**3GPP TSG RAN WG1 #102-e R1-200xxxx**

**e-Meeting, August 17th – 28th, 2020**

**Agenda item: 8.1.2.1**

**Source:** **Moderator (Nokia, Nokia Shanghai Bell)**

**Title: Summary of Enhancements for Multi-TRP URLLC for PUCCH and PUSCH**

**Document for: Discussion and Decision**

# Introduction

This document summarizes remaining issues on M-TRP PUCCH and PUSCH enhancement to collect further inputs, and the more detailed summary after the phase 2 email discussion [102-e-NR-feMIMO-03] can be found in [R1-2007182](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/R1-2007182.zip).

In here, Section 2.1 contains offline agreements which can be endorsed by the chairman, please comment if that is not the case. Section 2.2 summarizes the updated proposals based on phase 2 email discussion. Section 3 summarize the latest version of agreements/proposals after the phase 3 email discussion.

# Summary of PUCCH/PUSCH proposals (based on R1-2007182)

## Offline Agreements

The offline agreements that do not have any objections/concerns are summarized as follows,

**Offline Agreement 2:** To improve reliability and robustness for PUCCH using multi-TRP and/or multi-panel, consider all PUCCH formats.

**Offline Agreement 3:** To enable TDMed PUCCH ~~repetition~~transmission with different beams, support configuring/activating of multiple PUCCH Spatial Relation Info. RAN1 shall further study the exact schemes considering the following aspects,

* Method of configuration/activation of multiple spatial relation info
* Use of the same PUCCH resource or different PUCCH resource for PUCCH ~~repetition~~transmission
* Mapping between PUCCH repetition/symbol and spatial relation info among multiple PUCCH repetitions / multiple PUCCH symbols.

**Offline Agreement 4:** For configuration/indication of the number of PUCCH repetitions, RAN1 shall further study the following,

* Alt.1: Use Rel-15 like framework
* Alt.2: Dynamic indication of the number of PUCCH repetitions

**Offline Agreement 5:** For multi-TRP PUCCH transmission, further investigate required power control enhancement.

**Offline Agreement 9:** Further study M-TRP CG PUSCH reliability enhancements in Rel-17.

Comment if you have any objections (for the above offline agreements).

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| **Company** | **Comments** |
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## Remaining Proposals for Phase 3 discussion

#### Proposal 1: FL comments after phase 2

Based on comments received in phase 2 email discussion, QC and Samsung suggesting changes to proposal 1 (section 3.1, [1]).

QC mentioned that “if beam hopping is used within one PUCH resources, and assuming that we use similar procedures as frequency hopping, it is not technically a repetition”. This is agreed by all other companies (except Samsung). The suggested changes are taken into account in the latest proposal.

Samsung mentioned that “wording inter-/intra-slot repetition is restricted for a single PUCCH resource case. However, we think that using multiple PUCCH resources with the same UCI can be also treated as repetition”. Oppo, Xiaomi, and Spreadtrum seem to be Ok with either QC suggestion or Samsung suggestion. From the FL perspective, mentioning of “UCI repetition” (suggested by Samsung) may not fully address the issue of single PUCCH or multiple PUCCH resources. Also, please note that updated proposal 3 is capturing all different aspects, and proposal 1 only focuses on inter and intra slot scenarios. To solve the concern raised by Samsung, a note is included in the updated proposal (changes to the earlier version is marked with red).

**Proposed offline Agreement 1:** Support TDMed PUCCH ~~repetition~~ scheme(s) to improve reliability and robustness for PUCCH using multi-TRP and/or multi-panel. Study the following alternatives,

* Alt.1: supporting both inter-slot repetition and intra-slot repetition / intra-slot beam hopping.
* Alt.2: supporting only inter-slot repetition
* Note: It is not precluded to study the use of multiple PUCCH resources to repeat the same UCI in both inter-slot repetition and intra-slot repetition.

