**3GPP TSG RAN WG1 #101 R1-2004797**

**e-Meeting, May 25th – June 5th, 2020**

Source: moderator (vivo)

Title: Feature lead summary on [101-e-NR-eMIMO-ULFPTx-01]

Agenda Item: 7.2.6.4

Document for: Discussion and Decision

1. Introduction

Per guidance from Mr. Chairman, this is to kick-off following email discussion, please provide your views below.

[101-e-NR-eMIMO-ULFPTx-01] Additional entries of full power TPMI grouping indication with Mode 2 operation by 5/29 and corresponding TP (if any) by 6/5 – Rakesh (vivo)

* Issue 1 of the FL summary
* Companies are encouraged to provide simulation results
* Note that having this email thread does not automatically mean that additional entries will be included into the specification

For reference, the agreement from RAN1#99 is copied below.

**Agreement**

For 4 ports, number of bits to indicate TPMI(s) which can deliver UL full power:

* + Non Coherent 2 bits
	+ Partial coherent 4 bits
		- Additional entries on top of existing entries may be added to table 1 and table 2
	+ Whether is this capability reporting is optional or not will be discussed as part of UE capability discussions

Table 1.

|  |  |
| --- | --- |
| 4Tx, nonCoherent | 4Tx, partial coherent (4bit) |
| G0 | G0 |
| G1 | G1 |
| G2 | G2 |
| G3 | G3 |
|  | G4 |
|  | G5 |
|  | G6 |
|  |  |

Definition of G0~G6 can be found in the table below.

Table 2.



1. Remaining issues
	1. Issue 1: Additional entries of full power TPMI grouping indication with Mode 2 operation

There are diverging views/proposals on this issue in contribution submitted in this RAN1#101-e and following alternatives are listed:

Alt1: Whether to revise the number of bits for partial coherent case? i.e. revise the bit size to 3bits for 4Tx partial coherent

Alt2: Whether to revise TPMI groups G0~G6? i.e. revise the existing TPMI groups

Alt3: Whether to introduce more TPMI groups for 4Tx partial coherent? If yes, how many groups and TPMI group details

|  |  |
| --- | --- |
| Company | Comment |
| ZTE | For Alt 1, we do not agree to reduce the bit size to 3bits, because it means the number of supported UE PA architectures will be reduced from 16 to 8 for partial-coherent case. From the technical perspective, it make no sense to penalize this functionality by restricting the diversity of UE implementation. Instead, some more types of the partial-coherent 4-Tx UE with different PA architectures should be captured to optimize this functionality.For Alt 2, we propose to adopt the following modifications, because there are still some obvious logical leaks of the existing G0 to G6.* Considering the beam-forming gain from partial-coherent ports, precoding matrices , ,  and  should be added in the existing G1 and G2.
* In order to optimize TPMI group based full power capability reporting, entries of TPMI groups should be decoupled as much as possible and corresponds to independent PA architectures and coherent capabilities. Based on that, G3 is a redundant entry of G5 and should be removed accordingly.

For Alt 3, we propose to add six new TPMI groups, which are G0+G4, G0+G5, G1+G5, G0+G6, G1+G6 and G2+G6, with the following comments. * From the perspective of permutation and combination of antenna ports PA architecture, there are 76 out of 81 types of the partial-coherent 4-Tx UE should be captured. However, the size of partial-coherent 4-Tx UE is 4 bits, up to 16 TPMI groups can be adopted.
* As a middle ground between signaling overhead and supported UE types, if just consider the PA combination architecture, there are only 12 out of 15 types of the partial-coherent 4-Tx UE need to be captured. Further, the existing G0 to G6 have captured 6 PA combination architectures. Therefore, it is only need to capture the remaining 6 PA combinations.
* Based on the first two reasons, it is recommended that the maximum power value of PA for each port obey the following rule: port {1000} ≥ port {1002} ≥ port {1001} ≥ port {1003}. Correspondingly, G0+G4, G0+G5, G1+G5, G0+G6, G1+G6 and G2+G6 should be introduced.
 |
| Huawei, HiSilicon | 1. The TPMIs for , ,  and are obviously missing in the TPMIs reporting groups G1/2/3 for partial coherent UEs during the discussion stage. Since the TPMI for rank-2 [1 0 0 0; 0 0 1 0] is supported for full power transmission in G1/2/3, the same two antennas (1st and 3rd ) should be also support full power transmissions for the partial coherent UE. So, the missing 4 TPMIs are at least need to be included.

