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 #2 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 summary, proposals and views expressed on the proposals are summarized.

# 2 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 **(18)**: Qualcomm, Ericsson, ZTE, CATT, CMCC, NEC, Transsion, Apple, LGE, Lenovo, OPPO, Nokia, Xiaomi, Huawei, Hisilicon, Futurewei, Spreadtrum, Sharp
* 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.*

***FL Comment 2: Given two TAGs per serving cell is already agreed in RAN1#110, network signaling of two TACs is automatically agreed. We may not need to further discuss two TACs vs one TAC per serving cell. Please let me know if there are other views.***

# 3 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. |
| ZTE | Support Alt 2.  Basically, our understand is that DL reference timing in legacy is determined per serving cell rather than per TAG, which can be referred to the spec description (subclause 7.1 in TS 38.133) that “*The uplink frame transmission takes place before the reception of the first detected path (in time) of the corresponding downlink frame from the reference cell.*”, hence DL reference timing associated to TAG can be the same or different. In other words, we have different understanding of QC’s example that “This is not consistent with existing UL-CA with multiple TAGs.”.  Taking proposal 1 into consideration, Alt 2 has less spec impact than Alt 1 due to the DL reference timing is determined per serving cell still. Besides, it should be noted that Alt 1 requires more spec efforts on determining the association between TRP and DL reference timing. |
| Nokia | Support Alt. 1  Alt. 2 does not fully fit with two TACs. |
| Xiaomi | We prefer Alt.1. When using one reference timing, a timing offset may be required to compensate by NTA. |
| Huawei, Hisilicon | Support Alt.1.  In addition to the issues of Alt.2 mentioned by QC and Apple, another issue is that, with a single DL reference timing, like DL reference timing of the first TRP, the calculation of the second TRP is more complicated. Transmission timing gap of the two TRPs need to be considered, which may further degrade the accuracy of the second TA as quantization of the transmission timing gap can also introduce some error. |
| InterDigital | Support Alt.1 (two reference timings). Since we are discussing Multi-DCI based MTRP scenario, the UE should be able to track each individual link based on each DL reference from each TRP. Following Alt.2, two TRPs has to coordinate each other to control UE’s timing advance behaviors. |
| Futurewei | Support Alt.1 (two reference timings). Regarding Alt.2, in addition to the issues mentioned by other companies, we would also like to point out the potential performance degradation on PUSCH with Alt. 2. Based on our simulation results in R1-2205748, we observed that even if the UL receive timing offset/TA error is within a CP length, PUSCH performance degradation is possible and can be detrimental. What can be generally tolerable is [0,+50%] of CP length in UL receive timing offset/TA error. However, Alt.2 with only one reference timing can cause the UL receive timing offset/TA error falling out of the tolerable range, resulting in significant UL performance degradation. Alt.1 with two reference timings on the other hand, can make sure the UL receive timing offset/TA error is within the tolerable range, resulting in no UL performance degradation. |
| Samsung | We slightly preferred Alt2 as it requires the UE to maintain one DL reference time. Alt1 can also work, but it would require the UE to maintain two different reference timings for the DL, which seems to increase the UE’s complexity |
| Spreadtrum | Support Alt2. In our understanding, Alt1 would require UE to maintain two sets of DL links/ DL timing, which obviously would bring huge complexity on UE. In previous release, to alleviate UE’s implementation burden for M-TRP operation, the Rx timing reference from two TRP is limited within CP. In this agenda, the WID only states to enhance two TAs for multi-DCI based M-TRP. Thus, the principle on the Rx timing reference from two TRP limited within CP still should be obeyed. On top of the principle, as mentioned by DOCOMO that one reference timing together with per TRP TA, is sufficient to achieve that the UL timing misalignment at TRP is within a CP. |
| Intel | Alt-1, we think either of the alternatives work – its unclear how maintaining a second timing reference leads to UE complexity increase, the UE anyway would maintain DL timing for the second TRP. Design-wise we think Alt-1 is future-proof incase larger inter-TRP timing difference is considered in the future |
| Ericsson | Assuming that 2 TAGs is adopted, each timing is individually adjusted. So fundamentally, either alternative could work for mDCI in a static scenario. But it would seem to be more robust to have 2TAs, since the DL timing reference may be updated. If the UE has a single DL timing reference, and that timing reference is changed, it would impact the UL timing of both legs, which would be unfortunate. |
| CMCC | Support Alt. 1. Our understanding is that each TRP has its own reference timing and the TA. But if there is a switching between two TRPs, UE may not change the timing dynamically or in time, then the current reference timing would be used for transmission to the other TRP. |
