**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 1)

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This is a summary of round 1 email discussion on AI 8.1.2.3.

# Discussion

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

Companies are further invited to provide their views on the following draft proposals in the table below. In addition, as two companies specifically requested to have more focused study on inter-TRP interference measurement in the 1st GTW meeting, companies are encouraged to share their thoughts on this particular topic.

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

Table 1: Company views

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| --- | --- |
| **Company** | **Comments** |
| vivo | Regarding Proposal-1.1 from FL, we would like to further understand the motivation to only focus on Option2. Hope to hear more views on this issue.  In our understanding, Option2 does not provide any additional benefit compared to Option1 or Option3 with the following two aspects.   * Overhead of Option2 is obviously larger than Option1/3.  1. UCI payload size(bits/report)  |  |  |  |  |  | | --- | --- | --- | --- | --- | | Number of beam pairs | Option 1（N=2） | Option 2（M=2） | Option 3  （N=2） | | | 2 | 33 | 43 | report 1: 13 | report 2: 23 | | 4 | 43 | 83 | report 1: 23 | report 2: 23 | | 8 | 63 | 163 | report 1: 23 | report 2: 43 | | 16 | 83 | 323 | report 1: 43 | report 2: 43 |  * Companies claim additional benefit of Option2 is to measure interference, but according to our initial evaluation, the interference measurement does not provide any performance gains as shown in the following. L1-SINR criterion for selecting beams is illustrated below: regarding the CMR resources from another TRP as interference and then selecting one beam pair with highest capacity calculated on L1-SINR. The process of calculating capacity is as followings:  |  | | --- | | * Determine the signal panel pairs based on L1-RSRP，such as TRP 1 panel and UE panel 1, TRP 2 panel and UE panel 2 . * Calculate the value of L1-RSRP on each beam pair of each panel pair, including signal panel pairs (TRP 1 panel, UE panel 1), (TRP 2 panel, UE panel 2), and interference panel pair (TRP 1 panel, UE panel 2), (TRP 2 panel and UE panel 1). And then for each beam pair combination, which consists of (TRP 1 panel, UE panel 1) and (TRP 2 panel, UE panel 2), calculate the capacity as follows:   + Calculate the value of L1-SINR per UE panel according to the following formula. is signal power measured in UE panel 1 from TRP 1 and is signal power measured in UE panel 2 from TRP 2. is interference power measured in UE panel 2 from TRP1 and is interference power measured in UE panel 1 from TRP2. and are interference power from other TRPs, other than TRP1 and TRP2.   + Calculate capacity based on the value of L1-SINR per UE panel |  1. UPT with different measurement and report metrics in MTRP, FR2 InH  |  |  |  |  |  | | --- | --- | --- | --- | --- | | RU | Report metric | Mean | 5% | 50% | | 4% | L1-RSRP | 0.00% | 0.00% | 0.00% | | L1-SINR | -10.99% | -24.24% | -11.58% | | 16% | L1-RSRP | 0.00% | 0.00% | 0.00% | | L1-SINR | -24.42% | -53.42% | -29.24% | | 61% | L1-RSRP | 0.00% | 0.00% | 0.00% | | L1-SINR | -36.00% | -54.26% | -44.20% | |
| Huawei, HiSilicon | **For Proposal 1.1**, we support the proposal. Furthermore, we additionally support Option-3 for non-grouping cases, but it can be decided later. In our understanding on the proposal 1.1 is not for only Option-2, but agree on Option-2 first.  For the benefits of Option-2 compared with Option-1, firstly Option-2 can provide much more flexibility of beam pair reporting than Option-1 as shown in Figure-1of R1-2100211. Secondly, the interference between reported beam pairs (for simultaneous reception) can be measured and reported with L1-SINR. But for Option-1, since beams in each group is not for simultaneous reception, so UE cannot measure the inter-beam interference for beam pairs for simultaneously.  **For Proposal 1.2**, we prefer Alt-1.  **For Proposal 1.3**, ok at this stage. |
| MediaTek | In order to avoid sticking without progress, we suggest at least we can reach consensus at least on a **general** version of Proposal 1.2 first. We believe resource configuration enhancement is needed for all of these options. Based on the Draft Proposal 1.2, an example is provided as follows:  Draft Proposal 1.2:   * At least for Option 1 and/or Option2, if supported, down-select from the following alternatives in RAN1#104b-e   + Alt-1: Support configuration of two CMR resource sets corresponding to a periodic/semi-persistent CMR resource setting or an aperiodic trigger state     - UE reports two beams (e.g. CMR resource indices) that can be received simultaneously from different CMR resource 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   + Alt-2: Support configuration of two CMR resource subsets in a CMR resource set corresponding to a CMR resource setting     - UE reports two beams (e.g. CMR resource indices) that can be received simultaneously from different CMR resource subsets     - 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: Support indication of two 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 two beams (e.g. CMR resource indices) that can be received simultaneously from different 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 |
| APT | **Draft Proposal 1.2**: Regarding revision of MTK, we sympathize the intention to make the proposal general and we are also a fan of Option 1. However, in this way, the description of these three alternatives is needed to be changed as well, since they seem now tailored for Option 2. |
| Lenovo&MotM | For Proposal 1.1, support.  For Proposal 1.2, we prefer Alt-1.  For Proposal 1.3, support. |
