
1 Introduction

RAN1 has received a RAN4 LS (R4-2214972: LS on active TCI state list for UL TCI) with the following content:

===== start of R4-2214972 =====

In RAN4 #103-e and RAN4 #104-e meetings, RAN4 has discussed UL TCI state switching delay requirements for unified TCI. The delay requirements are based on whether the pathloss reference RS in the TCI state is maintained or not.

In RAN1 #105, it's agreed that the UE maintains the PL-RS of the activated UL TCI state or (if applicable) joint TCI state, which is as follows:

Table 1:

<p>Agreement</p> <p>On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is either included in UL TCI state or (if applicable) joint TCI state or associated with UL TCI state or (if applicable) joint TCI state.</p> <p>Whether a UE supports “beam misalignment or not” (detailed definition FFS) between the DL source RS in the UL or (if applicable) joint TCI state to provide spatial relation indication and the PL-RS is a UE capability</p> <p>Note: The term “beam misalignment” is for discussion purpose only</p> <p>Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2</p>
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RAN1 agreed that UE shall maintain path loss reference RS for up to 4 activated UL (or joint) TCI states, but the number of active UL TCI states can be up to 8 based on UE capability. If the number of UL (or joint) TCI states in active TCI list is larger than 4, the UE behavior for maintaining the pathloss reference RS is unclear. RAN4 notes that there is no UE capability related to maintained pathloss reference RS in TS38.306.

In 38.213 section 7.1, the UE behavior is defined when UE is provided with more than 4 RSs:

”If the UE is provided a number of RS resources for pathloss estimation for PUSCH/PUCCH/SRS transmissions that is larger than 4, the UE maintains for pathloss estimation RS resources corresponding to RS resource indexes q_d as described in clauses 7.1.1, 7.2.1, and 7.3.1.”

UE will maintain pathloss estimation corresponding to RS resource indexes . However, it's not clear what's the relationship between and active TCI state list.

RAN4 would like clarification from RAN1/2 on maintained pathloss reference RS.

Question 1: What is the relationship between q_d and active UL (or joint) TCI state list? How does network

configure the RS resource indexes q_d ?

Question 2: Is UE expected to maintain the pathloss RSs of all the pathloss reference RS in the active UL (or joint) TCI list?

Question 3: What is the UE behavior when number of active UL (or joint) TCI states is larger than 4 if corresponding pathloss RSs need to be maintained?

===== end of R4-2214972 =====

This summary includes the following:

- Proposed LS replies to the LS from RAN4 R4-2214972
- Summary of companies' inputs on the proposed replies

2 Discussion

Each of the following sub-sections refers to one question from the LS. Once the answers converge, the draft LS content will be provided.

2.1 Question 1: What is the relationship between q_d and active UL (or joint) TCI state list? How does network configure the RS resource indexes q_d ?

Companies proposals based on the Tdocs:

Spreadtrum Communications: In Rel-17 for unified TCI framework, if a UE is provided *TCIState* in *dl-OrJoint-TCIStateList* or *UL-TCIstate*, *PL-RS* is associated with or included in *TCIState* or *UL-TCIstate* and used as q_d for obtaining the downlink pathloss estimate for PUSCH, PUCCH, and SRS.

When up to 8 joint TCI states and/or pairs of separate TCI states are activated, *PL-RS* can be associated with or included in each activated *TCIState* or *UL-TCIstate* in the active UL or joint TCI state list.

For *PL-RS* configuration, the parameter *pathlossReferenceRS-Id* is provided in the IE *TCI-State* or *UL-TCIstate* and this ID of reference signal (e.g. a CSI-RS config or a SS block) is used to determine the RS resource indexes q_d .

Vivo: RAN1 confirms that when *PathlossReferenceRS-Id* is provided in the UL (or joint) TCI state, q_d is the *PathlossReferenceRS-Id*. Otherwise, q_d would refer to the resource index of the QCL-Type D source RS included in the UL (or joint) TCI state in FR2. As for the relationship, according to the RAN1 specification description, pathloss RS is associated with the UL (or joint) TCI state, while the path loss reference RS index, i.e., q_d is included in the UL (or joint) TCI state.

Lenovo: Each UL TCI state (or joint TCI state applicable to UL channel/signal) is configured with a PL-RS by higher layer parameter *pathlossReferenceRS-Id-r17* in each UL (or joint) TCI state configuration.

For a PUSCH, PUCCH and SRS (which is configured with higher layer parameter *useIndicatedTCIState*) transmission, the UE determines a RS index q_d as an SSB resource or CSI-RS resource indicated by *pathlossReferenceRS-Id-r17* configured for the indicated unified UL(or joint) TCI state.

