**3GPP TSG RAN WG1 #106bis-e R1-210xxxx**

**e-Meeting, October 11th – 19th, 2021**

Source: Moderator (CATT)

Title: Moderator summary #1 on enhancements on beam management for multi-TRP

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This document summarizes companies’ proposals in agenda 8.1.2.3. Only the essential issues with high company interests are listed in this summary. Other issues can be revisited at a later stage.

1. Beam measurement/reporting
   1. Issue 1.1: UE reporting of information related to Rx panel/antenna group

Views from company contributions on issue 1.1 are summarized as follows:

UE indicates if reported beams are associated to different RX spatial filters, or maximum number of supported layers corresponding to DL RS in a group, or whether two beams in a beam pair can be used for spatial multiplexing or diversity:

* **Alt-1**: whether beams are associated to different Rx filters/panels (Xiaomi, Qualcomm, Samsung, ETRI, Apple, CMCC)
* **Alt-2**: whether beams are received with spatial multiplexing or diversity (ZTE, Intel)
* **Alt-3**: maximum number of supported layer per DL RS in a group (MediaTek, Apple, Ericsson, ZTE)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | To clarify, we think Alt3 needs to be merged into Alt1. Standalone Alt3 cannot be helpful to identify the maiximum rank, since both DL RSs may be received from one panel. |
| vivo | We prefer Alt-1. |
| ZTE | We can also support Alt-3.  Besides, we also identify some remaining issues while two RS sets are configured for group based report procedure. For instance, whether Repetition, aperiodicTriggeringOffset for two sets should be configured with same value or not, and how to handle the corresponding CPU calculation of CSI. We prefer to have some further discussion. |
| OPPO | We do not support any of these 3 alts. The information all these three Alts shall belong to part of the CSI measurement and reporting. In Option 2, the UE reports one group of 2 Tx beams that can be received simultaneously. How/whether/how many layers the channel when these two Tx beam are used simulatenaouls shall be measured in mTRP CSI reporting, not here. |
| MediaTek | In AI 8.1.1 MP-UE, there is a similar discussion on UE can inform the max number of supported UL layers per SSBRI/CRI to NW by using a “logical index”. We see Alt-1 and Alt-3 can be supported by the same mechanism as well. We prefer to discuss issue 1.1 after there is a conclusion of MP-UE in AI 8.1.1. |
| DOCOMO | gNB knows the traffic type and overall scheduling information, so that gNB knows what type of two beams are needed from UE. In that case, gNB can configure the Rx panel/antenna related hypothesis for beam measurement, e.g., whether the two beams in each beam group are associated to different Rx filters/panels or whether the two beams in each beam group are for spatial multiplexing or diversity, and UE measures and reports the beam groups according to gNB’s indication.  Hence, we think above Alts should be configured by gNB, not reported by UE. |

* 1. Issue 1.2: Support of L1-SINR report

Views from company contributions on issue 1.2 are summarized as follows:

* Support measurement of interference arising from the other beam in the reported beam group
* IMR resource assumption, e.g.
  + reuse CMR of other beam in the beam group (Nokia/NSB, Qualcomm, CATT)
  + explicit IMR configuration (TCL, DOCOMO, Nokia/NSB, Lenovo/MotM), including ZP and/or NZP IMR

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We do not support L1-SINR since no performance gain is observed. |
| vivo | We don’t support L1-SINR since it can not reflect inter-beam interference. |
| ZTE | If IMR is explicitly configured, we observer significant gains through implicitly reporting low-interference beam. Some results can be found in our contribution R1-2108873. |
| OPPO | It is not feasible to support L1-SINR for opition 2 due to the diffculty of calculating mutual intereference.  If the IMR resource assumption is to resue the CMR of other beam, then the problem is we will meet a chicken-or- the egg problem: before UE calculates the L1-SINR, the UE does not know which two Tx beams shall be placed in one beam group. But before the UE knows which two Tx beams are in one beam group, the UE does not how to calculate the L1-SINR.  If the IMR resource is based on explicit IMR configruaiton, the issue is the inter-beam interference is not considered and the calculation of L1-SINR does not provide much valid information. |
| MediaTek | Not support L1-SINR |
| DOCOMO | Considering that group-based beam reporting has been supported for L1-SINR in Rel-16, it is also preferred to support group-based beam reporting option 2 for L1-SINR in Rel-17, which reflects inter-beam interference better. Explicit IMR configuration can be configured for each CMR, like CSI measurement configuration for NCJT. |

1. M-TRP Beam failure recovery
   1. Issue 2.1: Simultaneous configuration of cell-specific and TRP-specific BFR in a cell

Views from company contributions on issue 2.1 are summarized as follows:

