**3GPP TSG RAN WG1 Meeting #104-e R1-210nnnn**

**E-meeting, January 25th – February 5th, 2021**

Source: Moderator (CATT)

Title: Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 2)

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This is a summary of round 2 email discussion on AI 8.1.2.3, between GTW1 and GTW2.

# Discussion

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

For beam measurement, it is agreed in RAN1#103-e to down-select in RAN1#104-e.

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| Agreement (RAN1#103-e)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
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Proposals under discussion are summarized below.

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| Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels* Support at least option 2, where a single CSI-report consists of N beams pairs/groups and M (M>1) beams per pair/group, and different beams within a pair/group can be received simultaneously
	+ Support at least M = 2 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)
	+ Support extending the maximum value of N > 1, exact value FFS
* Further study the support of option 1 and option 3

Draft Proposal 1.2: * Down-select from the following alternatives in RAN1#104b-e
	+ Alt-1: For option 2, support configuration of S=2 CMR resource sets corresponding to a periodic/semi-persistent CMR resource setting or an aperiodic trigger state
		- UE reports M beams (e.g. CMR resource indices) from S=2 different CMR resource sets which can be received simultaneously
		- NOTE: UE may assume that different CMR resources in different CMR sets can be received simultaneously, and CMR resources in the same CMR set cannot be received simultaneously
		- FFS: whether S = M
	+ Alt-2: For option 2, support configuration of two CMR resource subsets in a CMR resource set corresponding to a CMR resource setting
		- UE reports M beams (e.g. CMR resource indices) from different CMR resource subsets, which can be received simultaneously
		- NOTE: UE may assume that different CMR resources in different CMR subsets can be received simultaneously, and CMR resources in the same CMR subset cannot be received simultaneously
		- FFS: a specific ID can be used to differentiate CMR resource subsets in a CMR resource set.
	+ Alt-3: For option 2, support indication of S=2 SSB sets, where CMRs are implicitly mapped to a

a CMR set where a CMR in the set is QCLed (Type D) with a SSB in the same SSB set* + - UE reports M=2 beams (e.g. CMR resource indices) from S=2 CMR sets
		- NOTE: UE may assume that different CMR resources in different CMR sets can be received simultaneously, and CMR resources in the same CMR set cannot be received simultaneously

Draft Proposal 1.3: * Study beam measurement/reporting with consideration of inter-TRP interference
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Discussion Summary:

A proposal to adopt at least option 2 supported by over 20 companies was not agreed in GTW1 due to some concerns on interference measurement and CSI overhead. One company claimed that option 2 has higher CSI overhead than option 1, where another company’s simulation results show sub-par performance of option 1/2 (using interference as feedback metric) than option 3 with RSRP. Discussion leading to GTW2 focused on these two issues.

* For CSI feedback overhead, there are different views as to whether the claim that option 2 has higher overhead than option 1 is accurate. Some companies (e.g. Nokia/NSB, CATT) believe the feedback overhead is dependent on the value of N/M, which is up to CSI-report configuration and option-agnostic. Some companies (Samsung/CATT) believe the claim of higher overhead for option 2 may be due to misconception on the candidate beam pair set size as CSI overhead. Some company (Apple) believes if the candidate beam pair set size increases, a fixed CSI overhead will result in lower scheduling flexibility, and in other words, an option with larger candidate beam pair set size requires higher CSI overhead to achieve the same scheduling flexibility. However, even considering candidate pair beam set size, some companies believe this is dependent on NW hardware implementation (e.g. how many TRPs are coordinating, whether different TRPs have the same/different number of panels, how many beams per panel) and comparison between different options may have different results in different scenarios. In summary, there does not seem to be consensus on this claim.
* For interference measurement, companies exchanged views on simulation results and their understanding on simulation assumption/behavior. There are misalignments in simulation assumptions/results/observations among companies and a clear conclusion seems missing.
* In summary: each option (or their combination) has a number of concerned companies.
* Alt1: Option 1
	+ OK:
	+ Not OK: HW/HiSi/Nokia/NSB/Intel/CATT
* Alt2: Option 2
	+ OK: Futurewei, OPPO, HW/HiSi, Lenovo/MoM,  ZTE, Intel, AT&T, Spreadtrum, APT, Nokia/NSB, CMCC, ETRI, Xiaomi, Samsung, Qualcomm, DOCOMO, Ericsson, LGE, CATT
	+ Not OK: vivo/Apple
* Alt3: Option 3
	+ OK: vivo, Nokia/NSB
	+ Not OK: Qualcomm /DOCOMO/Intel/ZTE/OPPO/Ericsson/Samsung
* Alt4: Option 1+2
	+ OK: Samsung
	+ Not OK: HW/HiSi/Nokia/NSB/Intel/Ericsson
* Alt5: Option 2+3
	+ OK Nokia/NSB
	+ Not OK: Qualcomm /DOCOMO/Intel/ZTE/OPPO/Ericsson/Samsung
* Alt6 (Based on suggestion from Ericsson): UE only reports 2 beams that can be simultaneously received, which is similar to R15
	+ Enhance the CMR configuration to let UE aware TRP for each CMR (proposal 1.2 related)
	+ OK: Ericsson
	+ Not OK: DOCOMO/Qualcomm/Xiaomi/ZTE/Samsung

