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

**e-Meeting, August 16th – 27th, 2021**

Source: Moderator (CATT)

Title: Moderator summary #1 on M-TRP simultaneous transmission with multiple Rx panels

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This document summarizes company contribution in agenda 8.1.2.3, M-TRP simultaneous transmission with multiple Rx panels. Given there are only three meetings left, the summary will focus on essential issues the FL consideres necessary to complete Rel.17, and issues with high company interests. Issues that are optimization in nature will be revisted at a later stage.

1. Beam measurement/reporting

**Action item:** Companies are invited to provide their preferences in **Table I** below.

**Table I**: list of issues and company positions

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| **#** | **Issue and proposals** | **Summary** |
| 1.1 | max # of beams (M) increased beyond 2     * BM reporting Option 1 * BM reporting Option 2 | Option 1: ZTE (M = 1/2/3/4)  No:  Option 2: Lenovo/MoM  No: |
| 1.2 | Aperiodic CMR resource configuration   * **Alt1**: One resource set list is included in the resource setting to indicate multiple CMR set IDs, and two indexes are included in the corresponding triggering state to indicate two of the multiple CMR set IDs * **Alt2**: Two resource set lists are included in the resource setting each indicates multiple CMR set IDs, and two indexes are included in the corresponding triggering state each indicating one of the multiple resource set IDs in each resource set list, respectively | Alt-1: MediaTek,  Alt-2: MedaiTek, CATT |
| 1.3 | SSBRI/CRI ordering in CSI-report   * **Alt1**: 1st SSBRI/CRI corresponds to CMR set with smaller set ID, and 2nd SSBRI/CRI corresponds to CMR set with larger set ID * **Alt2**: 1st SSBRI/CRI corresponds to 1st CMR set in resource setting, and 2nd SSBRI/CRI corresponds to 2nd CMR set in resource setting * **Alt-3**: 1st SSBRI/CRI corresponds to CMR set with higher RSRP, 2nd SSBRI/CRI corresponds to CMR set with lower RSRP | Alt-1: mediaTek  Alt-2: MediaTek, CATT, Intel, DOCOMO  Alt-3: MediaTek |
| 1.4 | UCI reduction   * Alt-1: 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   + **Alt-1.1**: 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;   + **Alt-1.2**: 1-bit indicating UCI payload partitioning (e.g. 7/4 bits or 4/7 bits) between 1st/2nd SSBRI/CRI in first beam group; 4 bits in all other groups; * Alt-2: Differential reporting within each beam group in a CSI-report   + For each group, including an 1-bit indicator of CMR set associated with the largest RSRP value in the group * Alt-2: No UCI reduction | Alt-1: HW/HiSilicon, Lenovo/MoM, NEC, OPPO, MediaTek, DOCOMO, vivo   * Alt-1.1: MediaTek * Alt-1.2: NEC   Alt-2: ZTE  Alt-3: CATT |
| 1.5 | UE reporting of information related to Rx panel/antenna-group   * Alt-1: UE reports panel ID / antenna-group ID or the reporting setting is associated with panel ID/antenna-group ID   + the reporting setting is associated with panel ID/ antenna-group ID * Alt-2: 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-2.1**: whether beams are associated to different Rx filters/panels (Apple, Xiaomi, Ericsson, CATT)   + **Alt-2.2**: whether beams are received with spatial multiplexing or diversity ([ ])   + **Alt-2.3**: maximum number of supported layer per DL RS in a group (MediaTek) * Alt-3: Postpone * Alt-4: Not support | Alt-1: LGE, DOCOMO (BM option 1)  Alt-2: ZTE, Samsung, Qualcomm, CMCC, MediaTek, Apple, LGE, Xiaomi, Ericsson, CATT  Alt-3: Nokia/NSB  Alt-4: |
| 1.6 | gNB indication of Rx panel hypothesis   * E.g. whether beam pairs in a group are used for spatial multiplexing or diversity | Support: Intel,  No: |
| 1.7 | Support L1-SINR report   * support measurement of interference arising from the other beam in the reported beam group * FFS: IMR resource assumption, e.g.   + reuse CMR of other beam in the beam group (LGE)   + explicit IMR configuration (TCL/Nokia/NSB), including ZP and/or NZP IMR | * Support: ZTE, CATT, Lenovo/MoM, Spreadtrum, Qualcomm, Intel, LGE, Xiaomi, TCL, Nokia/NSB, Sony, ETRI, * No: OPPO, Apple, vivo |
| 1.8 | Whether to adopt additional beam measurement/reportion option   * 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 * 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 * Association mechanism FFS | * Option 1: ZTE (with group ID and/or panel ID report), OPPO, DOCOMO, Sony * No: CMCC, Apple, Ericsson * Option 3: CATT, Nokia/NSB, vivo * No: CMCC, Apple, Ericsson |