* Support simultaneous configuration of cell-specific and TRP-specific BFR in a cell
  + Yes: CMCC, ITRI, TCL, Sony, LGE, NEC, FGI/APT, Lenovo/Moto, ZTE
  + No: Qualcomm, Intel, DOCOMO, CATT, Spreadtrum
* Up to 2 BFD-RS sets can be configured per at least Scell: FGI/APT, CATT, Nokia/NSB, Ericsson, NEC, ZTE

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | At current stage we do not see a problem to simultaneously configure cell-specific and TRP-specific BFR. Maybe we can revisit this issue after most of details for TRP-specific BFR is finished. |
| FGI/APT | We support the second bullet in general. But we suppose it can be applied for not only SCell but also PCell/PSCell. |
| vivo | For the procedure of BFR, we don’t support simultaneous configuration of cell-specific and TRP-specific BFR in a cell.  For the configuration of BFR-RS, we share similar view with FGI/APT. |
| ZTE | Based on the latest RAN2 agreement, the simultaneous operation of cell-specific and TRP-specific BFR has been supported. How to handle the configuration may be up to RAN2 also. In general, we also think that we may further review this issue in the maintanance session after the L1/MAC/RRC details have been stable. |
| OPPO | The definition of “simulatenous configuraiotn of cell-specific and TRP-specific” is not clear.  If it means “configuring BFD-RS for both cell-specific and TRP-specific and the UE detects beam failure for both cell-specific and TRP-specific”: then we do not support. That is not reasonable for pratical implemention. |
| DOCOMO | If TRP-specific BFR is configured, i.e., two BFD-RS sets are configured, there is no need to configure an extra BFD-RS set for cell-specific BFR. |
| Lenovo/MotM | For the first bullet, we support it.  For the second bullet, we also support it in general, but we prefer to include PCell/PSCell as well. |
| NEC | Similar view with OPPO that definition of “simulatenous configuration of cell-specific and TRP-specific” should be clarified.  If it’s the procedure, does RACH based fallback + TRP specific BFR mean simultaneous configuration? And regarding the level of a cell, we think both of cell specific BFR and TRP specific BFR should be supported, there may be cases that one BWP with single-TRP (then cell specific BFR) and another BWP with multi-TRP (then TRP specific BFR).  And regarding the BFD RS configuration, we share similar view with DoCoMo that up to 2 BFD RS sets are sufficient. |

* 1. Issue 2.2: Update of explicit BFD-RS set

Views from company contributions on issue 2.2 are summarized as follows:

* Support to Introduce MAC-CE for updating explicit BFD-RS set: CATT, ZTE, Samsung, DOCOMO, vivo
* Support to associate TCI state for PDCCH with a BFD RS: OPPO, Apple

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| vivo | We support to introduce MAC-CE for updating the QCL assumption(s) of BFD-RS(s) configured explicitly. Besides, we think reusing legacy mechanisms, e.g., RRC signalling, to update explicit BFD-RS set is fine. |
| ZTE | Support explict MAC-CE update for BFD-RS, in order to guarantee the same timeline between PDCCH beam update and explicit BFD RS configuration. |
| DOCOMO | Support both RRC and MAC CE based configuration of BFD-RS resource set(s). |
| Lenovo/MotM | We support at least RRC based explicit BFD-RS set configuration, and we are open to further support MAC CE based updating of BFD-RS set. |

* 1. Issue 2.3: Implicit BFD-RS set configuaration for CORESET with one TCI state

Views from company contributions on issue 2.3 are summarized as follows:

* The number of TCI states (X) in implicit BFD-RS determination
  + Alt-1 : 2 (Ericsson)
  + Alt-2 : The number of TCI states of CORESETs with CORESETPoolIndex = k (CATT)
* BFD-RS selection when the number of CORESETs with CORESETPoolIndex = k exceeds X
  + Alt-1: re-use or similar to the RLM-RS selection rule (Qualcomm, Huawei)
  + Alt-2: Up to UE implementation (Ericsson, Convida)
  + Alt-3 gNB implementation (no more than UE capability) (vivo)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We do not quite understand the first bullet. Some clarification may be needed.  For the second bullet, we support Alt1. |
| vivo | According to the discussion when the maximum number(X) of BFD RS is determined, the understanding is to at most X periodic CSI-RS resources would be configured for all the CORSETs. So it should be specified that UE does not expect larger than X periodic CSI-RS resources QCL-D’ed with configured CORESETs. |
| ZTE | Regarding first bullet, some clarification may be needed.  Regarding second bullet, we prefer to simplify the selection rule, rather than directly reusing the complicate rule for RLM-RS selection. |
| OPPO | For the 2nd bullets, we prefer Alt-1. |
| DOCOMO | For the 2nd bullets, support Alt-1. |
| Lenovo/MotM | For the first bullet, it’s not clear enough. For our understanding, the X is the number of TCI states is the number of RSs of a TCI state pool where one BFD-RS set is selected. If our understanding is correct, we support Alt-2.  For the second bullet, we support Alt-1. |