| Sony | Support Alt.2. Same view as NTT DOCOMO. |
| Sharp | We prefer Alt 1. In our view, in TDD case, timing of DL transmission and UL reception need to be aligned between gNBs. Consequently, for also two TRPs, two links should be individually managed. |
| vivo | Support alt 1. UE derives TA based on DL RS measurement, which means for 2 TAs UE has to measure 2 DL RSs from two TRPs, then it is natural that there are two reference timings |
| Transsion | We prefer Alt1. For Alt2, multi-TRP synchronization and propagation delay differences should be considered, which will lead to more spec impact. |
| **Mod** | Company positions are still more or less split between the two alternatives. Some observations based on the replies:   * Several companies noted that both alternatives could work * Several companies noted that both alternatives will involve specification impact * One company refers to their simulation results (in R1-2205748) which shows PUSCH performance degradation with Alt 2 even if the UL receive timing offset/TA error are within a CP length * Some companies mention that Alt 1 is future-proof in case larger inter-TRP timing difference is considered in the future.   Given the above observations (particularly performance results from R1-2205748), could we try to go with Alt 1?  ***Proposal 6:*** ***For multi-DCI multi-TRP operation with two TAs, two reference timings are considered***  This may need some discussion. Companies are asked to provide their comments on Proposal 6 below. |
| NTT DOCOMO | As commented, one reference timing is sufficient to ensure that the timing misalignment at TRP is within a CP. And we also noticed there is simulation results showing that there is performance degradation brought by timing misalignment even if it is within a CP. So from our perspective we need to discuss what is tolerable range of timing misalignment, whether within a CP length is sufficient or it should be within a value that is less than a CP length. |
| ZTE | Do NOT support.  Given that one reference timing is the baseline in legacy MDCI MTRP, it should be kept in Rel-18 as well when considering some negative impacts caused by two reference timings, i.e., gigantic spec impact especially in RAN2, UE implementation complexity, inevitable performance loss, etc. Basically, it is more reasonable to adopt one reference timing as the starting point for 2 TAs enhancement, and then further evaluate the motivation of two reference timings. In the light of the above, we propose:  ***Proposal 6:*** ***For multi-DCI multi-TRP operation with two TAs, one reference timing is the starting point.***   * ***Further study two reference timings considering performance gain, implementation complexity, specification effort, etc.***   [Moderator] Based on the replies the companies views are split with Alt 1 (two reference timings) having slightly more support. Please see if a compromised proposal below is a way forward. |
| Samsung | We prefer one reference time as it provides the desired functionality without the additional complexity of having two reference times. |
| OPPO | As pointed out by many, single reference timing would be sufficient for a serving cell to differentially adjust 2 TAs for 2 TRPs.  Without additional benefits justified, we hesitate to go with two DL reference timings. |
| NEC | We support one reference timing.  Especially we are against two reference timing for one TAG, considering that two TAGs are now allowed. |
| InterDigital | Support Moderator’s proposal 6 above. As we have agreement for two TAGs, we think two reference timings are also already agreed, unless otherwise. So, basically, one reference timing per TAG, and in total 2 reference timings on the cell with MTRP operation. |
| Huawei, Hisilicon | We support the proposal. However, we’d like to emphasis that the two DL reference timing are just used for maintenance of two TAs, rather than for DL reception. So, we suggest introducing the following note:  ***Proposal 6:*** ***For multi-DCI multi-TRP operation with two TAs, two reference timings are considered.***   * ***Note: the two DL reference timings are just for TA maintenance, not for DL reception.***   [Moderator] In the agreement from last meeting, we had the note “Note: reference timing above is the timing of the DL reception”. So, my understanding is that the two DL reference timings are also for DL reception. |
| Moderator | Similar to last round company positions are still split.   * 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   We can try to downselect one online.  ***Proposal 6***  For multi-DCI multi-TRP operation with two TAs, downselect one of 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 |
| Huawei, Hisilicon | We support the proposal. However, since the WID only focus on UL, to avoid the discussion to be extend to DL, we’d like to introduce the following note.  ***Proposal 6:*** ***For multi-DCI multi-TRP operation with two TAs, two reference timings are considered.***   * ***Note: it is assumed that the gap of the two DL reference timings are no larger than CP length.*** |
| CATT | Support the proposal and prefer Alt2. As mentioned before, one reference timing is enough for a serving cell to adjust 2 TAs for 2 TRPs without increasing additional complexity with two reference timings. |