Comment if you have any concerns,

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| **Company** | **Comments** |
| Apple | We think some clarification of the difference between “intra-slot repetition” and “intra-slot beam hopping” could be helpful. |
| Samsung | Support the FL proposal. |
| DOCOMO | We are fine with the proposal. But we agree with Apple that it is better to clarify the meaning of “intra-slot beam hopping”. |
| OPPO | Support FL’s proposal |
| Fujitsu | Support the proposal. Also fine with the clarification proposed by Apple. |
| LG | Support FL’s proposal |
| ZTE | Support FL’s proposal. |
| QC | Support the proposal. Also fine with adding more clarification, if needed, as follows:   * intra-slot repetition: One PUCCH resource carries UCI, another one or more PUCCH resources or the same PUCCH resource in another one or more sub-slots carries a repetition of the UCI * intra-slot beam hopping: UCI is transmitted in one PUCCH resource in which different sets of symbols have different beams |
| Xiaomi | Support FL’s proposal |
| CMCC | Support adding the clarification proposed by QC. |
| Ericsson | Support clarification proposed by QC. |
| vivo | Support |

#### Proposal 6: FL comments after phase 2

All companies (except Samsung) support the proposed offline agreement below. Samsung suggests considering single DCI and multi-DCI with equal priority. There is no priority mentioned in the proposal and support of multi-DCI based approach needs more investigation from other companies (majority). Therefore, this proposal reflects the majority understanding of this meeting.

**Proposed offline Agreement 6:** For M-TRP PUSCH reliability enhancement, support single DCI based PUSCH transmission/repetition scheme(s).

* Further study multi-DCI based PUSCH transmission/repetition scheme(s) to identify potential gains and required enhancements.

Comment if you have any concerns,

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| --- | --- |
| **Company** | **Comments** |
| Samsung | We are also fine with the proposal considering single DCI based PUSCH transmission/repetition scheme(s) first. |
| OPPO | Support FL’s proposal |
| Fujitsu | Support the proposal |
| LG | Support FL’s proposal |
| ZTE | Support FL’s proposal. |
| QC | Support |
| Xiaomi | Support FL’s proposal |
| CMCC | Support FL’s proposal |
| Ericsson | Support FL’s proposal |
| vivo | We also think both S-DCI and M-DCI should have same priority and it is not appropriate at this stage to agree to support only S-DCI while considering M-DCI for further study. Since all companies did not sufficiently discuss the pros and cons between two different DCI scheduling schemes. We prefer both S-DCI and M-DCI as starting point in this meeting and expect every company to elaborate their viewpoints in the next meeting.  **Revised proposal:** For M-TRP PUSCH reliability enhancement, study single DCI and multi-DCI based PUSCH transmission/repetition scheme(s) |

#### Proposal 7: FL comments after phase 2

Based on comments received so far, a majority of companies are fine with the proposal. However, there are some comments from LG, HW, Futurewei suggesting another change to the proposal (to study PUSCH transmission without repetition further). From the FL perspective, the update looks reasonable, and the proposal 7 is updated based on HW suggestion.

**Proposed offline Agreement 7:** For single DCI based M-TRP PUSCH reliability enhancement, support TDMed PUSCH repetition scheme(s) based on Rel-16 PUSCH repetition Type A and Type B.

* Further study PUSCH transmission without repetition as a potential candidate M-TRP PUSCH scheme

Comment if you have any concerns,

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| --- | --- |
| **Company** | **Comments** |
| Samsung | Support the FL proposal. |
| OPPO | Ok |
| Fujitsu | Support the proposal |
| LG | Support FL’s proposal |
| ZTE | Support FL’s proposal. |
| QC | Support |
| Xiaomi | Support FL’s proposal |
| CMCC | Support FL’s proposal |
| Ericsson | Ok. |
| vivo | With same reason above, there is no need to explicitly highlight the wording of “single DCI based”.  **Revised proposal:** For ~~single DCI based~~ M-TRP PUSCH reliability enhancement, support TDMed PUSCH repetition scheme(s) based on Rel-16 PUSCH repetition Type A and Type B.   * Further study PUSCH transmission without repetition as a potential candidate M-TRP PUSCH scheme |

