3GPP TSG RAN WG1 #101 R1-200xxxx

e-Meeting, May 20th – June 5th, 2020

Source: Moderator (OPPO)

Title: Discussion on Issue#b-6 in Email Thread 1

Agenda Item: 7.2.6.2

Document for: Discussion and Decision

1. Introduction

Rel-16 enhancement on MIMO WID includes objectives of enhancing multi-TRP/Panel transmission with ideal and non-ideal backhaul. During the work of rel-16, designs for multiple-PDCCH based and single-PDCCH based multi-TRP/Panel transmission were discussed and specified. This document provides the discussion for Issue #b-6 in multi-TRP email thread 1:

* Issue #b-6: Default TCI-state for PDSCH of Scheme 3 and Scheme 4

# Issue#b-6: Default TCI-state for PDSCH of Scheme 3 and Scheme 4

**Background**:

As specified in TS 38.214, the UE applies default TCI states of single-DCI based M-TRP on PDSCH of single-DCI based transmission the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL*. Companies [1] [7] [8] [11] [13] [14] [15] [16] [17] proposed designs of default TCI state particularly for PDSCH of URLLC scheme 3 and scheme 4. Their proposal can be summarized as the following three different categories:

1. vivo [1], Ericsson [17] and Lenovo [7] proposed to use the offset of **each** PDSCH transmission occasion to determine whether default TCI state(s) shall be applied or not.
   * Both vivo [1] and Ericsson [17] proposed that default TCI state(s) of single-DCI based M-TRP shall be applied based on the offset per PDSCH transmission occasion in Scheme 3 (proposed by [1]) or Scheme 4:
     + For a PDSCH transmission occasion with offset < *timeDurationForQCL*, one of the default TCI states of single-DCI based M-TRP is applied. The mapping between default TCI states and PDSCH transmission occasion follows the mapping rule between the indicated TCI states and PDSCH transmission occasion.
     + For a PDSCH transmission occasion with offset >= *timeDurationForQCL,* one of the indicated TCI state is applied.
   * Lenovo [7] proposed to specify the case when the indicated RepNumR16 is > 2 and CycMapping or SeqMapping is configured for scheme 4:
     1. When RepNumR16 is > 2 and CycMapping is configured:
        + if the scheduling offset between the reception of the DL DCI and the first PDSCH is less than the threshold timeDurationForQCL, while the scheduling offset between the reception of the DL DCI and the second PDSCH equal to or greater than the threshold timeDurationForQCL, the first TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states and the second indicated TCI state by the TCI field in the scheduling DCI are applied to the first and second PDSCH transmission occasions, respectively, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions. Otherwise, if the scheduling offset between the reception of the DL DCI and the second PDSCH is less than the threshold timeDurationForQCL(the scheduling offset between the reception of the DL DCI and the first PDSCH is also less than the threshold timeDurationForQCL), the first TCI states and the second TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states are applied to the first and second PDSCH transmission occasions, respectively, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.
     2. When RepNumR16 is > 2 and SeqMapping is configured:
        + if the scheduling offset between the reception of the DL DCI and the first PDSCH is less than the threshold timeDurationForQCL, and the scheduling offset between the reception of the DL DCI and the third PDSCH is larger than the threshold timeDurationForQCL, while the scheduling offset between the reception of the DL DCI and the second PDSCH equal to or greater than the threshold timeDurationForQCL, the first TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is applied to the first and second PDSCH transmissions occasions, and the second indicated TCI state by the TCI field in the scheduling DCI is applied to the third and fourth PDSCH transmissions, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions. Otherwise, if the scheduling offset between the reception of the DL DCI and the third PDSCH is less than the threshold timeDurationForQCL, the first TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is applied to the first and second PDSCH transmissions occasions, and the second TCI state corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is applied to the third and fourth PDSCH transmissions occasions, and the same TCI mapping pattern continues to the remaining PDSCH transmission occasions.
2. Samsung [8], Spreadtrum [11], Nokia [14], NEC [15] and NTT DOCOMO [16] proposed to use the offset of **1st** PDSCH transmission occasion to determine whether default TCI state(s) shall be applied or not:
   * the default TCI states of single-DCI based M-TRP are applied to all the PDSCH transmission occasions in Scheme 3 and Scheme 4 if the 1st PDSCH transmission occasion has offset < *timeDurationForQCL* and the mapping between the TCI states of those default TCI states of single-DCI based M-TRP and the PDSCH transmission occasion follows the rule specified for indicated TCI states.
3. Apple [13] that the UE shall apply the rel15 PDSCH default TCI state when scheme 3 or scheme 4 is configured. They explained that the feature of default TCI states of single-DCI M-TRP shall not be applied to scheme 3 and scheme 4.