# 4 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, InterDigital
* 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. |
| ZTE | We share the similar view with QC and apple, we support Alt 2.  One more thing needs to be clarified first. For the case of inter-cell MDCI based MTRP operation, the additional cell is the different from the serving cell, hence the previous agreement should be revised as:  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 cell * Alt 2: two *n-TimingAdvanceOffset* value per cell |
| Nokia | Agree with DCM. |
| Xiaomi | We prefer Alt 1 since the cooperative two TRPs generally share the same frequency range and duplex mode. |
| Huawei, Hisilicon | The debate between proponents of the two alternatives seems lies on the configuration of gNB in reality, i.e., whether the two TRPs will be configured with different duplex modes or not. In our view, allowing configuring up to two TA offsets can support both kind of implementations. For gNB configuring the same duplex mode for both TRPs, it can configure one TA offset for the two TRPs. While, for gNB configuring different duplex mode for two TRPs, it can configure two TA offsets for the two TRPs. So, we suggest following modification of the proposal and support the modified Alt 2.  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: up to two *n-TimingAdvanceOffset* value per serving cell |
| InterDigital | Agree with DOCOMO |
| Futurewei | Our preference is Alt 1 but we are open to Alt 2 to support more deployment scenarios. |
| Samsung | Support Alt.1. As for the reasons mentioned by QC, it is not clear that different coexistence can happen in two TRPs that are in the same serving cell (same geographical area). |
| Spreadtrum | Support Alt1, agree with DOCOMO. |
| Intel | We also think Alt-1 is sufficient |
| Ericsson | Although the parameter can be configured per cell, our understanding is that this is configured per band: even if DSS is configured in one cell, and not in the neighbor, we would still have to configure for LTE coexistence in all cells in that band. Still, Alt1 is a subset of Alt2, so Alt2 can be considered. But the issue can be deferred. |
| Lenovo | We prefer Alt 1. |
| CMCC | Our preference is Alt 1. In our network, we will not deploy the feature of MTRP to two TRPs where one is FDD and the other is TDD. But we are open if there is a real demand for that case. |
| Sharp | We prefer Alt 1. |
| vivo | Support alt 1, agree with DOCOMO’s comments and for multi DCI based, in our view, two TAs operate independently. |
| Transsion | We prefer Alt 1. Since the same duplex mode and same frequency resources for the two TRPs will be a typical deployment, a second *n-TimingAdvanceOffset* value per serving cell is unnecessary. |
| Mod | Majority of the companies think Alt1 is sufficient. The proponents of Alt 2 make the following arguments:   * Concern 1: Alt 1 will have impact to legacy UL-CA scenario * Concern 2: The value of *n-TimingAdvanceOffset* depends on actual deployment (e.g., possible coexistence with LTE, TDD/FDD CA, etc). If TDD/FDD CA is deployed at TRP#1, but only FDD CCs are used for TRP#2. In this case, TRP#1 needs *n-TimingAdvanceOffset* while TRP#2 does not. Alt 1 would force the same value of *n-TimingAdvanceOffset* at both TRPs.   Could proponents of Alt 1 address the above concerns expressed by Alt 2 proponents. We can continue discussing this issue offline, and aim to down-select one of the alternatives. Note that Alt 2 has been modified according to Huawei’s suggestion which is to allow the gNB the flexibility to configure one or two *n-TimingAdvanceOffset* values depending on deployment scenario.  **Proposal 7:** For multi-DCI multi-TRP operation with two TAs, down-select one of the alternatives:   * Alt 1: one *n-TimingAdvanceOffset* value per serving cell * Alt 2: up to two *n-TimingAdvanceOffset* value per serving cell |
| NTT DOCOMO | Regarding concern 1, if we understand correctly it refers to the concern that “it results in CC2 and CC3 to be forced to use the same *n-TimingAdvanceOffset* even though they are configured with different TAGs”. We agree that in legacy mechanism cells in same TAG have same n-TimingAdvanceOffset. But we think the key problem here is still whether two TRPs of a same cell need different n-TimingAdvanceOffset. As in QC’s example, TAG1 contains (TRP1 of CC1, CC2 with S-TRP), TAG2 contains (TRP2 of CC1, CC3 with S-TRP), if TRP1 and TRP2 of CC1 can share same n-TimingAdvanceoffset, it does not mean CC2 and CC3 are “forced” to use same n-TimingAdvanceoffset. Our understanding is that because CC2/CC3 can share same offset with TRP1/TRP2 of CC1, they can be configured in same TAG. If CC2/CC3 cannot share same offset with CC1 TRP1/TRP2, it means they are not suitable to be configured in same TAG.  Regarding concern 2, as in the example, there is a FDD CC1 with TRP1 and TRP2, and a TDD CC2 with S-TRP with TRP1. Since the n-TimingAdvanceOffset is provided per serving cell, we fail to see the problem here. More clarification may be helpful.  We support the proposal and we prefer Alt.1. |
| ZTE | Support Alt 2, which provides greater flexibility for MDCI based MTRP in reality. |
| Samsung | Support Alt1  Agree with the reasons provided by NTT DOCOMO. |
| OPPO | Agree with DOCOMO’s assessment on concern 1.  Since there is only one TA offset value, i.e. 13792 Tc for FR2 as defined in the table below in TS 38.133, if we didn’t get it wrong. Up to 2 TA offset values can only be possible and applicable at FR1.  Table 7.1.2-2: The Value of   |  |  | | --- | --- | | Frequency range and band of cell used for uplink transmission | (Unit: TC) | | FR1 FDD or TDD band with neither E-UTRA–NR nor NB-IoT–NR coexistence case | 25600 (Note 1) | | FR1 FDD band with E-UTRA–NR and/or NB-IoT–NR coexistence case | 0 (Note 1) | | FR1 TDD band with E-UTRA–NR and/or NB-IoT–NR coexistence case | 39936 (Note 1) | | FR2 | 13792 | | Note 1: The UE identifies  based on the information n-TimingAdvanceOffset as specified in TS 38.331 [2]. If UE is not provided with the information n-TimingAdvanceOffset, the default value of  is set as 25600 for FR1 band. In case of multiple UL carriers in the same TAG, UE expects that the same value of n-TimingAdvanceOffset is provided for all the UL carriers according to clause 4.2 in TS 38.213 [3] and the value 39936 of  can also be provided for a FDD serving cell.  Note 2: Void | |   Hence, we suggest to slightly change the proposal as  **Proposal 7:** For multi-DCI multi-TRP operation with two TAs, down-select one of the alternatives:   * Alt 1: one *n-TimingAdvanceOffset* value per serving cell * Alt 2: up to two n-TimingAdvanceOffset value per serving cell for FR1 only |
| LGE | We support Alt 1.  Regarding concern 1, we have similar view as DOCOMO. In QC’s example, CC2 and CC3 can have same n-TimingAdvanceoffset value, since the CC2 and CC3 could be in the same band or in the same band combination. In other words, TAG1 and TAG2 in the example include the group of cells within the same band or within the same band combination. |
| Huawei, Hisilicon | Support Alt 2, it’s more flexible for deployment since ‘concern 2’ may exist. |
| Ericsson | Majority of the companies prefer Alt 1. We can discuss this proposal online and go for down-selection.  ***Proposal 7 – rev1*:** For multi-DCI multi-TRP operation with two TAs, down-select one of the alternatives:   * Alt 1: one *n-TimingAdvanceOffset* value per serving cell   Alt 2: up to two n-TimingAdvanceOffset value per serving cell   * Support Alt 1 **(13)**: Nokia/NSB, vivo, Samsung, Futurewei, OPPO, LGE, CATT, Ericsson, Xiaomi, Sharp, NTT Docomo, Spreadtrum, MediaTek, InterDigital * Support Alt 2 **(6)**: Huawei/HiSilicon, Qualcomm, Apple, ZTE, NEC, TCL |
| CATT | Support proposal 7- rev 1 and we prefer Alt.1. |