| Apple | We have the following questions for option 2.  Q1: If UE reports 4 beams (2 from TRP 1 and 2 from TRP 2), which are received from different UE panels, to let gNB know whether each two can be received simultaneously, in option 1, UE reports 2 groups {1, 2}, {3, 4}, in option 2, UE reports 4 groups {1, 3}, {1, 4}, {2, 3}, {2, 4}. So, the overhead for option 2 could be larger than option 1 in this case. Is it correct understanding?  Q2: Our understanding is that it is hard to measure inter-beam interference. The key problem is UE Rx beam selection. Let’s assume there are 3 NW beams from two TRPs as shown in the figure below, {1}, {2, 3}. UE uses beam {1, 2, 3} to receive corresponding NW beams. Then to measure inter-beam interference, UE needs to use UE beam {1, 2} to receive NW beam {1, 2}, and UE beam {1, 3} to receive NW beam {1, 3}. But it is impossible for UE to scan all combinations when receiving corresponding DL RS, e.g. SSB 1 based one NW beam 1 as shown in the figure. So, is it correct understanding that none of the options can be used for inter-beam interference measurement? If not, how can UE apply the Rx beam for different NW beams?    Q3: According to the following agreements in Rel-15, do you agree that both option 1 and option 2 have been supported in Rel-15?  Agreements:         Support the following for group based beam reporting, if group based beam reporting is configured:  o   In a beam reporting instance, a UE can be configured to report N different Tx beams that can be received simultaneously    Note: UE may report N or fewer beams in a given reporting instance    N is configured by the gNB where N<= Nmax         Nmax depends on UE capability  o   FFS:  how to define the UE capability  o   N =2 is supported. Further study {4,8}         Notes: Information indicating group is not required to be reported in Rel-15  o   Note:    From the perspective of Alt-1, the UE reports one group with N Tx beams.    From the perspective of Alt-2, the UE reports N group with one Tx beam per each group.  o   Note: Mechanisms to reduce UE complexity for beam pair search should be further studied |
| Intel | To Apple:  Q1: **Overhead**: Yes, but option 2 also provides more information than option 1, so we are comparing apples to oranges.  Q2: **Impossible:** we don’t understand why it is “impossible” to measure pair-wise interference. This is up to UE implementation on how to reduce the search space (perhaps using RSRP information to prune some beam-pairs or hierarchical search etc.)  Q3: **Already agreed**: probably not a critical/relevant issue at this point.  To Vivo:  **Performance**: Firstly, L1-RSRP information is also available from option-2. we want to utilize L1-SINR information to differentiate between the case that 2 beams (in a reported beam-pair) that are received by 2 UE panels vs 2 beams (in a reported beam-pair) that are received by the same panel. Secondly, in the simulation results it appears that the best beam pair according to L1-SINR metric is worse than L1-RSRP metric – this probably depends on how UE is measuring interference (the beam used to measure interference perhaps) but only you can provide the answer. But this aspect we assume will be left for UE implementation such that the used interference reflects well the interference due to multi-TRP reception using the reported beam-pair. |
| Apple2 | To Intel:  Q1: could you clarify what “more information” is?  Q2: To clarify a little bit. The problem is about the UE Rx beam selection to measure inter-beam interference. If there are 64 SSBs in each TRP. How can UE select the Rx beam to receive each SSB for mutual interference measurement? We should note that UE would not optimize Rx beam for a particular CSI-reportConfig, since UE may be configured with multiple CSI-reportConfig for different functionalities, e.g. P1/P2/P3, group based, non-group based and so on. The SSB may also be configured for other functionalities, e.g. CBD/BFD/RLM.  The situation for beam reporting for aperiodic CSI-RS could be even worse.  Q3: To clarify more, during GTW, there is a comment that only option 2 is agreed in current spec. We would like to say that is not true, and check companies understanding about it. |
| Vivo2 | @Intel  Computation of L1-SINR is well documented in 38.215 between channel part and interference part. Some other more advanced measurement behavior should first be discussed and evaluated before we directly go to the “support” of a new report based on non-justified assumptions. For example, if we would like to use CSI-like calculation to evaluate beam pair performance, the related behavior and the relationship with CSI report would need further discussion. Based on these understanding, inter-beam interference should not used to justify support of Option2.  For your comment on overhead part, we would like to understand which additional information you are referring to. |
| Xiaomi | For proposal 1.1, support  For proposal 1.2, take Alt-1 as an example, since UE assumes CMR resource in the same CMR resource set cannot be received simultaneously, how can UE reports more than 2 beams which can be received simultaneously? For example, M=3, beam#1 from CMR resource set#1, beam#2 and beam#3 from CMR resource set#2, but in the assumption, beam#2 and beam#3 cannot received simultaneously. There must be a contradiction. So in our understanding, M cannot larger than 2.  For proposal 1.3, support. |
| LGE | For Proposal 1.1: Support. We sympathize with HW’s comment. We are also supporting option 3, but there is clear majority view on option 2 so prefer to support option 2 first. We are not objecting option 1 and option 3 and we can further discuss.  For Proposal 1.2: Ok, and we prefer Alt-1.  For Proposal 1.3: support.  Regarding Apple’s questions:  Q1) If UE has to report all of beam pairs which can be received simultaneously for option 2, the overhead for option 2 can be larger than that of option 1. But, UE don’t need to report all of combinations and also gNB don’t need to push UE to report all of combinations. As Intel commented, option 2 provides more information than option 1 when N, M of option 1 and 2 are same, e.g., UE reports best pair(s) within all of pairs from UE Rx circumstance perspective.  Q2) Agree with Intel. Or with further enhancement (group/pair candidates for option 2 can be configured for CMR resource configuration in advance to reporting), UE can explicitly measure L1-SINR of TRP1 and L1-SINR of TRP 2 simultaneously using multi Rx panel from the group/pair candidates configuration.  Q3) Agree. But share the same view with Intel |