Moderator Suggestion

Overall, option 2 has the most supports (22) and least concerns (2, vivo/apple). Other alternatives have considerable more concerns and fewer supports. Hence, the suggestion is to endorse at least option 2, and continue other options/cases in future meetings.

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| Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels* 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 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)
	+ Support extending the maximum value of N > 1, exact value FFS
* Further study the support of option 1 and option 3

Support (22): Futurewei, OPPO, HW/HiSi, Lenovo/MoM,  ZTE, Intel, AT&T, Spreadtrum, APT, Nokia/NSB, CMCC, ETRI, Xiaomi, Samsung, Qualcomm, DOCOMO, Ericsson, LGE, CATTConcerns (2): vivo, Apple |

Table 2.1: Company views

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| **Company** | **Comments** |
| ZTE | Support FL proposalAlthough we expect to support both Option-1 and Option-2 together as our first preference, we can support Draft proposal 1.1 for making progress. Next meeting, we can further discuss details of Option-1 and Option-3 and make a final decision whether one of them can be supported. |
| Lenovo&MotM | Support. |
| Apple | We are not sure whether Alt1/2/3 above means option 1/2/3 only.We also see the formulation for the draft proposal 1.1. is different from original option 2, which mandates UE to receive signals with multiple Rx panels. We should note that sometimes UE is not able to use two panels due to rotation or power saving.Based on the latest discussion in CSI, they are already discussing beam pairing which is similar to option 2. So what gNB needs should be a rough beam pairing information like option 1. For rough beam pairing information, option 2 has higher overhead than option 1. If we want to go with option 2, N should be up to 4, so that UE can report the pairing information for 4 NW beams. |
| OPPO | Support in principle with wording change suggestion. Suggest to remove “multiple Rx panels” . The term “panel” is not used spec. And “multi-TRP simultaneous transmission” in the main bullet is good enough to explain the intention.Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission ~~with multiple Rx panels~~* 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 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)
	+ Support extending the maximum value of N > 1, exact value FFS
* Further study the support of option 1 and option 3
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| DOCOMO | Support FL proposal and also fine with OPPO’s revision. |
| Spreadtrum | Support FL proposal, also fine with the update from OPPO. |
| Vivo | Not support.The common part of various alternatives is the following. Let’s start from the part with common interest:Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels* 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 and N=1 (NOTE: this is the Rel.16 configuration for group-based reporting)
	+ ~~Support extending the maximum value of N > 1, exact value FFS~~
* Further study the support of option 1 and option 3
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| Xiaomi | Support FL proposal. |
| LGE | Support the proposal.I think the wording pointed by OPPO is fine as is, since it is from WID.And regrading vivo’s revision, we are not OK because the revised proposal has no enhancement compared to Rel-15 group-based beam reporting. |
| Ericsson | We support the FL’s summary. We prefer to keep ‘with multiple Rx panels’ as this is the main purpose of this enhancement. Otherwise, the two beams could be simultaneously received using a single UE panel, in which case there may not be peak throughput improvement. But to alleviate OPPO’s concern, we can add a note that ‘this may not imply that the term panel will be captured in the specifications’. |
| CMCC | Support FL proposal, also fine with OPPO’s suggestion. |
| APT | For progress, we can support FL proposal with removing the NOTE as below. From previous discussions, we observe companies have different understanding on legacy behavior. Furthermore, without this NOTE, the value of this FL proposal still exists, so we suggest removing it to avoid discussion on legacy behavior. Draft Proposal 1.1: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels* 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 and N=1 ~~(NOTE: this is the Rel.16 configuration for group-based reporting)~~
	+ Support extending the maximum value of N > 1, exact value FFS

Further study the support of option 1 and option 3  |
| Huawei, HiSilicon | Support FL’s proposal. |
| Nokia/NSB | Support Proposal 1-1 with OPPO’s revision. We need to go forward to discuss on the key design issue of CMR configuration.  |
| Samsung | Support the FL’s proposal in principle and also fine with OPPO’s revision.  |

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

The following agreements were reached in GTW2.