# 5 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 **(9 companies)**

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

*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***   **[Mod] As two TAGs are not agreed yet, we can keep TA for now in the description of the options. Of course if two TAGs per serving cell are agreed, we can update as you suggest.** |
| 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. |
| ZTE | We are open to further down-select among option 1 and option 2.  For option 1, we think it should beam-group specific instead of beam specific in Rel-18 due to only 2 TAs can be used in MDCI MTRP operation but more than two beams can be activated, hence we suggest to revise option 1 as follows.   * ***Option 1: Associate TA to a group of TCI-states/spatial relations***   **[Mod] we could say one or more TCI states instead.**  For option 2, given that 2 TAs aims for MDCI MTRP operation and in which *CORESETPoolIndex* is used to identify TRP-ID, this method can be workable to such UL signals/RSs in the legacy MDCI MTRP operation. |
| 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. |
| Xiaomi | Both opinions are workable and we prefer to associate TA to CORESETPoolIndex since it is used to identify M-TRP. |
| Huawei, Hisilicon | For the two alternatives, we prefer Option 1. We agree with MTK that Option 1 has a better forward compatibility and can be also used for L1 mobility topic which also includes TA enhancement. In addition, although the WID targets on TA enhancement of mDCI case, it doesn’t mean TA issue any exist for mDCI case. Under the scenario, if a UE has TA problem (e.g., TA gap of the two TRPs exceeds CP length) under a mDCI configuration, it will surely have the same TA problem under sDCI configuration. If TA association is based on CORESETPoolIndex, how can it be used to solve the TA issue under sDCI configuration?  However, considering the issue of Option 1 mentioned by QC that it cannot be used for FR1 if legacy TCI framework is adopted, here we suggest another Option in which TA/TAG is associated with PL RS. As PL RS is always used for UL transmission in any case, such kind of solution can be used for both FR1 and FR2, and can also be used for sDCI MTRP, mDCI mTRP and L1 mobility scenario.  ***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*** * ***Option 3: Associate TA or TAG to PL RS*** |
| Futurewei | For associating TAs to UL channels/signals, our view is that each TA is associated with a different TAG (e.g., with a different TAG ID). A TAG may be configured for a SSB/TRS resource. Any UL signals/channels QCLed to the SSB/TRS resource, directly or indirectly, are then associated with the TAG identified by the TAG ID. So on high level we are fine with ZTE’s modified Option 1 and Huawei’s Option 3.  Regarding Option 2, as we commented in previous meeting, there is an issue in supporting two TA enhancement for inter-cell multi-DCI multi-TRP scenarios. In Rel-17 inter-cell multi-DCI multi-TRP, in order to associate coresetPoolIndex to additional PCI, the coreset within the coresetPoolIndex needs to be activated with Rel-17 TCI state which includes additionalPCI-r17 info. However, since Rel-17 inter-cell multi-DCI multi-TRP is based on Rel-15/16 TCI framework, it is unclear how the Rel-17 TCI state can be utilized to associate the coresetPoolIndex with additionalPCI-r17. Also in Rel-15/16 TCI framework, the UL channels/signals configuration utilizes spatial information, instead of joint or UL TCI state defined in Rel-17 TCI framework, it is unclear how the coresetPoolIndex can be associated with additionalPCI-r17. |
| Samsung | Support Option 1, association of TA with UL/Joint TCI state or spatial relation. This solution can be applicable to all channels (on the other hand not all channels are associated with a CORESETPOOLIndex). It can easily be extended to inter-cell L1/L2 mobility. |
| Spreadturm | Support option2. Fot M-DCI based M-TRP, coresetPoolIndex always exists to be associated with one TRP, which is independent of FR, intra-cell or inter-cell. |
| Intel | Option-1, CORESETPoolIndex is not related to uplink transmission – TRP-1 can schedule uplink to TRP-2. Also uplink transmissions that are not DCI indicated cannot be handled with CORESETPoolIndex |