So, we have three different alternatives on the design for scheme 3 and scheme 4 and we need down-select one:

**Proposal: In single-DCI based multi-TRP transmission, the default TCI state for scheme 3 and scheme 4 is down-selected from:**

* **Alt1: The UE use the time offset between the DCI and the *n*-th PDSCH transmission occasion to determine the TCI-state for *n*-th PDSCH transmission occasion:**
  + **If the time offset between the DCI and the *n*-th PDSCH transmission occasion is less than the threshold, one of default TCI state of single-DCI based multi-TRP is applied on the reception of *n*-th PDSCH transmission occasion. The mapping between the default TCI state to the PDSCH transmission occasion follows what is specified for the indicated TCI states.**
  + **If the time offset between the DCI and the *n*-th PDSCH transmission occasion is greater than or equal to the threshold, the corresponding TCI state indicated in the TCI field is applied on the reception of *n*-th PDSCH transmission occasion.**
* **Alt2: When the time offset between the DCI and the** **1st PDSCH transmission occasion is less than the threshold, the two default TCI-states are applied to PDSCH transmission occasions, respectively. The mapping between default TCI states and PDSCH transmission occasions follows the mapping specified for indicated TCI states in Section 5.1.2.1 in TS 38.214.**
* **Alt3: Rel-15 default TCI state is applied on Scheme 3 and Scheme 4.**

Please input your views and comments on these three alternatives:

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| --- | --- |
| Company | Views and comments |
| vivo | We support Alt 1.  What we are concerning is the performance for Scheme 3 and Scheme 4.  For Scheme 4, the repetition number comprises of {n2, n3, n4, n5, n6, n7, n8, n16}, which means much more PDSCH repetitions could be with offset larger than the threshold {s7, s14, s28}. When the offset of the first PDSCH repetition is less than the threshold, Alt 2 would cause performance degradation. Actually, for those repetitions with larger offset than the threshold, the indicated TCI states are to achieve the desired reliability. On the other hand, for Alt 2, if the network wants to transmit the PDSCH repetitions with the indicated TCI states, it has to schedule the first PDSCH repetition with larger offset than the threshold, which of cause would lead to some delay which may not meet the requirement of URLLC.  Alt 3 of cause have similar problem on performance as Alt 2. |
| CATT | Alt2 is preferred.  For alt1, in scheme 3, if the scheduling offset of the first repetition is less than the threshold, and TCI state A(one of the default TCI state) is applied for the first repetition, while the time offset of the second repetition is greater than or equal to the threshold, and one of the indicated TCI states (TCI state B) is applied for the second repetition, and if the default TCI state (TCI state A) for the first repetition and the indicated TCI state (TCI state B) are same, it’s actually a single-TRP intra-slot repetition transmission scheme with dynamic repetition number, which has never been discussed in Rel-16.  For alt 3, according to past agreement, supporting of 2 default beams is optional to UE. However, there isn’t any agreement prohibiting the use of two default beams in scheme 3 and 4 for the UE which is capable of supporting the default QCL mechanism introduced in Rel-16. Actually, at least for scheme 3, one of the motivations for supporting two default beams is to enable mTRP-based URLLC transmission with lower latency. |
| MediaTek | Alt2 is preferred. Alt1 is some optimization that should be avoided in the maintenance stage. If the gNB decides to indicate different TCI states in a DCI other than the default ones, it normally means that the default TCI state(s) are not good enough. Then, we would like to see some evidence, e.g., simulation results, showing Alt1 can bring some substantial gain than Alt2. As for Alt3, since the SDM scheme and one of the TDM schemes can be dynamically indicated, Alt3 may require a UE to equip with up to 3 Rx beams, one for R15 default TCI state and two for R16 default TCI states.  A similar clarification should also be made for the SDM scheme and the two FDM schemes. ZTE’s proposal can be a starting point: “*Two indicated TCI states can be replaced by the two default TCI states. The mapping among the default TCI states, DMRS ports and the allocated time/frequency resources can follow the case when the offset between PDCCH and the corresponding PDSCH is larger than the threshold.*” |
|  |  |
| ZTE | We are fine with either Alt.1 or Alt.2.  Alt.3 is unacceptable since it makes URLLC scheme 3 useless in FR2.  As MediaTek mentioned, the similar clarification should be made **on SDM scheme and FDM schemes** for the mapping between two default TCI states and allocated DMRS ports/PRBs. So if Alt.2 is agreed, it can be extended as follows for all of scheme 3, 2a, 2b and 1a.  “Two indicated TCI states can be replaced by the two default TCI states. The mapping among the default TCI states, DMRS ports and the allocated time/frequency resources can follow the case when the offset between PDCCH and the corresponding PDSCH is larger than the threshold.” |
| Spreadtrum | Support Alt.2.  In Rel-15, for multi-slot PDSCH in a single TRP case, we have the following specification:  *When the UE is configured with a multi-slot PDSCH, the indicated TCI state should be based on the activated TCI states in the first slot with the scheduled PDSCH, and UE shall expect the activated TCI states are the same across the slots with the scheduled PDSCH.*  We should inherit the same principle of R15 to apply it for scheme 3 and 4 for multi-TRP case, i.e., TCI state for each PDSCH depending on the first PDSCH occasion. gNB can ensure the performance by configuring proper default TCI states for UE. Thus, we prefer Alt.2. |
| NTT DOCOMO | Our 1st preference is Alt.2, second preference is Alt.1. Alt.3 is not preferred since it cannot support dynamic switching between SDM and TDM schemes. |
| QC | We support Alt2. Also, it should be clarified that the proposal is only applicable for the case that UE supports two default QCL assumptions. Agree with MTK and ZTE regarding the fact that two indicated TCI states can be replaced with two default TCI states not only in TDM but also for SDM and FDM.  In addition, as mentioned in the previous e-Meeting, Alt1 can result in 3 or 4 TCI states for scheme 4, which is against the agreement below:  **Agreement**  For single-DCI based M-TRP URLLC scheme 3 & 4   * The maximum number of TCI states is 2 |
| Apple | Support Alt 2. |
| Nokia | Support Alt.2.  The reasoning of Vivo on supporting Alt.1 is mainly using the higher number of repetitions in Scheme 4. However, it is hard to imagine latency-critical use case where UE scheduled repetitions larger than 2 or 3. The higher number of repetitions are more applicable when the latency targets are not critical compared to reliability requirements. In such cases, it is possible to have a larger offset between PDCCH and PDSCH such that the indicated TCI states can be used. Therefore, we do not see any additional benefits from Alt.1 over Alt.2. |
| NEC | Alt 2. And we also agree with ZTE that this should be applied to scheme 2a and 2b. |
| Samsung | We prefer Alt2.  Besides, we need to specify for the case when enhanced default beam is not enabled. Support of enhanced default beam is optional but current Alt1 and Alt2 only focus the case when enhanced default beam is enabled. To make complete solution, we suggest to modify Alt2 as follows.   * **Modified Alt2: When the time offset between the DCI and the 1st PDSCH transmission occasion is less than the threshold, and two default TCI-states are activated, the two default TCI-states are applied to PDSCH transmission occasions, respectively. The mapping between default TCI states and PDSCH transmission occasions follows the mapping specified for indicated TCI states in Section 5.1.2.1 in TS 38.214.**   + When single default TCI state is activated, the default TCI state is applied to all PDSCH transmission occasions, respectively.   When single default TCI state is activated, we suggest to apply the TCI state to all transmission occasions to ensure consistent UE behavior between the cases when default beam is enabled or not. |
| OPPO | Alt.2. It is not preferred to introduce 4 TCI states for scheme 3 and scheme 4. |
| Lenovo/MOT | We support Alt.1 and prefer our original proposal.  For Scheme 4 with RepNumR16 is > 2 and the scheduling offset between the DCI and the 1st PDSCH transmission is less than the threshold while the scheduling offset between the DCI and the 2nd PDSCH transmission is greater than the threshold, the indicated TCI state can be apply to the second PDSCH and the corresponding later PDSCH for better performance. And only up to two TCI states should be used for Scheme 4. |
| Ericsson | Although we proposed Alt 1 in our contribution, we are also fine to support Alt 2 as Alt 2 seems to be the majority view.  We notice that 2-3 companies are proposing to extend Alt2 to also other schemes such as schemes 2a, 2b and 1a. But this is essentially the proposal in Issue#b-5 from the original feature lead summary in prep phase. Since Issue#b-5 is not picked to be discussed in this email thread, we prefer to discuss whether Alt2 can be extended to schemes 2a, 2b, and 1a in a future meeting. |

