**3GPP TSG RAN WG1 Meeting #104-e R1-210nnnn**

**E-meeting, January 25th – February 5th, 2021**

Source: Moderator (CATT)

Title: Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 2)

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This is a summary of round 2 email discussion on AI 8.1.2.3, between GTW1 and GTW2.

# Discussion

* 1. Issue 1: Beam measurement/reporting for inter-TRP simultaneous transmission

For beam measurement, it is agreed in RAN1#103-e to down-select in RAN1#104-e.

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| Agreement (RAN1#103-e)  Down-select at least one of the following options for beam measurement/reporting enhancement to facilitate inter-TRP beam pairing in RAN1 #104-e   * Option 1: In a CSI-report, UE can report N>1 pair/groups and M>=1 beams per pair/group   + Different beams in different pairs/groups can be received simultaneously   + FFS: whether M is equal or can be different across different pair/group * Option 2: In a CSI-report, UE can report N(N>=1) pairs/groups and M (M>1) beams per pair/group   + Different beams within a pair/group can be received simultaneously * Option 3: UE report M(M>=1) beams in N (N>1) CSI-reports corresponding to N report setting   + Different beams in different CSI-reports can be received simultaneously   + FFS: whether/how to introduce an association between different CSI-reports   + FFS: whether/how to differentiate reported measurements for beams that are received simultaneously vs. beams that are not received simultaneously     - whether/how to introduce an indication along with the CSI-reports to indicate whether the beams in different CSI-reports can be received simultaneously |

Proposals under discussion are summarized below.

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| Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels   * Support at least option 2, where a single CSI-report consists of N beams pairs/groups and M (M>1) beams per pair/group, and different beams within a pair/group can be received simultaneously   + Support at least M = 2 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)   + Support extending the maximum value of N > 1, exact value FFS * Further study the support of option 1 and option 3   Draft Proposal 1.2:   * Down-select from the following alternatives in RAN1#104b-e   + Alt-1: For option 2, support configuration of S=2 CMR resource sets corresponding to a periodic/semi-persistent CMR resource setting or an aperiodic trigger state     - UE reports M beams (e.g. CMR resource indices) from S=2 different CMR resource sets which can be received simultaneously     - NOTE: UE may assume that different CMR resources in different CMR sets can be received simultaneously, and CMR resources in the same CMR set cannot be received simultaneously     - FFS: whether S = M   + Alt-2: For option 2, support configuration of two CMR resource subsets in a CMR resource set corresponding to a CMR resource setting     - UE reports M beams (e.g. CMR resource indices) from different CMR resource subsets, which can be received simultaneously     - NOTE: UE may assume that different CMR resources in different CMR subsets can be received simultaneously, and CMR resources in the same CMR subset cannot be received simultaneously     - FFS: a specific ID can be used to differentiate CMR resource subsets in a CMR resource set.   + Alt-3: For option 2, support indication of S=2 SSB sets, where CMRs are implicitly mapped to a   a CMR set where a CMR in the set is QCLed (Type D) with a SSB in the same SSB set   * + - UE reports M=2 beams (e.g. CMR resource indices) from S=2 CMR sets     - NOTE: UE may assume that different CMR resources in different CMR sets can be received simultaneously, and CMR resources in the same CMR set cannot be received simultaneously   Draft Proposal 1.3:   * Study beam measurement/reporting with consideration of inter-TRP interference |

Discussion Summary:

A proposal to adopt at least option 2 supported by over 20 companies was not agreed in GTW1 due to some concerns on interference measurement and CSI overhead. One company claimed that option 2 has higher CSI overhead than option 1, where another company’s simulation results show sub-par performance of option 1/2 (using interference as feedback metric) than option 3 with RSRP. Discussion leading to GTW2 focused on these two issues.