| Ericsson | In our view, the main advantages of opt1 are   * + it supports other scenarios,   + it is connected to UL transmissions in a systematic way   + it is simple to identify a DL timing reference |
| NEC | Support Option 1. |
| CMCC | Support the option 2. Our understanding is the TRP#1 will schedule one UE an UL transmission to TRP#1. Since the two TRPs are not ideally connected, that is the reason why we need multiple DCI scheduling. Or basically, one TRP should schedule the uplink transmission to itself. Then the UE could determine which TRP schedules the UL according to the CORESET pool index. |
| Sharp | We prefer Option 2. |
| vivo | Support option 2, in our view TA doesn’t change as dynamic as TCI states, option 2 simplifies the design |
| Transsion | We are open to down-select among option 1 and option 2.  For option 1, for M-DCI based M-TRP operation in Rel-18, the TCI states indicated by DCI are associated with different TRPs respectively, it is a straightforward solution. For option 2, with association between periodic/semi-persistent UL transmission (e.g. Type 1 configured grant PUSCH, PUCCH, SRS), it is a unified solution even for Rel-15/16 TCI framework. |
| Mod | Companies remain split between the two options. Some observations from the comments above:  Arguments in favor of Option 1:   * Option 2 needs further changes for some preconfigured UL channels/RSs (i.e., those not scheduled/triggered by CORESETs) * forward compatibility – the solution in Option 1 could be used for Rel-18 mobility where M-DCI may not be configured. * It is simple to identify DL timing reference with Option 1   Arguments in favor of Option 2:   * Option 1 may not work FR1 for a UE not supporting unified TCI framework (note that spatial relation does not exist for FR1) * Rel-17 inter-cell multi-DCI multi-TRP operation is based on Rel-15/16 TCI framework, and Option 1 may not be readily applicable to this scenario   Some companies suggest a compromise to adopt Option 1 for UEs that support unified TCI framework, and adopt Option 2 for UEs that do not support the unified TCI framework. Given the almost equal split between company preferences over the two options, we can further discuss the following compromised proposal:  ***Proposal 2 - Rev1: For associating TAs to UL channels/signals for multi-DCI based multi-TRP operation, support the following:***   * ***Association mode 1: For UEs that support unified TCI framework, associate TA to one or more joint/UL TCI-states*** * ***Association mode 2: For UEs that do not support unified TCI framework, associate each TA to a CORESETPoolIndex*** * ***Note that the gNB may configure either Association mode 1 or Association mode 2 depending on UE’s support of unified TCI framework.*** |
| Huawei, Hisilicon | We don’t agree with the revised proposal.  As mentioned by FL, there are several drawbacks of Option 1 and Option 2, like Option 1 cannot be used for FR1 and Option 2 has a poor forward compatibility to L1 mobiltiy. To solve these issues, we proposed Option 3 before. Here I propose it again.  The basic idea of Option 3 is that, DL RS like SSB can be divided into two groups, with each group corresponding to one TRP. For a UL transmission, if its PL RS belong to the first group, then the first TA is adopted. If its PL RS belong to the second group, the second TA is adopted. This is very simple and has no any above drawbacks of Option 1 and Option2. So, we think only Option 3 is enough. We don’t need to introduce two incomplete solution and configure them in different situation.  ***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*** * ***Option 3: Associate TA or TAG to PL RS*** |
| NTT DOCOMO | We prefer the previous proposal 2.  Regarding the proposal2 - Rev1, from our perspective, we don’t see the necessity to have two modes. Mode 2 is applicable to both unified TCI framework and Rel-15/16 beam management framework. |
| Google | Same as HW and DCM, we don’t favor the revised proposal. We support HW’s proposal. Further, we can support Option 1 and Option 3.  Our first preference is Option 1. As observations listed by FL, there is forward compatibility issue for Option 2. We should avoid the same debate happens again when Rel-18 mobility starts to discuss. In addition, it seems some companies have misunderstanding on Option 1. As ZTE mentioned, association with beam/TCI does not mean the number of TA values are above 2. One TA can be associated with one or more TCI states.  If Option 1 cannot be accepted by the Group, we can also live with Option 3. |
