**3GPP TSG RAN WG1 #105-e R1-210nnnn**

**e-Meeting, May 10th – 27th, 2021**

Source: Moderator (CATT)

Title: Moderator summary #3 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 on agenda 8.1.2.3, M-TRP simultaneous transmission with multiple Rx panels.

# Discussion

* 1. Beam measurement/reporting

Table 1

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| **#** | **Issue and proposals** | **Companies’ views** | **notes** |
| 1.1 | max # of beams (M) increased beyond 2     * Beam measurement reporting Option 1 * Beam measurement reporting Option 2 | Option 1: ZTE (max M = 4),  Option 2: |  |
| 1.2 | Q1: max # of pair/group (N)   * Alt1: maximum value N = {1, 2} * Alt2: maximum value N = {1, 2, 3, 4}   Q2: number of beam pairs/groups (N) reported in a single CSI-report   * 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 | Q1:   * Alt-1 (4): vivo, Spreadtrum, OPPO, Apple, * Alt-2 (19): Futurewei, Huawei, HiSilicon, InterDigital, Lenovo/MotM, ZTE, Qualcomm, SONY, Nokia/NSB, Samsung, MediaTek, AT&T, Ericsson, TCL, ETRI, Intel, DOCOMO,   Q2:   * Alt-1 (13 companies) : Futurewei, Huawei, HiSilicon, OPPO, SONY, MediaTek, LGE, Ericsson, CATT, ETRI, Intel, DOCOMO, Xiaomi, * Alt-2 (9 companies): InterDigital, vivo, ZTE, Qualcomm, Nokia/NSB, Samsung, CATT (if Alt-1 is mandately supported), TCL, Apple,Spreadtrum |  |
| 1.3 | CMR configurations for beam measurement option 2  Q1: Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting   * + Alt-1: set   + Alt-2: subset   Q2: SSBRI/CRI bandwidth   * Alt-1: from # of resources in the the associated set/subset * Alt-2: from total # of resources across both set/subset | Q1:   * Alt-1 (12 companies): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, CMCC, Qualcomm, OPPO, Apple, Sony, Intel, * Alt-2 (10 companies): vivo, CATT, Nokia/NSB, Samsung, AT&T, LGE, TCL, ETRI, DOCOMO   Q2:   * Alt-1 (5 companies): Lenovo/MotM, Qualcomm, OPPO, DOCOMO, Apple, Spreadtrum, Huawei, HiSilicon * Alt-2 (1 company): Samsung, |  |
| 1.4 | 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 | Alt1 (2): ZTE, DOCOMO (only for Option1), Huawei, HiSilicon  Alt-2 (9); vivo (same/different spatial filters), CMCC, Qualcomm, Apple (UE capability in the max number of layers per Rx beam), Samsung, Ericsson, Intel, Xiaomi, CATT |  |
| 1.5 | gNB indication of Rx panel related hypothesis   * Corresponding to issue 1.4 | Support: Intel (Alt-2) |  |
| 1.6 | Simultaneous report of beams suitable for S-TRP and M-TRP separately | Support: vivo, |  |
| 1.7 | Q1: Support L1-SINR  Q2: support interference measurement by taking into inter-beam interference within a group | Q1:   * Support (17): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, Qualcomm, OPPO (option 1), Sony, Nokia/NSB (only with dedicated IMR), AT&T, LGE, ETRI, DOCOMO, Xiaomi, CATT * No (3): vivo, OPPO, Apple,   Q2:   * Support (10): Huawei, HiSilicon, Lenovo/MotM, ZTE, LGE, CATT, DOCOMO, Xiaomi, CATT |  |
| 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   * Support (5): Lenovo/MotM, OPPO, Sony, DOCOMO, * No (2): Apple, Ericsson   Option 3   * Support (8): Huawei, HiSilicon, vivo, Nokia/NSB, AT&T, CATT), * No(3): Apple, Ericsson, DOCOMO |  |
| 1.9 | New beam measurement metric,   * Alt-1: based on throughput * Alt-2: based on latency requirement and/or power window between resources within pair/group or resources being power threshold (e.g. L1-RSRP/L1-SINR) | Alt-1:  Support: Qualcomm  Concern:  Alt-2:  Support:  Concern: |  |
| 1.10 | gNB indicates (for throughput or reliability), operation mode (FDM/SDM/TDM), and corresponding beam pair selection criterion (based on sum or minimum of metrics of the two reported beams). | Support: Qualcomm  Concern: |  |
| 1.11 | Mapping of CMR subset/set to TRP  Alt-1: spec transparent  Alt-2: specified (explicit for SSB-based CMR, implicit for CSI-RS based CMR) | Alt-1: Huawei, HiSilicon  Alt-2: Nokia/NSB, Apple |  |
| 1.12 | Latency reduction:   * Support beam reporting criteria that imposes UE to rank and report only measured CSI resources being within a certain power window or above a power threshold. | Support: Nokia/NSB  Concern: |  |
| 1.13 | Mechanism for fallback to STRP transmission, e.g.   * Alt-1: use Rel-15 group reporting (with a restriction on ‘per TRP’ with predefined TRP) * Alt-2: use Rel-15 non-group reporting (no restriction on simultaneous reception) * Alt-3: network configures the fallback reporting (based on Alt-1 or Alt-2) | Support: Nokia/NSB, Huawei, HiSilicon, DOCOMO  Concern: |  |
| 1.14 | Study enhancement for different TDD DL/UL configuration across multiple TRPs. | Support: LGE  Concern: |  |
| 1.15 | Reuse simultaneousReceptionDiffTypeD-r16 UE capability to indicate if the UE is capable of receiving beams within a beam pair/group with different Rx spatial filters. | Support: Ericsson  Concern: |  |

* + 1. CMR configuration

It was agreed in the last meeting to down-select from two candidate options (e.g. subset vs. set) for CMR configuration of beam measurement/reporting option 2. The number of companies supportling each proposal are roughly the same. Another open issues is the bitwidth of each CRI. More companies support calculating the bitwidth of each SSBRI/CRI based on the number of resources in the corresponding CMR set/subet. Please note these two issues need to be decided in RAN1#105-e.

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| 1.3 | CMR configurations for beam measurement option 2  Q1: Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting   * + Alt-1: set   + Alt-2: subset   Q2: SSBRI/CRI bandwidth   * Alt-1: from # of resources in the the associated set/subset * Alt-2: from total # of resources across both set/subset | Q1:   * Alt-1 (12 companies): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, CMCC, Qualcomm, OPPO, Apple, Sony, Intel, * Alt-2 (10 companies): vivo, CATT, Nokia/NSB, Samsung, AT&T, LGE, TCL, ETRI, DOCOMO   Q2:   * Alt-1 (5 companies): Lenovo/MotM, Qualcomm, OPPO, DOCOMO, Apple,Spreadtrum * Alt-2 (1 company): Samsung, |

Offline proposal:

* The bitwidth of each SSBRI/CRI is determined based on the number of SSB/CSI-RS resources in the associated CMR resource set/subset
  + NOTE: whether “set” or “subset” is adopted will be decided in RAN1#105-e.