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| 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 M-TRP BFR * Support 1-to-1 association between each BFD-RS set and an NBI-RS set
	+ FFS: Association details

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 resources can be configured with 2 spatial filter
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There are a few remaining issues on beam failure event report on PUCCH-SR. As this affects the ensuing discussion on the BFRQ MAC-CE content and UE assumption update upon reception of gNB response, it is helpful to align the understanding.

**Questions**:

* Q1: whether PUCCH-SR resources **can** be configured with 2 spatial filters (assuming will be supported in Rel.17 M-TRP PUCCH)
	+ Yes: ZTE, Apple, DOCOMO, Xiaomi, LGE, Ericsson, Fujitsu, APT, Convida
	+ No: Lenovo/MoM, OPPO (2 configurations, not 2 PUCCH-SR resources), Spreadtrum, CMCC, HW/HiSi, No
	+ FFS: vivo
	+ Mod observation: There is no common view. Further discussion is needed.
* Q2: When one dedicated PUCCH-SR resource is configured in a cell group for M-TRP BFR
	+ **Option 0 (**One PUCCH-SR is NOT allowed): Apple, HW/HiSi (?)
	+ **Option 1** (selection): ZTE (associated with TRP), Xiaomi, LGE (associated to TRP, or leave unspecified), Ericsson, HW/HiSi
	+ **Option 2** (repetition): DOCOMO, vivo, Fujitsu, APT, Convida
	+ **Option 3** (leave to RAN2): OPPO
	+ Mod observation: Diverging views between Option 1 and option 2. Given Q1 is undecided, Q2 can be postponed.
* Q3: When two dedicated PUCCH-SR resource are configured in a cell group for M-TRP BFR
	+ Q3.1: Is it agreeable that one PUCCH-SR resource is selected?
		- Yes: ZTE, Lenovo/MoM, Apple, DOCOMO, Spreadtrum, vivo, Xiaomi, LGE, CMCC, APT, HW/HiSi
		- No: Convida (leave to UE implementation)
		- Mod observation:
	+ Q3.2: If so, your view on the PUCCH-SR resource selection rule, and PUCCH-SR transmission scheme
		- PUCCH-SR resource selection:
			* **Option 1**: Association to TRP: Apple, ZTE. Lenovo/MoM, DOCOMO, Spreadtrum, vivo, Xiaomi, LGE, Ericsson, Fujitsu, CMCC, HW/HiSi, OPPO (resource association to TRP defined, other details left to RAN2), Nokia/NSB
			* **Option 2**: Unspecified: LGE, Convida
			* **Option 3**: Leave to RAN2: OPPO
		- PUCCH-SR transmission scheme (when 1 spatial filter is activated)
			* **Option 1** (same as single PUCCH-SR): ZTE, Xiaomi
* Q5: Whether PUCCH-SR for SCell can be reused for M-TRP
	+ Yes: ZTE, Lenovo/MoM, DOCOMO, vivo, CMCC
	+ FFS:
		- LGE: use a single SR PUCCH for BFRQ. If we really need to define a selection rule, it may be better to choose a SR PUCCH associated with less number of TRP failure
	+ Mod observation: more companies think this can be supported.
* Q6: Should the multi-TRP BFRQ MAC CE support BFRQ for multiple serving cells, as the Rel-16 SCell BFRQ MAC CE?
* Q7: Should it be supported to configure multi-TRP BFR on some SCells and single-TRP BFR on some other SCells?
* Q8: If yes to Q7, could beam failure on a multi-TRP SCell and beam failure on a single-TRP SCell be reported in the same BFRQ MAC CE?