* For CSI feedback overhead, there are different views as to whether the claim that option 2 has higher overhead than option 1 is accurate. Some companies (e.g. Nokia/NSB, CATT) believe the feedback overhead is dependent on the value of N/M, which is up to CSI-report configuration and option-agnostic. Some companies (Samsung/CATT) believe the claim of higher overhead for option 2 may be due to misconception on the candidate beam pair set size as CSI overhead. Some company (Apple) believes if the candidate beam pair set size increases, a fixed CSI overhead will result in lower scheduling flexibility, and in other words, an option with larger candidate beam pair set size requires higher CSI overhead to achieve the same scheduling flexibility. However, even considering candidate pair beam set size, some companies believe this is dependent on NW hardware implementation (e.g. how many TRPs are coordinating, whether different TRPs have the same/different number of panels, how many beams per panel) and comparison between different options may have different results in different scenarios. In summary, there does not seem to be consensus on this claim.
* For interference measurement, companies exchanged views on simulation results and their understanding on simulation assumption/behavior. There are misalignments in simulation assumptions/results/observations among companies and a clear conclusion seems missing.
* In summary: each option (or their combination) has a number of concerned companies.
* Alt1: Option 1
  + OK:
  + Not OK: HW/HiSi/Nokia/NSB/Intel/CATT
* Alt2: Option 2
  + OK: Futurewei, OPPO, HW/HiSi, Lenovo/MoM,  ZTE, Intel, AT&T, Spreadtrum, APT, Nokia/NSB, CMCC, ETRI, Xiaomi, Samsung, Qualcomm, DOCOMO, Ericsson, LGE, CATT
  + Not OK: vivo/Apple
* Alt3: Option 3
  + OK: vivo
  + Not OK: Qualcomm /DOCOMO/Intel/ZTE/OPPO
* Alt4: Option 1+2
  + OK: Samsung
  + Not OK: HW/HiSi/Nokia/NSB/Intel
* Alt5: Option 2+3
  + OK
  + Not OK: Qualcomm /DOCOMO/Intel/ZTE/OPPO
* Alt6 (Based on suggestion from Ericsson): UE only reports 2 beams that can be simultaneously received, which is similar to R15
  + Enhance the CMR configuration to let UE aware TRP for each CMR (proposal 1.2 related)
  + OK: Ericsson
  + Not OK: DOCOMO/Qualcomm/Xiaomi/ZTE/Samsung

Moderator Suggestion

Overall, option 2 has the most supports (22) and least concerns (2, vivo/apple). Other alternatives have considerable more concerns and fewer supports. Hence, the suggestion is to endorse at least option 2, and continue other options/cases in future meetings.

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| Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels   * Support a single CSI-report consisting of N beams pairs/groups and M (M>1) beams per pair/group, and different beams within a pair/group can be received simultaneously   + Support M = 2 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)   + Support extending the maximum value of N > 1, exact value FFS * Further study the support of option 1 and option 3   Support (22): Futurewei, OPPO, HW/HiSi, Lenovo/MoM,  ZTE, Intel, AT&T, Spreadtrum, APT, Nokia/NSB, CMCC, ETRI, Xiaomi, Samsung, Qualcomm, DOCOMO, Ericsson, LGE, CATT  Concerns: vivo, Apple |

Table 1: Company views

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| **Company** | **Comments** |
| ZTE | Support FL proposal  Although we expect to support both Option-1 and Option-2 together as our first preference, we can support Draft proposal 1.1 for making progress. Next meeting, we can further discuss details of Option-1 and Option-3 and make a final decision whether one of them can be supported. |
| Lenovo&MotM | Support. |
| Apple | We are not sure whether Alt1/2/3 above means option 1/2/3 only.  We also see the formulation for the draft proposal 1.1. is different from original option 2, which mandates UE to receive signals with multiple Rx panels. We should note that sometimes UE is not able to use two panels due to rotation or power saving.  Based on the latest discussion in CSI, they are already discussing beam pairing which is similar to option 2. So what gNB needs should be a rough beam pairing information like option 1. For rough beam pairing information, option 2 has higher overhead than option 1. If we want to go with option 2, N should be up to 4, so that UE can report the pairing information for 4 NW beams. |
| OPPO | Support in principle with wording change suggestion. Suggest to remove “multiple Rx panels” . The term “panel” is not used spec. And “multi-TRP simultaneous transmission” in the main bullet is good enough to explain the intention.  Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission ~~with multiple Rx panels~~   * Support a single CSI-report consisting of N beams pairs/groups and M (M>1) beams per pair/group, and different beams within a pair/group can be received simultaneously   + Support M = 2 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)   + Support extending the maximum value of N > 1, exact value FFS * Further study the support of option 1 and option 3 |
| DOCOMO | Support FL proposal and also fine with OPPO’s revision. |
| Spreadtrum | Support FL proposal, also fine with the update from OPPO. |