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| Company | Views |
| Apple | Regarding Q1, I am not sure whether common understanding is as follows. If this is the common understanding, it seems “set” or “subset” is just a terminology issue.   * CMRs in a set/subset correspond to a TRP   For Q2, we support Alt1. |
| **Lenovo&MotM** | **For Q1, we support Alt1.**  **For Q2, we support Alt 1.** |
| Qualcomm | For Q1: support Alt1  For Q2: support Alt1  Fine with the offline proposal |
| Huawei, HiSilicon | We prefer “set”. We don’t think it is necessary for mTRP BM to follow the design of mTRP CSI, as they serve different purposes.  First, configuring the measurement resources from both TRPs in one resource set will restrict the number of resources for each TRP, i.e., the number of resources for each TRP is halved compared with two resource sets. Doubling the size of the resource set is not a valid solution as it requires UE to double its parallel processing capability. For example, the resources in an aperiodic CSI-RS resource set are transmitted within one slot. Doubling the size of aperiodic CSI-RS resource set would require the UE to measure twice the amount of resources within a slot, which is quite challenging for UE implementation.  Secondly, with current specification, there are restrictions upon resources in one resource set. For example, CSI-RS resources in one resource set should have the same number of ports and RBs, the same starting RB, the same density, etc. If the resources of TRPs are configured in different subsets of a resource set, the resources of different TRPs will be facing such restrictions by default. However, such restriction may not be really necessary for resources of different TRPs. For example, if the two TRPs works with different bandwidth, it is not reasonable to restrict there CSI-RS resources have the same number of RBs.  Thrid, introducing subset will bring huge spec impacts like subset configuration, redefining CRI, redefining UE features including but not limited to:   * maxNumberSSB-CSI-RS-ResourceOneTx * maxNumberCSI-RS-ResourceTwoTx * maxNumberResWithinSlotAcrossCC-AcrossFR-r16 * maxNumberResWithinSlotAcrossCC-OneFR-r16   Instead of pursuing alignment with M-TRP CSI, a more feasible direction is to maximize reusing the existing BM framework, i.e., Alt-1, the only spec impact of which is to extend the number of resource sets to be measured from 1 to 2. |
| vivo | For Q1, we prefer Alt-2 considering low effort for specification impact. Two groups in one resource set had been agreed in MTRP CSI in 104-e, which can be reused for beam framework. As for the parameter “repetition”, we think it’s can be same for two subsets, which is the typical use case for simultaneous transmission and simultaneous reception. Alt-2 has no change on the current spec restriction that only one resource set in the resource setting for channel measurement, while Alt-1 changes.  For Q2, considering specification impact, the choice might be dependent on the answer for Q1. |
| Samsung | For Q1, we support subset and agree with vivo that set-specific parameters such as repetition on/off can be common for all subsets.  For Q2, at least for suset, we are not sure what is the benefit of assuming bitwidth within each subset. We prefer to decide between set and subset first. |
| DOCOMO | For Q1: Prefer Alt2. But we can also accept Alt1.  For Q2: support Alt1.  Support the FL proposal. |

* + 1. UE panel/antenna related feedback

On UE panel/antenna related feedback, two high level alternatives were discussed in the previous meeting. Alt-1 is supported by 2 companies, and alt-2 is supported by 9 companies. One company also supports gNB indication/configuration of UE hypothesis related to Alt-2 (e.g. whether reported beams associated to different Rx spatial filters, maximum number of supported layers, whether two beams can be used for sptial multiplexing or diversity).

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| 1.4 | 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 | Alt1 (2 companies): ZTE, DOCOMO (only for Option1), Huawei, HiSilicon  Alt-2 (9 companies); vivo (same/different spatial filters), CMCC, Qualcomm, Apple (UE capability in the max number of layers per Rx beam), Samsung, Ericsson, Intel, Xiaomi, CATT , MTK (same/different spatial filters) |

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| Company | views |
| Apple | Support Alt2. In our view, Alt1 is fit for option 1 if it is supported. If we go with Alt1, it becomes a mixed option 1 + option 2. |
| **Lenovo&MotM** |  |
| LGE | We are fine to study. |
| Qualcomm | Support Alt2 (same or different filters). We are also fine for Alt1 if the beams are measured only by the panel ID indicated in the reporting setting. |
| Huawei, HiSilicon | Support Alt-1. |
| MediaTek | Support Alt2 (same or different filters). |
| **vivo** | Support Alt-2. But we think an indication of whether the reported beams are simultaneously received by the same spatial filter or multiple spatial filters in beam report is enough, and the maximum number of supported layers can be left to CSI. |
| DOCOMO | Ok to study Alt2. |

* + 1. L1-SINR and interference measurement

L1-SINR measurement is supported by 17 companies, while 3 companies have concerns. Among the 17 supporting companies, one company only supports it for beam measurement option 1 (not agreed yet), and two companies only support if dedicated IMR is configured. 10 companies support to measure intra-group cross-beam interference in L1-SINR measurement.

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| 1.7 | Q1: Support L1-SINR report  Q2: support interference measurement by taking into inter-beam interference within a group | Q1:   * Support (17): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, Qualcomm, OPPO (option 1), Sony, Nokia/NSB (only with dedicated IMR), AT&T, LGE, ETRI, DOCOMO, Xiaomi, CATT * No (3): vivo, OPPO, Apple,   Q2:   * Support (10): Huawei, HiSilicon, Lenovo/MotM, ZTE, LGE, CATT, DOCOMO, Xiaomi, CATT |

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| Company | views |
| Apple | As discussed in our contribution, Q2 is not feasible. No additional benefit for L1-SINR in addition to L1-RSRP and CSI. |
| **Lenovo&MotM** | For Q1, support.  For Q2, support. |
| LGE | We think the benefit for L1-SINR is clear since the cross-beam interference is not reflected for L1-RSRP, where the simultaneous DL transmission with reported beam pair/group is the objective of WID. L1-SINR based metric for beam pair/group reporting should be supported in order to consider the cross-beam interference within the pair/group especially for option 2. |
| Qualcomm | For Q1: support  For Q2: support  We believe one good use case of L1-SINR is for cross-beam interference measurement. |
| Huawei, HiSilicon | For Q1, support the proposal.  For Q2, support the proposal. |
| **vivo** | We don’t support interference measurement model in MTRP transmission scheme that directly regarding one CMR resource in one beam pair as the interference of another CMR resource to calculate L1-SINR, which has been verified to have performance loss compared with L1-RSRP in our companion contribution R1-2104345. Therefore, we think it’s better to determine the procedure of MTRP beam report based on L1-RSRP firstly, and then discuss how to measure the inter-beam interference within a group. |
| DOCOMO | For Q1: support  For Q2: support. And whether to consider inter-beam interference within a group for L1-SINR measurement can be RRC configured. |

* + 1. Value of N (number of beam groups)

It was agreed to decide on the maximum value of N in a single CSI-report (2 vs. 4) in RAN1#105-e. 19 companies support N = 4, and 4 companies support N = 2.

Another issue is the number of actual beam groups (N) in a single CSI-report, e.g. whether fixed by RRC configuration or dynamically selected by UE.

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| 1.2 | Q1: max # of pair/group (N)   * Alt1: maximum value N = {1, 2} * Alt2: maximum value N = {1, 2, 3, 4}   Q2: number of beam pairs/groups (N) reported in a single CSI-report   * 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 | Q1:   * Alt-1 (4 companies): vivo, Spreadtrum, OPPO, Apple, * Alt-2 (19 companies): Futurewei, Huawei, HiSilicon, InterDigital, Lenovo/MotM, ZTE, Qualcomm, SONY, Nokia/NSB, Samsung, MediaTek, AT&T, Ericsson, TCL, ETRI, Intel, DOCOMO,   Q2:   * Alt-1 (13 companies) : Futurewei, Huawei, HiSilicon, OPPO, SONY, MediaTek, LGE, Ericsson, CATT, ETRI, Intel, DOCOMO, Xiaomi, * Alt-2 (9 companies): InterDigital, vivo, ZTE, Qualcomm, Nokia/NSB, Samsung, CATT (if Alt-1 is mandatorily supported), TCL, Apple, Spreadtrum |

Offline proposal:

* For beam measurement/reporting option 2, the maximum number of beam groups (N) in a single CSI-report is a UE capability and may take value from Nmax = {1,2,3,4} in Rel.17.