* 1. Issue 2.4: Association between BFD-RS set k and NBI-RS set j

Views from company contributions on issue 2.4 are summarized as follows:

To associate BFD-RS set k and NBI-RS set j:

* Alt-1: 1-to-1, fixed in spec (CATT, Intel, ITRI, vivo, Apple, MTK)
* Alt-2: 1-to-1, configurable (ZTE, ~~Apple,~~ Fujitsu, OPPO, Qualcomm, CMCC)
* Alt-3: 1-to-1, leave it to RAN2 (Convida, Nokia/NSB, ETRI, FGI/APT)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support Alt1. |
| FGI/APT | We support Alt-3 with the understanding that this issue belongs to RAN2’s expertise. |
| vivo | We support Alt-1 if NBI-RS set(s) is configured. |
| ZTE | We can also live with Alt3. |
| MediaTek | Support Alt1, this can be decided in RAN1 |
| DOCOMO | Support Alt-1, and we can also accept Alt-3. |
| Lenovo/MotM | We support Alt-1. |
| NEC | We prefer Alt-1. |

* 1. Issue 2.5: PUCCH-SR resource selection rule for LRR feedback

Views from company contributions on issue 2.5 are summarized as follows:

PUCCH-SR resource selection rule for LRR:

* Alt 2.5.2 A: FGI/APT, Apple, TCL
* On PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, there is no consensus to adopt alt-1 or alt-2. PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 B: InterDigital, Spreadtrum, CATT, Fujitsu, Qualcomm, Xiaomi, Lenovo/Moto, vivo, ~~OPPO~~
* On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 2 (e.g. association to failed BFD-RS set) if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 C: Samsung, NEC, CMCC, Xiaomi, CATT, Sony, Lenovo/Moto, vivo, ZTE
* On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 1 (e.g. association to non-failed BFD-RS set) if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 D: Convida, Ericsson, MTK
* Revert the past agreement on supporting configuration of up to 2 PUCCH-SR resources. A UE can be configured up to 1 PUCCH-SR resource in a cell group.

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We support Alt 2.5.2A and we can also compromise to send both PUCCH-SR resources with regard to reliability. Besides, we can also accept Alt 2.5.2D. |
| FGI/APT | We support Alt 2.5.2 A and also Alt 2.5.2 D |
| ZTE | We support Alt 2.5.2 C. |
| OPPO | We do not support Alt A, B or C because they all seem to assume that one SR configuraiton is associated with two PUCCH resources in one BWP, which is not aligned with the SR configruaiton design.  Per the design specified in 38.321, each SR configuraiton can only be assciarted with up to one PUCCH resource in one BWP. If gNB uses two PUCCH resoucres for TRP BFR, that would imply that gNB would configures two SR configurations for TRP BFR. Assuming one SR configuraiton assocaited with two PUCCH resource would cause much more troubles on the specification of SR trigger procedure, which shall be avoided.  We are ok with 2.5.2.D if we can not settle down a design. |
| MediaTek | Support Alt 2.5.2 D |
| DOCOMO | We support Alt 2.5.2 C.  Based on discussion in last meeting, we think it is better to start from following proposals.   * ***Support to configure an association between a TRP (e.g., BFD-RS set) on SpCell and a PUCCH-SR resource on SpCell.*** * ***FFS configure an association between a TRP (e.g., BFD-RS set) on SCell and a PUCCH-SR resource on SpCell*** |
| Lenovo/MotM | We support Alt 2.5.2. B and Alt 2.5.2.C in general. However, the association between a PUCCH-SR resource and a BFD-RS set configured in the cell where two PUCCH-SR resources are configured is the key point. The motivation of selection between 2 configured PUCCH-SR resources is to select the PUCCH-SR resource whose link is not failed yet. While UE can know whether the link of any of the two PUCCH-SR resources in a cell where TRP-specific BFR are configured in this cell, since UE knows which link of TRP is failed by monitoring the two BFD-RS sets. Therefore, if the cell configured with two PUCCH-SR resources are configured with TRP-specfic BFR, an association between each PUCCH-SR resource of two PUCCH-SR resources in the cell and each BFD-RS set of two BFD-RS sets in the cell can be built. Then, UE can select the PUCCH-SR resource associated with the non-failed BFD-RS set if only one BFD-RS sets is failed in the cell where 2 PUCCH-SR resources are configured. If both two BFD-RS sets are not failed or TRP-specific BFR is not configured in the cell where 2 PUCCH-SR resources are configured, then it’s up to UE implementation to select any one of 2 PUCCH-SR resources. |
| NEC | We think starting from proposal listed by DoCoMo is better. |

* 1. Issue 2.6: Number of activated spatial filters for PUCCH-SR resource

Views from company contributions on issue 2.6 are summarized as follows:

