

# RAN-R18-WS-eMBB-Apple - Version 0.0.4

## RAN

### 3GPP TSG RAN Rel-18 workshop RWS-210512

Electronic Meeting, June 28 - July 2, 2021

Agenda Item: 4.1

Source: Apple Inc.

Title: Email discussion summary for [RAN-R18-WS-eMBB-Apple]

Document for: Discussion/Decision

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## 1 Introduction

This document summarizes the Q&A style discussion regarding the below Apple contributions as part of the email discussion for [RAN-R18-WS-eMBB-Apple].

1. RWS-210493, Mobility and High Frequency Range Enhancement [1]
2. RWS-210494, Local Service Hosting Using Residential Gateways [2]
3. RWS-210499, Consideration on even further enhanced MIMO [3]

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## 2 Q&A

In case, companies have general comments and questions regarding Apple contributions for the eMBB related Rel-18 work, please use the feedback form below:

### Feedback Form 1:

### 2.1 Round 1 Comments/Questions to RWS-210493

In the contribution RWS-210493, “Mobility and High Frequency Range Enhancement”, we provided several proposals for the FR2/2.x related enhancement in RAN2 and RAN4, the proposals are listed as below for easy reference.

#### RAN2 related

**P1.** RAN2 to evaluate on further minimization of beam specific configuration/transition/operation delays in FR2/2.x.

For e.g: Approaches like enhancements to L2/L3 signaling, additional logic in L2 (e.g., timer based handling etc.)

**P2.** RAN2 to evaluate the enhancements to L2/L3 data-plane protocols for FR2.x and higher frequencies.

**P3.** RAN2 to evaluate procedures that enhance link control/re-establishment from L3 for FR1 and higher FR (beam) based mobility

**P4.** RAN2 to also evaluate enhancements based on L2 mobility starting with the Rel-17 as baseline.

For round 1, please provide your comments and questions regarding the RAN2 proposals of RWS-210493 in the feedback form below. Please also provide your view if some of the items listed in RAN2 proposals could be considered to be added as RAN2 impact as part of RAN1-driven WI.

**Feedback Form 2:**

**1 – MediaTek Inc.**

**Q1.** Minimization of beam specific configuration/transition/operation delays in FR2/2.x: Do you expect to introduce new MAC CEs or new timers?

**2 – Intel Corporation (UK) Ltd**

**For RAN2 based enhancements:**

Q1: Would you please clarify the motivation to introduce L2 feedback for beam management on top of L1 feedback? Any details regarding the motivation and solutions for data plane enhancements to handle increased data rate and asymmetric data rate?

**For RAN4 related enhancements:**

Q2: FR2 MPE: In alt1, does maximum UL duty cycle refer to the current UE capability maxUplinkDutyCycle- FR2, or a potential new one? Is the intention to have this new signaling be separate from the PHR P-MPR reporting?

Q3: UE antenna scaling: Besides reducing power consumption, is the expectation that min peak EIRP requirement will still be met upon scaling down the number of antenna elements used?

Q4: For harmonizing RLM and BFD/CBD: in general it is putting limitations on the network configurations. Especially between BFD and CBD, it is risky to have any restrictions on network configurations of the two sets of reference signal resources respectively. In our understanding, the UE copes really well actually the current RLM and BFD mechanisms. Please the proponent elaborate more what are the exact enhancements considered for Rel-18.

Also, is it proposed only for FR2/2.x, but not for FR1?

**3 – LG Electronics Inc.**

Q1) In slide 4, for RF, it was agreed not to introduce dynamic duty cycle for MPE in Rel-16. Would you like to re-visit this discussion in Rel-18?

Q2) For RLM and BFD/CBD, we think RAN1 need to involve this. What do you think?

Q3) In slide 5, antenna scaling can have impact on the RRM. Do you think this antenna scaling can have impact on UE mobility?

**4 – Nokia Corporation**

**Q1:** For FR1-aided FR2 link establishment, is the aim to enhance NR-DC only or would this also apply to EN-DC?

**Q2:** Would these FR2 enhancements require additional measurements done by the UE?

## 5 – Apple Hungary Kft.

[Answers]

For Q1 MediaTek:

we think both are possible as L2 control is anyway needed, but there can be timer based procedures as well, based on the L2 control exchange on beams for eg.

For Q1 of Intel:

For example (as mentioned in the MIMO paper below), we could have UE provide additional beam related feedback that might not be always pre-configured by the NW for the UE to just choose. The UE might have to provide details config about the UE's current state (for g., orientation and based on this what sort of beam sweeping the UE can do, and so such information is better conveyed with L2 signaling).

With higher SCS, we envision atleast some changes to RTT and RLC config and currently RLC config is not carrier based. We see some scope of improvement in Rel-18 considering that we decided to not make any changes to Rel-17.

For RAN4 questions from Intel:

Our intention is not to put limitation on network side for RS configuration of BFD/CBD, network can still independently configure the RSs for BFD/CBD. Our proposal of enhancement is to seek a harmonization between RLM procedure and BFD/CBD procedure (e.g., use BFD+CBD function to also cover RLM function, but details could be FFS), since both of those two procedures provide a mechanism for UE to detect the bad link and then try to recover from the bad link/beam. We are thinking if we could use BFD+CBD procedure to also help to trigger RLF for reestablishment directly if no good beam has been found for a certain time period, and UE may not need to wait another procedure(legacy RLM) to trigger the RLF. There are many commonalities between RLM function and BFD/CBD function, and most of the RSs could be reused between those two functions rather than maintaining two separated UE activities with redundancy physical layer evaluation (e.g., OOS evaluation/RS could be quite similar as BFDs but with different SNR/RSRP threshold, and IS evaluation/RS could be quite similar as CBD but may with different SNR/RSRP threshold).

This is only for FR2/2.x, since in this scenario the beam quality could directly or indirectly reflect the link quality. And furthermore, FR2/FR2.x is a noise limited scenario, the SNR evaluation performance might be similar as RSRP evaluation performance (it provides the possibility to harmonize those two functions).