* 1. Increasing M beyond 2 (issue 1.1)

Observation**:**

* On whether the number of reported beams in a group (M) should be increased beyond 2, at least one company is OK with supporting M > 2 for option 2. For option 1 (which has not been agreed yet), one company proposes to adopt M = 1/2/3/4.

Offline proposal

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| Company | views |
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* 1. Aperiodic CMR configuration (issue 1.2)

Observation:

* It was agreed in the last meeting that CMR resource associated with each TRP is represented by a CMR resource set. For periodic/semi-persistent CMR, this should be straightforward as one CMR resource setting comprises two CMR resource sets (each associated with a TRP). For aperioic CMR configuration, one company (MediaTek) proposes two alternatives. In one alternative, one CMR resource setting consists of a list of CMR sets, where an aperiodic triggering state can be associated with two CMR sets in the resource setting. In the other alternative, two CMR set lists are included in the resource setting, and a triggering state is associated with two CMR sets (in two CMR set lists respectively).

Offline proposal

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| Company | views |
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* 1. SSBRI/CRI ordering in CSI-report (issue 1.3)

Observation:

* The ordering of two beams in a reported beam group needs to be defined. Three alternatives are provided in Table I based on company proposals.

Offline proposal

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| Company | Views |
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* 1. UCI reduction scheme (issue 1.4)

Observation:

* Differential reporting has been supported in group-based reporting in earlier NR releases. One open issue from the last meeting is how/whether to support UCI reduction toward M-TRP. Several proposals are captured in Table I.

Offline proposal

* Support differential reporting as a UCI reduction scheme for beam measurement/reporting option 2.
* Details FFS.

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| Company | Views |
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* 1. UE panel/antenna related feedback (issue 1.5)

Observation:

* On UE panel/antenna related feedback, two high level alternatives were discussed in the previous meeting with a list of candidates itemized in Table I. One company proposed to delay this discussion until panel-ID related issue in AI 8.1.1. is more stabilized.

Offline proposal

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| Company | Views |
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* 1. gNB indication of UE panel related hypothesis (issue 1.6)

Observation:

* Related to UE indication of panel related information, it is possible that gNB provides indication/configuration of such panel-related hypotheis in CSI-report configuration.

Offline proposal

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| Company | Views |
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* 1. L1-SINR and interference measurement (issue 1.7)

Observation:

* Aside from already agreed L1-RSRP, whether L1-SINR should be supported remains open. Company views (including possible interference measurement resources and hypothesis) are summarized in Table I.

Offline proposal

* NOTE: The FL recommends to make a decision whether it is supported in RAN1#106-e.

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| Company | Views |
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* 1. Other BM options (issue 1.8)

Observation:

* It is open whether the two remaining options (option 1 and 3) for beam measurement/reporting should be supported in Rel.17. It appears that concerns on both options have not been resolved over the meetings, so the FL proposal is to adopt neither.

Offline proposal

* Do not support beam measurement/feedback option 1 and 3 in Rel.17 for M-TRP simultaneous transmission with multiple UE Rx panels.