Table 2.2-a: Company inputs

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| * Q1: whether PUCCH-SR resources **can** be configured with 2 spatial filters (assuming will be supported in Rel.17 M-TRP PUCCH)
* Q2: When one dedicated PUCCH-SR resource is configured in a cell group for M-TRP BFR
	+ For PUCCH-SR resource in FR1, UE behavior should be clear.
	+ For PUCCH-SR resource in FR2
	+ Q2.1: If the answer to Q1 is “2”, what’s UE transmission behavior? E.g.
		- Option 1: UE selects one spatial filter. Please explain selection rule (if necessary).
		- Option 2: UE applies a multi-TRP PUCCH repetition scheme in 8.1.2.1.
* Q3: When two dedicated PUCCH-SR resource are configured in a cell group for M-TRP BFR
	+ Q3.1: Is it agreeable that one PUCCH-SR resource is selected?
	+ Q3.2: If so, your view on the PUCCH-SR resource selection rule, and PUCCH-SR transmission scheme
* NOTE: For discussion of Q2/Q3, please clarify
	+ Q4: UE behavior when TRP failure status is different across cells
	+ Q5: Whether PUCCH-SR for SCell can be reused for M-TRP

Q6: Should the multi-TRP BFRQ MAC CE support BFRQ for multiple serving cells, as the Rel-16 SCell BFRQ MAC CE?Q7: Should it be supported to configure multi-TRP BFR on some SCells and Rel-16 single-TRP BFR on some other SCells?Q8: If yes to Q7, could beam failure on a multi-TRP SCell and beam failure on a single-TRP SCell be reported in the same BFRQ MAC CE? | Q1: * Yes: ZTE, Apple, DOCOMO, Xiaomi, LGE, Ericsson, Fujitsu, APT, Convida, Samsung
* No: Lenovo/MoM, OPPO (2 configurations, not 2 PUCCH-SR resources), Spreadtrum, CMCC, HW/HiSi, No
* FFS: vivo

Q2.1:* **Option 0 (**One PUCCH-SR is NOT ALLOWED): Apple, HW/HiSi (?)
* **Option 1** (selection): ZTE (associated with TRP), Xiaomi, LGE (associated to TRP, or leave unspecified), Ericsson, HW/HiSi
* **Option 2** (repetition): DOCOMO, vivo, Fujitsu, APT, Convida, Samsung
* **Option 3** (leave to RAN2): OPPO

Q3.1: select one PUCCH-SR? * Yes: ZTE, Lenovo/MoM, Apple, DOCOMO, Spreadtrum, vivo, Xiaomi, LGE, CMCC, APT, HW/HiSi
* No: Convida (but if yes, leave selection to UE implementation)

Q3.2: (if Yes to Q3.1)* PUCCH-SR resource selection:
	+ **Option 1**: Association to TRP: Apple, ZTE. Lenovo/MoM, DOCOMO, Spreadtrum, vivo, Xiaomi, LGE, Ericsson, Fujitsu, CMCC, HW/HiSi, OPPO (resource association to TRP defined, other details left to RAN2)
	+ **Option 2**: Unspecified: LGE, Convida
	+ **Option 3**: Leave to RAN2: OPPO
* PUCCH-SR transmission scheme:
	+ **Option 1** (same as single PUCCH-SR): ZTE, Xiaomi

Q4:* Yes: ZTE, Lenovo/MoM, DOCOMO, vivo, CMCC
* FFS:
	+ LGE: use a single SR PUCCH for BFRQ. If we really need to define a selection rule, it may be better to choose a SR PUCCH associated with less number of TRP failure

Q5: * Yes: ZTE, Lenovo/MoM, Spreadtrum, Xiaomi, LGE (especially when PCell is in FR1), Convida
* FFS: vivo, CATT

Q6: * Yes: CATT, Convida
* No:

Q7: * Yes: Convida
* No: CATT

Q8: * Yes: Convida
* No:
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Table 2.2-b: Company inputs