Whether PUCCH-SR resource can have 1 or 2 activated spatial filters

* Alt-1: Only 1 (Spreadtrum, Intel)
* Alt-2: up to 2; diversity (e.g. AI 8.1.2.1) when 2 spaial filters are activated (Xiaomi, FGI/APT, vivo, ZTE)
* Alt-3: up to 2; filter selection when 2 spatial filters are activated (Qualcomm, LGE, Xiaomi, ETRI)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support Alt2. We failed to see the necessity for enhancement like Alt1/3. Maybe we do not need to discuss the whole issue. |
| ZTE | Support Alt2. |
| OPPO | Alt2. Why do we dicuss this here ? the SR for TRP BFR is sent in PUCCH resource but we shall not change the design of PUCCH resource. |
| DOCOMO | Support Alt2. |
| Lenovo/MotM | Support Alt 1. Multiple beams are supported for PUCCH repetition now. And it will complicate the interference in gNB side if it allows UE to select one beam from two beams. |

* 1. Issue 2.7: Content of MAC-CE related to SpCell when transmitted on msg3, msgA

Views from company contributions on issue 2.7 are summarized as follows:

Content of MAC-CE related to SpCell when transmitted on msg3, msgA:

* Alt-1: 1-bit SP field (reuse Rel-16 design) (DOCOMO, CATT, ~~OPPO~~)
* Alt-2: Two bits corresponding to two TPRs of SpCell (ZTE)
* Alt-3: RAN2 issue (Nokia, MTK)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support Alt3. We noticed RAN2 agreed something related to MAC CE content in last RAN2 meeting. Whether to use 1-bit or 2-bit SP field seems to be a RAN2 issue. |
| vivo | In our view, this issue only arises when RACH-based BFRQ is triggered. after discussion in the previous meetings, we think only when either of the following two conditions is met, RACH-based BFRQ will be triggered :   * Only one TRP in SpCell is declared of beam failure, but no PUCCH-SR configured and no available UL grant. * Both TRPs in SpCell are declared of beam failure within the predefined window ;   For the first case, the contents of MAC CE had been determined in the last meeting. For the second case, we think the failed CC indexes, the indications of failure event, the indications of whether new beam if found, candidate resource indices of both TRPs should be carried in MAC CE to recover both TRPs simultaneously and maintain mTRP operation as much as possible. As for the design of MAC CE, it is up to RAN2. |
| ZTE | Alt-1 may NOT work in our views. CBRA may be intialized by two types of events: #1 two TRPs in PCell both failed; #2 there is no available/configured SR. For the latter, identifying which TRP fails is necessary. |
| OPPO | We are ok to leave it to RAN2 design. |
| MediaTek | Support Alt3 |
| DOCOMO | We support Alt-1, and we can accept Alt-3. |
| Lenovo/MotM | As vivo mentioned the cases when RACH-based BFRQ will be triggered, different events should be supported. We also think the design of MAC CE should be up to RAN2. While it’s better to send a LS to RAN2 on the supported events to trigger a RACH-based BFRQ and the corresponding UE behaviours. |
| NEC | Prefer Alt 1, and maybe we can discuss this after we agree scenarios for RACH based fallback for BFR. In case of both TRPs failed, and RACH based BFR triggered, we think recovery from one TRP is enough.  And we are also fine to just leave it to RAN2. |

* 1. Issue 2.8: Beam/power update for PUCCH after receiving gNB response

Views from company contributions on issue 2.8 are summarized as follows:

Support beam/power update for PUCCH after receiving gNB response.

* Introduce association between PUCCH and TRP, e.g. through BFD-RS set ID, CORESETPoolIndex, etc.
  + Support: ZTE, Lenovo/MoM, Fujitsu, Qualcomm, Sony, ETRI, CATT, DOCOMO
  + Not support: OPPO, MediaTek, vivo

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support, but CORESETPoolIndex may needed to be provided in SP/P PUCCH resource. |
| FGI/APT | Support |
| vivo | Do not support beam/power update for PUCCH after receiving gNB response. The gains of such association does not justify specification effort. |
| ZTE | Support. |
| OPPO | Do not support to introduce the assocaition between TRP ID and PUCCH only for the purpose of PUCCH resource beam re-set.  This issue of association has been dicussed a lot in rel-16. It has big impact all many aspects of mTRP uplink transmisison. We cannot simply make a conclusion here by only considering this particular issue. |
| MediaTek | Not support due to spec effort and unclear gain |
| DOCOMO | Support |
| Lenovo/MotM | Support. |
| NEC | Support |

* 1. Issue 2.9: Beam/power update for PDSCH after receiving gNB response

Views from company contributions on issue 2.9 are summarized as follows:

Support beam/power update for PDSCH after receiving gNB response.