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| Company | Views |
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1. M-TRP Beam failure recovery

**Action item**: Companies are invited to provide your preferences in **Table II**.

**Table II**: list of issues and company positions

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | Simultaneous configuration of cell-specific and TRP-specific BFR in a cell | Yes: APT/FGI, CMCC, MediaTek, ITRI, TCL, Nokia/NSB, Sony,  No : Qualcomm, Intel, DOCOMO, CATT |
| 2.2  BFD-RS | Q1: # of BFD-RS resources per set   * Alt1: max value is 2 * Alt2: max value is a UE capability, including possible candidate value of 1   Q2: # total number of BFD-RS resource across two sets is a UE capability | Q1:   * Alt-1: FGI/APT, Convida, * Alt-2: Qualcomm, Apple, LGE, TCL, vivo, ETRI   Q2:  Yes: Qualcomm |
| 2.3  BFD-RS | Explicit vs. implicit BFD-RS  Q1: Explicit configuration   * Each BFD-RS set should be configured with a CORESSETPoolIndex   Q2: Implicit configuration of BFD-RS set k (k=0,1) for M-DCI   * 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)   Q3: Implicit configuration BFD-RS set k for S-DCI, e.g.   * Option 1: Based on TCI of CORESETs with CORESETPoolIndex = k; Extend CORESETPoolIndex to S-DCI (for BFD-RS set generation) * Option 2: From TCI states associated with activated TCI codepoint   Q4: Support 1-to-1 association between BFD-RS set with CORESETPoolIndex | Q1: ZTE, Spreadtrum, Samsung, Fujitsu, FGI/APT, Qualcomm, CMCC, MediaTek, LGE, ITRI, Convida, Ericsson, Nokia/NSB, vivo, Sony, ETRI,  NO: OPPO  Q2: ZTE, Lenovo/MoM, Samsung, Fujitsu, OPPO, FGI/APT, Qualcomm, CMCC, MediaTek, AT&T, LGE, Xiaomi, ITRI, Convida, Ericsson, Nokia/NSB, Nokia/NSB, vivo, ETRI  Q3: HW/HiSilicon, Lenovo/MoM, Samsung, Fujitsu, MediaTek, CATT, Intel, AT&T, CMCC, LGE, Xiaomi, ITRI, Sony, Nokia/NSB (option 2)  No: Ericsson  Q4: MediaTek, CATT (if explicit BFD-RS is adopted), OPPO,  No: LGE |
| 2.4  BFD-RS | Introduce MAC-CE for updating explicit BFD-RS set | Support: CATT, ZTE |
| 2.5  NBI-RS | Association between BFD-RS set k and NBI-RS set j   * Alt-1: 1-to-1, fixed in spec * Alt-2: 1-to-1, configurable * Alt-3: 1-to-1, leave it to RAN2 | Alt-1: CATT, Intel, Apple, ITRI, ETRI,  Alt-2: ZTE, Fujitsu, OPPO (via CORESETPoolindex), Qualcomm, CMCC (via CORESETPoolIndex),  Alt-3: Convida, Nokia/NSB, |
| 2.6  PUCCH-SR resource | PUCCH-SR resource selection rule for LRR feedback   * 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 (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: * 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: * 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. | Alt-2.5.2 A: FGI/APT, Apple, LGE, TCL  Alt-2.5.2 B: ZTE (SCell), InterDigital, Spreadtrum, CATT, Fujitsu, Qualcomm, Xiaomi, ETRI  Alt-2.5.2 C: ZTE (SpCell), Samsung, NEC, CMCC, Xiaomi, CATT, Nokia/NSB  Alt-2.5.2 D: Convida, Ericsson |
| 2.7  PUCCH-SR resource | 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 spaial filters are activated  Alt-3: up to 2; filter selection when 2 spatial filters are activated  Alt-4: up to 2; transmission method undefined when 2 spatial filters are activated | Alt-1: Spreadtrum,  Alt.2: CATT  Alt-3: Qualcomm, Intel,  Alt-4: APT/FGI, Apple, Convida, |
| 2.8  MAC-CE | Q: One or two MAC-CE for TRP-specific BFR   * Alt-1: one MAC-CE * Alt-2: two MAC-CE * Alt -3: leave it to RAN2 | Alt-1: HW/HiSilicon, CATT, MediaTek (2-bit bitmap), LGE, TCL, Nokia/NSB  Alt-2: ZTE(?)  Alt-3: |
| 2.9  MAC-CE | Indication of failed TRP in MAC-CE   * Alt-1: failed BFD-RS set ID * Alt-2: failed CORESETPoolIndex | Alt-1: HW/HiSilicon, LGE, CATT. TCL, Nokia/NSB, vivo  Alt-2: ZTE, OPPO, Sony, ETRI, |
| 2.10  MAC-CE | Q1: Whether 1 or 2 TRP receives new beam report for each SCell   * Alt-1: resource index representing identified new beam (if found) for only 1 failed TRP, irrespective of 1 or 2 TRP failure * Alt-2: resource index representing identified new beam (if found) for each failed TRP   Q2: format of new beam   * Alt-1: separate encoding (e.g. log2(N1) bit for TRP1, log2 (N2) bit for TRP2, where N1/N2 are # NBI-RS resources in set 1 and 2) * Alt-2: joint encoding | Q1:   * Alt-1: DOCOMO * Alt-2: HW/HiSilicon, DOCOMO, CATT   Q2:   * Alt-1: CATT * Alt-2: Convida |
| 2.11  Beam/power update | UE assumption of DL QCL-typeD and UL filter/power control after receiving gNB response  Q1: If a single TRP fails   * Failed TRP update by new beam (if reported)   Q2: If both TRPs fail   * Each failed TRP updated by its corresponding new beam (if reported)   Q3: Support beam update for PDCCH   * Introduce association between BFD-RS set and CORESETs   Q4: Support beam/power update for PUCCH   * Introduce association between PUCCH and TRP, e.g. through BFD-RS set ID, CORESETPoolIndex, etc.   Q5: Support beam/power update for all data/control channels | Q1: Support: CATT  Q2: Support: CATT  Q3: Support: ZTE, Lenovo/MoM, Spreadtrum, Fujitsu, OPPO, MediaTek, CATT, Sony, ETRI  No:  Q4: Support: ZTE, Lenovo/MoM, Spreadtrum, Fujitsu, APT/FGI, Qualcomm, DOCOMO, Sony, ETRI  No: OPPO  Q5: Support: Apple  No: |
| 2.12  RACH based fallback | Support CBRA based fallback on SpCell as a result of per-TRP beam failure, conditions FFS. | Support: Hw/HiSilicon, ZTE, CATT, NEC, FGI/APT, Intel, LGE, Asustek, Nokia/NSB, OPPO, Xiaomi, Asustek,  No: |
| 2.13  RACH based fallback | Support CFRA based fallback | Support: Asustek  No: |