Please note that, in the coverage limited cases, for rank-1 full power transmission, the two antennas transmission with [1 0 1 0], [1 0 -1 0], [1 0 j 0] and [1 0 –j 0] is with beamforming gain compared to only with one antenna transmission, such as [1 0 0 0] and [0 1 0 0]. The simulation results are shown as in **Figure-1**. And we also provided the simulation results on performance comparison on the whole partial coherent rank-1 codebook with G1 for full power, and the whole partial coherent rank-1 codebook with G1+4TPMIs for full power transmission in **Figure-2**.Then, use Alt.2 just add the four TPMIs in the exist G1/2/3, or just add new 3 TPMI groups as Alt.3, i.e., the 4 TPMIs+G1/2/3. We are fine both of alternatives. cid:image001.jpg@01D62FC0.6F7233F0Figure-1 The performance with adding the missing 4 TPMIs (G1 and G1+4TPMIs)C:\Users\z00221589\AppData\Roaming\eSpace_Desktop\UserData\z00221589\imagefiles\86A5F101-6DBD-48E6-AE95-10232512814C.pngFigure-2 The performance with adding the missing 4 TPMIs (the whole partial coherent rank-1 codebook with G1 full power and the whole partial coherent rank-1 codebook with G1+4TPMIs for full power)1. Since there is 4 bits for UE reporting agreed for 4Tx, we are fine to add more TPMI groups to reflect the true PA architectures as ZTE proposed to minimize the UE architecture restrictions for full power transmission.
 |
| Apple | We think this is the sequence of the questions that we need to answer Alt3: Whether to introduce more TPMI groups for 4Tx partial coherent? If yes, how many groups and TPMI group details We think more TPMI is needed. The current 7 TPMI groups cannot provide full flexibility in terms of UE capability reporting to address all the possible UE PA architecture and implementation decision. Alt2: Whether to revise TPMI groups G0~G6? i.e. revise the existing TPMI groupsWe slightly prefer to revise excising TPMI group Alt1: Whether to revise the number of bits for partial coherent case? i.e. revise the bit size to 3bits for 4Tx partial coherent Too early to answer, we need to reach a conclusion whether we will add new groups first.  |
| Samsung | First, Alt2 is not within the scope this email discussion, and also beaks the previous agreement made in RAN1#99, so, it should be removed. I deleted it from above.Now, we support Alt1 due the following reasons.* The current spec is not broken (hence beyond the scope of normative maintenance work)
* Additional TPMI groups is a minor optimization of this feature, hence is non-essential
* Additional TPMI groups, if any, will bring small performance gain.
* There is hardly any quantitative analysis (simulation results) provided by the proponents supporting additional TPMIs. Without any simulation analysis, it is unclear how the need for additional TPMI groups can be discussed.

Re the argument about missing PA combinations or/and missed TPMIs, we would like understand the following:* Is there any PA combination which can’t be supported (may not be optimized) by the agreed G0-G6?
* If yes, are they really important for real UE implementations?
* If no, there is at least one TPMI among G0-G6 that supports a given PA combination. Then, why do we need another TPMI group for the given PA combination. The proponents need to provide simulation results in support of their proposals in order to understand the need for any additional TPMI groups.
 |
| NTT DOCOMO | Regarding Alt1, we do not agree on reducing the bit size from 4 bits to 3 bits at this stage. This is because, as per our understanding, the current TPMI groups cover only a limited number of PA architectures. Regarding Alt2, one thing we need to clarify is whether there are two TPMI group tables for non-coherent and partial-coherent UEs. It seems, there are different understandings between companies about this fact. In case if there are different TPMI group tables, we are fine with updating existing entries.Regarding Alt3, we support introducing new TPMI groups to partial-coherent UEs for allowing more PA architectures to benefit from UL full power feature. However, we think companies should first align their understanding on following points:1. Regarding the coherent port combinations of 4Tx partial-coherent UE, it is generally understood that, port pairs {0, 2} and{1, 3} are coherent. We should respect this port coherency when designing new TPMI groups. Hence, new TPMI groups for partial-coherent UEs need to consider antenna port switching is applicable only between coherent ports
2. While complying to 1 above, the mapping rule between Tx chain and antenna port is up to the UE implementation. In other words, if a given TPMI can provide UL full Tx power for PA architecture , then that TPMI can provide UL full Tx power for PA architecture as well

