3GPP TSG RAN WG1 #105-e R1-210xxxx

e-Meeting, May 10th – 27th, 2021

Source: Lenovo, Motorola Mobility, Ericsson, Intel Corporation, vivo

Title: On PMI sharing for CSI enhancements under multi-TRP framework

Agenda Item: 8.1.4

Document for: Discussion and Decision

# Introduction

In RAN1#104bis-e, it was agreed to study whether PMI and/or RI can be shared among two hypotheses for Option 1 CSI reporting with X>0, i.e., at least one CSI corresponding to NCJT and one CSI corresponding to single-TRP transmission are reported. In this document we aim at providing further details on how PMI/RI sharing works for two different hypotheses, as well as discuss the tradeoff between performance and CSI feedback overhead saving.

# CSI Reporting for DL multi-TRP/Panel Transmission

In RAN1#104bis-e [1], the following agreements were made for CSI enhancements under multi-TRP transmission:

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| **Agreement** A 2-part CSI report is supported in Rel-17 for a CSI reporting configuration associated with NCJT measurement hypothesis with following clarifications:* Within CSI part 1
	+ CRI, RI, WB CQI and SB CQI for the first CW are reported with consistent payload and zero padding (if needed). FFS further details
	+ FFS whether RI can be shared between NCJT CSI and single-TRP CSIs to reduce CSI feedback overhead
	+ FFS whether additional field is needed, at least for Option 2
* Within CSI part 2:
	+ FFS further compression/omission/Sharing of PMI among Single-TRP and NCJT hypotheses
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## CSI Reporting mechanism for NCJT

Different alternatives for CSI Reporting mechanism were proposed for NCJT, and a decision was reached in RAN1#104-e [2] to support two options, as follows

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| AgreementFor a CSI report associated with a Multi-TRP/panel NCJT measurement hypothesis configured by single CSI reporting setting, support following two options:* Option 1: the UE can be configured to report X CSIs associated with single-TRP measurement hypotheses and one CSI associated with NCJT measurement hypothesis
	+ X = 0, 1, 2
		- If X=2, two CSIs are associated with two different single-TRP measurement hypotheses with CMRs from different CMR groups
		- Support of X=1,2 is UE optional for the UE supporting option 1
	+ FFS omission of CSI associated with NCJT measurement hypothesis
* Option 2: the UE can be configured to report one CSI associated with the best one among NCJT and single-TRP measurement hypotheses
	+ FFS how to report recommended measurement hypothesis associated with that CSI report
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Assume the case where the UE is configured with CSI reporting under Option 1 with X=2, where the NCJT hypothesis corresponds to transmission from TRP A and TRP B, and the two single-TRP hypotheses corresponds to transmission from TRP A and TRP B, respectively.



Figure 1: Conventional PMI/RI design under (a) NCJT, (b) single-TRP A and (c) single-TRP B hypotheses

Conventionally, the UE reports the following PMI/RI under this setup, as shown in Figure 1:

1. PMI0, RI0 for TRP A under NCJT hypothesis (Figure 1a)
2. PMI1, RI1 for TRP B under NCJT hypothesis (Figure 1a)
3. PMI2, RI2 for TRP A under single-TRP hypothesis (Figure 1b)
4. PMI3, RI3 for TRP B under single-TRP hypothesis (Figure 1c)

For the prior three hypotheses, three CQI values are reported: CQINCJT, CQIA and CQIB corresponding to NCJT, single-TRP transmission with TRP A and single-TRP transmission with TRP B, respectively. Clearly, this setup provides optimized CSI feedback for all three transmission hypotheses, however the overall CSI feedback has roughly triple the overhead size as conventional CSI feedback under single-TRP transmission.



Figure 2: Proposed PMI/RI sharing design under (a) NCJT, (b) single-TRP A and (c) single-TRP B hypotheses

One way to reduce the overall CSI feedback is via adopting an alternative design that is based on PMI/RI sharing as shown in Figure 2, as follows

1. PMI0, RI0 for TRP A under NCJT hypothesis (Figure 2a)
2. PMI1, RI1 for TRP B under NCJT hypothesis (Figure 2a)
3. PMI0, RI0 for TRP A under single-TRP hypothesis (Figure 2b)
4. PMI1, RI1 for TRP B under single-TRP hypothesis (Figure 2c)

For the prior three hypotheses, three CQI values are reported: CQINCJT, CQI\*A and CQI\*B corresponding to NCJT, single-TRP transmission with TRP A and single-TRP transmission with TRP B, respectively. Although this setup does not provide optimized PMI, RI for the two single-TRP hypotheses since PMI2≠PMI0, RI2≠RI0, and PMI3≠PMI1, RI3≠RI1, it significantly reduces the CSI feedback overhead, since 2 PMI and 2 RI values are omitted from reporting. Also, it is worth mentioning that although the PMI and RI are not optimized with respect to single-TRP hypotheses under PMI/RI sharing, the CQI values (CQI\*A and CQI\*B) are optimized for the PMI/RI sharing setup, and hence provide a precise characterization of the channel quality.

An example of the setup for PMI/RI sharing is provided in Table 1 below, as follows.