* + Yes: Samsung, OPPO
  + No: vivo, MTK

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support. This operation is partly supported in PCell BFR. In addition, in the field, PDCCH and PDSCH always share the same beam, if PDCCH beam fails, PDSCH beam fails as well. |
| FGI/APT | Support. |
| vivo | Do not support. No need to introduce new UE behavior in Rel.17.  • For PDSCH TCI-presentinDCI = ON, UE should follow NW-provided beam, e.g. Rel.16 rule.  • For PDSCH TCI-presentinDCI = OFF, PDSCH will anyway continue to follow scheduling PDCCH or lowest CORESET (Rel.16 rule). No new UE behavior is needed. |
| ZTE | Support |
| OPPO | Support.  Ths same function is support in SCell BFR already and the reason for supporting that is because there is no CORESET-BFR in SCell BFR. The same reason is applicalble here. |
| MediaTek | Share the same view with vivo, this can be implemented by current spec w/o additonal spec support. |
| DOCOMO | Not needed. |
| Lenovo/MotM | Do not support. Same view with vivo. |

* 1. Issue 2.10: Association between CORESET(s) and failed BFD-RS set

Views from company contributions on issue 2.10 are summarized as follows:

To associate CORESET(s) with failed BFD-RS set

* Alt-1: Through CORESETPool index (Nokia, CATT, Sony, TCL, ZTE(implicit), Fujitsu, MTK,, vivo, Qualcomm,OPPO)
* Alt-2: Either by RRC signalling or MAC CE (Lenovo/MoM, Qualcomm, ZTE(explicit))
* Alt-3: Through QCL-TypeD property of the CORESET (FutureWei)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support Alt-1. But it should be for mDCI mode only. |
| ZTE | For explicit configuration for BFD-RS by RRC/MAC-CE, we think that Alt-2 is needed. But for the implicit manner, Alt-1 is sufficient. |
| OPPO | Support Alt-1 |
| MediaTek | Support Alt-1 for M-DCI, which is already agreed for implicit BFD-RS configuration. |
| DOCOMO | For mDCI based MTRP, of course Alt-1 is used.  For sDCI based MTRP, support following new Alt. 4:  ***Alt-4 : Support association configuration between TCI state and BFD-RS set.***  It is because, for single-DCI based MTRP with per-TRP BFR, to update the new beam of CORESET for the failed TRP, there should be an association between CORESET and TRP (e.g., BFR-RS set). However, in case of CORESETs with 2 activated TCI states for single-DCI based MTRP for per-TRP BFR, to update the new beam(s) for the failed TRP(s), association between CORESETs and BFD-RS set is not sufficient, and there should be an association between one TCI state of the CORESET and the TRP. Hence, to support above cases for single-DCI based MTRP with per-TRP BFR, it is better to support association between TCI state and BFD-RS set. In that case, after receiving BFR response, for a CORESET with 2 activated TCI states, the TCI state(s) associated with the failed BFD-RS set(s) is updated to corresponding new beam. If per-cell BFR is configured for single-TRP operation or single-DCI based MTRP operation, the CORESETs with 2 activated TCI states can be updated to be with 1 TCI state only after receiving BFR response. And then gNB can re-configure the 2 activated TCI states for those CORESETs based on UE beam measurement/reporting. |
| Lenovo/MotM | Support Alt-2 since Alt-1 can only be applied for implicit manner. |
| NEC | Support Alt-1 for multi-DCI.  And we should also discuss the case for single-DCI, where Alt-2 is prefered. |

* 1. Issue 2.11: SCS of the 28 symbols

Views from company contributions on issue 2.11 are summarized as follows:

The SCS of the 28 symbols is:

* Alt-1: reuse the same mechanism of Rel-16 SCell BFR (MTK, Fujitsu)
* Alt-2: the smallest SCS of the response receiving CC and the reported CC(s) in BFRQ. (Sony)
* Alt-3: the largest SCS of the response receiving CC and the CC with failed TRP. (QC)
* Alt-4: the smallest SCS of the response receiving CC and the cell(s) with one or more failed TRPs (Nokia, ZTE)
* Alt-5: the smallest of the SCS configurations of the active DL BWP for the PDCCH reception and of the active DL BWP(s) of all failed BFD-RS sets and/or cells indicated by BFR MAC-CE. (CATT)
* Alt-6: the smallest of the SCS configurations of the active DL BWP for the PDCCH reception and of the active DL BWP(s) of the BFD-RS sets and/or cells which corresponding failure events and new beams are indicated by BFR MAC-CE. (vivo)

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support Alt2, which is aligned with R16 |
| vivo | We reveise our proposal in Alt-6. |
| ZTE | First of all, we do not have a clear R16 solution due to the fact the corrresponding CR/conclusion has not been approved. Then, to be honest, we do no identify the clear difference among Alt-1, Alt-2, Alt-4 and Alt-5. Maybe, we need to clarify: the SCS of the 28 symbol is detemined per TRP or per CC. For instance, the gNB response is received in CC0, TRP1 in CC1 and CC2 fails, but TRP2 in CC3 and CC4 fails. |
| OPPO | Whatever specifed in rel16 can be re-used here. |
| MediaTek | Since gNB response for Rel-16 SCell BFR is reused for Rel-17 MTRP BFR, the SCS of the 28 symbols can be determined by el-16 mehanism as well. |
| DOCOMO | Support Alt-1. |