For the SRS that is not provided *useIndicatedTCIState*, a RS index q_d for obtaining a pathloss estimate for the SRS transmission is provided by PL-RS configured in the UL(or joint) TCI state of an SRS resource with lowest SRS-ResourceId in the SRS resource set.

ZTE: RAN1 confirms that q_d in TS 38.213 refers to active PL RS(s) (involving being-used PL-RS) for UL PUSCH/PUCCH/SRS transmissions. The RS resource indexes can be explicitly associated with UL (or joint) TCI state(s) for unified TCI by RRC.

LG Electronics: If the UL (or joint) TCI state configuration includes PL-RS configuration, q_d is same as the UL (or joint) TCI states that are activated by ‘TCI States Activation/Deactivation for UE-specific PDSCH MAC-CE’.

CATT: If the UE is configured and activated *dl-OrJoint-TCIStateList-r17*, q_d is associated with *dl-OrJoint-TCIStateList-r17*. If the UE is configured and activated *TCI-UL-State-r17*, q_d is included in the *TCI-UL-State-r17*.

RS resource indexes q_d is the index of the reference signal (SSB/CSI-RS) configured in *PUSCH-PathlossReferenceRS/PUCCH-PathlossReferenceRS*

Apple: As specified in clause 7 of TS 38.213, the ‘ q_d ’ refers to a RS index used for DL pathloss estimation for a UL transmission with an active UL or joint TCI state. For each UL or joint TCI state (regardless of active or deactivated), the associated RS index ‘ q_d ’ is explicitly configured using ‘pathlossReferenceRS-Id-r17’ sub-IE in ‘*dl-OrJoint-TCIStateList-r17*’ or ‘*TCI-UL-State-r17*’ IE by RRC signaling.

Samsung During Rel-17, RAN1 discussed whether there needs to be beam alignment between q_d and the spatial relation RS of the UL or Joint TCI state, but concluded to leave this to RAN4 to decide.

Ericsson: q_d indicates the RS the UE would use to estimate the pathloss for an UL transmission of PUSCH, PUCCH or SRS, and that RS would be one of the RSs in the activated UL (or joint) TCI states. For the unified TCI framework, the NW signals q_d by indicating (via DCI) which TCI state to use. If only one TCI state is activated by MAC CE, the DCI indication is not needed, and is determined from that single activated TCI state.

Proposed answer to Question 1:

Answer 1: According to 38.213, “the RS index for obtaining the downlink pathloss estimate for PUSCH, PUCCH, and SRS transmission is provided by *PL-RS* associated with or included in the indicated *TCIState* or *UL-TCIState*.”

[...]

”if *followUnifiedTCIStateSRS* is not provided for a SRS resource set and for a SRS resource from the SRS resource set, [...] a RS index q_d for obtaining a pathloss estimate for the SRS transmission is provided by PL-RS associated with or included in the *TCIState* or *UL-TCIState* of an SRS resource with lowest *SRS-ResourceId* in the SRS resource set”

During Rel-17, RAN1 **agreed UE capability on**~~discussed whether there needs to be~~**supporting beam misalignment** between q_d and the spatial relation RS of the UL or Joint TCI state, but concluded to leave **the detailed definition of beam misalignment**~~this~~ to RAN4 to decide.

[[**Moderator comment after round 1:** No updated answer! There are 9 company comments, everybody is OK with the proposed answer, except one company.: extending a bit the text from 38.213, as insicated by

Huawei. Reformulated the last bullet, majority of companies are fine with it, from my perspective it is good for RAN4 to know where we were with the RAN1 discussion and beam alignment/misalignment is linked to this topic as one may consider it when multiple TCI states are linked to the same PS-RS.]