These are reasonable considerations and with these, all possible PA architectures (as shown in our tdoc R1-2004397) can be covered with 8 new TPMI groups. In particular, we believe TPMI groups, #1, #2, #6, #14, #15, #16, #17 and #19 in the Annex are enough to cover all possible PA architectures  |
| InterDigital | Alt1: Supported. As it provides adequate resolution to support a wide range of PA configurations. Also, it helps to reduce unnecessary overhead.Alt2: Not a valid alternative to be considered. Per chairman’s guidance, it is clearly out of the scope of this email thread.Alt3: Do not support. The current specification already supports many different PA configuration. Also, it is not clear to us whether there is sufficient technical evidence to justify introducing additional TPMI groups. |
| QC | Alt 1: Do not support. Alt 2: Support revise G1/G2/G3 for partial coherent UEs, because apparently, the agreement made before has an error not including partial coherent precoders ,,, in G1/G2/G3. An error is an error. Let’s admit it and correct it. Alt 3: we are in general supportive to add more entries for TPIM grouping for partial coherent UEs. However, just a reminder to the group, we should not use up all 9 reserved entries. The reason is that, I believe that NO UE vendor is building 4 Tx UEs now. We are proposing new entries based on what we believe are reasonable PA combinations now. No one can make sure that we have exhausted all reasonable PA combinations for 4 Tx UEs. If in the future, based on new requirements, a certain PA combination becomes interested to pursue but we already used up all entries, which is a situation we want to avoid. Therefore, I suggest we just add 3 or 4 new entries that are necessary, and leave 5 or 6 entries reserved for future. To facilitate the discussion, I suggest, let’s identify the additional PA combinations that are necessary to add, rather than discuss which TPMI groups to add. It is much easier to understand the motivation by looking at a proposed new PA combination rather than a TPMI group. After we identify those additional PA combinations, agreeing on the TPMIs should be very straightforward. In particular, QC think the following PA combinations are beneficial and should be added for partial-coherent UEs. * G7: (23+20) + (17+17) dBm
* G8: (23+23) + (20+20) dBm
* G9: (23+23) + (23+23) dBm