* 1. Simultaneous configuration of cell-specific and TRP-specifc BFR in the same CC (issue 2.1)

Observation:

* It remains open whether cell-specific and TRP-specific BFR can be simultaneously configurd in the same cell. To decide on this issue, a clear definition of “cell-specific” vs. “TRP-specific” BFR is needed.
* It should be clear that TRP-specific BFR requires two BFD-RS sets configured in a CC, to allow per-TRP failure detection.
* Cell-specific BFR has two interpretations.
  + Interpretation 1: refers to RACH-based fall back scheme (e.g. Rel.15/16).
  + Interpratation 2: refers to a case where one BFD-RS is configured in a CC. Simultaneous configuration of “cell-specific” and “TRP-specific” BFR can then be interpretated as 3 BFD-RS in a CC corresponding to two seprate BFR procedures, each associated to 1 and 2 BFD-RS sets.
  + The FL’s understanding is that the intended discussion is to clarify the use case of interpretation 2. Interpration 1 (e.g. interaction with RACH-based fallback) is discussed in a separate sub-agenda.

Offline definition (for purpose of facilitating discussion)

* Simultaneous configuration of cell-specific and TRP-specific BFR in the same CC refers to the configuration of 3 BFD-RS sets in a CC, where cell-specific and TRP-specific BFR are associated to 1 and 2 BFD-RS sets, respectively.

Action item:

* Please comment if the offline definition above is agreeable.
* Please share your views on issue 2.1 in Table II.

Offline proposal:

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| Company | Views |
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* 1. BFD-RS resource set size (issue 2.2)

Observation:

* Toward the end of last meeting, the majority of companies were willing to support a UE capability on the maximum number of BFD-RS resources per set. The FL recommends to agree on this.

Offline proposal

* The maximum number of BFD-RS resources per set is a UE capability, including a possible candidate value of 1 in Rel.17.
  + FFS: whether the maximum total number of BFD-RS resources across two BFD-RS sets is a UE capability.