### **RAN4 related**

**P5.** RAN4 to investigate and introduce dynamic or semi-static signaling to enable the adaptation of maximum UL duty cycle or other MPE-complid means to enable better FR2 coverage and/or performance that are visible to the network.

**P6.** RAN4 to investigate and introduce a harmonized link monitoring/recovery mechanism to unify the RLM and BFD/CBD within single UE procedure

**P7.** RAN4 to investigate the impact of UE antenna scaling in FR2 and FR2.x on NW performance and to identify potential solutions to mitigate impact on NW performance

**P8.** RAN4 to investigate methods to simplify UL power control for FR2.x and identify potential solutions

Please provide your comments and questions regarding the RAN4 proposals of RWS-210493 in the feedback form below

### Feedback Form 3:

#### 1 – Intel Corporation (UK) Ltd

##### For RAN4 related enhancements:

Q2: FR2 MPE: In alt1, does maximum UL duty cycle refer to the current UE capability maxUplinkDutyCycle-FR2, or a potential new one? Is the intention to have this new signaling be separate from the PHR P-MPR reporting?

Q3: UE antenna scaling: Besides reducing power consumption, is the expectation that min peak EIRP requirement will still be met upon scaling down the number of antenna elements used?

Q4: For harmonizing RLM and BFD/CBD: in general it is putting limitations on the network configurations. Especially between BFD and CBD, it is risky to have any restrictions on network configurations of the two sets of reference signal resources respectively. In our understanding, the UE copes really well actually the current RLM and BFD mechanisms. Please the proponent elaborate more what are the exact enhancements considered for Rel-18.

Also, is it proposed only for FR2/2.x, but not for FR1?

#### 2 – Apple Hungary Kft.

##### For RAN4 related enhancements:

Q2: FR2 MPE: In alt1, does maximum UL duty cycle refer to the current UE capability maxUplinkDutyCycle-FR2, or a potential new one? Is the intention to have this new signaling be separate from the PHR P-MPR reporting?

A2: Yes, it refers to the existing UE capability. As discussed before in RAN4, in addition to existing PHR based P-MPR reporting, it is beneficial to consider introducing new signaling for more flexible maximum UL duty cycle indication via MAC-CE.

Q3: UE antenna scaling: Besides reducing power consumption, is the expectation that min peak EIRP requirement will still be met upon scaling down the number of antenna elements used?

A3: since this is primarily targeting the UE without coverage issue, e.g. inner cell UE, min peak EIRP requirement may not be very critical.

## 2.2 Answers

### RAN2 related

#### Answer to MediaTek

we think both are possible as L2 control is anyway needed, but there can be timer based procedures as well, based on the L2 control exchange on beams for eg.

#### Answer to Intel

For example (as mentioned in the MIMO paper below), we could have UE provide additional beam related feedback that might not be always pre-configured by the NW for the UE to just choose. The UE might have to provide details config about the UE's current state (for g., orientation and based on this what sort of beam sweeping the UE can do, and so such information is better conveyed with L2 signaling).

With higher SCS, we envision atleast some changes to RTT and RLC config and currently RLC config is not carrier based. We see some scope of improvement in Rel-18 considering that we decided to not make any

changes to Rel-17.

### **Response to Intel on RAN4 related question**

Our intention is not to put limitation on network side for RS configuration of BFD/CBD, network can still independently configure the RSs for BFD/CBD. Our proposal of enhancement is to seek a harmonization between RLM procedure and BFD/CBD procedure (e.g., use BFD+CBD function to also cover RLM function, but details could be FFS), since both of those two procedures provide a mechanism for UE to detect the bad link and then try to recover from the bad link/beam. We are thinking if we could use BFD+CBD procedure to also help to trigger RLF for reestablishment directly if no good beam has been found for a certain time period, and UE may not need to wait another procedure(legacy RLM) to trigger the RLF. There are many commonalities between RLM function and BFD/CBD function, and most of the RSs could be reused between those two functions rather than maintaining two separated UE activities with redundancy physical layer evaluation (e.g., OOS evaluation/RS could be quite similar as BFDs but with different SNR/RSRP threshold, and IS evaluation/RS could be quite similar as CBD but may with different SNR/RSRP threshold). This is only for FR2/2.x, since in this scenario the beam quality could directly or indirectly reflect the link quality. And furthermore, FR2/FR2.x is a noise limited scenario, the SNR evaluation performance might be similar as RSRP evaluation performance (it provides the possibility to harmonize those two functions).

## 2.3 Round 2 Q&A to RWS-210493

Please provide your further round2 questions/comments to RWS-210493.

### **Feedback Form 4:**

#### **1 – HuaWei Technologies Co.**

Thank you for the paper. We are wondering if you are considering wider scenarios for L1/L2 mobility in Rel-18, given that it is not included in Rel-17, e.g. inter-frequency, FR1 etc., and what is the major difference of your proposal compared with L1/L2 mobility?

## 2.4 Round 2 Answers to RWS-210493

### **RAN2 related**

#### **Answer to Huawei**

Thanks for bringing up this important point. Our intention was to take-up from where Rel-17 left off. Now that inter-frequency, FR1 etc are now left out of Rel-17, we view they should be part of the mobility enhancements. In addition to this, we think some sort of conditional handover like mobility is also possible with L2 (similar to the CHO we have with L3) and so we view wider L2 mobility aspects are possible enhancements in Rel-18.

## 2.5 Round 1 Comments/Questions to RWS-210494

While we believe that SA2 WG will need to initiate the primary study item based on SA1 agreements so far in 22.858 and 22.859, contribution RWS-210494, “Local Service Hosting Using Residential Gateways”, provides several proposals for the FR2/2.x related enhancement in RAN2 and RAN3 with respect to CPE and IAB nodes, the proposals are listed as below for easy reference.