Notation wise, the two PAs in () are coherent, and the PAs in different () are non-coherent. With G7, a UE can conveniently support full power with PUCCH/PRACH by putting PUCCH/PRACH transmission on antenna port 0, without extra effort to implement S-CDD to support full power for PUCCH/PRACH. For PUSCH full power transmission, it can support G0+G4. With G8, the UE can support full power with any precoder in 2Tx codebook when it reduced to a 2 Tx UE in case of max number of MIMO layers is reduced to 2 in BWP switch. On top of that, as a 4 Tx UE, it can support full power with both pair of coherent PAs. When on pair of coherent antennas gets hand-blocked, it allows NW to switch precoders to transmission full power with the other pair of coherent PAs. With G9, the UE can support full power with any partial and noncoherent precoders either as a 4 Tx UE or reduced to a 2 Tx UE. Rel-16 should allow and support this “super UE”, which give NW full flexibility to schedule PUSCH with any precoder even at cell edge. |
| CATT | For a 4Tx partial-coherent UE with 2 full-rated PAs, all TPMIs in G1 and G4 can deliver full power. For a 4Tx partial-coherent UE with 3 full-rated PAs, all TPMIs in G2 and G5 can deliver full power. It is suggested to introduce two additional TPMI groups, e.g. TPMI groups with G1+G4, and G2+G5.  |
| OPPO | Alt.1: Not support. It is not a good way to revert previous agreement at the maintenance stage. Moreover, reduction of reporting bits will introduce unnecessary restriction on UE implementationAlt.2: Not support. It is not a good way to revert previous agreement at the maintenance stage. A partial-coherent UE have the flexibility to support full power transmission by non-coherent TMPI. The revised TMPI grouped (e.g., suggested by Huawei, QC) can be added to the whole table as new TPMP groups, rather than changing G1/G2/G3 directly.Alt.3: Support. The current table is quite restricted and some type of UE may suffer 3dB coverage loss due this restriction. For example, PA architecture of [23 20 23 20] dBm for a partial-coherent UE is one of typical implementations. No matter the UE report G1 or G6, it will loss 3dB power for some TPMI(s) even though it can support additional 3dB power transmission for this TPMI(s). In order to avoid the above-mentioned disadvantages, the union set of G1 and G6 should be allowed for the reporting of TPMI groups for [23 20 23 20] dBm |
| LG | Alt.1: Not support. It is too early to decide this. Alt.2: Slightly preferred. G1~G3 is mainly targeted for non-coherent UE. So, in case of partial-coherent UE, G1~G3 can be revised to include following TPMIs: , ,But, we also ok with OPPO’s proposal that the revised TPMI grouped can be added to the whole table as new TPMP groups.Alt.3: Support. At least, we can consider #5, #6, #15, #22 TPMI groups in the Annex for additional TPMI groups.  |
| Intel | In the existing agreement for TPMI group reporting for Mode 2 UE with 4 ports, we agreed that 2 bits are used for non-coherent (G0 to G3), 4 bits are used for partial coherent (G0 to G6).It can be seen from the agreement that both non-coherent and partial coherent TPMI grouping are using the same table, which means that for partial coherent, the non-coherent TPMI groups (G0 to G3) are included.Please note that the TPMI group reporting is related with the UE capability reporting. For the 4-port UE capable of partial coherence, it should also report the non-coherent TPMIs enabling full power since the gNB may configure non-coherent codebook subset for the UE.However, in our agreement, the binary value is used for the TPMI group reporting for 4-port UE instead of bitmap. Therefore, the UE can not report multiple TPMI groups in Table 2 even if it supports.For example, for a partial coherent UE with PA [23 20 20 17], for non-coherent TPMI group, it can support G0. For partial coherent TPMI group, it can support G5. But with current agreement, it can report only one group.From other companies’ views, we can see some combinations among the non-coherent TPMI group and partial-coherent TPMI group are proposed. But it will make the TPMI group table very complicated.One possible way to proceed is to remove the non-coherent TPMI groups from the 4-Tx partial coherent.Please see the proposal below:*For 4-port UE, the TPMI group reporting for Mode 2 is as below:**- 4-port non-coherent, 2 bits as shown in Table 1 below**- 4-port partial coherent, 2 bits as shown in Table 1 below**- G0 to G6 is defined in Table 2 (as shown in Section 1 in this document)**- For non-coherent UE with 4 ports, it only reports non-coherent TPMI groups with 2 bits**- For partial-coherent UE with 4 ports, it reports partial coherent TPMI groups with 2 bits and optionally report non-coherent TPMI groups with 2 bits.*Table 1.

|  |  |
| --- | --- |
| 4Tx, nonCoherent | 4Tx, partial coherent (~~4~~ 2 bit) |
| G0 | ~~G0~~ G4 |
| G1 | ~~G1~~ G5 |
| G2 | ~~G2~~ G6 |
| G3 | ~~G3~~ |
|  | ~~G4~~ |
|  | ~~G5~~ |
|  | ~~G6~~ |
|  |  |

