**3GPP TSG RAN WG1 #106bis-e R1-211xxxx**

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

Source: Moderator (CATT)

Title: Moderator summary #2 on enhancements on beam management for multi-TRP

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This document summarizes the remaining issues on enhancements of beam management for multi-TRP.

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

***FL Proposal 1.1: gNB configures/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***
  + ***Alt-1a: gNB configures UE to report beams are associated with same and/or different RX spatial filters***
* ***Alt-2: whether beams are received with spatial multiplexing or diversity*** 
  + ***Alt-2a : gNB configures UE to report beams for spatial multiplexing or diversity.***
* ***Alt-3: maximum number of supported layer per DL RS in a group***

Companies’ views on issue 1.1 are listed as follows:

* Alt-1: Xiaomi, Qualcomm, Samsung, ETRI, Apple, CMCC, Huawei, HiSilicon, Ericsson (2nd preference) , InterDigital
  + Alt-1a: Nokia/NSB, DOCOMO
* Alt-2: ZTE, Intel, Sony
  + Alt-2a: DOCOMO
* Alt-3: Apple (suggest to merge Alt-1 and 3), Ericsson, ZTE
* Discuss this issue after there is a conclusion of MP-UE in AI8.1.1: MediaTek, Futurewei, LGE, InterDigital(2nd preference)
* Alt-1~3 are not supported: OPPO

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | We’re generally fine with the FL proposal 1.1.  But if the main bullet says ‘gNB configures/UE indicates’, we’re fine to remove Alt-1a and Alt-2a. |
| ZTE | We support the FL proposal in principle. A clear agreement of listing candidates will be beneficial for subsequent discussion. But, it seems that the similar candidates are both mentioned in main and sub-bullets. It may be redundant, and we can simplify the main bullet. |
| OPPO | Do not support the proposal because none of the Alt1~3 works. They are propose something that has no metric and all those related information would have to be measured and determined again in CSI measurement and report.  Alt1: no matter what UE reports for each group of beams, the gNB would have to measure the CSI of the channel with those beams to obtain the real CSI information.  Alt2: whether one channel condition can support diversity or spatial multiplexing can only be determined during CSI measurement, not in L1-RSRP beam measurement.  Alt3: the number of layer or rank can only be measured and determined in CSI measurement. |

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

***FL Proposal 1.2: Support L1-SINR for beam reporting option 2***

* ***IMR resource assumptions:*** 
  + ***Alt-1: reuse CMR of other beam in the beam group***
  + ***Alt-2: explicit IMR configuration, including ZP and/or NZP IMR***

Companies’ views on issue 1.2 are listed as follows:

* Support L1-SINR: DOCOMO, Futurewei, Huawei, HiSilicon, TCL, Sony, Intel
  + Alt-1: Nokia/NSB, CATT, Huawei, HiSilicon
  + Alt-2: TCL, DOCOMO, Nokia/NSB, Lenovo/MotM, Huawei, HiSilicon, Qualcomm, ZTE, Samsung, LGE, Ericsson, ETRI, InterDigital
* Not support L1-SINR: vivo, OPPO, MediaTek, Apple

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support FL proposal 1.2, and prefer Alt-2. |
| ZTE | We suggest to go with majority views, i.e., Alt-2. |
| OPPO | We do not support proposal 1.2. Just as we explained in previous round, either Alt-1 or Alt-2 does not work.  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. |

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

***FL Proposal 2.1:***

* ***Support simultaneous configuration of Rel-15/16 BFR and TRP-specific BFR in a cell***
* ***Up to 2 BFD-RS sets can be configured per CC (including Scell and SpCell)***

Companies’ views on issue 2.1 are listed as follows:

* Support: Support
* Not support:

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | We can support the 2nd bullet. We suggest removing the 1st bullet. |
| ZTE | We can support the above FL proposal. |
| OPPO | We do not support the proposal because “***simultaneous configuration***” is not clear. |
| Convida | We do not support the proposal either.  It would be good to clarify the procedure first, before deciding what to configure. |

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

***FL Proposal 2.2: Support to update explicit BFD-RS set via MAC-CE.***

Companies’ views on issue 2.2 are listed as follows:

* Support: CATT, ZTE, Samsung, DOCOMO, vivo, Convida, CMCC, TCL, InterDigital
* Not support: Spreadtrum, Nokia/NSB, Futurewei, Qualcomm, LGE, Ericsson, Intel, Lenovo/MotM

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support FL proposal 2.2. |
| ZTE | Opponent companies still have not reply the question of how to handle the timeline misalignment issue if only RRC explicit configuration is supported. |
| OPPO | We support the solution of configuring BFD-RS in each TCI state, which can even minimize the signaling requirement on MAC CE. |
| Convida | Support the proposal. |

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

***FL Proposal 2.3: For implicit configuration of BFD-RS set for M-DCI***

* ***The number of TCI states (X) in implicit BFD-RS determination***
  + ***Alt-1: X=min(2, the number of TCI states of CORESETs with CORESETPoolIndex = k)***
  + ***Alt-2: X=the number of TCI states of CORESETs with CORESETPoolIndex = k***
* ***TCI state selection when X exceeds the UE capability on the maximum number of BFD-RS resources per set***
  + ***Alt-1: re-use or similar to the RLM-RS selection rule***
  + ***Alt-2: Up to UE implementation***
  + ***Alt-3: gNB implementation (no more than UE capability)***

***Note: it’s agreed in previous meeting that BFD-RS set k (k = 0, 1) is derived based on X TCI of CORESETs with CORESETPoolIndex = k***

Views from companies on issue 2.3 are summarized as follows:

* The number of TCI states (X) in implicit BFD-RS determination
  + Alt-1 : ZTE(No spec impact)
  + Alt-2 :
* ***TCI state selection when X exceeds the UE capability on the maximum number of BFD-RS resources per set***
  + Alt-1: ZTE
  + Alt-2:
  + Alt-3:

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | For 1st bullet, we support Alt-2. For 2nd bullet, we support Alt-1.  And we should add following FFS because Rel-16 rule considers CORESETs with 1 activated TCI states only.  FFS: CORESETs with 2 activated TCI states. |
| ZTE | For second proposal, we think that some clarification on the candidate of ‘similar to the RLM-RS selection rule’ is needed. In our views, if greater than 2, the BFD-RS may just based on the RS of TCI state of CORESET with lower ID. |
| OPPO | Support Alt1 for both. |
| Convida | Prefer to follow Rel-15/16 principles, i.e. Alt 2 for both. |

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

***FL Proposal 2.4: To associate BFD-RS set k and NBI-RS set j***

* ***Alt-1: 1-to-1, fixed in spec***
* ***Alt-3: 1-to-1, leave it to RAN2***

Companies’ views on issue 2.4 are listed as follows:

* Alt-1: Apple, vivo(if NBI-RS set(s) is configured), MediaTek, DOCOMO, Lenovo/MotM, NEC, CMCC, HW, Samsung, LGE, TCL, Sony, Intel
* Alt-2: HW
* Alt-3: FGI/APT, ZTE, DOCOMO(2nd), Nokia/NSB, Futurewei, HW(2nd), QC(2nd), LGE, Ericsson, ETRI, Qualcomm

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Alt-1 is our first preference, and Alt-3 is our second preference. |
| ZTE | It may not be an essential issue, and can be left to RAN2. |
| OPPO | Ok with Alt-3. |
| Convida | Both are ok. |

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

In GTW session, the following agreement has been reached:

**Agreement**

Support to configure an association between a BFD-RS set on SpCell and a PUCCH-SR resource / SR configuration for per TRP BFR.

* FFS: Configure an association between a BFD-RS set on SCell and a PUCCH-SR resource / SR configuration for per TRP BFR

A UE capability signaling is introduced for indicating the support of this association. Above applies only for multi-DCI case.