**RAN2 related**

**P9.** 3rd party Residential gateway Capability definitions

- Minimum set of parameters viable for 3rd party residential gateways

**P10.** Impact analysis/benefits analysis of RLC Relays and PDCP Relays

For round 1, please provide your comments and questions regarding RWS-210494 on support of Local Service Hosting using residential gateways in RAN2

**Feedback Form 5:**

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**RAN3 related**

**P11.** 3rd party residential Gateway Authentication and Registration with CU

- in split CU-DU architecture cases

**P12.** Standardization of F1 interfaces

- to accommodate 3rd party residential gateway

**P13.** PDCP/SDAP Session establishments

For round 1, please provide your comments and questions regarding RWS-210494 on support of Local Service Hosting using residential gateways in RAN3

**Feedback Form 6:**

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**2.6 Round 2 to RWS-210494**

Please provide your questions/comments to RWS-210494 below.

**Feedback Form 7:**

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**2.7 Comments/Questions to RWS-210499**

In the contribution RWS-210499, “Consideration on even further enhanced MIMO”, we provided several proposals for the MIMO enhancement in RAN1, the proposals are listed as below for easy reference

**P14.** Beam Management Enhancement

**P14.1** Specify beam failure recovery enhancement with regard to uplink beam failure status and mechanism to recover from uplink beam failure.

**P14.2** Investigate and if needed specify latency reduction for UE beam refinement, e.g. UE triggered aperiodic CSI-RS for P3, intra-symbol beam sweeping based on IFDMA based CSI-RS and to introduce a new QCL type to provide spatial Tx parameters.

**P14.3** Investigate and if needed specify event-based beam report to reduce beam selection latency for both intra-cell and inter-cell mobility.

**P14.4** Specify that network can provide some QCL relationship between SSBs to reduce beam selection latency for P1 for SCell activation, intra-cell/inter-cell mobility and new beam identification.

**P.15** UE coordination-based beam management and CSI report

**P15.1** With regard to overhead reduction for beam/CSI measurement/report/selection and UE power saving, or to facilitate NW Multi-user scheduling, specify UE coordination-based beam measurement/report/selection and CSI feedback.

**P16.** CSI feedback enhancement

**P16.1** Investigate and if needed specify CSI report enhancement to report PMI/CQI for more than 1 ranks in a CSI report instance, and/or, more hypothesis for MU-MIMO scheduling.

**P16.2** Investigate and if needed specify CSI report enhancement to handle the UE dynamic CSI processing complexity related capacity and to avoid requiring UE to report stale CSI explicitly when the CSI report configuration exceeds UE capability

**P17.** MU-MIMO enhancement

**P17.1** Investigate and if needed specify MU-MIMO enhancement including the scheduling information enhancement to assist advanced UE MU detection receiver.

For round 1, please provide your comments and questions regarding RWS-210499 on MIMO enhancement in RAN1 below.

**Feedback Form 8:**

<p><b>1 – LG Electronics Inc.</b></p> <p>Regarding the proposed UL BFR, could you explain the reason that this cannot be handled by NW implementation (e.g. via using UL beam management, UL closed-loop power control)?</p>
<p><b>2 – vivo Communication Technology</b></p> <p>”Specify beam failure recovery enhancement with regard to uplink beam failure status and mechanism to recover from uplink beam failure” - BFR is generally controlled by gNB, if UL fails how does UE know? What is procedure if UE has knowledge or no knowledge?</p>
<p><b>3 – Beijing Xiaomi Mobile Software</b></p>

-  
Q1: for proposal 1.1, we think it is gNB who can detect the uplink beam failure. Thus with this information, gNB can indicate a new beam to UE. In addition, the enhancement to reduce the impact of MPE are under discussion in Rel-17 currently. So we are wondering what enhancement is here?

-  
Q2: for proposal 2.1, it is a good point to reduce the overhead. But we think it is difficult to group the UE. In order to group UEs, additional information related to location need to be reported from UE to gNB, thus additional measurement and signaling overhead will be introduced. And also the security issue should be considered.

#### **4 – ZTE Corporation**

Thanks so much for sharing this contribution. On QCL relationship between SSBs, we further think that this issue can be extended for cross-CC scenarios, e.g., QCL relationship among SSBs from different CCs.

#### **5 – Motorola Mobility Germany GmbH**

[Lenovo, Motorola Mobility]: Question on P15.1

-  
For UE-coordination based beam management, do you envision sharing beam measurements across multiple UEs? We somewhat have similar thinking that independent CSI measurements and reporting for beam management is not efficient, especially for scenarios where the multiple UEs follow similar path. It is in our contribution RWS-210396.

#### **6 – Samsung Research America**

- (p3) re UE reporting CSI for multiple ranks, at least for Type II, low rank CSI can be derived based on high rank CSI. Is the proposal to enhance the accuracy of low-rank reporting by adding some additional info?

#### **7 – MediaTek Inc.**

We understand that MU-MIMO scheduling with appropriate PMI and CQI is gNB implementation is not restricted by UE report. A smart gNB may perform better MU scheduling even with single UE report e.g.. by using past scheduling and ACK/NACK info.

#### **8 – Intel Corporation (UK) Ltd**

1. For UE coordinated operation, do you consider direct communication between UEs?
2. For MU-MIMO enhancement, considering e.g. eType II codebook to reciprocity based precoding, do you expect significant residual intra-cell interference to motivate such advanced interference processing at the UE?

#### **9 – Spreadtrum Communications**

For Proposal 1.1, in our views, if gNB detects UL beam failure, gNB can change UL beam by beam indication. If UE detects UL beam failure, e.g. due to MPE, UE should report MPE event based on R17. Therefore, the current spec works well. More clarification on the BFR enhancement for UL beam failure is needed.

For Proposal 1.4: What is 'QCL relationship related information' for the SSBs?

For Proposal 2.1: We are not clear how to determine a group of UEs that share the same Tx beam. Also, what kind of information is coordinated between UEs?