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

Draft Proposal 2.1: 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)

Draft Proposal 2.2: For M-TRP BFR, BFD-RS configuration

* Support explicit RRC/MAC-CE configuration of BFD-RS set, for both S-DCI and M-DCI
* Support implicit configuration of BFD-RS set
  + If all CORESETs in a BWP are configured/activated with one TCI
    - For M-DCI, BFD-RS set k (k = 0, 1…) is based on TCI state of CORESETs with *CORESETPoolIndex = k*
  + FFS: decided in RAN1#104-e whether/how to support implicit configuration for S-DCI, e.g. BFD-RS set k (k = 0, 1 …) is based on TCI state of CORESETs in CORESET subset k (k = 0, 1...)FFS: if at least one CORESET is activated with multiple TCI states, if supported.

Draft Proposal 2.3: For M-TRP BFR

* Support 1-to-1 association between BFD-RS set k (k=0, 1…) and NBI-RS set j (j = 0, 1…),
  + FFS: k = j.

Draft Proposal 2.4: For BFRQ of M-TRP BFR

* In RAN1#104-e, down-select from the following options :
  + Option 1: Up to one dedicated PUCCH-SR resource in a cell group, with one UL Tx spatial filter for each PUCCH-SR resource
  + Option 2: Up to one dedicated PUCCH-SR resources in a cell group, with two UL Tx spatial filters for each PUCCH-SR resource
  + Option 3: Up to two dedicated PUCCH-SR resources in a cell group, with one UL Tx spatial filter for each PUCCH-SR resource
    - For option 2 and 3, study the selection of PUCCH-SR resource(s) and/or the UL Tx spatial filter
* Support BFRQ MAC-CE that can convey information of failed CC indices, one new candidate beam per 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, and applicable cell type (SCell vs. SpCell)

Draft Proposal 2.5: BFRQ response

* Support the same gNB response as in Rel.16 SCell BFR (i.e. DCI with toggled NDI scheduling a same HARQ process ID as the PUSCH carrying BFRQ MAC-CE)

Draft Proposal 2.6: UE QCL/spatial relation assumption /UL power control upon gNB response

* Support PDCCH/PUCCH QCL/spatial relation assumption / UL power control update with the latest reported new candidate beam, per associated failed TRP, based on Rel.16 mechanism.