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| **Company** | **Comments** |
| ZTE | Q1: Yes;Q2: We slightly prefer Option-1. Each of spatial relations can be implicitly associated with a TRP, e.g., through configuring spatialRelationInfo. For maximizing gains of spatial diversity, the spatial relation for a TRP should be associated with a spatial domain filter pointing to another TRP.Q3.1: Yes. Q3.2: Similar to our suggestion in Q2, Each of resources can be implicitly associated with a TRP, e.g., through configuring spatialRelationInfo. For maximizing gains of spatial diversity, the PUCCH-SR for a TRP should be associated with a spatial domain filter pointing to another TRP. For mDCI-mTRP, association between one of PUCCH-SR resource(s) and CORESETPoolIndex should be supported.Regarding UE behavior when TRP failure status is different across cells, in our views, the granularity of TRP-specific beam recovery is per TRP per cell. If so, we think that all is clear.Regarding whether PUCCH-SR for SCell can be reused for M-TRP, the answer is yes, and it can be up to gNB implementation.  |
| Lenovo&MotM | Q1: No. Only PUCCH resource with repetition can be configured with 2 spatial filters in R17 currently. Whether PUCCH-SR resource can be configured with 2 spatial filter is not discussed in R17.Q2: Each PUCCH-SR resource can be configured to be associated with a TRP index (CORESETPoolIndex, BFD-RS set index), therefore, UE can determiner to select which PUCCH-SR resource in FR1 and FR2.Q3: Q3.1: Yes. Q3.2: When UE detects that all beams in a BFR-RS set are all failed, then it will select the PUCCH-SR resource associated with the BFR-RS set to transmit the beam failure recovery request if each PUCCH-SR resource can be associated with a BFR-RS set index.Note: According to “UE behavior when TRP failure status is different across cells”, UE will transmit PUCCH-SR to request UL resource to report beam failure as long as there is beam failure in one TRP in at least one cell. And the followed MAC CE can tell gNB in which cell and which TRP there is beam failure.According to “Whether PUCCH-SR for SCell can be reused for M-TRP”, we support to reuse the PUCCH-SR of SCell for M-TRP because it can reduce the overhead. |
| Apple | Q1: YesQ2: If one PUCCH-SR is configured, it means gNB only enable BFR for one TRPQ3.1: YesQ3.2: Each SR is for BFR for a TRP, and UE can select one to report. If both fails, UE can send two SRs. |
| OPPO | Q1: the answer is NO. The spatial filter is configured in PUCCH, not SR configuration. One SR configuration is associated with one or more PUCCH resource. Whether 1 or 2 spatial filter is configured to one PUCCH does not depend on the SR configuration.Q2: when on SR is configured, the UE would just use that SR when per-TRP beam failure is claimed. That shall belong to the RAN2 SR procedure design.Q3: when two SR configured to mTRP BFR, the gNB can configure an association between SR configuration and TRP. When beam failure is claimed for one TRP, the UE can trigger the corresponding SR if there is no PUSCH grant. Again, that shall belong to RAN2 design. |
| DOCOMO | Q1: Yes. It is based on gNB configuration.Q2: We think it should be Option2. If one PUCCH-SR resource is configured in FR2, there are following two cases:* Case1: no per-TRP BFR configured. Only per-cell BFR is configured. In this case, 2 spatial filters mean PUCCH repetition.
* Case2: some CCs are configured with per-TRP BFR. But gNB configures one PUCCH-SR resource. In this case, it means that gNB just wants to follow R16 PUCCH-SR BFR triggering (even though the MAC CE for BFR is enhanced for per-TRP BFR). Otherwise, gNB will configure two PUCCH-SR resources. Hence, in this case, 2 spatial filters also mean PUCCH repetition.