* 1. Issue 2: M-TRP Beam failure recovery

The following agreement was reached in GTW2.

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| Agreement:  For M-TRP BFR   * Support 2 BFD-RS sets per BWP, and up to N resources per BFD-RS set   + FFS: value of N (e.g. fixed in specification, or UE capability) * FFS: number of BFD RSs across all BFD-RS sets per DL BWP (e.g. fixed maximum value or UE capability)   Agreement:  For M-TRP BFR   * Support 1-to-1 association between each BFD-RS set and an NBI-RS set   + FFS: Association details   Agreement:  For BFRQ of M-TRP BFR   * Option 3: Up to two dedicated PUCCH-SR resources in a cell group   + FFS: Whether PUCCH-SR for SCell can be reused for M-TRP * Support BFRQ MAC-CE that can convey information of failed CC indices, one new candidate beam for the failed TRP/CC (if found), and whether new candidate beam is found   + Support at least indication of a single TRP failure     - FFS: whether/what information of failed TRP(s) is conveyed in the MAC-CE     - FFS: whether/how to support indication of more than one TRP failure, corresponding BFR procedure, and applicable cell type (SCell vs. SpCell) * FFS: UE behavior when TRP failure status is different across cells * FFS: whether PUCCH SR resources can be configured with 2 spatial filter |

There are a few remaining issues on beam failure event report on PUCCH-SR. As this affects the ensuing discussion on the BFRQ MAC-CE content and UE assumption update upon reception of gNB response, it is helpful to align the understanding.

**Questions**:

* Q1: whether PUCCH SR resources can be configured with 2 spatial filters
* Q2: When one dedicated PUCCH-SR resource is configured in a cell group
  + For PUCCH-SR resource in FR1, UE behavior should be clear.
  + For PUCCH-SR resource in FR2
  + Q2.1: If the answer to Q1 is “2”, what’s UE transmission behavior? E.g.
    - Option 1: UE selects one spatial filter. Please explain selection rule (if necessary).
    - Option 2: UE applies a multi-TRP PUCCH repetition scheme in 8.1.2.1.
* Q3: When two dedicated PUCCH-SR resource are configured in a cell group
  + Q3.1: Is it agreeable that one PUCCH-SR resource is selected?
  + Q3.2: If so, your view on the PUCCH-SR resource selection rule, and PUCCH-SR transmission scheme
* NOTE: For discussion of Q2/Q3, please clarify
  + UE behavior when TRP failure status is different across cells
  + Whether PUCCH-SR for SCell can be reused for M-TRP