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| **Step 1:**The UE computes PMI0, RI0 for TRP A under NCJT hypothesis**Step 2:**The UE computes PMI1, RI1 for TRP B under NCJT hypothesis **Step 3:**The UE computes CQINCJT for NCJT hypothesis from TRP1 and TRP2, based on PMI0/RI0 and PMI1/RI1**Step 4:**The UE computes CQI\*A for single-TRP hypothesis from TRP A, based on PMI0, RI0**Step 5:**The UE computes CQI\*B for single-TRP hypothesis from TRP B, based on PMI1, RI1 |

Table 1: CSI computation for Option 1 with X=2 using two PMI/RI values and three CQI values

From Table 1, the UE can compute CSI for three transmission hypotheses using two PMI and two RI quantities, where PMI0/RI0 and PMI1/RI1 for NCJT hypothesis that are associated with TRP A and TRP B are reused for single-TRP hypothesis with TRP A and single-TRP hypothesis with TRP B, respectively, and the three CQI values corresponding to the NCJT hypothesis and the two single-TRP hypotheses are CQINCJT, CQI\*A and CQI\*B, respectively. A similar mechanism can be adopted for Option 1 with X=1, where only 2 PMI, 2 RI and 2 CQI values are needed to support both NCJT and the single-TRP hypotheses. Further details on CSI feedback structure and CSI configuration signaling under the proposed approach can be discussed further, including whether the PMI/RI sharing approach is configured with a higher-layer parameter, and also whether this approach is restricted to FR1, e.g., when the CMRs corresponding to single-TRP hypotheses can be reused for NCJT hypothesis.

Evaluation results are provided in Section 2.2 comparing PMI/RI sharing across NCJT and single-TRP hypotheses to the case where RIs and PMIs for NC-JT CSI and two single TRP CSIs are reported separately. The results show negligible performance losses for PMI/RI sharing across NCJT and single-TRP hypotheses when compared to the case where RIs and PMIs for NCJT CSI and two single TRP CSIs reported separately. Table 2 shows an example of overhead reduction for a scenario with 2 ports per TRP, where 27% overhead is saved with RI/PMI sharing. Larger saving can be achieved when there are more than 2 ports per TRP.

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| CSI type | Bit width |
| sTRP CSI (subband) | 57 |
| NCJT CSI (subband) | 84 |
| NCJT CSI + 2 x sTRP CSI (subband) | 198 |
| NCJT CSI + 2 x sTRP CSI, sharing RI/PMI (subband) | 144 |
| Overhead saving due to RI/PMI sharing  | **27%** |

Table 2: CSI savings with RI/PMI sharing, 2 ports per TRP, 10MHz BW, subband size = 4RBs, type-I CB

In light of that, we have the following proposal

1. Support PMI, RI sharing across NCJT and single-TRP hypotheses for CSI reporting under Option 1 with X=1,2
* Support one or more of the following:
	+ Enabling/Disabling PMI, RI sharing via higher-layer configuration
	+ Dynamic indication of PMI, RI sharing in the CSI report
* FFS: Other details

## PMI/RI sharing evaluation results

In this section, we evaluate and compare the performance of two different schemes for the CSI report in DL multi-TRP transmissions:

* **Scheme 1 (baseline):** RIs and PMIs for NC-JT CSI and two single TRP CSIs are reported separately.
* **Scheme 2 (PMI/RI sharing):** RIs and PMIs for NC-JT CSI and two single TRP CSIs are shared.

Simulation’s parameters are summarized in Table 3. The evaluations are provided for the Indoor Hotspot scenario where a cluster size of 2 TRPs is assumed. The Indoor Hotspot scenario has 12 ceiling mounted TRPs facing down. The TRPs are partitioned into six fixed coordination clusters with 2 TRPs in each coordination cluster. Each TRP is equipped with two cross polarization Tx antennas and the UEs are equipped with two pairs of dual polarized isotropic Rx antennas.

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| **Parameters** | **Values** |
| Frequency Range | 4 GHz, SCS: 15 kHz, BW: 10 MHz |
| BS Antenna Configuration | (M, N, P, Mg, Ng) = (1, 1, 2, 1, 1). (dV, dH) = (0.5, 0.5) λ |
| UE Antenna Configuration | Isotropic antenna (M, N, P) = (1, 2, 2). (dV, dH) = (0.5, 0.5) λ |
| Traffic Model | Non-full buffer |
| Transmission scheme | Up to rank 2 transmission per TRP |
| Target BLER | 10% |
| Scenario | Indoor Hotspot, 12 sites, 1TRP/site, 3km/h |
| Coordination cluster | 2 TRPs per cluster |

Table 3 Simulation parameters for the evaluation of CSI reporting schemes for DL multi-TRP transmissions

The mean and cell-edge user throughput are shown in Figure 3, where the curves labeled with ‘CSI sharing’ correspond to Scheme 2. It can be seen that system performance is almost identical for the two schemes.



(a)Mean user throughput (b) Cell-edge user throughput

Figure 3: System performance with and without RI/PMI sharing (Scheme 1 is shown in blue and Scheme 2 is shown in orange).

# Conclusion

For CSI enhancements for NCJT multi-TRP, we have discussed PMI/RI sharing across single-TRP and NCJT hypotheses. We therefore have the following proposal:

1. Support PMI, RI sharing across NCJT and single-TRP hypotheses for CSI reporting under Option 1 with X=1,2
* Support one or more of the following:
	+ Enabling/Disabling PMI, RI sharing via higher-layer configuration
	+ Dynamic indication of PMI, RI sharing in the CSI report
* FFS: Other details

# References

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| [1]  | 3GPP TSG RAN WG1 #104bis-e, "Draft Meeting Report," E-meeting, Apr. 12-20, 2021. |
| [2]  | 3GPP TSG RAN WG1 #104-e, "Draft Meeting Report," Jan. 25- Feb. 5, 2021. |