* 1. Issue 2.12: RACH based feedback

Views from company contributions on issue 2.12 are summarized as follows:

* Support CBRA based feedback on SpCell as a result of per-TRP beam failure: CATT, FGI/APT, Intel, LGE, Asustek, Nokia/NSB, OPPO, MediaTek, Lenovo/MoM, vivo
* Support CFRA based feedback on SpCell as a result of per-TRP beam failure: Lenovo/MoM, Nokis/NSB (if configured), LGE, OPPO, ASUSTek, MediaTek

Companies are invited to provide their preferences and comments in the table below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support CBRA only. The overhead for CFRA is too large. |
| FGI/APT | We share similar views with Apple. |
| vivo | We share similar views with Apple. |
| ZTE | Based on previous agreement, if a single TRP fails in SpCell, TRP-specific BFR procedure should be initialized. We fail to understand why we need to further introduce CBRA/CFRA based feed back herein. If the motivation is to clarify the UE behavior in the case that two TRPs both fail in SpCell, we think that CFRA/CBFA should be both supported. |
| MediaTek | The scenario(s) triggers the CBRA/CFRA based feedback on SpCell need to be clarified together in the proposal.  Possible scenarios captured from FL summary in the previous meeting as follows:   * Scenario 1: When beam failure is detected on all BFD-RS sets on the SpCell * Scenario 2: at least one TRP fails on SpCell * Scenario 3: at least one pre-defined TRP fails on SpCell * Scenario 4: at least one TRP fails and no PUCCH-SR is configured, and no UL grant is available * Scenario 5: If MAC-CE based reporting does not work (details FFS) * Scenario 6: When no PUCCH-SR is configured   We support both CBRA and CFRA for Scenario 1 and Scenario 4 |
| DOCOMO | We share similar view with ZTE. What does “as a result of per-TRP beam failure” mean? If it means two TRPs fail in SpCell, we think that both CFRA and CBFA can be supported, which depends on gNB configuration. |
| Lenovo/MotM | We support both CFRA and CBRA. |
| NEC | Prefer CBRA only, and we share similar view with MediaTek that the scenarios should also be discussed. |

1. 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 beam measurement in support of M-TRP simultaneous transmission

* 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
  + Support extending the maximum value of N > 1, exact value FFS
  + N=1 and N=2
    - FFS: Other values larger than 2
    - FFS: Whether the UE could report beams are received with different RX beams
* Further study the support of option 1 and option 3
* The above applies at least for L1-RSRP
  + FFS: L1-SINR

**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 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 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 resource can be configured with 2 spatial relations
  1. RAN1#104b-e

**Agreement**

For beam reporting option 2

* On the maximum number of beam pairs/groups (N) that can be reported in a single CSI-report, discuss and down-select from the following two alternatives in RAN1#105-e:
  + Alt1: Support maximum value N = {1, 2}
  + Alt2: Support maximum value N = {1, 2, 3, 4}
* FFS: Introduce a UE capability Ncap on the maximum value of N in Rel.17
* On the number of beam pairs/groups (N) reported in a single CSI-report, discuss and down select between the following two alternatives in RAN1#105-e
  + Alt1: The value of N is fixed by RRC configuration
  + Alt2: The value of N is upper bounded by a maximum value Nmax configured by RRC, and dynamically selected/indicated by UE

**Agreement**

On CMR resource configuration for beam reporting option 2, adopt the following alternative:

* Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting
  + FFS: extension to aperiodic CMR resource setting
* Each reported beam pair in a single CSI-report consists of M = 2 SSBRI / CRI values, where each SSB-RI / CRI points to a CMR resource in a different CMR resource set or subset.
* Decide in RAN1#104b-e whether to adopt “set” or “subset” in the above.

**Agreement**

* Support simultaneous configuration of cell-specific BFR and TRP-specific BFR in different CCs.
* FFS: whether cell-specific and TRP-specific BFR can be configured in the same CC.

**Agreement**

* Support S-DCI and M-DCI in TRP-specific BFR in Rel.17
  + S-DCI is low priority, M-DCI is high priority
  + Unified design for S-DCI and M-DCI should not be precluded due to the prioritization

**Agreement**

On BFD-RS of TRP-specific BFR

* BFD-RS resource number:
  + The total number of RSs in two BFR-RS sets per DL BWP is a UE capability
  + On the maximum number of RS per BFD-RS set, down-select from the following two alternatives in RAN1#105-e
    - Alt1: max value is 2
    - Alt2: max value is a UE capability, including possible candidate value of 1