#### **10 – Guangdong OPPO Mobile Telecom.**

Thanks for the contribution. Regarding "UE coordination-based beam management and CSI report", does it mean that UE can initiate some beam management based on its measurement? If so, we also have interest on this topic.

#### **11 – Qualcomm communications-France**

Q1: Regarding UL beam failure (Proposal 1.1), what are the actions that UE needs to perform given that network is the entity aware of UL beam quality? Is it intended to enhance the Rel. 15 SRS for BM or is this more about signaling enhancements?

Q2: Regarding "UE coordination-based beam measurement/report/selection and CSI feedback" (Proposal 2.1), are UEs responsible to identify the grouping (e.g. through SL) or is it network's responsibility (e.g. positioning based)? Also, how RF capability imbalance (e.g. in terms of number of Rx antennas) or UE rotation / orientation (e.g. panel rotation in FR2) among the group of UEs can be addressed with the proposal?

Q3: Regarding the first part of proposal 3.2 (CSI report enhancement to handle the UE dynamic CSI processing complexity related capacity), given that in existing specifications start and end time of CPU/resource/port occupation is defined, is the intention to enhance CPU priority rules for dropping or is the intention to make the start and end time more flexible and up to UE implementation?

#### **12 – HuaWei Technologies Co.**

Thanks for the contribution, one question is: For UE cooperation, is the cooperation decided by UE or gNB?

#### **13 – CATT**

Proposal 1: could you please clarify the expected gain against the existing Rel.17 UL beam management functionality? Uplink beam measurement/configuration/update is currently managed by gNB. What extra procedure and functionality is foreseen in Rel.18?

Proposal 3.1: In our view this is already possible in Rel.17 based on implementation (triggering multiple CSI-reports together).

#### **14 – Beijing Lenovo Software Ltd.**

Q1 (P1.1): UL beam failure can be dealt with by gNB using the beam management procedure. What makes you think it is not sufficient?

Q2 (P1.2): Have you done any evaluation for intra-symbol beam sweeping? We are concerned with the accuracy of beam measurement if beam dwelling time is too short.

Q3 (P1.4): Can you provide more details on the QCL relationships between SSB do you have in mind? Does it limit gNB implementation of the SSB beams?

Q4 (P3.1): Are you thinking of some kind of hierarchy for CSI with different ranks? How much can gNB derive about a lower rank CSI from a high rank CSI in the current CSI feedback?

Q5 (P4.1): In current release a UE has all the information of DMRS regarding MU-MIMO. Different layers are orthogonal and do not cause interference. Can you provide more details on the additional enhancement you envision for DL MU-MIMO?

## 15 – Apple Hungary Kft.

[Answers]

### Response to LG

Q:

Regarding the proposed UL BFR, could you explain the reason that this cannot be handled by NW implementation (e.g. via using UL beam management, UL closed-loop power control)?

A:

When UL beam failure happens, UL beam management cannot handle this issue, but it may lead to an even worse situation. As gNB may not be able to decode ACK correctly so that gNB cannot change the beam, however UE may change the beam since UE already sends an ACK. Then the UL beam mismatch could happen. UL CL-PC cannot be helpful as well, as UE may have already reached the peak Tx power, since if the link budget is not good enough, UE has to use a higher Tx power based on OL-PC. Therefore, implementation cannot always handle the problem.

### Response to vivo

Q:

”Specify beam failure recovery enhancement with regard to uplink beam failure status and mechanism to recover from uplink beam failure” - BFR is generally controlled by gNB, if UL fails how does UE know? What is procedure if UE has knowledge or no knowledge?

A:

NW can know current interference over thermal noise status, and our initial thinking is that it can configure a proper L1-RSRP threshold for UE to detect whether UL beam failure happens or not based on measurement of DL RS

### Response to Xiaomi

Q1:

For proposal 1.1, we think it is gNB who can detect the uplink beam failure. Thus with this information, gNB can indicate a new beam to UE. In addition, the enhancement to reduce the impact of MPE are under discussion in Rel-17 currently. So we are wondering what enhancement is here?

A1:

This is a general enhancement, which is not only used to address the MPE issue. The link budget for UL and DL are different, and usually UL link budget is not as good as DL. So, it could be possible UL beam fails but DL beam can still work even both UL and DL share the same beam.

Q2:

For proposal 2.1, it is a good point to reduce the overhead. But we think it is difficult to group the UE. In order to group UEs, additional information related to location need to be reported from UE to gNB, thus additional measurement and signaling overhead will be introduced. And also the security issue should be considered.

A2:

Our initial thinking is that we can consider to group the UEs that belong to the same user. Nowadays, we see one user may take multiple UEs, e.g. phones, watch and so on, and such UEs are often in the similar

location. For UEs from one user, there should be no security issue with certain coordination. Furthermore, our intension is not to report the UE location to the gNB or anything that will threaten the UE security itself.

### **Response to ZTE**

Q:

Thanks so much for sharing this contribution. On QCL relationship between SSBs, we further think that this issue can be extended for cross-CC scenarios, e.g., QCL relationship among SSBs from different CCs.

A:

We also consider the SSBs across CCs for the SSB QCL indication.

### **Response to Motorola**

Q:

For UE-coordination based beam management, do you envision sharing beam measurements across multiple UEs? We somewhat have similar thinking that independent CSI measurements and reporting for beam management is not efficient, especially for scenarios where the multiple UEs follow similar path. It is in our contribution RWS-210396.

A:

Yes, we consider sharing beam measurements across multiple UEs.

### **Response to Samsung**

Q:

(p3) re UE reporting CSI for multiple ranks, at least for Type II, low rank CSI can be derived based on high rank CSI. Is the proposal to enhance the accuracy of low-rank reporting by adding some additional info?