Feedback Form 1: Feedback for Question/Answer 1

<p>1 – ZTE Corporation.</p> <p>We are fine for the first bullet, but for the second one, it seems not relevant to RAN4’s question that is to ask RAN1/RAN2 to clarify the configuration/activation procedure for q_d, instead of beam alignment or not.</p>
<p>2 – Oy LM Ericsson AB</p> <p>Support the moderator proposal.</p>
<p>3 – Qualcomm communications-France</p> <p>Suggest to modify the 2nd bullet as in ” ”: During Rel-17, RAN1 ”agreed UE capability on whether supporting beam misalignment” between q_d and the spatial relation RS of the UL or Joint TCI state, but concluded to leave the ”detailed definition of beam misalignment” to RAN4 to decide.</p>
<p>4 – Samsung Research America</p> <p>Support feature lead reply. Also fine with the proposed update from Qualcomm</p>
<p>5 – Spreadtrum Communications</p> <p>Support QC’s updated proposal.</p>
<p>6 – LG Electronics Inc.</p> <p>Support the FL’s answer and also fine with the QC’s version.</p>
<p>7 – Beijing Lenovo Software Ltd.</p> <p>Support QC’s version.</p>
<p>8 – HUAWEI TECHNOLOGIES Co. Ltd.</p> <p>As ZTE pointed out, we also think that there is no need to talk about beam misalignment as it seems unrelated to Q1. Further, we prefer the following exact quote from 38.213:</p> <p>”the RS index q_d for obtaining the downlink pathloss estimate for PUSCH, PUCCH, and SRS transmission is provided by <i>PL-RS</i> associated with or included in the indicated <i>TCIState</i> or <i>UL-TCIstate</i> except for SRS transmission that is not provided <i>followUnifiedTCIstateSRS</i>”</p> <p>”if <i>followUnifiedTCIstateSRS</i> is not provided for a SRS resource set and for a SRS resource from the SRS resource set,[...]a RS index q_d for obtaining a pathloss estimate for the SRS transmission is provided by <i>PL-RS</i> associated with or included in the <i>TCIState</i> or <i>UL-TCIState</i> of an SRS resource with lowest <i>SRS-ResourceId</i> in the SRS resource set”</p>

9 – Apple Poland Sp. z.o.o.

Support the first bullet. We do not see the relevance of 2nd bullet for the Q1. Adding it may cause unnecessary confusion.

Feedback Form 2: Feedback for updated Answer 1

1 – Samsung Research America

RAN4 has asked RAN1: "How does network configure the RS resource indexes q_d ". Therefore, we think that the part on beam alignment/misalignment between PL-RS and spatial RS is relevant.

2 – Apple Poland Sp. z.o.o.

We still think it is unnecessary to mention 'beam alignment' aspect as it is irrelevant to RAN4 question. Note that what RAN4 asked is 'how to configure', it is sufficient to point out that it is provided for each joint or UL TCI-state. Although the 'alignment/misalignment' is related to PL-RS, it was not asked by RAN4. There are many aspects for PL-RS, we do not need to list them for information. Instead, we should focus on the received question and provide a precise and direct answer

3 – HUAWEI TECHNOLOGIES Co. Ltd.

We also prefer not to discuss beam misalignment here

2.2 Question 2: Is UE expected to maintain the pathloss RSs of all the pathloss reference RS in the active UL (or joint) TCI list?

Companies proposals based on the Tdocs:

Spreadtrum Communications: According to RAN1 spec (section 7 in 38.213), a UE does not expect to simultaneously maintain more than four pathloss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions, except for SRS transmissions configured by SRS-PosResourceSet.

Thus, only when the number of pathloss RSs in the active UL or joint TCI list is equal to or less than 4, the UE can maintain all the pathloss RSs in the active UL or joint TCI list.

It can be realized based on network implementation that the number of pathloss RSs in the active UL or joint TCI list is not exceed 4.

Vivo: RAN1 had agreed that UE shall maintain path loss reference RS for up to 4 activated UL (or joint) TCI states, which means the maximum number of path loss reference RS UE can maintain is 4. Therefore, from RAN1 perspective, UE does not expect the number of path loss reference RS in the active UL (or joint) TCI list to be larger than 4. With this restriction, UE shall maintain the pathloss RSs of all the pathloss reference RS in the active UL (or joint) TCI list.

Lenovo: When the number of pathloss RSs configured all the active UL (or joint) TCI state(s) and the PL-RS determined for all the SRS resource sets for the UE is equal to or less than 4, the pathloss RSs of all the pathloss reference RS in the active UL (or joint) TCI state shall be maintained by the UE.

ZTE: No. Only first 4 path-loss RS(s) in the active UL (or joint) TCI state(s) are maintained, and for the rest, if any, the UE does not need to maintain them.

LG Electronics: Yes

CATT: In RAN1 #104-e meeting, it was agreed that the total number of maintained PL-RSs per CC is no more than 4.

Apple: Yes, a UE is expected to maintain the pathloss RSs of all active UL (or joint) TCI states. But the total number of pathloss RSs of all active UL (or joint) TCI states is not expected to be larger than 4.

Samsung Yes, the UE is expected to maintain the pathloss RSs of all the pathloss reference RS in the active UL or joint TCI list.

Ericsson: No, the UE is only required to maintain up to four pathloss RSs.

Proposed answer to Question 2:

Answer 2: A UE is expected to maintain the pathloss RSs of all active UL (or joint) TCI states. But the total number of **different** path-loss RSs of all active UL (or joint) TCI states is not expected to be larger than 4.