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| Company | Technical views |
| Apple | For Q1, we can accept offline proposal as lont as there is a UE capability  For Q2, we support Alt2. |
| Spreadtrum | For Q1, we are not clear about the use case supporting more larger value of Nmax, e.g., 3,4. But for the majority, we are fine if it is a UE capability. |
| **Lenovo&MotM** | For Q1, we support Alt 2.  For Q2, we support Alt 1. |
| LGE | We are generally fine with the value of Nmax in the proposal, but some clarification on UE capability is needed. From our understanding, Nmax value has no impact on UE complexity since the complexity for L1-RSRP/SINR calculation and comparsion depends on the number of configured CMRs. Nmax value just determines UCI payload. Therefore, we don’t see the need of reporting this value as UE capability. |
| Qualcomm | For Q1: support Alt2  For Q2: support Alt2. Alt1 should clarify UE behavior if no N groups can be found  Fine with the offline proposal |
| Huawei, HiSilicon | For Q1, support Alt 2. |
| MediaTek | Supprot the Offline proposal  For Q2, support Alt1. How to handle if no N groups with good qualities can be found can be up to UE impmentation, e.g., UE still can report pair(s) of beams pair with qualities not that good. |
| **vivo** | For Q1, we support the maximum number of beam groups (N) in a single CSI-report is a UE capability, but we think it may take value from Nmax = {1,2} in Rel.17. Number of UCI bits would be doubled if we support N as large as 4. The motivation is unclear in FR2 for such big UCI overhead increase.  For Q2, we support Alt2. |
| Samsung | For Q1, we support Alt. 2  For Q2, support Alt. 2 |
| DOCOMO | Support the FL proposal. |

* + 1. Others

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| 1.1 | max # of beams (M) increased beyond 2     * Beam measurement reporting Option 1 * Beam measurement reporting Option 2 | Option 1: ZTE (max M = 4),  Option 2: |
| 1.5 | gNB indication of Rx panel related hypothesis   * Corresponding to issue 1.4 | Support: Intel (Alt-2) |
| 1.6 | Simultaneous report of beams suitable for S-TRP and M-TRP separately | Support: 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   * Support (5): Lenovo/MotM, OPPO, Sony, DOCOMO, * No (2): Apple, Ericsson   Option 3   * Support (8): Huawei, HiSilicon, vivo, Nokia/NSB, AT&T, CATT), * No(3): Apple, Ericsson, DOCOMO |
| 1.9 | New beam measurement metric,   * Alt-1: based on throughput * Alt-2: based on latency requirement and/or power window between resources within pair/group or resources being power threshold (e.g. L1-RSRP/L1-SINR) | Alt-1:  Support: Qualcomm  Concern:  Alt-2:  Support:  Concern: |
| 1.10 | gNB indicates (for throughput or reliability), operation mode (FDM/SDM/TDM), and corresponding beam pair selection criterion (based on sum or minimum of metrics of the two reported beams). | Support: Qualcomm  Concern: |
| 1.11 | Mapping of CMR subset/set to TRP  Alt-1: spec transparent  Alt-2: specified (explicit for SSB-based CMR, implicit for CSI-RS based CMR) | Alt-1:  Alt-2: Nokia/NSB |
| 1.12 | Latency reduction:   * Support beam reporting criteria that imposes UE to rank and report only measured CSI resources being within a certain power window or above a power threshold. | Support: Nokia/NSB  Concern: |
| 1.13 | Mechanism for fallback to STRP transmission, e.g.   * Alt-1: use Rel-15 group reporting (with a restriction on ‘per TRP’ with predefined TRP) * Alt-2: use Rel-15 non-group reporting (no restriction on simultaneous reception) * Alt-3: network configures the fallback reporting (based on Alt-1 or Alt-2) | Support: Nokia/NSB  Concern: |
| 1.14 | Study enhancement for different TDD DL/UL configuration across multiple TRPs. | Support: LGE  Concern: |
| 1.15 | Reuse simultaneousReceptionDiffTypeD-r16 UE capability to indicate if the UE is capable of receiving beams within a beam pair/group with different Rx spatial filters. | Support: Ericsson  Concern: |

Companies are welcome to provide their views on other issues in Table I that are not covered in section 2.1.1 – 2.1.4.

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| Company | Technical views |
| Apple | Agree with FL that these can be deprioritized |
| Huawei, HiSilicon | For 1.8, support Option 3, as it is beneficial for non-ideal backhaul base. |
| vivo | For issue 1.6, due to the number of report beam pairs is more than 1, we think the simultaneous report of beams suitable for S-TRP and M-TRP separately is beneficial for the network to achieve dynamic switch between MTRP and STRP flexibly, other than RRC reconfiguration or trigger another beam report.  For issue 1.8, we prefer Option 3 at least in non-ideal backhaul scenarios with following reasons:   * highest scheduling flexibility with the same UCI payload size per PUCCH/PUSCH resource for non-ideal backhaul scenarios.   throughput gain can be achieved by Option 3 in non-ideal backhaul cases, which is verified by simulation results in Table 2 to 3 in our companion contribution R1-2104345. |