A:

Yes, one of the intentions is to enhance the accuracy of low rank reporting, since we see the best low rank precoder may be different from the high rank precoder, although a subset of high rank precoder can be good. Also, when the lower rank is used at the gNB for scheduling, gNB would also need accurate CQI reporting

### **Response to MTK**

Q:

We understand that MU-MIMO scheduling with appropriate PMI and CQI is gNB implementation is not restricted by UE report. A smart gNB may perform better MU scheduling even with single UE report e.g.. by using past scheduling and ACK/NACK info.

A:

Yes, we agree that gNB can have some implementation solution already to facilitate its multi-user pairing, for example, using HARQ-ACK statistics you mentioned or maybe NZP-IMR. However, those solutions may either be less accurate or may increase latency or increase overhead. If UE can provide more advanced CSI reporting, it might help to reduce the overhead/latency, and/or, improve MU scheduling accuracy.

### **Response to Intel**

Q1:

1. For UE coordinated operation, do you consider direct communication between UEs?

A1:

We are open to consider some communication between UEs, but it can be either based on SL or other ways

Q2:

2. For MU-MIMO enhancement, considering e.g. eType II codebook to reciprocity based precoding, do you expect significant residual intra-cell interference to motivate such advanced interference processing at the UE?

A2:

It depends on the gNB MU pairing algorithm and the accuracy of the CSI at gNB. If gNB can pair two users that are almost completely orthogonal, then the intra-cell interference could be less an issue. However, we would prefer the way that UE can more actively participate in the process via advanced CSI reporting. This can handle the case when MU pairing still leaves non-negligible intra-cell interference, and, it can also be used to better reflect the different IC capability of the UE in a more transparent way, e.g., linear MMSE, non-linear IC, decode and cancel, etc..

### **Response to Spreadtrum**

Q1:

For Proposal 1.1, in our views, if gNB detects UL beam failure, gNB can change UL beam by beam indication. If UE detects UL beam failure, e.g. due to MPE, UE should report MPE event based on R17. Therefore, the current spec works well. More clarification on the BFR enhancement for UL beam failure is needed.

A1:

This is a general enhancement, not for MPE only. The reason is asymmetric link budget between UL and DL. Please refer to our response to LG/vivo/Xiaomi.

Q2:

For Proposal 1.4: What is 'QCL relationship related information' for the SSBs?

A2:

It is to tell UE whether the SSBs are based on the same beam or highly correlated beam, e.g. QCL-TypeD

Q3:

For Proposal 2.1: We are not clear how to determine a group of UEs that share the same Tx beam. Also, what kind of information is coordinated between UEs?

A3:

Our initial thinking is that the UEs can share some beam measurement results

### **Response to OPPO**

Q:

Regarding "UE coordination-based beam management and CSI report", does it mean that UE can initiate some beam management based on its measurement? If so, we also have interest on this topic.

A:

The UE coordination-based BM and CSI is to avoid redundant beam/CSI measurement for UEs with similar location so as to save UE power, and it can avoid multiple beam indication signaling to save system overhead.

### **Response to Qualcomm**

Q1:

Regarding UL beam failure (Proposal 1.1), what are the actions that UE needs to perform given that network is the entity aware of UL beam quality? Is it intended to enhance the Rel. 15 SRS for BM or is this more about signaling enhancements?

A1:

Our initial thinking is that NW can provide RSRP threshold for UE to monitor the UL beam quality, since NW can aware current interference over thermal noise status. If beam failure happens, some legacy BFRQ approach can be reused to report the beam failure event.

Q2:

Regarding “UE coordination-based beam measurement/report/selection and CSI feedback” (Proposal 2.1), are UEs responsible to identify the grouping (e.g. through SL) or is it network’s responsibility (e.g. positioning based)? Also, how RF capability imbalance (e.g. in terms of number of Rx antennas) or UE rotation / orientation (e.g. panel rotation in FR2) among the group of UEs can be addressed with the proposal?

A2:

UEs are responsible to identify the grouping. It is true that UE needs to be aware of the RF capability imbalance, and when UE performs beam/CSI measurement, it can consider to do some compensation with regard to RF capability imbalance.

Q3:

Regarding the first part of proposal 3.2 (CSI report enhancement to handle the UE dynamic CSI processing complexity related capacity), given that in existing specifications start and end time of CPU/resource/port occupation is defined, is the intention to enhance CPU priority rules for dropping or is the intention to make the start and end time more flexible and up to UE implementation?

A3:

There are two things we think the current CPU can be enhanced (1) CPU rule is soft, in the senses that gNB can still configure more CPU than the UE capability. In which case, according to 38.214, UE still needs to report the stale CSI for the CSI that exceeds the UE CPU capability. This demands unreasonable amount of UE memory (2) The CPU counting rule is made arbitrary and the actual UE CSI processing timeline can be different. This is a problem that 3GPP cannot resolve. But combined with issue 1, it means UE either needs to under-report its CSI capability, or UE needs to dimension large memory for storing the stale CSI. This is the main problem we would like to address

### **Response to Huawei**

Q:

one question is: For UE cooperation, is the cooperation decided by UE or gNB?

A:

UE cooperation is firstly decided by UE and gNB can decide whether to group such UEs or not.

## **Response to CATT**

Q1:

Proposal 1: could you please clarify the expected gain against the existing Rel.17 UL beam management functionality? Uplink beam measurement/configuration/update is currently managed by gNB. What extra procedure and functionality is foreseen in Rel.18?

A1:

If UL beam failure happens, UL BM cannot be really helpful, but it would make the situation worse. UE would change the UL beam after transmitting ACK, but gNB may fail to decode such ACK. Then the beam mismatch would happen. Our initial thinking is to introduce some UL BFD and reuse the legacy BFR procedure. The UL BFD can be based on L1-RSRP, and gNB can provide a good threshold since it has some information on interference over thermal noise.

Q2:

Proposal 3.1: In our view this is already possible in Rel.17 based on implementation (triggering multiple CSI-reports together).

A2:

Triggering multiple CSI reports with different rank restriction is one possible way, but it would unnecessarily lead to higher CPU, and higher UE complexity. Moreover, it may require higher overhead, since UE needs to report the whole CSI for each rank.