[[**Moderator comment after round 1:** No updated answer! There are 9 company comments, everybody is OK with the proposed answer, except one company.: answer 2 seems stable also based on the updated wording!]]

Feedback Form 3: Feedback for Question/Answer 2

<p>1 – ZTE Corporation.</p> <p>Not our preference, but we can live with that if supported by majority companies. One update for clarification:</p> <p>Answer 2: A UE is expected to maintain the pathloss RSs of all active UL (or joint) TCI states. But the total number of <u>different</u> path-loss RSs of all active UL (or joint) TCI states is not expected to be larger than 4.</p>
<p>2 – Qualcomm communications-France</p> <p>Fine with ZTE's change by adding "different"</p>
<p>3 – Samsung Research America</p> <p>Support moderator's reply. Also fine with update from ZTE.</p>
<p>4 – Spreadtrum Communications</p> <p>Fine with ZTE's updated reply.</p>
<p>5 – LG Electronics Inc.</p> <p>Fine with ZTE's modification on FL reply.</p>

6 – Beijing Lenovo Software Ltd. Fine with ZTE's update.
7 – HUAWEI TECHNOLOGIES Co. Ltd. OK with both FL original proposal and ZTE modification
8 – Apple Poland Sp. z.o.o. Ok with ZTE modification to make answer precise and clear.

Feedback Form 4: Feedback for updated Answer 2

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2.3 Question 3: What is the UE behavior when number of active UL (or joint) TCI states is larger than 4 if corresponding pathloss RSs need to be maintained?

Companies proposals based on the Tdocs:

Spreadtrum Communications: When the number of active UL or joint TCI states is larger than 4, a UE does not expect that the number of different pathloss RSs associated with or included in these up to 8 active UL or joint TCI states is larger than 4. There may be multiple active UL or joint TCI states with the same pathloss RS.

Vivo: It is more reasonable that the network configuration/activation should be based on the UE capability, which means the number of path loss reference RS in the active UL (or joint) TCI list should not be larger than 4. Thus, when the number of active UL (or joint) TCI states is larger than 4, some path loss reference RSs associated with the active TCI states should be the same.

Lenovo: The network should ensure that all the PL-RS configured for all the active UL (or joint) TCI states and the PL-RS determined for all the SRS resource sets which does not use the indicated TCI state is no more than 4.

ZTE: RAN1 confirms that when number of active UL (or joint) TCI states is larger than 4, and if corresponding pathloss RS of indicated TCI state is not maintained, the following in the case of NM = 1, as specified in Section 8.14.3 in TS 38.133, is reused.

LG Electronics: When the number of active UL (or joint) TCI states is larger than 4, UE still expect that the total number of PL RSs included in active UL/joint TCI states is smaller than or equal to 4, meaning that same PL-RS may be repeated across multiple UL/joint TCI states.

CATT: The UE behaviour is not specified in the current spec if active UL(or joint) TCI states is larger than 4. From RAN1's point of view, a predefined rule for UE behaviour can be specified for this case, e.g. UE can delete the pathloss RSs maintained according to order of the activated UL(or joint) TCI states ID or the pathloss RS ID.

Apple: A UE does NOT expect to receive a TCI state activation MAC-CE that activates a list of active UL (or joint) TCI states resulting in more than 4 pathloss RSs for measurement, which should be ensured by network

configuration. In any case, the maximum number of pathloss RSs maintained by the UE is up to 4.

- It is a valid configuration that the number of active UL (or joint) TCI states is larger than 4. However, in this case, one DL pathloss RS maybe associated with more than one active UL (or joint) TCI states such that the maximum number of pathloss RSs associated with more than 4 active UL (or joint) TCI states is still up to 4.

Samsung: The UE should not be configured to maintain more than 4 PL-RS. The same PL-RS can be used in more than one UL or Joint TCI states.

Ericsson: The selection of which pathloss RSs to maintain is up to UE implementation.

Proposed answer to Question 3:

Answer 3: The UE should not be configured to maintain more than 4 PL-RS. The same PL-RS can be used in more than one UL or Joint TCI states.

[**Moderator comment after round 1:** No updated answer! There are 9 company comments, everybody is OK with the proposed answer, except one company.