With this change, there is no overhead increasing compared with the existing agreement. And it is more flexible by allowing combination between the non-coherent TPMI groups and partial coherent TPMI groups.We are open for discussion. |
| vivo | Alt1. Not support, since we have to revise previous agreement.Alt2. Not support, but we are open to introduce new TPMI group entries, since 9 entries are reserved in current TPMI groups table.Alt3. We have to consider diverse UE RF architectures in real implementation in future, some TPMI group entries are necessary. Since there are total 26+3(revision of G1, G2 and G3) entries, these entries with more supported companies can be considered with high priority. |
| CMCC | For Alt 1, not prefer, we prefer to keep 4 bits for the reported TPMI(s), and add more entries to add flexibility to support more PA architectures.For Alt2, Support. Specifically, for partial-coherent 4Tx UE, updated G1 and G2 to include  , and remove G3 since G3 will be exactly the same as G5 if G3 is also updated to include . We think the original G1/2/3 is not reasonable, it should be corrected.For Alt3, we support to add more entries to support more PA architectures. At least the following PA architectures can be considered, i.e., One 23dBm PA + One 20dBm PA (e.g., 23+17+20+17), One 23dBm PA + Three 20dBm PA (e.g., 23+20+20+20), Two 23dBm PA + Two 20dBm PA (e.g., 23+20+23+20), Three 23dBm PA + One 20dBm PA (e.g., 23+23+23+20). |
| Ericsson | As I commented earlier, in my understanding, a 4 Tx UE with PAs that are at least 17 dBm can support full power, so the question is not if PA power combinations are restricted by the specification. The question is if a particular PA power combination can be fully exploited to deliver the required performance. So we need to understand both the performance gain and the Tx chain architecture that is assumed.So far we have results from Huawei, which is a step forward over the discussion so far, and appreciated. These results show for rank 1 when a subset of the codebook is used, that ~0.5 dB gain is possible. A 4 Tx partially coherent UE that is configured with a 2 Tx fully coherent codebook will be able to use the simulated TPMIs : , ,, and so for us to have an understanding of the potential gains, it is necessary to have results with the full codebook. Also, this enhancement only improves rank 1, so the system gains will diminish according to the frequency with which higher ranks are used. We do understand the intuition behind adding the above TPMIs. However, we think it is fair to say that the spec is not broken, given the potential gains shown so far.Therefore, we support Alt 1, do not support Alt 2, and do not support Alt 3. |
| Nokia, NSB | Alt 1: It would be hard to revise the previous agreement of 4-bit indication, given many objections from companies. Alt 2: revising the TPMI groups is within the scope of previous agreements of RAN1 #99. These “marked” entries in Table 2 were provisional during the RAN1 #99 discussion. This shall impact TPMI groups G1 to G6.Alt 3: In general we support of adding extra TPMI groups. Given that there are quite a lot of diverse proposals in this meeting, it would be hard to reach consensus. We would agree that the TPMI groups of Mode-2 4Tx partial-coherent UE shall depend on UE’s implementational architectures. Making some agreements on extra architectures will be helpful to reach a final agreement.  |

# References

[1] R1-2003402, “Feature lead summary on ULFPTx”, vivo, RAN1#101-e

**Annex**

|  |  |  |
| --- | --- | --- |
| **TPMI groups** | **Precoder** | **Source company** |
| 1 |  | DCM |
| 2 | , | DCM |
| 3 | , ,  | LG |
| 4 |  | NOK |
| 5 |  | HW, LG, CATT, OPPO |
| 6 | ,,,, | QC, ZTE, DCM, CMCC, OPPO |
| 7 |  | NOK |
| 8 |  | NOK |
| 9 |  | NOK |
| 10 | , ,, | LG, vivo |
| 11 | , , , ,, | LG |
| 12 | , , , ,,, | vivo |
| 13 | , , , ,,,, | vivo |
| 14 | ,, , , , , , ,  | DCM, ZTE |
| 15 | ,, , , , , , , ,, , , *,* *,* *,*  | DCM, ZTE, CMCC, LG, OPPO |
| 16 | , , ,, , , , , , ,  | DCM, ZTE |
| 17 | , , ,, , , , , , , ,, , , *,* *,* *,*  | DCM, OPPO,ZTE, OPPO |
| 18 | ,,,,,,,,, | QC, CMCC,LG |
| 19 | , , , ,, , , , , , , ,, , , *,* *,* *,*  | DCM, ZTE, CMCC, LG, OPPO |
| 20 | ;; | CMCC, LG |
| 21 | ;; | CMCC, LG |
| 22 |  | HW, LG, OPPO |
| 23 |  | HW |
| 24 | , ,,, | LG |
| 25 |  in partial/noncoherent codebooksubset for 4 Tx UE | QC |
| 26 | , , ,,,,  | CATT, OPPO |