## **Response to Lenovo**

Q1:

UL beam failure can be dealt with by gNB using the beam management procedure. What makes you think it is not sufficient?

A1:

Please see our response to LG/vivo/Xiaomi/Spreadtrum/CATT

Q2:

Have you done any evaluation for intra-symbol beam sweeping? We are concerned with the accuracy of beam measurement if beam dwelling time is too short.

A2:

It has been studied since R14, and according to the simulation results, we do not see significant performance degradation.

Q3:

Can you provide more details on the QCL relationships between SSB do you have in mind? Does it limit gNB implementation of the SSB beams?

A3:

The QCL indication could be like QCL typeD indication. It does not restrict gNB implementation, but it just gives gNB opportunity to provide information on SSB QCL to facilitate UE beam tracking. So there is no restriction on gNB Tx beam.

Q4:

Are you thinking of some kind of hierarchy for CSI with different ranks? How much can gNB derive about a lower rank CSI from a high rank CSI in the current CSI feedback?

A4:

Yes, we are. The higher rank CSI cannot always contain the best precoder for lower rank.

Q5:

In current release a UE has all the information of DMRS regarding MU-MIMO. Different layers are orthogonal and do not cause interference. Can you provide more details on the additional enhancement you envision for DL MU-MIMO?

A5:

For DMRS, they are orthogonal by design, however, for PDSCH, they are not. UE performance under MU-MIMO depends on how well the interference cancellation that UE can perform. Therefore, some scheduling assistance can be provided by the gNB to help UE to perform more advanced IC, for example, the information can contain the antenna port, the MCS, etc.

## 2.8 Answers to RWS-210499

### Response to LG

Q:

Regarding the proposed UL BFR, could you explain the reason that this cannot be handled by NW implementation (e.g. via using UL beam management, UL closed-loop power control)?

A:

When UL beam failure happens, UL beam management cannot handle this issue, but it may lead to an even worse situation. As gNB may not be able to decode ACK correctly so that gNB cannot change the beam, however UE may change the beam since UE already sends an ACK. Then the UL beam mismatch could happen. UL CL-PC cannot be helpful as well, as UE may have already reached the peak Tx power, since if the link budget is not good enough, UE has to use a higher Tx power based on OL-PC. Therefore, implementation cannot always handle the problem.

### Response to vivo

Q:

”Specify beam failure recovery enhancement with regard to uplink beam failure status and mechanism to recover from uplink beam failure” - BFR is generally controlled by gNB, if UL fails how does UE know? What is procedure if UE has knowledge or no knowledge?

A:

NW can know current interference over thermal noise status, and our initial thinking is that it can configure a

proper L1-RSRP threshold for UE to detect whether UL beam failure happens or not based on measurement of DL RS

### **Response to Xiaomi**

Q1:

For proposal 1.1, we think it is gNB who can detect the uplink beam failure. Thus with this information, gNB can indicate a new beam to UE. In addition, the enhancement to reduce the impact of MPE are under discussion in Rel-17 currently. So we are wondering what enhancement is here?

A1:

This is a general enhancement, which is not only used to address the MPE issue. The link budget for UL and DL are different, and usually UL link budget is not as good as DL. So, it could be possible UL beam fails but DL beam can still work even both UL and DL share the same beam.

Q2:

For proposal 2.1, it is a good point to reduce the overhead. But we think it is difficult to group the UE. In order to group UEs, additional information related to location need to be reported from UE to gNB, thus additional measurement and signaling overhead will be introduced. And also the security issue should be considered.

A2:

Our initial thinking is that we can consider to group the UEs that belong to the same user. Nowadays, we see one user may take multiple UEs, e.g. phones, watch and so on, and such UEs are often in the similar location. For UEs from one user, there should be no security issue with certain coordination. Furthermore, our intension is not to report the UE location to the gNB or anything that will threaten the UE security itself.

### **Response to ZTE**

Q:

Thanks so much for sharing this contribution. On QCL relationship between SSBs, we further think that this issue can be extended for cross-CC scenarios, e.g., QCL relationship among SSBs from different CCs.

A:

We also consider the SSBs across CCs for the SSB QCL indication.

## **Response to Motorola**

Q:

For UE-coordination based beam management, do you envision sharing beam measurements across multiple UEs? We somewhat have similar thinking that independent CSI measurements and reporting for beam management is not efficient, especially for scenarios where the multiple UEs follow similar path. It is in our contribution RWS-210396.

A:

Yes, we consider sharing beam measurements across multiple UEs.

## **Response to Samsung**

Q:

(p3) re UE reporting CSI for multiple ranks, at least for Type II, low rank CSI can be derived based on high rank CSI. Is the proposal to enhance the accuracy of low-rank reporting by adding some additional info?

A:

Yes, one of the intentions is to enhance the accuracy of low rank reporting, since we see the best low rank precoder may be different from the high rank precoder, although a subset of high rank precoder can be good. Also, when the lower rank is used at the gNB for scheduling, gNB would also need accurate CQI reporting

## **Response to MTK**

Q:

We understand that MU-MIMO scheduling with appropriate PMI and CQI is gNB implementation is not restricted by UE report. A smart gNB may perform better MU scheduling even with single UE report e.g.. by using past scheduling and ACK/NACK info.

A:

Yes, we agree that gNB can have some implementation solution already to facilitate its multi-user pairing, for example, using HARQ-ACK statistics you mentioned or maybe NZP-IMR. However, those solutions may either be less accurate or may increase latency or increase overhead. If UE can provide more advanced CSI reporting, it might help to reduce the overhead/latency, and/or, improve MU scheduling accuracy.

## **Response to Intel**

Q1:

1. For UE coordinated operation, do you consider direct communication between UEs?

A1:

We are open to consider some communication between UEs, but it can be either based on SL or other ways

Q2:

2. For MU-MIMO enhancement, considering e.g. eType II codebook to reciprocity based precoding, do you expect significant residual intra-cell interference to motivate such advanced interference processing at the UE?