* 1. M-TRP Beam failure recovery

**Table II**

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| **#** | **Issue** | **Companies’ views** | **notes** |
| 2.0  BFR configuration | Configuration of cell-specific BFR and TRP-specific BFR on the same cell | * Support (12): Lenovo/MotM, CMCC, Sony, Nokia/NSB (at least SpCell), Samsung (SCell triggered if both TRP fail), MediaTek (CBRA-based cell-specific), LGE, APT, TCL, Xiaomi (SpCell only), Huawei, HiSilicon * No (4): Qualcomm, Intel, DOCOMO, CATT * Postpone: vivo, APT, |  |
| 2.1  BFD-RS | # of BFD-RS resources per set   * Alt1: max value is 2 * Alt2: max value is a UE capability, including possible candidate value of 1 | * Alt1 (7): Huawei, HiSilicon, InterDigital, Nokia/NSB, APT, Convida * Alt2 (9): vivo, Spreadtrum, Qualcomm, Apple, LGE, TCL, ETRI, DOCOMO, CATT |  |
| 2.2 BFD-RS | Clarify whether/how to define BFD-RS selection rule for implicit BFD-RS when total number of QCL-typeD RS of all CORESETs exceed UE capability | Support: LGE  Concern: |  |
| 2.3  BFD-RS | Explicit vs. implicit BFD-RS  Q1: Explicit configuration  Q2: Implicit configuration of BFD-RS set k (k=0,1) for M-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k   Q3: Implicit configuration BFD-RS set k for S-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k * Extend CORESETPoolIndex to S-DCI (for BFD-RS set generation) | * Q1 (15): vivo (both), Spreadtrum, ZTE, Qualcomm, Fujitsu, Sony, Samsung, MediaTek, AT&T, LGE, Ericsson, APT, Convida, ETRI, DOCOMO, Huawei, HiSilicon * Q2 (21): vivo, ZTE, Qualcomm, OPPO (CORESETPoolIndex), Apple (CORESETPoolIndex), Sony, NEC, Nokia/NSB, Samsung, MediaTek, AT&T, LGE, Ericsson, APT, Convida, ETRI, Intel, DOCOMO, Xiaomi, CATT, Huawei, HiSilicon * Q3 (11): vivo (when one TRP fail in CC1 and no TRP fail in CC2, FFS other cases), Sony, NEC (both S/M), Nokia (and SFN/non-SFN PDCCH enhancement), Samsung, MediaTek (extend CORESETPoolIndex), AT&T, LGE, Convida, ETRI, Intel (extend CORESETPoolIndex to SDCI), CATT, Huawei, HiSilicon |  |
| 2.4  BFD-RS | Introduce MAC-CE for updating explicit BFD-RS set | * Support: ZTE, CATT (if implicit BFD-RS is not supported) , DOCOMO |  |
| 2.5  BFD-RS | Implicit BFD-RS generation, when a CORESET is configured with two TCI states   * Alt1: based on both TCI states | * Support: Ericsson * Postpone: Convida |  |
| 2.6  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 (7): CMCC, Apple, ETRI, CATT, Intel, Huawei, HiSilicon, DOCOMO  Alt-2 (4): Qualcomm, Fujitsu, Nokia/NSB, Huawei, HiSilicon  Alt-3: |  |
| 2.7  NBI-RS | NBI RS sets are disjoint | Support: Convida  Concern: |  |
| 2.8  NBI-RS | NBI-RS configuration is optional   * If not configured, UE supports triggering of A-CSI to obtain new beams | Support: vivo  Concern: |  |
| 2.9  PUCCH-SR resource | Whether/how to associate PUCCH-SR resource and SR configuration   * Alt-1: 2 PUCCH-SR are associated to 1 SR configuration * Alt-2: 2 PUCCH-SR are associated to 2 separate SR configuration * Alt-3: leave to RAN2 (no RAN1 impact) | Alt-1: Qualcomm, DOCOMO, CATT  Alt-2: OPPO  Alt-3: CATT, Huawei, HiSilicon |  |
| 2.10  PUCCH-SR resource | PUCCH-SR resource selection rule for LRR feedback   * 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 | Alt-1 (11): Huawei, HiSilicon, vivo, Lenovo/MotM (1 TRP fail, or when 1 SR configuration has 2 PUCCH-SR), Sony, NEC (when SpCell has two TRP), Samsung (if PUCCH-SR has 1 filter), Ericsson, ETRI, DOCOMO,  Alt-2 (15): InterDigital, vivo, Lenovo/MotM (1 TRP fail), ZTE, Qualcomm, OPPO, Fujitsu, Sony, Apple (if each PUCCH-SR belongs to one SR configuration), Nokia/NSB, ASUSTek, Xiaomi, CATT, Huawei, HiSilicon  Alt-3 (9): Lenovo/MotM (when neither/both TRP fail in the PUCCH-Cell, or when 2 SR configurations are configured each with 1 PUCCH-SR), Spreadtrum, Apple (if both PUCCH-SR belongs to one SR configuration), NEC (when SpCell is configured with one TRP), Samsung (if PUCCH-SR has two filters), LGE, APT, Convida, Intel |  |
| 2.11  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, Intel,  Alt-2: vivo, DOCOMO  Alt-3: Qualcomm (select filter associated with failed TRP)  Alt-4: Apple, LGE, APT, ETRI, CATT |  |
| 2.12  PUCCH-SR resource | Whether to reuse PUCCH-SR of SCell BFR for MTRP BFR   * Alt-1: leave to gNB implementation * Alt-2: Yes * Alt-3: No | Alt-1:  Alt-2: CMCC  Alt-3: No |  |
| 2.13  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: Lenovo/MotM, CATT, MediaTek, LGE, TCL, Intel, Huawei, HiSilicon, DOCOMO  Alt-2: ZTE, Ericsson (?)  Alt-3: |  |
| 2.14  MAC-CE | Indication of failed TRP in MAC-CE (NOTE: this question may depend on the outcome of 2.13)   * Alt-1: indication of failed BFD-RS set * Alt-2: indication of CORESETPoolIndex | Alt-1: Huawei, HiSilicon, CATT, vivo, Nokia/NSB, LGE, DOCOMO  Alt2: OPPO, Sony, |  |
| 2.15  MAC-CE | Indication of new beam in MAC-CE   * 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 | Alt1: DOCOMO,  Alt2: Huawei, HiSilicon, CATT, DOCOMO |  |
| 2.16  MAC-CE | Q: whether to support BFRQ MAC-CE for SpCell with normal PUSCH   * NOTE: In Rel.16 it is only supported in msg3 | Support: MediaTek  Concern: |  |
| 2.17  Beam update | Q: 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: Applicable channel   * at least PDCCH, * FFS: others * FFS: association of PUCCH with TRP (if PUCCH beam update is supported)   Q4: deactivation of CORESETs for a TRP, if no new beam is found | Q1: vivo, Qualcomm, CATT, DOCOMO  Q2: vivo, Qualcomm, CATT, Huawei, HiSilicon, DOCOMO  Q3:   * PDCCH: Sony, OPPO, CATT, vivo, ZTE, Qualcomm, MediaTek, ETRI, Huawei, HiSilicon, DOCOMO * PDSCH: vivo (M-DCI), Apple * PUCCH: Support (ZTE, Qualcomm, Sony, ETRI, DOCOMO, Apple, CATT), No (OPPO) * All channels: Apple   Q4:  Support: vivo, ZTE  Concern: |  |
| 2.18  RACH | Q1: CBRA based RACH  Q2: CFRA-based RACH | Q1:  Support: ZTE/Intel/DOCOMO  Concern: OPPO  Q2:  Support: OPPO  Concern: |  |
| 2.19  other | New BFRR mechanism  a MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure.  a MAC CE deactivation command to de-activate the failed TRP so that to achieve the switch of transmission hypothesis from MTRP to STRP.  a PDCCH to trigger a beam measurement and reporting procedure for the failed TRP. | Support: vivo  Concern: |  |
| 2.20  other | Implicit BFD-RS is only supported if Rel.17 TCI framework supports M >1 | Support: Futurewei  Concern: |  |
| 2.21  Other | Prioitize TRP1 of PCell, if beam failure is detected on both TRP | Support: InterDigital  Concern: |  |
| 2.22  Other | Fallback to single-TRP transmission   * Conditions FFS (e.g. 1 TRP fail without new beam found, or 2 TRPs fail and new beam found on 1 TRP) | Support: vivo  Concern: |  |
| 2.23  other | LRR has higher priority than normal SR   * FFS: prioritization between LRR for TRP-specific BFR and LRR for SCell BFR | Support: Lenovo/MotM  Concern: |  |
| 2.24  other | Study how to avoid transmission of PUSCH carrying MAC-CE to failed TRP | Support: Lenovo/MotM  Concern: |  |
| 2.25  other | For mDCI mTRP, the implicit BFD RSs associated with a *CORESETPoolIndex* can be the QCL-TypeD RSs in up to X TCI states for CORESETs sharing the same *CORESETPoolIndex*.   * X can be determined in spec or via UE capability. | Support: Qualcomm, Huawei, HiSilicon  Concern: |  |
| 2.26  other | support per-TRP BFD-RS configurations for both intra-cell and inter-cell multi-DCI based multi-TRP operation. | Support: Ericsson  Concern: |  |
| 2.27  other | M-DCI in TRP-specific BFR, if one TRP is declared beam failure and if the time offset between the reception of the DL DCI and the corresponding PDSCH is less than a threshold, UE keeps one default Rx beam for receiving potential PDSCH transmitted from non-failed TRP | Support: ASUSTek  Concern: |  |
| 2.28  other | If the UE detects beam failure in the first BFD-RS set, it shall try to  find a new candidate beam from the first NBI-RS set with L1-RSRP above a threshold, if any. If the UE detects beam failure in the second BFD-RS set, it shall try to find a new candidate beam from the second NBI-RS set with L1-RSRP above a threshold, if any. | Support: Convida  Concern: |  |
| 2.29  other | * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a first NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the first NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the first NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a second NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the second NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the second NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. | Support: Convida  Concern: |  |

* + 1. Simultaneous configuration of cell-specific and TRP-specifc BFR on the same cell

In the last meeting the following proposal was discussed.

**Offline Proposal (RAN1#104b-e)**:

* FFS: whether cell-specific and TRP-specific BFR can be configured in the same CC.

Company inputs in RAN1#105-e are summarized in the following table.

|  |  |  |
| --- | --- | --- |
| 2.0  BFR configuration | Configuration of cell-specific BFR and TRP-specific BFR on the same cell | * Support (12): Lenovo/MotM, CMCC, Sony, Nokia/NSB (at least SpCell), Samsung (SpCell triggered if both TRP fail), MediaTek (CBRA-based cell-specific on SpCell), LGE, APT/FGI (at least SpCell), TCL, Xiaomi (SpCell only) , Huawei, HiSilicon * No (4): Qualcomm, Intel, DOCOMO, CATT * Postpone: vivo, |

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| --- | --- |
| Company | Technical views |
| Apple | In our view, by default this is allowed, which is subjected to UE capability.  We would like to understand why such restriction is needed. Could proponents clarify it? |
| **Lenovo&MotM** | Support. |
| APT/FGI | Support |
| LGE | We think simultaneous configuration of cell-specific BFR and TRP-specific BFR is valid at least for SpCell, in order to support RACH-based BFRQ in SpCell, in addition to TRP-specific BFRQ. |
| Qualcomm | Not support simultaneous configuration of both in the same CC. UE needs to measure more BFD RSs, manage multiple types of PHY indicator triggers, and the MAC-CE needs to indicate which failure type per CC. Also, TRP specific BFR can also indicate cell level BFR if both TRPs fail. So no use case to configure both. |
| Huawei, HiSilicon | We share similar view as LG. |
| MediaTek | Supprot for SpCell only, i.e., RACH-based BFR + TRP-specific BFR can be allowed for SpCell |
| vivo | We would like to postpone the discussion of this issue until the procedure of TRP-specific BFR is clearer. Without the basic design and common understanding of how TRP-specific BFR procedure works, it would be too complicated to consider how TRP specific BFR and cell specific BFR are bundled. |
| Samsung | Corrected a typo in our views. Support SpCell BFR when two TRP BFRs occur within a time period. |
| DOCOMO | We should clarify what does ‘cell-specific and TRP-specific BFR can be configured in the same CC’ mean.  If it means that UE can be configured with 3 sets of BFD-RSs (2 sets for TRP-specific BFR, 1 set for cell-specific BFR), we do not support it.  But if it means that in case of two TRPs failure for TRP-specific BFR on SpCell, RACH-based BFR can be performed, we can support it. |

* + 1. BFD-RS number

It was agreed in the last meeting to down select from two options on the number of BFD-RS resources per BFD-RS set in RAN1#105-e. It appears the number of supporting companies are close, with slightly more companies supporting to introduce a UE capability rather than reusing a fixed value (2) in Rel.16.