#### Proposal 8: FL comments after phase 2

All companies support the proposal. However, HW has a suggestion to change the wording of SRI(s) to beams (last sub-bullet). Suggestion looks reasonable, and the proposal is updated as below,

**Proposed offline agreement 8**: To support single DCI based M-TRP PUSCH repetition scheme(s), up to two beams are supported. RAN1 shall further study the details considering,

* Codebook based and non-codebook based PUSCH
* Enhancements on SRI/TPMI/power control parameters/TA/any other
* Mapping between PUSCH repetitions and ~~SRI(s)~~beams

Comment if you have any concerns,

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| **Company** | **Comments** |
| Apple | We think TA should be removed. |
| Samsung | In addition to beams, mapping between PUSCH repetitions and power control parameters/TA/any other can be also considered. |
| OPPO | Share the same view as Apple that TS should be removed.  Samsung’s comments are valid. One simple way to address this is to remove the 3rd sub-bullet since the beam is included in the main bullet and other factors are included in the 2nd sub-bullet. |
| Fujitsu | Support the proposal |
| LG | Support FL’s proposal |
| ZTE | Support FL’s proposal. |
| QC | Same view as Apple. To clarify further, the decision of having two TAGs in one CC does not belong to this AI. If such a case is agreed in other AIs (e.g. 8.1.1), then mapping to repetitions can of course be discussed here. |
| Xiaomi | Same view as apple. |
| CMCC | Support FL’s proposal. If multi-TA is agreed in other AIs, the mapping can also be discussed here. |
| Ericsson | Similar view as Apple and QC. |
| vivo | With same reason above, there is no need to explicitly highlight the wording of “single DCI based”.  **Revised proposal:** To support ~~single DCI based~~ M-TRP PUSCH repetition scheme(s), up to two beams are supported. RAN1 shall further study the details considering,   * Codebook based and non-codebook based PUSCH * Enhancements on SRI/TPMI/power control parameters/TA/any other * Mapping between PUSCH repetitions and ~~SRI(s)~~beams   Furthermore, since the UE in FR1 do not configure analog beam, should we consider M-TRP PUSCH enhancement for FR1? Our view is that the scope of Item 2a in Rel-17 can preclude UL channels enhancement, it is up to gNB's implementation to acquire improvement of performance. |

# Summary of PUCCH/PUSCH proposals (After Phase3)

**Summary of agreements endorsed and new proposal 10.**

**Agreement**

Support TDMed PUCCH scheme(s) to improve reliability and robustness for PUCCH using multi-TRP and/or multi-panel. Study the following alternatives,

* Alt.1: supporting both inter-slot repetition and intra-slot repetition / intra-slot beam hopping.
* Alt.2: supporting only inter-slot repetition
* Note1: It is not precluded to study the use of multiple PUCCH resources to repeat the same UCI in both inter-slot repetition and intra-slot repetition.
* Note2: The alternatives are clarified as below,
  + inter-slot repetition: One PUCCH resource carries UCI , another one or more PUCCH resources or the same PUCCH resource in another one or more slots carries a repetition of the UCI .
  + intra-slot repetition: One PUCCH resource carries UCI , another one or more PUCCH resources or the same PUCCH resource in another one or more sub-slots carries a repetition of the UCI
  + intra-slot beam hopping: UCI is transmitted in one PUCCH resource in which different sets of symbols have different beams

**Agreement**

To improve reliability and robustness for PUCCH using multi-TRP and/or multi-panel, consider all PUCCH formats.