Based on above analysis, for different cases, 2 spatial filters mean PUCCH repetition.Q3.1: Yes.Q3.2: Each PUCCH-SR is associated with a TRP on PCell/PSCell. On all CCs, if a TRP fails, PUCCH-SR associated with the other TRP can be transmitted. If different/both TRPs fail on different CCs, a default PUCCH-SR (or a selected PUCCH-SR based on some rule) from the two PUCCH-SR resources can be transmitted. |
| Spreadtrum | Q1:No. In Rel-17, one PUCCH configured with two spatial information is only supported for repetition for reliability.Q3.1: Yes;Q3.2: The PUCCH SR resource could be implicitly associated with one TRP, e.g., by CORESETPoolIndex.We have agreed that BFRQ MAC CE can include the information of failed CC indices, one new candidate beam for the failed TRP/CC (if found), and whether new candidate beam is found, indication of a single TRP failure. Even if TRP failure status is different across CCs, the UE behavior is still clear. For example, if TRP1 associated with CORESETPoolIndex =0 failed for carrier 1, and TRP3 associated with CORESETPoolIndex =1 failed for carrier 2, then UE could choose PUCCH SR resource associated with CORESETPoolIndex =0 to convey TRP1 failure for carrier 1, and choose PUCCH SR resource associated with CORESETPoolIndex =1 to convey TRP2 failure for carrier 2.In our understanding, PUCCH-SR for SCell can be reused for M-TRP. |
| vivo | * Q1: can be discussed in PUCCH repetition AI;
* Q2: When one dedicated PUCCH-SR resource is configured in a cell group, the behavior for FR2 is the same as in FR1; And if number of spatial relation is two, UE applies a multi-TRP PUCCH repetition scheme in 8.1.2.1.
* Q3: When two dedicated PUCCH-SR resource are configured in a cell group, one PUCCH-SR resource can be selected based on which TRP failed. The PUCCH-SR is associated with TRP.
* MAC CE report content includes CC index. For each failed CC, the failed TRP index would be reported. It does not matter whether the TRP failure status is same or different across cells.
* We should first focus first on the case where the PUCCH-SR are different for TRP-specific BFR and cell-specific BFR.
	+ For the case when TRP specific BFR and cell specific BFR are configured both for Pcell, there is no such issue.
	+ For the case when TRP specific BFR and cell specific BFR are configured for the Scell, reusing the same PUCCH-BR is possible. But this can be discussed later.
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| Xiaomi | * Q1: Yes
* Q2.1: UE will select the spatial filter associated to the non-failed TRP.
* Q3.1: Yes
* Q3.2: Same as Q2.1
* As for the UE behavior when TRP failure status is different across cells, UE should decide whether two UL spatial filter failed or not. If two UL spatial filter did not fail, UE sends PUCCH-SR with each UL spatial filter respectively. If only one UL spatial filter did not fail, UE sends PUCCH-SR with this non-failed UL spatial filter. Else, UE will choose PUCCH from other cell group.
* We think PUCCH-SR for SCell can be reused for M-TRP.
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| LGE | Q1: Yes.Q2: Support Option 1. UE may choose the one corresponding to the survived TRP as explained by ZTE but the selection rule may not need to be specified because both TRP will monitor the SR resource anyway.Q3.1: YesQ3.2: UE may choose the one corresponding to the survived TRP but the selection rule may not need to be specified because each TRP will monitor each respective SR resource.- Regarding the first note, we think the TPR failure state can be different across cells, e.g. S-TRP in some CCs and 2-TRP in some other CCs. For another example, different TRP pair can be used in different CCs, e.g. TRP#0 and TRP#1 in CC#1 and TRP#0 and TRP#2 in CC#2, especially in the case of inter-band CA. In these cases, if two SR-PUCCH resources are configured, it is ambiguous for UE to determine which SR-PUCCH is in better quality. For this case, it is better to use a single SR PUCCH for BFRQ. If we really need to define a selection rule, it may be better to choose a SR PUCCH associated with less number of TRP failure.- Regarding the second note, we support to reuse PUCCH-SR for SCell specified in Rel-16 especially when PCell is in FR1. Depending on UE channel status, serving beams for both TRP can failed together (same BF condition as in Rel-15/16) and to include this case, a common SR PUCCH can be used for both TRP-specific BFR and cell-specific BFR, where TRP failure indication field in the BFR MAC-CE can indicate whether it is for one TRP failure or two TRP failure. |
| Ericsson | Q1: YesQ2.1: our preference is Option 1. In this case, each spatial filter may correspond to a TRP. The UE will pick the spatial filter corresponding to the TRP that did not have BFR.Q3.1 Yes.Q3.2 One PUCCH-SR resource corresponds to one TRP. The UE will pick the PUCCH-SR resource corresponding to the TRP that did not have BFR. |
| Fujitsu | Q1: Yes. The mechanism for mTRP PUCCH transmission can be reused.Q2: Option 2 is preferred. A new selection rule (option 1) seems unnecessary and may have considerable standard impact.Q3: Yes. If two dedicated PUCCH-SR resource are configured in a cell group, each PUCCH-SR is associated with a TRP. In our view, these PUCCH-SRs can be configured either in PCell or PUCCH-SCell. Moreover, whether to transmit a PUCCH-SR depends on the status of the corresponding TRP (beam failure happens or not). For example, if at least one of the CC of a TRP experiences beam failure, the PUCCH-SR for the TRP is triggered. Anyway, the following MAC-CE will provide more details on CC/TRP index(es). |
| CMCC | Q1: No. We think it is not necessary to configure 2 spatial filters. Q3.1: Yes.Q3.2: If two PUCCH SR resource are configured, each PUCCH-SR resource could associated to a TRP(e.g. by BFD RS set). If one TRP failed, UE would use PUCCH-SR associated to the TRP. Regarding UE behavior when TRP failure status is different across cells, we think the selection rule can still work, and if the PCell/PUCCH SCell configured with PUCCH-SR is failed, a fallback mechanism may be needed. |