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| 2.1  BFD-RS | # of BFD-RS resources per set   * Alt1: max value is 2 * Alt2: max value is a UE capability, including possible candidate value of 1 | * Alt1 (7): Huawei, HiSilicon, InterDigital, Nokia/NSB, Convida * Alt2 (9): vivo, Spreadtrum, Qualcomm, Apple, LGE, TCL, ETRI, DOCOMO, CATT, APT/FGI, MTK |

Offline proposal:

* Introduce a UE capability on the maximum number of BFD-RS resources per set, which includes possible candidate value of 1.

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| Company | Technical views |
| **Lenovo&MotM** | Support. |
| APT/FGI | Support |
| LGE | Support. |
| Qualocmm | Support |
| MediaTek | Support offline proposal |
| vivo | Support |
| DOCOMO | Support |

It was agreed in the last meeting that the total number of BFD-RS resources in a DL BWP is a UE capability. One company proposes to clarify UE behavior when the total number of QCL-typeD RS of all CORESETs exceeds UE capability. Note this issue assumes implicit BFD-RS determination will be adopted in Rel.17.

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| 2.2 BFD-RS | Clarify whether/how to define BFD-RS selection rule for implicit BFD-RS when total number of QCL-typeD RS of all CORESETs exceed UE capability | Support: LGE, Apple, MTK  Concern: |

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| --- | --- |
| Company | Technical views |
| Apple | Support to define a clear rule for mDCI BFR. This is helpful for UE capability to avoid potential under-report like approach, as discussed in R16. |
| LGE | Support. |
| Qualcomm | Support to clarify |
| MediaTek | Supprot |
| DOCOMO | Support |

* + 1. BFD-RS set determination

It was agreed in RAN1#104-e to support both M-DCI and S-DCI (with lower priority) in Rel.17, without precluding a unified framework. It has also been agreed that at least one of explicit and implicit BFD-RS set determination is to be adopted. Company inputs are summarized below.

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| 2.3  BFD-RS | Explicit vs. implicit BFD-RS  Q1: Explicit configuration  Q2: Implicit configuration of BFD-RS set k (k=0,1) for M-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k   Q3: Implicit configuration BFD-RS set k for S-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k * Extend CORESETPoolIndex to S-DCI (for BFD-RS set generation) | * Q1 (15): vivo (both), Spreadtrum, ZTE, Qualcomm, Fujitsu, Sony, Samsung, MediaTek, AT&T, LGE, Ericsson, APT/FGI (both), Convida, ETRI, DOCOMO, Huawei, HiSilicon * Q2 (21): vivo, ZTE, Qualcomm, OPPO (CORESETPoolIndex), Apple (CORESETPoolIndex), Sony, NEC, Nokia/NSB, Samsung, MediaTek, AT&T, LGE, Ericsson, APT/FGI, Convida, ETRI, Intel, DOCOMO, Xiaomi, CATT, Huawei, HiSilicon * Q3 (11): vivo (when one TRP fail in CC1 and no TRP fail in CC2, FFS other cases), Sony, NEC (both S/M), Nokia (and SFN/non-SFN PDCCH enhancement), Samsung, MediaTek (extend CORESETPoolIndex), AT&T, LGE, Convida, ETRI, Intel (extend CORESETPoolIndex to SDCI), CATT, Huawei, HiSilicon |

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| Company | Technical views |
| Qualcomm | We are fine for Q1-Q3. In Q3, another name can be used to diffentiate from mDCI, e.g. CORESETPoolIndex-sDCI |
| Huawei, HiSilicon | For Q1, Q2 and Q3, support the proposal. |
| MediaTek | Supprot for Q1, Q2, and Q3. |
| vivo | We support explicit configuration for MDCI and SDCI, and implicit configuration at least for MDCI. |
| DOCOMO | Support Q1 and Q2. |

For explicit BFD-RS (if supported), two companies propose to introduce MAC-CE for dynamically updating explicit BFD-RS sets. The motivation is to allow faster update of RRC configured BFD-RS set.

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| 2.4  BFD-RS | Introduce MAC-CE for updating explicit BFD-RS set | * Support: ZTE, CATT (if implicit BFD-RS is not supported), DOCOMO |

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| Company | Technical views |
| Apple | Do not support. This is to implement the functionality of implicit configuration. We think it is a redundant approach |
| **Lenovo&MotM** | Same view with Apple, don’t support. |
| LGE | Agree with Apple and Lenovo/MotM. |
| Qualcomm | No need. gNB can choose implicit way |
| DOCOMO | We can further study it. It is useful in case of explicit BFD-RS configuration. |

For a CORESET with two activated TCI states (e.g. Rel.17 PDCCH enhancement), at least one company proposes to include both TCI states in implicit BFD-RS determination. An offline proposal was discussed in the last meeting but no conclusion was reached.

**Offline Proposal (RAN1#104b-e):**

* For a CORESET associated with more than 1 activated TCI states
  + For implicit BFD-RS set determination, BFD-RS set associated with this CORESET is based on QCL-typeD source RS of all activated TCI states
  + FFS: BLER determination based on two TCI states, e.g. whether separate BLER are independently derived from each TCI state, or a common BLER is derived from all TCI states, or leave to RAN4

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| 2.5  BFD-RS | Implicit BFD-RS generation, when a CORESET is configured with two TCI states   * Alt1: based on both TCI states | * Support: Ericsson * Postpone: Convida |

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| Company | Technical views |
| Apple | As announced by Chair in last meeting, it is to be handled in SFN AI |
| APT/FGI | We have the same understanding as Apple |
| LGE | Support the proposal. |
| Qualcomm | Support |
| DOCOMO | Agree with Apple to handle it in SFN AI. |

* + 1. NBI-RS set

It has been agreed there is a 1-to-1 association between BFD-RS set and NBI-RS set. The following proposal has been discussed in RAN1#104b-e.

Offline Proposal (RAN1#104-e)

* On the 1-to-1 association between BFD-RS sets and NBI-RS sets, support the following association
  + Alt-1: First BFD-RS set associated with first NBI-RS set, and second to the second (NOTE: how to capture this can be up to RAN2)

Company views in this meeting on their association are summarized below. The FL proposes to continue using the offline proposal in RAN1#104b-e as a starting point for discussion.

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| 2.6  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 (7): CMCC, Apple, ETRI, CATT, Intel, Huawei, HiSilicon  Alt-2 (4): Qualcomm, Fujitsu, Nokia/NSB  Alt-3: |

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| Company | Technical views |
| **Lenovo&MotM** | Support Alt 1. |
| LGE | Either alt-1 or alt-3 is fine for us. |
| Qualcomm | Support Alt2 for flexibility |
| Huawei, Hisilicon | Slightly prefer Alt-1. Can accept Alt-2. |
| vivo | Support Alt-2 if two NBI-RS sets are configured. |
| DOCOMO | Support Alt.1. Such flexibility of Alt.2 is unnecessary. |

It was discussed in the previous meeting whether two NBI-RS resource sets should be disjoint, but no concusion was reached. FL proposes to clarify this issue.