**Agreement**

Adopt the following beam failure detection criteria for each BFD-RS set

* The physical layer in the UE assesses the radio link quality per BFD-RS set and indicates the BFD-RS set index to higher layers every X ms, if the hypothetical PDCCH BLER of all BFD-RS in the corresponding set of BFD-RS is higher than a threshold
  + X is max{minimal periodicity of BFD RS in the set, 2ms}

**Agreement**

A UE configured with TRP-specific BFR can be configured with 1 PUCCH-SR resource in a cell group

* NOTE: it has been agreed in RAN1#104-e that a UE can be configured with up to 2 PUCCH-SR resources in a cell group

**Agreement**

For the TRP specific BFR, for a UE configured with two PUCCH-SR resources in a cell group when beam failure is detected in a one or more CCs in one or more of BFD-RS sets configured in one or more of CCs,

* Down select one of the following PUCCH-SR resource selection rules when SR is triggered (or their combinations) for the study, without precluding other alternatives, in RAN1#105-e
  + Alt-1: PUCCH-SR resource associated with other/non-failed BFD-RS set, association details FFS
  + Alt-2: PUCCH-SR resource associated with failed BFD-RS set, association details FFS
  + Alt-3: Leave it up to UE implementation
* Note: PUCCH-SR resource is PUCCH resource carrying SR
* FFS: Whether two PUCCH-SR resources are under the same or different SR resource configuration or SR configuration (eventual decision may or may not happen in RAN1)

**Agreement**

On CMR resource configuration for beam reporting option 2, decide in RAN1#105-e whether to adopt “set” or “subset”:

* NOTE: the following has been agreed
  + Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting
    - FFS : extension to aperiodic CMR resource setting if two CMR resource sets are supported
  + Each reported beam pair in a single CSI -report consists of M = 2 SSBRI/CRI values, where each SSBRI /CRI points to a CMR resource in a different CMR resource set or subset.
* FFS : bitwidth of each SSBRI/CRI determined based on the number of SSB/CSI-RS resources from the associated set/subset, or across two sets/subsets
  1. RAN1#105-e

**Agreement**

For CMR configuration for option 2, adopt

* Alt-1: “set”

**Agreement**

The bitwidth of each SSBRI/CRI is determined based on the number of SSB/CSI-RS resources in the associated CMR resource set

* FFS: specify the association between SSBRIs/CRIs in a reported group and CMR resource sets

**Agreement**

* For beam measurement/reporting option 2, the maximum number of beam groups in a single CSI-report is a UE capability and may take value from Nmax = {1,2,3,4} in Rel.17.
  + FFS: If UCI payload reduction for Nmax>=2 is needed and if so, how
* The number of beam groups (N) reported in a single CSI-report
  + Alt1: The value of N is configured by RRC signalling

**Agreement**

Select one of the following alternatives with possible modification in RAN1#106-e

* Alt 2.5.2 A:
  + On PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, there is no consensus to adopt alt-1 or alt-2. PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 B:
  + On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 2 if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 C:
  + On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 1 if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 D:
  + Revert the past agreement on supporting configuration of up to 2 PUCCH-SR resources. A UE can be configured up to 1 PUCCH-SR resource in a cell group.
  1. RAN1#106-e

**Agreement**

For aperiodic report of beam reporting option 2,

* When associated with aperiodic resource setting, extend the existing RRC parameter *CSI-AssociatedReportConfigInfo* to be configured with two CMR resource sets where each may be configured with their corresponding QCL information.
  + FFS: Detailed association scheme
* When associated with periodic/semi-persist resource setting, the resource setting comprises two CMR resource sets.

**Conclusion**

There is no consensus to support M>2 beams per group for beam reporting option 2 in Rel.17.

**Agreement**

Support differential L1 RSRP reporting as a UCI reduction scheme for beam measurement/reporting option 2.

**Agreement**

Differential reporting across all beam groups in a CSI-report

* Including 1-bit indicator of the CMR set associated with the largest RSRP value in all groups
  + NOTE: best beam is assumed in the 1st group
  + 1-bit indicating CMR set with higher RSRP value (e.g. 0 indicating 1st SSBRI/CRI from 1st CMR set, 1 indicating 1st SSBRI/CRI from 2nd CMR set); UCI payload partitioning = 7/4 bits for 1st/2nd SSBRI/CRI in first beam group; 4 bits for all beams in other groups;

**Agreement**

For multi-TRP BFR, a single MAC-CE is used at least for BFRQ for all TRPs in all CCs in a cell group, which includes

* Indices of failed BFD-RS set (as an indication of failed TRP link)
* Indices of CC containing the failed TRP link
* An indicator whether a new candidate beam is identified in the NBI-RS set associated with the failed BFD-RS set, and an resource indicator representing the new candidate beam (if identified) based on the number of NBI-RS resources in the corresponding NBI-RS set.
* FFS: Content of MAC-CE related to SpCell when transmitted on msg3, msgA
* Note: MAC-CE signaling design details are up to RAN2
* The term “failed TRP link” is used here for discussion purposes only

**Agreement**

The maximum number of BFD-RS resources per set is a UE capability, including a possible candidate value of 1 in Rel.17.