Table 2: Company inputs

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| **Company** | **Comments** |
| ZTE | Q1: Yes;  Q2: We slightly prefer Option-1. Each of spatial relations can be implicitly associated with a TRP, e.g., through configuring spatialRelationInfo. For maximizing gains of spatial diversity, the spatial relation for a TRP should be associated with a spatial domain filter pointing to another TRP.  Q3.1: Yes.  Q3.2: Similar to our suggestion in Q2, Each of resources can be implicitly associated with a TRP, e.g., through configuring spatialRelationInfo. For maximizing gains of spatial diversity, the PUCCH-SR for a TRP should be associated with a spatial domain filter pointing to another TRP. For mDCI-mTRP, association between one of PUCCH-SR resource(s) and CORESETPoolIndex should be supported.  Regarding UE behavior when TRP failure status is different across cells, in our views, the granularity of TRP-specific beam recovery is per TRP per cell. If so, we think that all is clear.  Regarding whether PUCCH-SR for SCell can be reused for M-TRP, the answer is yes, and it can be up to gNB implementation. |
| Lenovo&MotM | Q1: No. Only PUCCH resource with repetition can be configured with 2 spatial filters in R17 currently. Whether PUCCH-SR resource can be configured with 2 spatial filter is not discussed in R17.  Q2: Each PUCCH-SR resource can be configured to be associated with a TRP index (CORESETPoolIndex, BFD-RS set index), therefore, UE can determiner to select which PUCCH-SR resource in FR1 and FR2.  Q3: Q3.1: Yes. Q3.2: When UE detects that all beams in a BFR-RS set are all failed, then it will select the PUCCH-SR resource associated with the BFR-RS set to transmit the beam failure recovery request if each PUCCH-SR resource can be associated with a BFR-RS set index.  Note: According to “UE behavior when TRP failure status is different across cells”, UE will transmit PUCCH-SR to request UL resource to report beam failure as long as there is beam failure in one TRP in at least one cell. And the followed MAC CE can tell gNB in which cell and which TRP there is beam failure.  According to “Whether PUCCH-SR for SCell can be reused for M-TRP”, we support to reuse the PUCCH-SR of SCell for M-TRP because it can reduce the overhead. |
| Apple | Q1: Yes  Q2: If one PUCCH-SR is configured, it means gNB only enable BFR for one TRP  Q3.1: Yes  Q3.2: Each SR is for BFR for a TRP, and UE can select one to report. If both fails, UE can send two SRs. |
| OPPO | Q1: the answer is NO. The spatial filter is configured in PUCCH, not SR configuration. One SR configuration is associated with one or more PUCCH resource. Whether 1 or 2 spatial filter is configured to one PUCCH does not depend on the SR configuration.  Q2: when on SR is configured, the UE would just use that SR when per-TRP beam failure is claimed. That shall belong to the RAN2 SR procedure design.  Q3: when two SR configured to mTRP BFR, the gNB can configure an association between SR configuration and TRP. When beam failure is claimed for one TRP, the UE can trigger the corresponding SR if there is no PUSCH grant. Again, that shall belong to RAN2 design. |
| DOCOMO | Q1: Yes. It is based on gNB configuration.  Q2: We think it should be Option2. If one PUCCH-SR resource is configured in FR2, there are following two cases:   * Case1: no per-TRP BFR configured. Only per-cell BFR is configured. In this case, 2 spatial filters mean PUCCH repetition. * Case2: some CCs are configured with per-TRP BFR. But gNB configures one PUCCH-SR resource. In this case, it means that gNB just wants to follow R16 PUCCH-SR BFR triggering (even though the MAC CE for BFR is enhanced for per-TRP BFR). Otherwise, gNB will configure two PUCCH-SR resources. Hence, in this case, 2 spatial filters also mean PUCCH repetition.   Based on above analysis, for different cases, 2 spatial filters mean PUCCH repetition.  Q3.1: Yes.  Q3.2: Each PUCCH-SR is associated with a TRP on PCell/PSCell. On all CCs, if a TRP fails, PUCCH-SR associated with the other TRP can be transmitted. If different/both TRPs fail on different CCs, a default PUCCH-SR (or a selected PUCCH-SR based on some rule) from the two PUCCH-SR resources can be transmitted. |
| Spreadtrum | Q1:No. In Rel-17, one PUCCH configured with two spatial information is only supported for repetition for reliability.  Q3.1: Yes;  Q3.2: The PUCCH SR resource could be implicitly associated with one TRP, e.g., by CORESETPoolIndex.  We have agreed that BFRQ MAC CE can include the information of failed CC indices, one new candidate beam for the failed TRP/CC (if found), and whether new candidate beam is found, indication of a single TRP failure. Even if TRP failure status is different across CCs, the UE behavior is still clear. For example, if TRP1 associated with CORESETPoolIndex =0 failed for carrier 1, and TRP3 associated with CORESETPoolIndex =1 failed for carrier 2, then UE could choose PUCCH SR resource associated with CORESETPoolIndex =0 to convey TRP1 failure for carrier 1, and choose PUCCH SR resource associated with CORESETPoolIndex =1 to convey TRP2 failure for carrier 2.  In our understanding, PUCCH-SR for SCell can be reused for M-TRP. |

* 1. Issue 3: Simultaneous reception of signals with different QCL-TypeD assumptions

Companies are invited to provide their views on the following proposal.