| APT | **Re. Q1**: We think when only one PUCCH SR resource is indicated and UE supports PUCCH repetition in Rel-17, there is no need to prevent network from setting so. Similar to DCM, it is up to network implementation. **Re. Q2.1**: It should be Option 2, i.e., PUCCH repetition. **Re. Q3.1**: Yes. **Re. Q3.2**: To us, PUCCH-SR is just used for obtaining UL resource for BFRQ MAC-CE. Also, when two PUCCH-SR are configured, one PUCCH-SR is associated with one TRP respectively. With that understanding, when the failed TRP is in the serving cell with PUCCH-SR(s) configured, UE should transmit the PUCCH-SR associated with non-failed TRP; otherwise, UE can transmit any PUCCH-SR for requesting UL resource since each PUCCH-SR can reach to network. **Regarding NOTE**: - UE behavior when TRP failure status is different across cells: We think the key point is whether the failed TRP is in the serving cell with PUCCH-SR(s) configured. If not, UE can choose anyone. - Whether PUCCH-SR for SCell can be reused for M-TRP: Yes.  |
| Huawei, HiSilicon | **Q1:** No. We have two PUCCH-SR resources with two spatial relation corresponding to two TRPs, it is not necessary with two spatial filters for a PUCCH-SR resource.**Q2:** If the two filters for a PUCCH-SR is supported, then Option 1 need to be selected. Each spatial relation can be associated with a TRP (e.g., associated with a NBI-RS set), UE can select the PUCCH associated with the TRP without BFR. For PUCCH repetition, it is meaningless as one TRP has already failed, which causes extra waste of resource.**Q3.1:** Yes, support selecting one PUCCH-SR.**Q3.2:**  Each PUCCH-SR can be associated with a TRP (e.g., associated with a NBI-RS set), UE can select the one associated with the TRP without BFR. If TRP failure status is different across cells, independent BFR procedure is executed in different cells.For reusing resource from SCell, we need some further study. |
| Convida Wireless | Q1: Yes, but only by supporting the multi-TRP PUCCH enhancements developed in 8.1.2.1, incl. configuration/activation of 2 spatial relations, per-TRP power control, etc.Q2: Support Option 2.The DL failure of a TRP in SCell1 does not imply that the UL of a TRP has failed in the PUCCH-SCell. Even if beam failure would be based on RSRP, SCell1 and the PUCCH-SCell could be in different bands in FR2, e.g. PUCCH-SCell in low FR2 band and SCell1 in high band in FR2. Beamforming and propagation conditions could be quite different between PUCCH-SCell and SCell1. Furthermore, the UE could be served by different sets of TRPs for DL on SCell1 and UL on PUCCH-SCell for various reasons. Additionally, BFR isn’t based on RSRP but on SINR. DL interference can be very different on different FR2 SCells, not to mention the interference difference between DL and UL. Hence, we prefer not to have the UE select one UL Tx spatial filter on the PUCCH-SCell based on a TRP failure on another SCell. Instead, it’s better to support enhanced reliability for PUCCH-SR using option 2.Q3.1: Our preference is no. The two PUCCH resources are anyway configured, so the UE could use both for improved reliability/diversity. The information on which TRP(s) on which cell(s) that have failed will anyway be indicated by the MAC CE.Q3.2: Most companies seem to prefer Yes in Q3.1. In this case, it can be up to the UE to select one or both PUCCH-SR resource(s).Different TRPs can fail in different SCells in FR2, e.g. due to different beamforming and propagation characteristics, different interference/traffic, etc. Hence, new candidate beam or failed TRP index should be reported per cell.Yes, PUCCH-SR for SCell can be reused for M-TRP, especially for PUCCH on PCell in FR1, which is the typical case in practice.It might be good to also try to converge on the issues in the suggested questions below:Q4: Should the multi-TRP BFRQ MAC CE support BFRQ for multiple serving cells, as the Rel-16 SCell BFRQ MAC CE?Q5: Should it be supported to configure multi-TRP BFR on some SCells and Rel-16 single-TRP BFR on some other SCells?Q6: If yes to Q5, could beam failure on a multi-TRP SCell and beam failure on a single-TRP SCell be reported in the same BFRQ MAC CE?  |
| TCL | Q1: No, it is not necessary to configure two spatial filters for a PUCCH-SR resource.Q2: We prefer Option 1. Each spatial filter can be configured to be associated with a TRP index(e.g., CORESETPoolIndex) and UE can select the spatial filter corresponding to the non-failed TRP.Q3.1: Yes.Q3.2: Each PUCCH-SR resource can be configured to be associated with a TRP index(e.g., CORESETPoolIndex) and UE can select the PUCCH-SR resource corresponding to the non-failed TRP. |
| Nokia/NSB | * Q1: prefer single spatial relation per PUCCH-SR resource. But, this is not the scope of this AI, up to PUCCH AI discussion. For Rel-15/16 single spatial relation per PUCCH resource, for Rel-17, TDMed PUCCH resource can be activated with two spatial relations.
* Q2: Q2.1: If supported, UE applies a multi-TRP PUCCH repetition scheme in 8.1.2.1. But, how to support TRP identification is unclear for this case.
	+ In FR1, it is not clear how to distinguish failed TRP and send UL DCI. One solution is transmitting two UL DCI from two TRPs.
	+ In FR2, to distinguish failed TRP, Network should use different reception algorithm from the URLLC PUCCH reception, where TRP identification is not required for URLLC. Also, there is also a possibility that PUCCH can be received for failed TRP due to DL/UL asymmetry.
* Q3: When two dedicated PUCCH-SR resource are configured in a cell group
	+ one PUCCH-SR resource is associated to a TRP, and PUCCH resource associated to the failed TRP is sent.
	+ TRP association can be done by explicitly by coresetPoolIndex or by implicitly by spatial relation of the PUCCH resources.