**Agreement**

Support the following BFD-RS configurations in Rel.17 for UEs with one activated TCI state per CORESET:

* Implicit configuration:
  + M-DCI:
    - BFD-RS set k (k = 0, 1) is derived based on X TCI of CORESETs with CORESETPoolIndex = k
    - FFS: value of X (determined in spec or UE capability), and TCI selection rule when the number of CORESETs with CORESETPoolIndex = k exceeds X (e.g. reuse RLM RS selection rule)
* FFS: CORESETs with more than 1 activated TCI states

Possible Agreement

Support the following BFD-RS configurations in Rel.17 for UEs with one activated TCI state per CORESET:

* Explicit configuration: RRC configuration BFD-RS resources in BFD-RS set k, k = 0, 1
  + With reference to how UE selects the BFD-RS, it is the same as in Rel-15
  + FFS: CORESETs with more than 1 activated TCI states.

**Conclusion**

BFD-RS configurations in Rel.17 for UEs with one activated TCI state per CORESET via implicit configuration for S-DCI mTRP is not supported in Rel-17.

1. Reference
2. [R1-2108759](file:///C:\Users\suxin\AppData\Local\Docs\R1-2108759.zip) Enhancements on beam management for multi-TRP in Rel-17 Huawei, HiSilicon
3. [R1-2108792](file:///C:\Users\suxin\AppData\Local\Docs\R1-2108792.zip) Beam management for simultaneous multi-TRP transmission with multi-panel reception FUTUREWEI
4. [R1-2108811](file:///C:\Users\suxin\AppData\Local\Docs\R1-2108811.zip) On Beam Management Enhancements for Multi-TRP InterDigital, Inc.
5. [R1-2108873](file:///C:\Users\suxin\AppData\Local\Docs\R1-2108873.zip) Enhancements on beam management for Multi-TRP ZTE
6. [R1-2108898](file:///C:\Users\suxin\AppData\Local\Docs\R1-2108898.zip) Discussion on enhancements on beam management for multi-TRP Spreadtrum Communications
7. [R1-2108954](file:///C:\Users\suxin\AppData\Local\Docs\R1-2108954.zip) Further discussion on MTRP multibeam enhancement vivo
8. [R1-2109031](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109031.zip) Enhancements on beam management for multi-TRP Fujitsu
9. [R1-2109041](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109041.zip) Enhancements on beam management for multi-TRP OPPO
10. [R1-2109106](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109106.zip) Enhancements on beam management for multi-TRP Lenovo, Motorola Mobility
11. [R1-2109108](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109108.zip) Enhancements on beam management for multi-TRP TCL Communication Ltd.
12. [R1-2109125](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109125.zip) Discussion on beam management for multi-TRP NEC
13. [R1-2109187](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109187.zip) Beam reporting and beam failure recovery for multi-TRP CATT
14. [R1-2109273](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109273.zip) Enhancements on beam management for multi-TRP CMCC
15. [R1-2109381](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109381.zip) Enhancement on beam management for Multi-TRP Xiaomi
16. [R1-2109471](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109471.zip) Enhancements on beam management for multi-TRP Samsung
17. [R1-2109545](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109545.zip) Enhancement on beam management for multi-TRP MediaTek Inc.
18. [R1-2109594](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109594.zip) Multi-TRP enhancements for beam management Intel Corporation
19. [R1-2109661](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109661.zip) Discussion on beam management for MTRP NTT DOCOMO, INC.
20. [R1-2109774](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109774.zip) Enhancements on beam management for multi-TRP Sony
21. [R1-2109807](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109807.zip) Enhancements on beam management for multi-TRP ETRI
22. [R1-2109833](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109833.zip) Discussion of enhancements on beam management for multi-TRP FGI, Asia Pacific Telecom
23. [R1-2109873](file:///C:\Users\suxin\AppData\Local\Docs\R1-2109873.zip) Enhancements on Beam Management for Multi-TRP/Panel Transmission Nokia, Nokia Shanghai Bell
24. [R1-2110016](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110016.zip) Views on Rel-17 multi-TRP BM enhancement Apple
25. [R1-2110080](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110080.zip) Enhancements on beam management for multi-TRP LG Electronics
26. [R1-2110106](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110106.zip) On Multi-TRP BFR Convida Wireless
27. [R1-2110114](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110114.zip) Discussion on beam management for multi-TRP ASUSTEK
28. [R1-2110168](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110168.zip) Enhancements on beam management for multi-TRP Qualcomm Incorporated
29. [R1-2110241](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110241.zip) Discussion on beam management for multi-TRP ITRI
30. [R1-2110288](file:///C:\Users\suxin\AppData\Local\Docs\R1-2110288.zip) Remaining issues on beam management for multi-TRP Ericsson