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| **Draft Proposal 3.1:**   * **Investigate, and specify if needed, enhancement to release constraints due to QCL -TypeD collision for UEs  that can receive signals with two different QCL -TypeD properties**   + **The following options are considered:**     - **Option 1: To enhance priority rule to facilitate UE  to receive downlink  signals with two different QCL -TypeD properties, e.g. PDCCH QCL prioritization rule enhancement**     - **Option 2: To release some scheduling restrictions which mandate gNB to schedule downlink  signals with the same QCL -TypeD property or prohibit to schedule some downlink  signals overlapped in time domain, e.g. PDSCH + SSB**     - **Other options are not precluded**   + **FFS: definition of QCL -TypeD collision, e.g., different QCL Type D RS(s) under the same UE panel.** |

Table 3: Additional company inputs: issue 3

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| **Company** | **Input** |
| ZTE | Support. In our views, it is a good starting point to kick off discussion of this topic. |
| Lenovo&MotM | Support |
| Apple | Support |
| OPPO | Support. It is good to start discussing this issue. |
| DOCOMO | Support. |
| Spreadtrum | Support |

# Previous agreements

* 1. RAN1#102-e

**Agreement**

For L1-RSRP, consider measurement / reporting enhancement to facilitate inter-TRP beam pairing

* Option-1: Group-based reporting,
  + e.g., beam restriction to facilitate inter-TRP pairing.
* Option-2: Non-group-based reporting

**Agreement**

Evaluate and study at least but not limited to the following issues for multi-beam enhancement

* Issue 1: Consideration of inter-beam interference
* Issue 2: For group-based reporting, increased number of groups and/or beams per group
* Issue 3: UE Rx panel related beam measurement/report
  + NOTE: “UE panel” is used for discussion purpose only

**Agreement**

* Evaluate enhancement to enable per-TRP based beam failure recovery starting with Rel-15/16 BFR as the baseline.
* Consider following potential enhancement aspects to enable per-TRP based beam failure recovery
  + Issue 1: TRP-specific BFD
  + Issue 2: TRP-specific new candidate beam identification
  + Issue 3: TRP-specific BFRQ
  + Issue 4: gNB response enhancement
  + Issue 5: UE behavior on QCL/spatial relation assumption/UL power control for DL and UL channels/RSs after receiving gNB response

**Agreement**

Study Rel.17 enhancements on beam management for multi-TRPs with following priority

* High priority:
  + Beam measurement/reporting enhancement
  + Beam failure recovery for multi-TRP
* Low priority
  + Simultaneous reception of same type of channel/RS with different QCL-TypeD
  + Simultaneous reception of different type of channel/RS with different QCL-TypeD
  1. RAN1#103-e

Agreement

Down-select at least one of the following options for beam measurement/reporting enhancement to facilitate inter-TRP beam pairing in RAN1 #104-e

* Option 1: In a CSI-report, UE can report N>1 pair/groups and M>=1 beams per pair/group
  + Different beams in different pairs/groups can be received simultaneously
  + FFS: whether M is equal or can be different across different pair/group
* Option 2: In a CSI-report, UE can report N(N>=1) pairs/groups and M (M>1) beams per pair/group
  + Different beams within a pair/group can be received simultaneously
* Option 3: UE report M(M>=1) beams in N (N>1) CSI-reports corresponding to N report setting
  + Different beams in different CSI-reports can be received simultaneously
  + FFS: whether/how to introduce an association between different CSI-reports
  + FFS: whether/how to differentiate reported measurements for beams that are received simultaneously vs. beams that are not received simultaneously
    - whether/how to introduce an indication along with the CSI-reports to indicate whether the beams in different CSI-reports can be received simultaneously
* FFS: value of N and M in each option
* FFS: Association between different beams in above options and different TRP/UE panels
* FFS: Identify new use cases per option compared with R16 (including backhaul)
* FFS: whether different beams in different pairs/groups/reports can be received by same spatial filter per option