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| 2.7  NBI-RS | NBI RS sets are disjoint | Support: Convida  Concern: |

Offline Proposal:

* When two NBI-RS sets are configured , set k and j are disjoint (k, j = 0, 1)
  + This applies to at least SCell. FFS for SpCell (e.g. whether NBI-RS set associated with TRP associated with CORESET #0 may include NBI-RS associated with the other TRP)

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| Company | Technical views |
| Apple | Do not support the proposal. Both sets can have common beams from a thrid TRP. |
| APT/FGI | Do not support. It seems network impletation. |
| LGE | We think the proposal is not needed. It is more related with gNB implementation. |
| Qualcomm | No need. It should be NW implementation |
| MediaTek | No need. Up to NW implementation. |
| vivo | We have some concern on the offline proposal. If two NBI-RS set are configured, the RS resources in each set may not only from one TRP, but from multiple TRPs. In such way, UE can select any other TRPs in a goog radio link freely to maintain MTRP operation mode as much as possible. Sine some RS resources in two NBI-RS sets may be from the same TRP other than the two working TRPs, the two NBI-RS set can not be disjoint. |
| DOCOMO | No need. Up to NW implementation. |

It was agreed in previous meetings that “For M-TRP BFR, support 1-to-1 association between each BFD-RS set and an NBI-RS set”, therefore the number of BFD-RS sets and NBI-RS sets can be the same in one CC. One company proposes to allow configuration of NBI-RS to be optional, e.g. only BFD-RS sets are configured in a CC.

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| 2.8  NBI-RS | NBI-RS configuration is optional   * If not configured, UE supports triggering of A-CSI to obtain new beams | Support: vivo  Concern: |

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| Company | Technical views |
| Apple | Do not support. We can use similar approach in SCell BFR like gNB should configure at least 1 CBD RS. This does not increase overhead, since cross-CC CBD RS is allowed, and gNB can simply configure the SSBs if overhead is a problem. |
| Lenovo&MotM | Same view with Apple, don’t support. |
| Qualcomm | No need. The same rule for SCell BFR should be applied. |
| MediaTek | Fail to see the need |
| **vivo** | Support. we don’t think the configuration of TRP-specific NBI-RS set(s) for TRP-specific BFR is a necessity, and it can be replaced by aperidic beam report, especially for multi-DCI-based MTRP. And compared with periodic measurement of NBI-RS resources configured in the two sets, aperiodic beam measurement consumes less resource, which is beneficial for the network to schedule within the limited UE capability flexibly. |
| DOCOMO | No need. |

* + 1. PUCCH-SR

For the case where two PUCCH-SR resources are configured, it was agreed in the previous meeting to discuss UE behavior in terms of PUCCH-SR resource selection for LRR transmission, and down-select from the following three alternatives in RAN1#105-e. One company suggests this issue should be discussed together with the association between PUCCH-SR and SR configuration.

***Agreement (RAN1#104b-e)***

*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)*

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| 2.9  PUCCH-SR resource | Whether/how to associate PUCCH-SR resource and SR configuration   * Alt-1: 2 PUCCH-SR are associated to 1 SR configuration * Alt-2: 2 PUCCH-SR are associated to 2 separate SR configuration * Alt-3: leave to RAN2 (no RAN1 impact) | Alt-1: Qualcomm, DOCOMO, CATT, APT/FGI  Alt-2: OPPO  Alt-3: CATT, APT/FGI, Huawei, HiSilicon |
| 2.10  PUCCH-SR resource | PUCCH-SR resource selection rule for LRR feedback   * 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 | Alt-1 (11): Huawei, HiSilicon, vivo, Lenovo/MotM (1 TRP fail, or when 1 SR configuration has 2 PUCCH-SR), Sony, NEC (when SpCell has two TRP), Samsung (if PUCCH-SR has 1 filter), Ericsson, ETRI, DOCOMO,  Alt-2 (15): InterDigital, vivo, Lenovo/MotM (1 TRP fail), ZTE, Qualcomm, OPPO, Fujitsu, Sony, Apple (if each PUCCH-SR belongs to one SR configuration), Nokia/NSB, ASUSTek, Xiaomi, CATT, MTK  Alt-3 (9): Lenovo/MotM (when neither/both TRP fail in the PUCCH-Cell, or when 2 SR configurations are configured each with 1 PUCCH-SR), Spreadtrum, Apple (if both PUCCH-SR belongs to one SR configuration), NEC (when SpCell is configured with one TRP), Samsung (if PUCCH-SR has two filters), LGE, APT/FGI, Convida, Intel |

Companies are invited to share their views on these two issues.

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| Company | Technical views |
| Apple | For 2.9, we are fine with either Alt1 or Alt2. If we go with Alt3, it would be difficult to handle 2.10, and this is like RAN1 agrees something but do not know the usage and lets RAN2 decide. It may be possible that RAN2 just reverts what RAN1 agreed. |
| **Lenovo&MotM** | For 2.10, the PUCCH-SR resource selection should consider whether the cell where the PUCCH-SR resources configured to be transmitted is configured with TRP-specific BFR.If yes, then Alt 1 or Alt 2 is selected. If not, then Alt 3 is selected. It should be discussed separately.Therefore, we propose that to refine the proposal 2.10 as follows:  PUCCH-SR resource selection rule for LRR feedback when TRP-specific is configured in the cell where the PUCCH-SR resources are configured to be transmitted.   * 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   PUCCH-SR resource selection rule for LRR feedback when TRP-specific is not configured in the cell where the PUCCH-SR resources are configured to be transmitted.   * 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 |
| APT/FGI | Regarding 2.10, we support Alt. 3.  One reason is UE behaviour would be unclear when failed TRP(s) is different across serving cells. Under such case, we may need other rules or a default PUCCH-SR. In our views, the benefit of Alt.1/2 exists when there is only one failed TRP.  Another one is that UE does not always need a PUCCH-SR to acquire UL grant or convey information of failed TRP(s). UE can transmit a TRP-BFR MAC-CE whenever there is available PUSCH resource. Even we introduce a selection rule, we may not usually experience so-called benefit. |
| LGE | We are fine with either Alt-1 or Alt-2 for 2.9. |
| Qualcomm | For 2.9, support Alt1 to save SR ID  For 2.10, support Alt2. Alt1 may not work for more than 2 TRPs which may happen in future release |
| Huawei, HiSilicon | For 2.9, support Alt-3.  For 2.10, slightly prefer Alt-1. Can aceept Alt-2. |
| MediaTek | On 2.10, Supprot Alt2. Much straitforword. We would like to clarify is does 2.10 only focus on one CC? |
| vivo | For issue 2.9, we prefer Alt-2 to configure 2 PUCCH-SR resources to 2 separate SR configuration, each SR configuration assocating with a SR resource configuration and a TRP. In such way, the high level parameters, like *sr-TransMax* and *periodictyAndOffset* can be configured independently, and the MAC layer operation, like *sr-ProhibitTimer* and *SR\_COUNTER* can be excuted independently, which is more flexible and in line with TRP-specific procedure.  For issue 2.10, we think both Alt-1 and Alt-2 are OK. |
| DOCOMO | For 2.9, support Alt1.  First, SR ID can be saved since the number of SR configurations is limited and up to 8 per cell group. Second, the purpose of SR for BFR is to ask for UL grant, hence, there is no need to configure two SR configurations for the same purpose. Third, in case of 2 SRs, when a SR is triggered for a TRP, the corresponding PUCCH-SR resource is transmitted. There is no need to further discuss the PUCCH-SR resource selection rule in RAN1. But RAN2 needs to further consider the relationship and procedures of the two SR configurations, which is not preferred considering limited TU in RAN2. So that it is better for RAN1 to finish the per-TRP BFR design.  For 2.10, support Alt.1. It is related to the logic to configure the association between PUCCH and TRP, which is not a pure RAN2 issue.  The SR for BFR can be shared with other logic channel based on RAN2 spec. So it means that the SR can be used in normal operation, e.g., to be used to ask for UL grant for the associated TRP when the TRP is in normal operation and does not fail. In this case, when the TRP fails, the SR for BFR, which is shared with other logic channel, cannot work anymore. Only the SR associated with the other non-failed TRP can work. We think this should be the logic of association configuration between SR and TRP. |

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 relation info. 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. Companies are invited to share more views below.

