on two TAs for multi-DCI”, RAN1#110, August 2022.

[17] R1-2205817, InterDigital, Inc., “On Utilization of Multiple TA”, RAN1#110, August 2022.

[18] R1-2206485, Google, “Discussion on two TAs for multi-DCI”, RAN1#110, August 2022.

[19] R1-2206464, NEC, “Discussion on two TAs for multi-DCI”, RAN1#110, August 2022.

[20] R1-2206210, Lenovo, “Discussion of two TAs for multi-DCI UL transmission”, RAN1#110, August 2022.

[21] R1-2205823, TCL Communication Ltd., “Discussion on two TAs for multi-DCI based on multi-TRP operation”, RAN1#110, August 2022.

[22] R1-2205982, Spreadtrum Communications, “Discussion on two TAs for multi-DCI based multi-TRP”, RAN1#110, August 2022.

[23] R1-2206264, OPPO, “Two TAs for multi-DCI”, RAN1#110, August 2022.

[24] R1-2206668, Transsion Holdings, “Discussion on TA enhancement for multi-DCI based multi-TRP operation”, RAN1#110, August 2022.

[25] R1-2206571, Intel Corporation, “On two TAs for multi-DCI”, RAN1#110, August 2022.

[26] RP-213598, Revised WID: MIMO evolution for downlink and uplink, Samsung, RAN#94-e, December 2021.