| ZTE | Basically, we fail to see *CORESETPoolIndex* is only used for non-unified TCI framework, which should be discussed in AI 9.1.1.1 instead of here. That means this updated proposal should be postponed until any related outcome can be obtained from the running discussion in AI 9.1.1.1, but that is quite premature. Hence this proposal should revert to the previous version in principle.  ***Proposal 2 - Rev1: For associating TAs to UL channels/signals for multi-DCI based multi-TRP operation, support the following:***   * ***Option 1: associate TA to one or more joint/UL TCI-states*** * ***Option 2: associate each TA to a CORESETPoolIndex***   Note that *CORESETPoolIndex* should be used anyways for both intra-cell and inter-cell operations when MDCI based MTRP in Rel-16/17, we support option 2 to reach a unified design as legacy. |
| Samsung | Preference is Option 1 of the previous proposal. For channels having an UL TCI state, association can be based on TRP used to transmit or receive the channel/signal |
| OPPO | We would like to repeat one of our argument on drawback of Option 1, which seemed not clearly captured.  That is if TA associated with indicated unified TCI (i.e. UL/joint TCI), it could result in two or more TAs per each TRP. For instance, there could be SRS resource set not configured with *followUnifiedTCIstateSRS-r17*, so these SRS resources with the set follows one UTCI #1, whereas PUCCH/PUSCH follow another UTCI #2. In this case, how to determine the associated TA for UL could be an open issue.  With this being said, we still prefer Option 2. |
| NEC | We are fine with HW’s update.  And we share the concerns to tie DL configuration (like CORESETPoolIndex) with every UL transmission. |
| Intel | Our preference is not to have such modes – we can keep option-1 and use FFS for the case of UEs not supporting UTCI framework in FR1. We are also OK with the proposal from Huawei and discuss down-selection further |
| LGE | We support the proposal 2 - Rev1 from FL. This can be the middle ground of two options. |
| Sharp | We are fine with ZTE’s proposal. We prefer to down select one solution to strive for simple and effective design as much as possible. Therefore, we support Option 2 (CORESETpoolIndex) that does not need to have two modes. |
| Ericsson | After some offline discussion, we have the following revised proposal. We can try downselection in RAN1#110bis-e:  ***Proposal 2 – rev2:***  ***For associating TAGs to target UL channels/signals for multi-DCI based multi-TRP operation, downselect one of the options in RAN1#110bis-e:***   * ***Option 1: Associate TAG to TCI-state/spatial relation*** * ***Option 2: Associate TAG to CORESETPoolIndex*** * ***Option 3: Associate TAG to PL RS*** * ***~~Option 4: Associate TAG to target UL channels/RSs~~***   Option 1 Supported by (**10 companies**): Huawei/HiSilicon, Samsung, MediaTek, LGE, Intel, CATT, Ericsson, Google, Transsion, NEC  Option 2 Supported by (**13 companies**): Qualcomm, ZTE, vivo, Apple, Xiaomi, Lenovo, Spreadtrum, Transsion, OPPO, Nokia, Sharp, NTT Docoomo, CMCC  Option 3 Supported by (**1 company**): Huawei/HiSilicon, Futurewei, Google |
| Huawei, Hisilicon | If my memory is correct, Google and Futurewei also showed their support on Option 3. If I am wrong, please correct me.  For Option 3, to make it more clear, we’d like to have following modification:  ***For associating TAGs to target UL channels/signals for multi-DCI based multi-TRP operation, downselect one of the options in RAN1#110bis-e:***   * ***Option 1: Associate TAG to TCI-state/spatial relation*** * ***Option 2: Associate TAG to CORESETPoolIndex*** * ***Option 3: Associate TAG to DL RS group. For a UL transmission, UE adopts the TAG associated with the DL RS group to which the PL RS of the UL transmission belongs ~~PL RS~~.*** * ***~~Option 4: Associate TAG to target UL channels/RSs~~***   Since no matter in which scenario UE need to determine a PL RS for a UL transmission, taking PL RS as an anchor to find the corresponding TAG is the most robust solution that can be applied for all cases including FR1, FR2, sDCI MTRP, mDCI mTRP, L1/L2 mobility and others. |
| CATT | Support proposal 2-rev2. |