Table 2: Company inputs

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| **Company** | **Comments** |
| vivo | For proposal 2.5, support the following update.  Draft Proposal 2.5: BFRQ response   * Support the same gNB response as in Rel.16 SCell BFR (i.e. DCI with toggled NDI scheduling a same HARQ process ID as the PUSCH carrying BFRQ MAC-CE)   FFS considering as response the MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure; |
| OPPO | Proposal 2.2: Do not support the proposal.  Do not support explicit configuration. The TCI-state for PDCCH can be even indicated by DCI. How can we use high layer signaling to configure BFD RS. Furthermore, we do not support to enhance BFR for S-DCI. There is no use case to support per-TRP BFR for S-DCI system because there is no explicit TRP in S-DCI system. Furthermore, we are designing repetition of PDCCH from two TRPs,  We suggest to update the 2.2 as follows:  Draft Proposal 2.2: For M-TRP BFR, BFD-RS configuration   * ~~Support explicit RRC/MAC-CE configuration of BFD-RS set, for both S-DCI and M-DCI~~ * Support implicit configuration of BFD-RS set   + If all CORESETs in a BWP are configured/activated with one TCI     - For M-DCI, BFD-RS set k (k = 0, 1…) is based on TCI state of CORESETs with *CORESETPoolIndex = k*   + ~~FFS: decided in RAN1#104-e whether/how to support implicit configuration for S-DCI, e.g. BFD-RS set k (k = 0, 1 …) is based on TCI state of CORESETs in CORESET subset k (k = 0, 1...)FFS: if at least one CORESET is activated with multiple TCI states, if supported.~~   Proposal 2.6: we do not support including PUCCH here because there is no association between the PUCCH resource and TRP/CORESETPoolIndex. That at least needs FFS.  Furthermore, Rel.16 mechanism can not be used because Rel.16 is not per-TRP.  We suggest to update 2.6 as follows:  Draft Proposal 2.6: UE QCL/spatial relation assumption /UL power control upon gNB response   * Support PDCCH/~~PUCCH QCL/spatial relation assumption / UL power control update~~ with the latest reported new candidate beam, per associated failed TRP~~, based on Rel.16 mechanism~~. |
| Huawei, HiSilicon | General fine for the proposals.  For Proposal 2.4, Option-3 is preferred. |
| APT | **Draft Proposal 2.5/2.6**: Since we have mentioned “M-TRP BFR” in main bullets of proposals 2.1 to 2.4, we should also make similar changes for proposal 2.5/2.6 to make them aligned and clear. |
| Lenovo&MotM | **For Proposal 2.1, support.**  **For Proposal 2.2, we only support implicit configuration.**  **For Proposal 2.3, support.**  **For Proposal 2.4, we suggest to discuss this issue for SpCell and SCell separately since the priority of SpCell and SCell is different. For SpCell, we support Option 3, while for SCell, we support Option 1.**  **For Proposal 2.5, support.**  **For Proposal 2.6, we don’t support to reuse the scheme of R16 for UL power control update. Because there is a discussion about TPC commands enhancement for PUCCH in multiple TRPs, two closed loop indexes may be configured for PUCCH to different TRPs. Therefore, whether the closed loop index of all PUCCH resources can be 0 should be further discussed.** |
| Apple | As we commented, for proposal 2.4, we suggest we remove all “UL Tx spatial filter” related part. |
| MediaTek | On draft Proposal 2.4, we believe the discussion point of PUCCH-SR resource is when TRP-specific beam failure happens on a PUCCH cell, how to avoid SR transmission on the link of the failed TRP. Then, these options should be limited for the case if a PUCCH cell is configured in FR2 since we don't have to handle beam failure in FR1. Thus, we prefer the following update, and this may address Apple’s concern.  Draft Proposal 2.4: For BFRQ of M-TRP BFR   * In RAN1#104-e, down-select from the following options if a PUCCH cell of a cell group is configured in FR2 :   + Option 1: Up to one dedicated PUCCH-SR resource in the cell group, with one UL Tx spatial filter for each PUCCH-SR resource   + Option 2: Up to one dedicated PUCCH-SR resources in the cell group, with two UL Tx spatial filters for each PUCCH-SR resource   + Option 3: Up to two dedicated PUCCH-SR resources in the cell group, with one UL Tx spatial filter for each PUCCH-SR resource     - For option 2 and 3, study the selection of PUCCH-SR resource(s) and/or the UL Tx spatial filter   On draft Proposal 2.6, share same view with OPPO. |
| Xiaomi | Support all proposals and prefer Option 2 in proposal 2.4 |
| LGE | Generally fine with the above draft proposals. As we commented on email, for proposal 2.2, explicit BFD-RS can be supported regardless of whether S-DCI or M-DCI based M-TRP transmission is configured. We prefer to remove “for both S-DCI and M-DCI” in the first bullet.  Regarding the issue of supporting explicit BFD as well as implicit BFD, explicit BFD was introduced for UE-specifically beamformed CSI-RS and implicit BFD was mainly for TRP-specific CSI-RS in Rel-15/16. Since both types of CSI-RS are possible depending on different NW deployment, RAN1 have been agreed to support both options for BFR in Rel-15/16. We are not sure why Rel-17 BFR should be different from Rel-15/16 and limits the use of BFR in one of the NW implementation options. |