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| Company | Views |
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* 1. BFD-RS set determination (issue 2.3)

Observation:

* Explicit configuration:
  + the majority of companies support this operation, except one company. Given that QCL-typeD of TCI states may correspond to aperidic RS, and that beam failure detection should be based on periodic/semi-persistent RS, it appears that explicition configuration is required in Rel.17.
* Implicit configuration for M-DCI:
  + Majority of companies support this operation, with no concern raised, where BFD-RS set k (k = 1, 2) is based on CORESETs with CORESETPoolIndex = k.
* Implicit configuration for S-DCI:
  + A large number of companies (including operators) support this operation, with a small number of companies with lingering question on its need, which was clarified by supporting companies in the past.
  + Given the majority view, the FL wishes to check if the concerned companies would oppose this functionality.

Offline proposal



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| Company | Views |
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* 1. BFD-RS set update by MAC-CE (issue 2.4)

Observation:

* Two companies support update of BFD-RS sets by MAC-CE, which is currently only possible by RRC. Among these two companies, one company supports this functionality only if implicit BFD-RS is not supported (for at least S-DCI).

Offline proposal

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| Company | Views |
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* 1. NBI-RS set association to BFD-RS set (issue 2.5)

Observation:

* It has been agreed there is a 1-to-1 association between BFD-RS set and NBI-RS set. Three options on BFD-RS/NBI-RS set association are pending a down-selection.

Offline proposal

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| Company | Views |
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* 1. PUCCH-SR resource selection (issue 2.6)

Observation:

* In case of one TRP failure (one SCell and/or SpCell), whether/how to perform PUCCH-SR resource selection for LRR has been debated in several meetings. Four candidate options were captured in Chairman’s notes for down-selection in RAN1#106-e.
* An offline email discussion was conducted between RAN1#105-e, where another two alternatives were discussed.

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| *Offline Proposal1 in email*   * *For PUCCH-SR resource selection for TRP-specific BFR,* * *Support to configure an association between a TRP (e.g., BFD-RS set) on SpCell and a PUCCH-SR resource on SpCell.*   *Offiline Proposal2 in email*   * *When 2 PUCCH-SR resources are configured on SpCell, if SR for BFR is triggered (e.g., by any TRP/cell failure in the cell group), the two PUCCH-SR resources are transmitted.* |

* The FL does not intend to spend online time on this, unless concensus can be reached offline. Note that if concensus is not possible, option A is the default assumption.

Offline proposal

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| Company | Views |
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* 1. PUCCH-SR spatial filter (issue 2.7)

Observation:

* In Rel.16, a PUCCH resource can have 1 activated UL spatial relation info at any time. With Rel.17 PUCCH enhancement for M-TRP, it is possible that a PUCCH resource can have more than 1 activated UL spatial filters. Several companies discussed whether Rel.17 PUCCH-SR for M-TRP BFR should be allowed to have more than 1 activated UL spatial relation info, and if so, transmission scheme.
* The FL believes this is not the most essential issue for Rel.17 completion. Unless consensus can be reached, the FL proposes to postpone this issue to later stage.

Offline proposal

* Postpone to future meetings.

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| Company | Views |
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* 1. BFRA MAC-CE content (issue 2.8, 2.9, 2.10)

Observation: There are three main issues on MAC-CE design

* Whether one or two MAC-CEs are used for BFRQ report.
* What information is conveyed in the MAC-CE
* Format of information in the MAC-CE

Offline proposal

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| Company | Views |
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* 1. QCl/Spatial filter and power update after gNB response (issue 2.11)

Observation:

* A large number of companies support QCL assumption update for CORESETs that have been identified as failed and for which a new beam has been reported. For implicit BFD-RS determination, applicable CORESETs can be derived from the assoction of CORESETs to BFD-RS and NBI-RS sets. For explicit BFD-RS determination, association of BFD-RS sets to applicable CORESETs have been proposed, e.g. via CORESETPoolIndex.
* A few company support spatial filter and power control parameter update for PUCCH. Association between applicable PUCCH resources and new beam is needed in this case, e.g. via association between PUCCH resources and CORESETPoolIndex.
* One company supports QCL/spatial filter and power control parameter update for all DL/UL data/control channels, across CCs in a band.