Answer to Ericsson: my interpretation is the following: it is a fact/agreement that the UE can maintain a maximum of 4 PL-RS, this is the first phrase of the answer. It is also a fact that the UE can be configured with more than 4 TCI states (something you desire), so one resolution to make this work is that the same PL-RS is used for more than one TCI state, something we say in the second part of the answer. If you have another proposal for this clarification, please let me/us know! If there is some sensitivity on the second part of the answer we can work on this... But in this moment I think Answer 3 is technically correct, not breaking any existing specification text]

Feedback Form 5: Feedback for Question/Answer 3

<p>1 – ZTE Corporation.</p> <p>Okay, but it seems that we have to endure the restriction of PL-RS configuration finally (especially for the UE only supporting beam alignment). As usual, the path loss RS is to reuse the same RS for QCL TypeD in TCI state.</p>
<p>2 – Qualcomm communications-France</p> <p>Fine for the FL's answer</p>
<p>3 – Samsung Research America</p> <p>Support moderator's answer</p>
<p>4 – Spreadtrum Communications</p> <p>Support moderator's reply.</p>
<p>5 – Oy LM Ericsson AB</p> <p>Don't support. The (only) reasonable configuration is that each TCI state contains a different PL-RS. With the proposed answer, the UE could never support more than 4 active TCI states.</p>

6 – LG Electronics Inc. Support FL’s answer.
7 – Beijing Lenovo Software Ltd. Support FL’s answer.
8 – HUAWEI TECHNOLOGIES Co. Ltd. Support FL’s answer
9 – Apple Poland Sp. z.o.o. Support FL’s answer.

Feedback Form 6: Feedback for Answer 3

<p>1 – Oy LM Ericsson AB</p> <p>RAN4 asked:</p> <p>2.3 Question 3: What is the UE behavior when number of active UL (or joint) TCI states is larger than 4 if corresponding pathloss RSs need to be maintained?</p> <p>RAN4 did not specifically ask “if they all have different PL-RS”, but I think that is implied. The configuration possibility is there, and it is valid. Stating that this can be avoided by network configuration is not an answer to the question “what is the UE behaviour when...”.</p> <p>As we see it, there are two possible ways the UE could act:</p> <ul style="list-style-type: none">- It could reject the RRC configuration- It could select which PL-RS to “maintain” <p>Like CATT commented, RAN1 could have defined a rule which PL-RSs to “maintain”, but it’s too late for that now. When something is not described in the specification, it is usually up to implementation – in this case up to UE implementation. But the proposed response hints to that it is an incorrect configuration, which would imply that a UE could reject the RRC configuration.</p> <p>It is good that RAN4 sent us this, because it is important to know. The configuration where we configure the same PL-RS in multiple TCI states is not really workable from a performance point of view. Note that this would also imply that the QCL-TypeD RS and the PL-RS would be different.</p> <p>As we see it, the response should be either “error case” or “up to UE implementation”.</p>

2 – Samsung Research America

Question to Ericsson, if the UE is configured with more than 4 active TCI states that have more than 4 PL-RS. The UE selects 4 PLSR to maintain. If the UE is signaled a TCI state whose PL-RS is not being maintained by the UE, what will the UE do in this case? For example, UE has active TCI states with PL-RS A, B, C, D and E. UE maintains PL-RS: A, B, C and D. UE is indicated TCI state with PL-RS E to use for UL Tx. UE doesn't have the PL corresponding to PL-RS E, what will the UE do for that UL TX.

3 – Apple Poland Sp. z.o.o.

We share the same question as Samsung. In our view, if the case happens in real network, it may cause un-predicable UL interference if the associated PL is not maintained at UE side. One potential use case, not sure it is really useful or not, the PL-RS maybe used a wider beam e.g., SSB and the QCLED RS in UL TCI-states maybe based on narrow beam CSI-RS. In this case, it is possible 4 PL-RS with more than four UL TCI-states.

3 Annex

The following input Tdocs were submitted:

Table 2:

R1-2208532	Draft reply LS on active TCI list for UL TCI	Spreadtrum Communications
R1-2208583	Draft reply LS on active TCI state list for UL TCI	vivo
R1-2208750	Draft reply LS on active TCI state list for UL TCI	Lenovo
R1-2208757	Draft reply LS to RAN4 on active TCI state list for UL TCI	ZTE
R1-2208758	Discussion on issues raised in RAN4 LS on active TCI state list for UL TCI	ZTE
R1-2208799	Discussion on LS on active TCI state list for UL TCI	OPPO
R1-2208888	Draft reply LS on active TCI state list for UL TCI	LG Electronics
R1-2208944	Draft reply LS on active TCI state list for UL TCI	CATT
R1-2209554	Draft reply LS on active TCI state list for UL TCI	Apple

R1-2209687	Draft reply LS on on active TCI state list for UL TCI	Samsung
R1-2210091	Draft reply LS on active TCI state list for UL TCI	Ericsson
R1-2210218	Discussion on the RAN4 LS on active TCI state list for UL TCI	Huawei, HiSilicon