We can continue to discuss further details on the association between a BFD-RS set and a CC. The following FL proposal is listed for discussion:

***FL Proposal 2.5: For the rule of PUCCH-SR resource selection, down select one out of the following alternatives.***

* ***Alt-1:***
* ***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:***
* ***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.***

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

* Alt-1:
* Alt-2: ZTE

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Our first preference is Alt-2, and second preference is Alt-1.  But we think it may be better if we can resolve the FFS in above agreement first. Because, if the FFS is not supported, the condition ‘if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource’ in Alt-1/2 will not happen.  Regarding the FFS, we do not support it. First, the TRP information on SCell and SpCell can be different. Second, the interference conditions and BFD results on SCell and SpCell can be also difference even if the TRP information is the same. Hence, there is no need to configure an association between a BFD-RS set on SCell and a PUCCH-SR resource.  In that case, TRP/cell-specific beam failure on SCell does not impact PUCCH-SR resource selection result, which is left to UE implementation. Only the TRP-specific beam failure on SpCell impacts PUCCH-SR resource selection result, e.g., if one TRP fails on SpCell, one PUCCH-SR associated with non-failed TRP is selected.  Such solution can also relax some companies’ concern on supporting Alt-1/2. |
| ZTE | We identify some benefits if beam and power control of PUCCH update is also supported.  In short, the mTRP-BFR will follow the rule that SR-PUCCH, and a group of PUCCH resources are both associated with TRP, and the group of PUCCH will recovered if receiving gNB response. As a result, the SR-PUCCH will be recovered automatically. Based on that, using the SR-PUCCH from non-failed TRP (with non-failed beam) will be straightforward. |
| OPPO | Since we agreed the association. Why do not just let the UE triggered the associated PUCCH-SR resource/SR configuration.  Suggest change the proposal to:   * ***The UE triggers the associated PUCCH-SR resource / SR configuration for the failed BFD-RS set.*** |
| Convida | We have some concerns.  In our understanding, the purpose of the agreement was to improve reliability of PUCCH-SR and subsequent PDCCH (for scheduling PUSCH) for the multi-TRP SpCell case. This means that the beam failure status on the SpCell should determine the PUCCH-SR resource selection.  With this understanding, the proposal might contradict the agreement. If the failed BFD-RS set on the SpCell is associated with a different PUCCH-SR resource than the failed BFD-RS set on an SCell, the proposal results in that PUCCH-SR resource selection is up to the UE implementation. However, the intention of the agreement is that the failed BFD-RS set on the SpCell should determine the selection? |

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

Base on discussion in round 1, the following alternatives are listed for further discussion.

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

* Alt-1: only 1
* Alt-2: up to 2; diversity (e.g. AI 8.1.2.1) when 2 spatial filters are activated
* Alt-3: up to 2; filter selection when 2 spatial filters are activated
* Alt-4: no need to discuss

Views from companies on issue 2.6 are summarized as follows:

* Alt-1:
* Alt-2: ZTE
* Alt-3:
* Alt-4:

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support Alt-2. |
| ZTE | It seems that there is no further spec impacts, if going with Alt-2. |
| OPPO | We do not need to discuss this issue. It is part of PUCCH resource design and not part of BFR design. |
| Convida | Support Alt-2, but also agree with OPPO. |

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

Views from companies 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)
* Alt-2: Two bits corresponding to two TPRs of SpCell
* Alt-3: RAN2 issue

Views from companies on issue 2.7 are summarized as follows:

* Alt-1: 1-bit SP field (reuse Rel-16 design)
* Alt-2: Two bits corresponding to two TPRs of SpCell
* Alt-3: RAN2 issue

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support Alt-1. |
| ZTE | Alt-2. As we mentioned before, Alt-1 can NOT work in such case.  CBRA may be initialized by two types of events: #1 two TRPs in PCell both failed; #2 there is no available/configured SR (already supported in the spec). For the latter, identifying which TRP fails is necessary. |
| OPPO | It is about the MAC CE message design. In our view, the MAC CE designed for the per-TRP BFR shall be reused here. But it is also ok to leave it to RAN2. |
| Convida | Agree with OPPO. |

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

***FL Proposal 2.8: 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.***

***Note: the term TRP is used only for the purposes of discussions***

Companies’ views on issue 2.8 are listed as follows:

* Support: Apple, FGI/APT, ZTE, Lenovo/MoM, Fujitsu, Qualcomm, Sony, ETRI, CATT, DOCOMO, NEC, Xiaomi, CMCC, TCL, Sony, InterDigital, Qualcomm, Intel, [Ericsson], Lenovo/MotM
* Not support: vivo, OPPO, MediaTek, Convida, LGE