1. Reference
2. R1-2003397 On remaining issues on M-TRP vivo
3. R1-2003469 Maintenance of multi-TRP enhancements ZTE
4. R1-2003531 Remaining issues on multi-TRP in R16 Huawei, HiSilicon
5. R1-2003627 Discussion on remaining issues of multi-TRP/panel transmission CATT
6. R1-2003660 Remaining issues on multi-TRP transmission MediaTek Inc.
7. R1-2003742 Corrections to multi-TRP Intel Corporation
8. R1-2003819 Remaining issues on multi-TRP/panel transmission Lenovo, Motorola Mobility
9. R1-2003881 On Rel.16 multi-TRP/panel transmission Samsung
10. R1-2003928 Text proposals on enhancements on multi-TRP/panel transmission LG Electronics
11. R1-2003954 Remaining issues on multi-TRP/panel transmission CMCC
12. R1-2003987 Discussion on remaining issues of multi-TRP operation Spreadtrum Communications
13. R1-2004047 Text proposals for enhancements on multi-TRP and panel Transmission OPPO
14. R1-2004229 Remaining issues for Multi-TRP enhancement Apple
15. R1-2004265 Maintenance of Rel-16 Multi-TRP operation Nokia, Nokia Shanghai Bell
16. R1-2004311 Remaining issues on multi-TRP transmission NEC
17. R1-2004395 Remaining issues on multi-TRP/panel transmission NTT DOCOMO, INC
18. R1-2004432 Remaining issues on Multi-TRP/Panel Transmission Ericsson
19. R1-2004463 Multi-TRP Enhancements Qualcomm Incorporated
20. R1-2004592 Clarification on Multi-TRP URLLC Scheme 4 Convida Wireless
21. R1-2004719 FL summary #2 for Multi-TRP/Panel Transmission Moderator(OPPO)