**Agreement**

To enable TDMed PUCCH transmission with different beams, support configuring/activating of multiple PUCCH Spatial Relation Info. RAN1 shall further study the exact schemes considering the following aspects,

* Method of configuration/activation of multiple spatial relation info
* Use of the same PUCCH resource or different PUCCH resource for PUCCH transmission
* Mapping between PUCCH repetition/symbol and spatial relation info among multiple PUCCH repetitions / multiple PUCCH symbols.

**Agreement**

For configuration/indication of the number of PUCCH repetitions, RAN1 shall further study the following,

* Alt.1: Use Rel-15 like framework
* Alt.2: Dynamic indication of the number of PUCCH repetitions

**Agreement**

For multi-TRP PUCCH transmission, further investigate required power control enhancement.

**Agreement**

For M-TRP PUSCH reliability enhancement, support single DCI based PUSCH transmission/repetition scheme(s).

* Further study multi-DCI based PUSCH transmission/repetition scheme(s) to identify potential gains and required enhancements.
* Note: This agreement does not reflect any prioritization of single DCI based PUSCH transmission/repetition over multi-DCI based PUSCH transmission/repetition. Ran1 can further discuss that in the next meeting.

**Agreement**

For single DCI based M-TRP PUSCH reliability enhancement, support TDMed PUSCH repetition scheme(s) based on Rel-16 PUSCH repetition Type A and Type B.

* Further study PUSCH transmission without repetition as a potential candidate M-TRP PUSCH scheme

**Agreement**

To support single DCI based M-TRP PUSCH repetition scheme(s), up to two beams are supported. RAN1 shall further study the details considering,

* Codebook based and non-codebook based PUSCH
* Enhancements on SRI/TPMI/power control parameters/any other
* Note1: Companies are encouraged to provide additional details on how above enhancements are applied to different PUSCH repetitions (e.g. mapping between PUSCH repetitions and beams)
* Note2: Studying enhancements/aspects related to TA is not precluded.

**Agreement**

Further study M-TRP CG PUSCH reliability enhancements in Rel-17.

**Proposal 10**

On the mapping between PUSCH repetitions and beams in single DCI based multi-TRP PUSCH repetition Type A and Type B, further study the following,

* For both PUSCH repetition Type A and B, how the beams are mapped to different PUSCH repetitions (or slots),
  + Alt.1: cyclical mapping pattern (~~same as in Rel-16 PDSCH Scheme 4~~ the first and second beam are applied to the first and second PUSCH repetition, respectively, and the same beam mapping pattern continues to the remaining PUSCH repetitions).
  + Alt.2: sequential mapping pattern (~~same as in Rel-16 PDSCH Scheme 4~~ the first beam is applied to the first and second PUSCH repetitions, and the second beam is applied to the third and fourth PUSCH repetitions, and the same beam mapping pattern continues to the remaining PUSCH repetitions).
  + Alt.3: Half-Half pattern (the first beam is applied to the first half of PUSCH repetitions, and the second beam is applied to the second half of PUSCH repetitions)
  + Alt.~~3~~4: Other variants (e.g. configurable mapping patterns)
  + Note: For PUSCH repetition type B, the variants considering slot level beam mapping with the same mapping principals (replacing repetition with slot) in Alt.1/2/3 are also included.
* For PUSCH repetition Type B, which repetition type that the beams shall consider for the mapping,
  + Alt.1: beams are mapped to the nominal repetitions
  + Alt.2: beams are mapped to the actual repetitions
  + Alt.3: beams are mapped to different slots (not in the granularity of actual/nominal repetition)
  + Alt.4: Other variants
* Consider additional requirements on switching gap(s) between two PUSCH repetitions towards different TRPs considering beam~~/panel~~ switching latency aspects.
* Note: use of the above solutions to multi-DCI based PUSCH repetition and TDMed PUSCH transmission without repetition (when there are agreed to support) is not precluded.

# 4 References

[R1-2007182](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Inbox/R1-2007182.zip) Summary of AI:8.1.2.1 Enhancements for Multi-TRP URLLC for PUCCH and PUSCH Nokia, NSB