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support FL proposal 2.8. |
| ZTE | TRP can be replaced by ‘BFD-RS set’ as we did before. |
| OPPO | DO not support.  As we commented in previous round, 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. |

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

***FL Proposal 2.9: After receiving gNB response, the UE assumes the QCL assumption of PDSCH associated with the failed TRP to be the latest reported qnew.***

Companies’ views on issue 2.9 are listed as follows:

* Support: ZTE
* Not support:

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | We think it is not needed. But we can live with it. |
| ZTE | Support. |
| OPPO | Support |

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

***FL Proposal 2.10: To associate CORESET(s) with failed BFD-RS set***

* ***For implicit BFD-RS set configuration for M-DCI***
  + ***Through CORESETPool index***
* ***For explicit BFD-RS configuration***
  + ***Through CORESETPool index for M-DCI***
  + ***For S-DCI***
  + ***Alt1: Support association configuration between TCI state and BFD-RS set for S-DCI***
  + ***Alt2: Support association configuration between CORESET and BFD-RS set for S-DCI***

Companies’ views on issue 2.10 are listed as follows:

* Support: ZTE
* Not support:

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support FL proposal 2.10.  And we prefer Alt1 for S-DCI.  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. 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. |
| ZTE | Support. For S-DCI, we can live with Alt-2. |
| OPPO | Support the first bullet.  For explicit BFD-RS configuration: we prefer to discuss it after we settle down the design of explicit BFD-RS configuration, the method of which is still FFS now. |
|  |  |

* 1. Issue 2.11: SCS of the 28 symbols

***FL Proposal 2.11: SCS of the 28 symbols is the smallest SCS of the response receiving CC and the cell(s) with one or more failed TRPs.***

Companies’ views on issue 2.11 are listed as follows:

* Support:
* Not support:

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | Support. |
| ZTE | In our view, per-TRP may be much more straightforward and is beneficial for non-ideal backhaul scenario. So we suggest that the FL proposal is updated as follows:  ***FL Proposal 2.11: SCS of the 28 symbols is the smallest SCS of the response receiving CC and the cell(s) with the same ~~one or more~~ failed TRPs.*** |

* 1. Issue 2.12: RACH based transmission

The following agreement has been reached in GTW session:

**Agreement**

***FL proposal 2.12-1: RACH-based transmission can be triggered on a SpCell at least in the following scenarios***

* ***Scenario 1: When beam failure is detected on all BFD-RS sets on the SpCell***
* ***FFS: other scenarios***
  + ***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***

Regarding issue 2.12, in this round of discussion, we can focus on the following possible agreement:

**Possible Agreement**

***For RACH-based fallback, only CBRA is supported.***

Companies’ views on the above possible agreement are listed as follows:

* Support: OPPO
* Not support: ZTE(both CFRA and CBRA)

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

|  |  |
| --- | --- |
| Company | Comments |
| NTT DOCOMO | We prefer to support both CBRA and CFRA as CFRA has been supported in Rel-16 even though it may be not configured by gNB. Anyway, whether to configure CFRA for BFR can be decided by gNB.  But we can also live with CBRA only. |
| ZTE | Reserving RACH resource for CFRA is based on gNB configuration, and we do not see the reason why CFRA can NOT be configured if mTRP-BFR is enabled. It does not make sense. BTW, from spec perspective, the BFR procedure is just to initialize the RACH procedure, and how to perform RACH procedure, e.g., based on CBRA or CFRA, is individually specified.  It seems that there is some misunderstanding that CFRA is the identical to R15 BFR (it is different from issue 2.1). In fact, besides for R15 BFR, gNB still can configured CFRA for other purposes. |
| OPPO | We can live with CBRA only. Supporting both seems to be over-design. The CFRA does have large overhead. |
| Convida | We also think CBRA is sufficient.  To support CFRA, the gNB needs to configure more CFRA-BFR-related parameters, such as a candidateBeamRSList, recovery SeachSpace/CORESET, etc.. What would the relation be between the candidateBeamRS for CFRA and the per-TRP CB-RS sets? Is it worth it to use one CORESET only for the fallback?  If the CB-RS configured for CFRA are below the RSRP threshold, it seems the procedure falls back to CBRA anyway? |

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.

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