# 6 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. |
| ZTE | Support FL’s proposal 4.  Regarding the update from Google, it is not proper to inter-cell MTRP operation where the additional cell is different from serving cell. Hence we think the original version from FL is accurate enough. |
| Nokia | Support |
| Xiaomi | Similar view with QC. |
| Huawei, Hisilicon | Support the updated version from Google which seems clearer. |
| Futurewei | Support in principle. Fine with Google’s updates. |
| Samsung | This can be further discussed based on the outcome of proposal 1. |
| Spreadtrum | Agree in principle. |
| Intel | Same view as QC, if 2 TAGs are associated then we don’t need this |
| Ericsson | Same view as QC. In addition, if we only have one TAG, and no other mechanism to update TA, then we can only have one timer. |
| NEC | Support two timers.  And we agree with QC that no need to discuss it if two TAGs configured in a serving cell.  (note that we support only one TAG for a serving cell.) |
| CMCC | Support the proposal. |
| Sharp | Same view as QC. |
| vivo | We can discuss this proposal later depending on progress on other proposals |
| Transsion | Support in principle. Fine with Google’s updates. |
| Mod | Given two TAGs per serving cell are agreed, each TAG will have its own configurable timer according to TAG configuration in current spec. Hence, as suggested by Qualcomm, we may not need an agreement for two time alignment timers, and we can close this proposal. Please let me know if there are other views. |
| Google | We agree with FL’s assessment. But maybe we need to send an LS to RAN2 to inform this (including agreement of 2 TAG)? |
|  |  |