|  |  |  |
| --- | --- | --- |
| 2.11  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, Intel,  Alt-2: vivo, APT/FGI, DOCOMO  Alt-3: Qualcomm (select filter associated with failed TRP)  Alt-4: Apple, LGE, ETRI, CATT |

|  |  |
| --- | --- |
| Company | Technical views |
| Lenovo&MotM | Support Alt-1. |
| Qualcomm | Support Alt3 to minimize resource usage. |
| vivo | In our view, up to two spatial filters per PUCCH-SR resource are enough. When two PUCCH-SR resources are configured, each one having one spatial filter towards a TRP, one of them should be selected to transmit based the above selection rules. And when only one PUCCH-SR resource, configuring two spatial realtions is aimed for reliability of PUCCH. |
| DOCOMO | Previously we agreed to support up to 2 PUCCH-SR resources (one PUCCH-SR per TRP) for BFR, and we believe the intension is to exclude Alt.3.  In this case, whether each PUCCH-SR resource can have 1 or 2 activated spatial filters is up to gNB and may be configured. To keep the logic of ‘one PUCCH-SR per TRP’, the two spatial filters/beams should be for repetition purpose and from the same TRP.  Hence, we support Alt.2. |

Another issue is whether reusing PUCCH-SR for SCell BFR (if configured) for TRP-specific BFR should be supported. Companies are invited to provide their views.

|  |  |  |
| --- | --- | --- |
| 2.12  PUCCH-SR resource | Whether to reuse PUCCH-SR of SCell BFR for MTRP BFR   * Alt-1: leave to gNB implementation * Alt-2: Yes * Alt-3: No | Alt-1: Apple, APT/FGI  Alt-2: CMCC, LGE, MTK  Alt-3: |

|  |  |
| --- | --- |
| Company | views |
| Apple | Support Alt1 |
| Lenovo&MotM | Firstly, whether the SR configuration ID of SCell BFR is same to the SR configuration ID of TRP-specific BFR should be further clarified. If there are different, whetheter a same PUCCH-SR can be configured in two SR configurations. In our opinion, it can’t since gNB can’t distinguish the two SR configurations. Therefore, it needs more clarify about this issue. |
| APT/FGI | Support Alt-1 |
| LGE | Support Alt-2. |
| Qualcomm | Support Alt2 to minimize overhead. |
| MediaTek | Support Alt-2. |
| DOCOMO | Support Alt-2. One SR for BFR is sufficient. |

* + 1. BFRA MAC-CE content

The following offline proposal was discussed in RAN1#104b-e but was not agreed. There are basically two issues, e.g. whether 1 or 2 MAC-CEs are used for BFRQ reports, and contents of the MAC-CE. The second issue depends on the outcome of the first.

***Offline Proposal (RAN1#104b-e)***

* *A single MAC-CE is used for BFRQ report for all TRPs in all CCs in a cell group*
* *The MAC-CE carries information of failed TRP identifiers, e.g.* 
  + *Alt-1: indices of BFD-RS set where beam failure is detected,*
  + *Alt-2: implicitly through resource index representing identified new beam, if found, else explicitly through BFD-RS set index*
  + *other alternatives are not precluded*
* *For each failed TRP for a CC, BFRQ carries information whether a new candidate beam is found, and resource index representing identified new beam (if found).*

Company views on MAC-CE design/contents in this meeting are summarized below.

|  |  |  |
| --- | --- | --- |
| 2.13  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: Lenovo/MotM, CATT, MediaTek, LGE, TCL, Intel, Apple, Spreadtrum, APT/FGI, Huawei, HiSilicon  Alt-2: ZTE, Ericsson (?)  Alt-3: |
| 2.14  MAC-CE | Indication of failed TRP in MAC-CE (NOTE: this question may depend on the outcome of 2.13)   * Alt-1: indication of failed BFD-RS set * Alt-2: indication of CORESETPoolIndex | Alt-1: Huawei, HiSilicon, CATT, vivo, Nokia/NSB, LGE, Apple,Spreadtrum, MTK, DOCOMO  Alt2: OPPO, Sony, |
| 2.15  MAC-CE | Indication of new beam in MAC-CE   * 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 | Alt1: DOCOMO,  Alt2: Huawei, HiSilicon, CATT, DOCOMO, Apple,Spreadtrum, APT/FGI, LGE |

|  |  |
| --- | --- |
| Company | Technical views |
| Apple | Our view is provided. |
| Lenovo&MotM | For 2.13, Alt-1.  For 2.14, Alt-1,  For 2.15, Alt-2. |
| LGE | Our view is added. |
| Qualcomm | For 2.13: support Alt1  For 2.14: support Alt1  For 2.15: support Alt2 |
| Huawei, Hisilicon | For 2.13, support Alt-1.  For 2.14, support Alt-1.  For 2.15, support Alt-2. We suggested some rephrasing to avoid “beam index” and align with current spec language |
| MediaTek | For 2.13, support Alt-1.  For 2.14, support Alt-1. |
| vivo | For issue 2.13, we prefer only one BFR MAC CE for TRP-specific BFR and specific design can be left to RAN2.  For issue 2.14, considering the unified design for sDCI and mDCI scenes, we think Alt-1 is better. |
| Samsung | For 2.14, support Alt. 1 |
| DOCOMO | For 2.13, Alt-1.  For 2.14, Alt-1. |

It is also proposed to support BFRA MAC-CE transmission for SpCell with normal PUSCH. Companies are invited to share their views.

|  |  |  |
| --- | --- | --- |
| 2.16  MAC-CE | Q: whether to support BFRQ MAC-CE for SpCell with normal PUSCH   * NOTE: In Rel.16 it is only supported in msg3 | Support: MediaTek, Support, APT/FGI  Concern: |

|  |  |
| --- | --- |
| Company | Technical views |
| Apple | Support to have a unified solution |
| Lemovo&MotM | Would you further clarify the normal PUSCH? Does it mean that BFRQ MAC CE is transmitted in a PUSCH not triggered by a PUCCH-SR? If yes, support it since Scell BFR is already supported. |
| LGE | From existing RAN2 SR/BFR procedure perspective, it is natural to send a MAC-CE if UL-SCH is already available (i.e. on any PUSCH scheduled previously). If it is not available, SR PUCCH is triggered. Thus, we think that we do not need any agreement in RAN1. |
| Qualcomm | Support |
| MedaiTek | Supprot. Current RAN2 spec only suuprt transmit BFRQ MAC-CE for SpCell in Msg3.  Maybe we can change “normal” PUSCH to “any” PUSCH. |
| DOCOMO | Need further discussion on the condition to support BFRQ MAC-CE for SpCell with any PUSCH. |

* + 1. UE assumption after BFR response

The following offline proposal was discussed in RAN1#104b-e.

*Offline proposal (RAN1#104-e) : After receiving BFR response*

* *For each failed TRP, the DL QCL-typeD assumption of all CORESETs associated with that TRP with 1 activated TCI state is updated by the RS associated with the latest reported new candidate beam (if found when NBI-RS set is configured).*
  + *FFS: How to associate CORESET(s) with each TRP*
  + *FFS: timeline for the new beam updte after receiving BFR response*
* *FFS: Update of QCL-type D assumption UL spatial filter/power control assumption for PUCCH, and other channels/RSs.*
* *The above applies at least to SCell; FFS SpCell*

Company views in RAN1#105-e are summarized below.

|  |  |  |
| --- | --- | --- |
| 2.17  Beam update | Q: 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: Applicable channel   * at least PDCCH, * FFS: others * FFS: association of PUCCH with TRP (if PUCCH beam update is supported)   Q4: deactivation of CORESETs for a TRP, if no new beam is found | Q1: vivo, Qualcomm, CATT,Spreadtrum, APT/FGI. LGE, MTK, DOCOMO  Q2: vivo, Qualcomm, CATT,Spreadtrum, LGE, Huawei, HiSilicon, MTK, DOCOMO  Q3:   * PDCCH: Sony, OPPO, CATT, vivo, ZTE, Qualcomm, MediaTek, ETRI, Spreadtrum, LGE, Huawei, HiSilicon, DOCOMO * PDSCH: vivo (M-DCI), Apple * PUCCH: Support (ZTE, Qualcomm, Sony, ETRI, DOCOMO, Apple, CATT), No (OPPO), Spreadtrum * All channels: Apple, APT/FGI   Q4:  Support: vivo, ZTE  Concern: |

|  |  |
| --- | --- |
| Company | Technical views |
| Apple | We think this is for mDCI only. |
| Lenovo&MotM | For Q1: support.  For Q2: support.  For Q3: support.  For Q4: Not support. |
| LGE | Our view is added. |
| Qualcomm | For Q1: support  For Q2: support  For Q3: support  For Q4: No need. It is up to gNB for further beam training or deactivation  We are fine for the offline proposal |
| Huawei, HiSilicon | Added our views to table above. |
| MediaTek | For Q1: support.  For Q2: support.  For Q3: support. |
| DOCOMO | For Q1: support.  For Q2: support.  For Q3: support.  For Q4: Not support. |

* + 1. RACH-based fallback

The following offline proposal was discussed in RAN1#104b-e without conclusion.