A2:

It depends on the gNB MU pairing algorithm and the accuracy of the CSI at gNB. If gNB can pair two users that are almost completely orthogonal, then the intra-cell interference could be less an issue. However, we would prefer the way that UE can more actively participate in the process via advanced CSI reporting. This can handle the case when MU pairing still leaves non-negligible intra-cell interference, and, it can also be used to better reflect the different IC capability of the UE in a more transparent way, e.g., linear MMSE, non-linear IC, decode and cancel, etc..

## **Response to Spreadtrum**

Q1:

For Proposal 1.1, in our views, if gNB detects UL beam failure, gNB can change UL beam by beam indication. If UE detects UL beam failure, e.g. due to MPE, UE should report MPE event based on R17. Therefore, the current spec works well. More clarification on the BFR enhancement for UL beam failure is needed.

A1:

This is a general enhancement, not for MPE only. The reason is asymmetric link budget between UL and DL. Please refer to our response to LG/vivo/Xiaomi.

Q2:

For Proposal 1.4: What is 'QCL relationship related information' for the SSBs?

A2:

It is to tell UE whether the SSBs are based on the same beam or highly correlated beam, e.g. QCL-TypeD

Q3:

For Proposal 2.1: We are not clear how to determine a group of UEs that share the same Tx beam. Also, what kind of information is coordinated between UEs?

A3:

Our initial thinking is that the UEs can share some beam measurement results

### **Response to OPPO**

Q:

Regarding "UE coordination-based beam management and CSI report", does it mean that UE can initiate some beam management based on its measurement? If so, we also have interest on this topic.

A:

The UE coordination-based BM and CSI is to avoid redundant beam/CSI measurement for UEs with similar location so as to save UE power, and it can avoid multiple beam indication signaling to save system overhead.

### **Response to Qualcomm**

Q1:

Regarding UL beam failure (Proposal 1.1), what are the actions that UE needs to perform given that network is the entity aware of UL beam quality? Is it intended to enhance the Rel. 15 SRS for BM or is this more about signaling enhancements?

A1:

Our initial thinking is that NW can provide RSRP threshold for UE to monitor the UL beam quality, since NW can aware current interference over thermal noise status. If beam failure happens, some legacy BFRQ approach can be reused to report the beam failure event.

Q2:

Regarding "UE coordination-based beam measurement/report/selection and CSI feedback" (Proposal 2.1), are UEs responsible to identify the grouping (e.g. through SL) or is it network's responsibility (e.g. positioning based)? Also, how RF capability imbalance (e.g. in terms of number of Rx antennas) or UE rotation / orientation (e.g. panel rotation in FR2) among the group of UEs can be addressed with the proposal?

A2:

UEs are responsible to identify the grouping. It is true that UE needs to be aware of the RF capability imbalance, and when UE performs beam/CSI measurement, it can consider to do some compensation with regard to RF capability imbalance.

Q3:

Regarding the first part of proposal 3.2 (CSI report enhancement to handle the UE dynamic CSI processing complexity related capacity), given that in existing specifications start and end time of CPU/resource/port occupation is defined, is the intention to enhance CPU priority rules for dropping or is the intention to make the start and end time more flexible and up to UE implementation?

A3:

There are two things we think the current CPU can be enhanced (1) CPU rule is soft, in the senses that gNB can still configure more CPU than the UE capability. In which case, according to 38.214, UE still needs to report the stale CSI for the CSI that exceeds the UE CPU capability. This demands unreasonable amount of UE memory (2) The CPU counting rule is made arbitrary and the actual UE CSI processing timeline can be different. This is a problem that 3GPP cannot resolve. But combined with issue 1, it means UE either needs to under-report its CSI capability, or UE needs to dimension large memory for storing the stale CSI. This is the main problem we would like to address

### **Response to Huawei**

Q:

one question is: For UE cooperation, is the cooperation decided by UE or gNB?

A:

UE cooperation is firstly decided by UE and gNB can decide whether to group such UEs or not.

### **Response to CATT**

Q1:

Proposal 1: could you please clarify the expected gain against the existing Rel.17 UL beam management functionality? Uplink beam measurement/configuration/update is currently managed by gNB. What extra procedure and functionality is foreseen in Rel.18?

A1:

If UL beam failure happens, UL BM cannot be really helpful, but it would make the situation worse. UE would change the UL beam after transmitting ACK, but gNB may fail to decode such ACK. Then the beam mismatch would happen. Our initial thinking is to introduce some UL BFD and reuse the legacy BFR procedure. The UL BFD can be based on L1-RSRP, and gNB can provide a good threshold since it has some information on interference over thermal noise.

Q2:

Proposal 3.1: In our view this is already possible in Rel.17 based on implementation (triggering multiple CSI-reports together).

A2:

Triggering multiple CSI reports with different rank restriction is one possible way, but it would unnecessarily lead to higher CPU, and higher UE complexity. Moreover, it may require higher overhead, since UE needs to report the whole CSI for each rank.

## **Response to Lenovo**

Q1:

UL beam failure can be dealt with by gNB using the beam management procedure. What makes you think it is not sufficient?

A1:

Please see our response to LG/vivo/Xiaomi/Spreadtrum/CATT

Q2:

Have you done any evaluation for intra-symbol beam sweeping? We are concerned with the accuracy of beam measurement if beam dwelling time is too short.

A2:

It has been studied since R14, and according to the simulation results, we do not see significant performance degradation.

Q3:

Can you provide more details on the QCL relationships between SSB do you have in mind? Does it limit gNB implementation of the SSB beams?

A3:

The QCL indication could be like QCL typeD indication. It does not restrict gNB implementation, but it just gives gNB opportunity to provide information on SSB QCL to facilitate UE beam tracking. So there is no restriction on gNB Tx beam.