# 7 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. |
| Intel | Same view as QC, TA acquisition for inter-cell mTRP should be discussed |
| Huawei, Hisilicon | For TAG configuration, only intra-cell MTRP case is considered by proposal 1. TAG configuration of inter-cell MTRP (e.g., TAG configuration for non-serving cells corresponding to configured addition PCIs) case should also be discussed. |

***FL Comment:*** We made an agreement on supporting two TAGs per serving cell in RAN1#110. Huawei commented above that the agreement only covers the intra-cell MTRP case. Huawei further suggest to discuss TAG configuration of inter-cell MTRP. FL would like to check companies views on the need for a separate proposal on TAG configuration of inter-cell MTRP.

***Question: Companies are asked to provide their view on the need for a separate proposal on TAG configuration of inter-cell MTRP (e.g., TAG configuration for non-serving cells corresponding to configured additional PCIs).***

|  |  |
| --- | --- |
| **Company Name** | **Comments** |
| Samsung | This could be handled in mobility WI |
| Huawei, Hisilicon | It should be discussed since two TAs enhancement for inter-cell M-TRP has been agreed. |
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# 8 References

[1] R1-2205919, ZTE, “TA enhancement for multi-DCI”, RAN1#110, August 2022.

[2] R1-2206025, vivo, “Discussion on two TAs for multi-DCI-based multi-TRP operation”, RAN1#110, August 2022.

[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.

[12] R1-2206247, Ericsson, “Two TAs for multi-DCI”, RAN1#110, August 2022.

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

[14] R1-2207451, Sharp, “Two TAs for multi-DCI”, RAN1#110, August 2022.

[15] R1-2207394, NTT DOCOMO, INC., “Discussion on two TAs for multi-DCI”, RAN1#110, August 2022.

[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.