**Agreement**

* For M-TRP beam failure detection, support independent BFD-RS configuration per-TRP, where each TRP is associated with a BFD-RS set.
  + FFS: The number of BFD RSs per BFD-RS set, the number of BFD-RS sets, and number of BFD RSs across all BFD-RS sets per DL BWP
  + Support at least one of explicit and implicit BFD-RS configuration
    - With explicit BFD-RS configuration, each BFD-RS set is explicitly configured
      * FFS: Further study QCL relationship between BFD-RS and CORESET
    - FFS: How to determine implicit BFD-RS configuration, if supported
* For M-TRP new beam identification
  + Support independent configurat**i**on of new beam identification RS (NBI-RS) set per TRP if NBI-RS set per TRP is configured
    - FFS: detail on association of BFD-RS and NBI-RS
    - Support the same new beam identification and configuration criteria as Rel.16, including  L1-RSRP, threshold

Agreement

* Support TRP-specific BFD counter and timer in the MAC procedure
  + The term TRP is used only for the purposes of discussions in RAN1 and whether/how to capture this is FFS

Agreement

* Support a BFRQ framework based on Rel.16 SCell BFR BFRQ
  + In RAN1#104-e, select one from the following options
    - Option 1: Up to one dedicated PUCCH-SR resource in a cell group
      * A cell group refers to either MCG, SCG, or PUCCH cell group
      * FFS: number of spatial filters associated with the PUCCH-SR resources
      * FFS: How the SR configuration is done
    - Option 2: Up to two (or more) dedicated PUCCH-SR resources in a cell group
      * A cell group refers to either MCG, SCG, or PUCCH cell group
      * FFS: whether each PUCCH-SR resource is restricted to be associated to one spatial filter
      * FFS: How the SR configuration is done
  + FFS: Whether no dedicated PUCCH-SR resource can be supported in addition to Option 1 or Option 2
* Study whether and how to provide the following information in BFRQ MAC-CE
  + Index information of failed TRP(s)
  + CC index (if applicable)
  + New candidate beam index (if found)
  + Indication whether new beam(s) is found
  + FFS: whether/how to incorporate multi-TRP failure
  1. RAN1#104-e

Agreement:

For M-TRP BFR

* Support 2 BFD-RS sets per BWP, and up to N resources per BFD-RS set
  + FFS: value of N (e.g. fixed in specification, or UE capability)
* FFS: number of BFD RSs across all BFD-RS sets per DL BWP (e.g. fixed maximum value or UE capability)

Agreement:

For M-TRP BFR

* Support 1-to-1 association between each BFD-RS set and an NBI-RS set
  + FFS: Association details

Agreement:

For BFRQ of M-TRP BFR

* Option 3: Up to two dedicated PUCCH-SR resources in a cell group
  + FFS: Whether PUCCH-SR for SCell can be reused for M-TRP
* Support BFRQ MAC-CE that can convey information of failed CC indices, one new candidate beam for the failed TRP/CC (if found), and whether new candidate beam is found
  + Support at least indication of a single TRP failure
    - FFS: whether/what information of failed TRP(s) is conveyed in the MAC-CE
    - FFS: whether/how to support indication of more than one TRP failure, corresponding BFR procedure, and applicable cell type (SCell vs. SpCell)
* FFS: UE behavior when TRP failure status is different across cells
* FFS: whether PUCCH SR resources can be configured with 2 spatial filter

# Reference

1. R1-2101862, “Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 0)”, Moderator (CATT)
2. R1-2101973, “Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 1)”, Moderator (CATT)