Other details on Note can be discussed after the completion of the basic design.  |
| Samsung | * Q1: Yes
* Q2.1: We slightly prefer option 2 with repetition.
* Q3.1: Yes
* Q3.2: association with TRP via e.g., CORESETPoolIndex; if one TRP fails, the UE could transmit on the PUCCH-SR associated with the working TRP
 |

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

Companies are invited to provide their views on the following proposal.

|  |
| --- |
| **Draft Proposal 3.1:*** **Investigate, and specify if needed, enhancement to release constraints due to QCL -TypeD collision for UEs  that can receive signals with two different QCL -TypeD properties**
	+ **The following options are considered:**
		- **Option 1: To enhance priority rule to facilitate UE  to receive downlink  signals with two different QCL -TypeD properties, e.g. PDCCH QCL prioritization rule enhancement**
		- **Option 2: 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**
		- **Other options are not precluded**
	+ **FFS: definition of QCL -TypeD collision, e.g., different QCL Type D RS(s) under the same UE panel.**
 |

Observation:

* Yes: ZTE, Lenovo/MoM, Apple, OPPO, DOCOMO, Spreadtrum, Xiaomi, Ericsson, Fujitsu, CMCC, APT, TCL
* NO: HW/HiSi

Table 2.3: Additional company inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| ZTE | Support. In our views, it is a good starting point to kick off discussion of this topic. |
| Lenovo&MotM | Support |
| Apple | Support |
| OPPO | Support. It is good to start discussing this issue. |
| DOCOMO | Support. |
| Spreadtrum | Support |
| Xiaomi | Support  |
| Ericsson | Support |
| Fujitsu | Support |
| CMCC | Support |
| APT | Supportive  |
| Huawei, HiSilicon | Deprioritize the issues in the discussion as we agreed in RAN1#102. We need to finalize the two main issues, i.e., beam measurement and reporting, and MTRP BFR, at first. |
| TCL | Support |
| Nokia/NSB | Similar view as Huawei. It is better to discuss after all simultaneous reception scenario have been discussed in AI8.1.2.1 (PDCCH), AI8.1.4 (CSI-RS) and also in this AI on CSI-RS for BM. The selection of the above options should be different per scenarios. |
| Samsung | Support the FL’s proposal |

# 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 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 M-TRP BFR

* Support 1-to-1 association between each BFD-RS set and an NBI-RS set
	+ FFS: Association details

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 resources can be configured with 2 spatial filter

# Reference

1. R1-2101862, “Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 0)”, Moderator (CATT)
2. R1-2101973, “Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 1)”, Moderator (CATT)