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

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| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **notes** |
| 3.1 | Introduce at least one of the following methods should be considered when beam collision between different DL channel(s) and RS(s) occurs.   * Alt 1: UE can prioritize the reception of a DL channel or RS with higher priority. * Alt 2: UE can use a predefined beam to receive the conflicting DL channels or RSs. * Alt 3: UE can use the indicated beam and corresponding panel to receive the DL channel or RS with higher priority, and meanwhile UE can use the other active panel and a predefined beam to receive the other DL channel or RS with lower priority. | Support: ZTE, InterDigital |  |
| 3.2 | * Support to enhance on DL SPS PDSCH reception for multi-DCI based multi-TRP case. * In overlapping PDSCH without corresponding PDCCH transmissions receiving occasions from multiple TRP, one PDSCH with lowest configured sps-ConfigIndex for each TRP could be received. * PDSCH without corresponding PDCCH transmission associates with the same value of CORESETPoolIndex as CORESET where PDCCH activating the PDSCH lies in. | Support: Spreadtrum |  |
| 3.3 | In multi-DCI based mTRP, the existing QCL prioritization rule for overlapped CORESETs should be applied within CORESETs with same CORESETPoolIndex. | Support: Qualcomm |  |
| 3.4 | Release some constraints due to QCL-TypeD collision for UEs that can receive two beams simultaneously, where the starting point is to release the constraints for SSB/CSI-RS for RLM/BFD/CBD. | Support: Apple |  |
| 3.5 | * + Support a higher layer signaling to indicate whether to enable simultaneous reception of multiple channels/RSs with different QCL-TypeD at UE.   + Discuss UE behavior for S-DCI and M-DCI separately | Support: DOCOMO: |  |

Table 3: Additional company inputs: issue 3

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| **Company** | **Input** |
| Lenovo&MotM | We have the same view with Apple on “Release some constraints due to QCL-TypeD collision for UEs that can receive two beams simultaneously”. In addition to mentioned SSB/CSI-RS for RLM/BFD/CBD, simultaneous transmission on PDCCH and simultaneous transmission on CSI-RS for beam management can be also discussed. |
| Huawei, HiSilicon | These issues are low priority for discussion. |
| Apple | The objective is to handle simultaneous reception related BM enhancement, we suggest we list potential study points for next steps. |
| Spreadtrum | Support to discuss the above issues |
| ZTE | This issue is essential and should be discussed with priority. From our perspective, the following aspects have been identified for DL simultaneous reception: PDCCH+PDSCH, PDSCH+PDSCH, PDSCH+CSI-RS, CSI-RS+CSI-RS. |
| InterDigital | We agree with ZTE that the issues proposed by ZTE are essential and should be discussed. |

# 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

# Reference

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