Offline proposal

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| Company | Views |
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* 1. RACH-based fallback (issue 2.12, 2.13)

Observation:

* Issue 2.12 (CBRA): A large number of companies support CBRA-based fallback on SpCell *as a result of* per-TRP beam failure detection. Several triggering conditions are proposed.
* Issue 2.13 (CFRA): One company proposes CFRA-based fallback.

Offline proposal

* CBRA-based transmission can be triggered on SpCell as a result of beam failure detection for per-TRP BFR
  + FFS: exact triggering condition
* FFS: CFRA based transmission on SpCell

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| Company | Views |
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1. Simultaneous reception of signals with different QCL-typeD assumption

**Table III**: list of issues and company positions

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| **#** | **Issue and proposals** | **Companies’ views** |
| 3.1 | Alt1: **To enhance priority rule to facilitate UE  to receive downlink  signals with two different QCL -TypeD properties, e.g. PDCCH QCL prioritization rule enhancement**  Alt2: **To release some scheduling restrictions which mandate gNB to schedule downlink  signals with the same QCL -TypeD property or prohibit to schedule some downlink  signals overlapped in time domain, e.g. PDSCH + SSB** | Alt1:  Support: Apple  Concern:  Alt2:  Support: Apple  Concern; |
| 3.2 | Type of combinations to be enhanced:  Case 1: PDCCH+PDCCH  Case 2: PDCCH+PDSCH  Case 3: CSI-RS + CSI-RS | Case 1:  Support: Lenovo, MediaTek  Concern:  Case 2:  Support: MediaTek  Concern:  Case 3:  Support: Lenovo  Concern: |
| 3.3 | Study both S-DCI and M-DCI | Support: DOCOMO  Concern: |

Observation:

Offline proposal:

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| Company | Views |
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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. Reference

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| --- | --- | --- |
| [R1-2106791](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106791.zip) | Enhancements on beam management for multi-TRP | Sony |
| [R1-2106868](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106868.zip) | Enhancements on beam management for multi-TRP | Samsung |
| [R1-2106938](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106938.zip) | Enhancements on beam reporting and beam failure recovery for multi-TRP | CATT |
| [R1-2107031](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107031.zip) | Enhancements on beam management for multi-TRP | Fujitsu |
| [R1-2107081](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107081.zip) | Beam management for simultaneous multi-TRP transmission with multi-panel reception | FUTUREWEI |
| [R1-2107145](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107145.zip) | Discussion on beam management for multi-TRP | NEC |
| [R1-2107206](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107206.zip) | Enhancements on beam management for multi-TRP | OPPO |
| [R1-2107298](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107298.zip) | Discussion of enhancements on beam management for multi-TRP | FGI, Asia Pacific Telecom |
| [R1-2107326](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107326.zip) | Enhancements on beam management for multi-TRP | Qualcomm Incorporated |
| [R1-2107393](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107393.zip) | Enhancements on beam management for multi-TRP | CMCC |
| [R1-2107470](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107470.zip) | Enhancements on beam management for multi-TRP | ETRI |
| [R1-2107487](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107487.zip) | Enhancement on beam management for multi-TRP | MediaTek Inc. |
| [R1-2107573](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107573.zip) | Multi-TRP enhancements for beam management | Intel Corporation |
| [R1-2107690](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107690.zip) | Beam Management Enhancements for multi-TRP | AT&T |
| [R1-2107721](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107721.zip) | Views on Rel-17 multi-TRP BM enhancement | Apple |
| [R1-2107817](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107817.zip) | Enhancements on beam management for multi-TRP | LG Electronics |
| [R1-2107841](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107841.zip) | Discussion on beam management for MTRP | NTT DOCOMO, INC. |
| [R1-2107896](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107896.zip) | Enhancement on beam management for Multi-TRP | Xiaomi |
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| [R1-2108021](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108021.zip) | On Multi-TRP BFR | Convida Wireless |
| [R1-2108030](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108030.zip) | Discussion on beam management for multi-TRP | ASUSTEK COMPUTER (SHANGHAI) |
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| [R1-2108055](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108055.zip) | Enhancements on Beam Management for Multi-TRP/Panel Transmission | Nokia, Nokia Shanghai Bell |