*Offline Proposal (RAN1#104-e): CBRA-based transmission can be triggered on a SpCell for per-TRP BFR as 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*
* *NOTE: It is RAN1’s understanding that RAN1 decision does not preclude RAN2 from studying other scenarios.*

Company inputs in this meeting is summarized below.

|  |  |  |
| --- | --- | --- |
| 2.18  RACH | Q1: CBRA based RACH  Q2: CFRA-based RACH | Q1:  Support: ZTE/Intel/DOCOMO  Concern: OPPO  Q2:  Support: OPPO |

|  |  |
| --- | --- |
| Company | Technical views |
| Apple | We support CBRA based RACH when BFR-SR is not configured, which is similar to R16 BFR |
| Lenovo&MotM | We support CFRA based RACH if it’s configured, if not, then support CBRA based RACH. |
| Qualcomm | We are fine for CBRA only or CFRA if configured + CBRA otherwise, slightly prefer CBRA only to reduce overhead |
| DOCOMO | Fine to support both. |

* + 1. Others

For issues in Table II (section 2.2) that are not covered in the above sections, companies are invited to share their views.

|  |  |  |
| --- | --- | --- |
| 2.19  other | New BFRR mechanism  a MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure.  a MAC CE deactivation command to de-activate the failed TRP so that to achieve the switch of transmission hypothesis from MTRP to STRP.  a PDCCH to trigger a beam measurement and reporting procedure for the failed TRP. | Support: vivo  Concern: |
| 2.20  other | Implicit BFD-RS is only supported if Rel.17 TCI framework supports M >1 | Support: Futurewei  Concern: |
| 2.21  Other | Prioitize TRP1 of PCell, if beam failure is detected on both TRP | Support: InterDigital  Concern: |
| 2.22  Other | Fallback to single-TRP transmission   * Conditions FFS (e.g. 1 TRP fail without new beam found, or 2 TRPs fail and new beam found on 1 TRP) | Support: vivo  Concern: |
| 2.23  other | LRR has higher priority than normal SR   * FFS: prioritization between LRR for TRP-specific BFR and LRR for SCell BFR | Support: Lenovo/MotM  Concern: |
| 2.24  other | Study how to avoid transmission of PUSCH carrying MAC-CE to failed TRP | Support: Lenovo/MotM  Concern: |
| 2.25  other | For mDCI mTRP, the implicit BFD RSs associated with a *CORESETPoolIndex* can be the QCL-TypeD RSs in up to X TCI states for CORESETs sharing the same *CORESETPoolIndex*.   * X can be determined in spec or via UE capability. | Support: Qualcomm  Concern: |
| 2.26  other | support per-TRP BFD-RS configurations for both intra-cell and inter-cell multi-DCI based multi-TRP operation. | Support: Ericsson  Concern: |
| 2.27  other | M-DCI in TRP-specific BFR, if one TRP is declared beam failure and if the time offset between the reception of the DL DCI and the corresponding PDSCH is less than a threshold, UE keeps one default Rx beam for receiving potential PDSCH transmitted from non-failed TRP | Support: ASUSTek  Concern: |
| 2.28  other | If the UE detects beam failure in the first BFD-RS set, it shall try to  find a new candidate beam from the first NBI-RS set with L1-RSRP above a threshold, if any. If the UE detects beam failure in the second BFD-RS set, it shall try to find a new candidate beam from the second NBI-RS set with L1-RSRP above a threshold, if any. | Support: Convida  Concern: |
| 2.29  other | * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a first NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the first NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the first NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a second NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the second NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the second NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. | Support: Convida  Concern: |

|  |  |
| --- | --- |
| Company | Technical views |
| vivo | For issue 2.19 and 2.22, to consume less resource and align the operation between gNB and UE, the BFRR mechsim needs to be enhanced. Three schemes for BFRR enhancement in different use cases are listed as following:   * When new beam(s) has been found and reported, except legacy BFRR mechaim, a MAC CE activation command to update the TCI states for the CORESET(s) related to the failed TRP/BFD-RS set is first way of enhanced BFRR. Compared with legacy mechsim, the new mechsim may avoid extra signal to update or reconfigure the BFD-RS if implicily configured, because it is updated with the updated CORESET(s).   When no NBI-RS is configured or NBI-RS(s) is configured but no new beam is found, a MAC CE to deactivite the failed TRP to fallback to sTRP, or a PDCCH triggering a aperiodic beam report for the failed TRP is the second and third way of enhanced BFRR respectively. Compared with legacy mechsim, the second mechsim triggers UE behaviour to fallback to sTRP operation mode and align operation on transmitter and recevier, and the third mechsim triggers to find new beam(s) to maintain mTRP operation mode as much as possible. |

* 1. Simultaneous reception of signals with different QCL-typeD assumption

|  |  |  |
| --- | --- | --- |
| **#** | **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: Spreadtrum (Rel.16 rule applied for each TRP), ZTE, Qualcomm (for each CooolsetPool), LGE, Apple  Concern:  Alt2:  Support: Apple  Concern; |
| 3.2 | NW provides indication of antenna group ID to DL channel/RS | Support: ZTE  Concern: Apple |
| 3.3 | Type of combinations to be enhanced:  Case 1: PDCCH+PDCCH  Case 2: PDCCH+PDSCH  Case 3: CSI-RS + CSI-RS | Case 1:  Support: Spreadtrum, MediaTek, LGE, Apple  Concern:  Case 2:  Support: ~~Spreadtrum,~~ MediaTek, Apple  Concern:  Case 3:  Support: Lenovo/MM, Apple  Concern: |
| 3.4 | Study both S-DCI and M-DCI | Support: DOCOMO  Concern: |

Companies are invited to share their views below. From the FL’s perspective, it appears that there are some interests on Alt-1 (issue 3.1), at least for the case of PDCCH + PDCCH simultaneous reception.

|  |  |
| --- | --- |
| Company | Technical views |
| Apple | Our view is provided.  For issue 3.1, our understanding is that Alt1 and Alt2 are not competing alterantives, but to handle different kinds of issues. There are two ways for QCL typeD collision handling defined in R15:   1. Priority rule (RAN1) 2. Scheduling restriction (partly in RAN1, partly in RAN4)   Alt1 is to enhance current priority rule and alt2 is to release some scheduling restrictions. |
| Qualcomm | For 3.1, support Alt1.  For 3.2, it seems not a complete solution. But might be useful to combine with 3.1 Alt1  For 3.3, at least PDCCH.  For 3.4, support |
| MediaTek | For 3.1, support Alt1. Scheduling restriction part can be left to RAN4  For 3.2: Not support  For 3.3: Supprot at least Case 1 and 2  For 3.4: Suppeor at least M-DCI |
| DOCOMO | For 3.1, agree with Apple.  For 3.3, Case1 and 2 can be prioritized.  For 3.4, support |

Offline proposal:

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. Reference
2. R1-2103858, “Moderator summary #1 on beam management enhancement for M-TRP with multiple Rx panels”, Moderator (CATT)
3. R1-2103906, “Moderator summary #2 on beam management enhancement for M-TRP with multiple Rx panels”, Moderator (CATT)
4. R1-2103996, “Moderator summary #3 on beam management enhancement for M-TRP with multiple Rx panels”, Moderator (CATT)