Q4:

Are you thinking of some kind of hierarchy for CSI with different ranks? How much can gNB derive about a lower rank CSI from a high rank CSI in the current CSI feedback?

A4:

Yes, we are. The higher rank CSI cannot always contain the best precoder for lower rank.

Q5:

In current release a UE has all the information of DMRS regarding MU-MIMO. Different layers are orthogonal and do not cause interference. Can you provide more details on the additional enhancement you envision for DL MU-MIMO?

A5:

For DMRS, they are orthogonal by design, however, for PDSCH, they are not. UE performance under MU-MIMO depends on how well the interference cancellation that UE can perform. Therefore, some scheduling assistance can be provided by the gNB to help UE to perform more advanced IC, for example, the information can contain the antenna port, the MCS, etc.

## 2.9 Round 2 to RWS-210499

Please provide your questions/comments to round 2 aspects for RWS-210499

### Feedback Form 9:

#### 1 – Beijing Xiaomi Mobile Software

Thanks for your answers. For proposal 2.1, it is a good idea to group the UEs that belong to the same user.

#### 2 – Samsung Research America

- (p1) Re the case when UL beam fails but not DL beam, is this because of lack of beam correspondence or due to MPE?

- (p3) Thanks for the answer.

-

But for Type II CSI, rank 1-2 case, layer 1 precoder of rank 2 precoding matrix is also the rank 1 precoder, so reporting both rank 1 and rank 2 precoder may not be needed. For rank > 2 case in R16, the precoders for rank > 2 and rank =1-2 can be different. If both are reported, CSI overhead increases (overhead vs throughput trade-off needs to be checked).

-

Re accurate CQI for low rank, the gNB can have a rough estimate of low rank CQI based on high rank CQI by implementation. The main question is whether ore accurate CQI for low rank nets to gain in overhead vs throughput trade-off.

### **3 – ZTE Corporation**

Thank you so much for your reply. Regarding UE coordination-based beam measurement/report/selection and CSI feedback, could you please clarify how the multiple UEs are grouped, e.g., reported by UEs, or any rules?

## **2.10 Round 2 Answers to RWS-210499**

### **Response to Xiaomi**

Comments: Thanks for your answers. For proposal 2.1, it is a good idea to group the UEs that belong to the same user. Response: Thank you. Hopefully we can have some relevant work to do in R18.

### **Response to Samsung**

Q1: - (p1) Re the case when UL beam fails but not DL beam, is this because of lack of beam correspondence or due to MPE?

A1: It is true that lack of beam correspondence and MPE are part of the cases. Another possible case is imbalance link budget between UL and DL. Usually UL link budget is smaller than DL, since the Tx power for UL is smaller than DL.

Q2: - (p3) Thanks for the answer.

But for Type II CSI, rank 1-2 case, layer 1 precoder of rank 2 precoding matrix is also the rank 1 precoder, so reporting both rank 1 and rank 2 precoder may not be needed. For rank > 2 case in R16, the precoders for rank > 2 and rank =1-2 can be different. If both are reported, CSI overhead increases (overhead vs throughput trade-off needs to be checked).

Re accurate CQI for low rank, the gNB can have a rough estimate of low rank CQI based on high rank CQI by implementation. The main question is whether more accurate CQI for low rank nets to gain in overhead vs throughput trade-off.

A2: It is true that the CSI overhead would increase, but there is always a tradeoff between overhead vs throughput. If we do not report CQI, but just some simple PMI report, the overhead may not increase too much. Our initial thinking is that for rank > 2 case, for the best rank, we can report both wideband PMI and subband PMI, but for other ranks, wideband PMI should be enough, since this is used to provide some scheduling flexibility.

### **Response to ZTE**

Q: Thank you so much for your reply. Regarding UE coordination-based beam measurement/report/selection and CSI feedback, could you please clarify how the multiple UEs are grouped, e.g., reported by UEs, or any rules?

A: Our initial thinking is that the grouping is reported by UE, and one possible way is that UEs that belong to the same user can be grouped. The gNB can make the final decision based on the UE report.

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## 3 Summary

### 3.1 RWS-210493 : Mobility and High Frequency Range Enhancement

#### **RAN2 related summary:**

Four companies expressed interest in asking further questions on the RAN2 aspects of this paper related to the L2 feedback on top of L1 based feedback on beam handling, on whether timers or MAC CE would be needed and on FR2 mobility enhancements. Further enquiries about the scope of L2 based mobility from RAN2 perspective including the leftovers from Rel-17 L2 based mobility are also discussed.

One company also enquired about the motivation and solutions for data plane enhancements with higher SCS (for eg., 960SCS)

#### **RAN4 related summary:**

Two companies enquired about the UL duty-cycle, antenna scaling and the MPE aspects esp in relation with the Red-17 UE capability.

Questions related to the topics of harmonizing RLM/BFD and the involvement of RAN1 were also discussed.

### 3.2 RWS-210494 : Local Service Hosting Using Residential Gateways

There were no questions/comments on this topic from the companies. We envision that atleast some of this needs discussion in SA WGs and based on the discussions, RAN WGs activities can be aligned.

### 3.3 RWS-210499 : Consideration on even further enhanced MIMO

There is widespread interest in further enhancing the eMIMO aspects with atleast 14 companies participating in the questions/answers sessions over two round. While several topics related to MIMO were discussed, the below ones were predominant:

Companies had questions on the UL beam management operation and the proposed UL BFR with the view that the gNB handles the UEs UL beam, and these were answered with both technical and practical aspects.

Companies also had interest in finding more about the inter-UE co-ordination for the MU MIMO operation as seen from the gNB perspective. Aspects about UE coordination-based beam measurement/report/selection and CSI feedback were discussed.

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## 4 References

[1] RWS-210493, Mobility and High Frequency Range Enhancement

[2] RWS-210494, Local Service Hosting Using Residential Gateways

[3] RWS-210499, Consideration on even further enhanced MIMO