**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-2105220**

**Electronic Meeting, 12th – 20th April, 2021**

**Agenda item:** 10.9

**Source:** Huawei

**Title:** Email discussion summary for [98-bis-e][147] Additional enhancements for NB-IoT and LTE-MTC

**Document for:** Information

# Introduction

*In this email thread, AI 10.9 Additional enhancements for NB-IoT and LTE-MTC is discussed. The topics are divided into:*

1. *Work plan*
2. *NB-IoT related*
3. *LTE-MTC related*

# Topic #1: Work Plan

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2107255 | Huawei, HiSilicon, Ericsson | **RAN4#98bis:**   * Start discussion on the feasibility of power reduction for PRACH, PUCCH, and full-PRB PUSCH for UEs supporting PUSCH sub-PRB resource allocation, align simulation assumptions if necessary * Start discussion on UE RF impact on 16QAM for NB-IoT, including MPR, EVM, etc. Align simulation assumptions. * Start discussion on BS RF impact on 16QAM for NB-IoT   **RAN4#99:**   * Continue discussion on the feasibility of power reduction for PRACH, PUCCH, and full-PRB PUSCH for UEs supporting PUSCH sub-PRB resource allocation * Continue discussion on UE RF impact on 16QAM for NB-IoT. * Continue discussion on BS RF impact on 16QAM for NB-IoT. * Start discussing the RAN4 related aspects on how to specify the new signaling for neighbor cell measurements and corresponding measurement triggering before RLF.   **RAN4#100:**   * Continue discussion on the feasibility of power reduction for PRACH, PUCCH, and full-PRB PUSCH for UEs supporting PUSCH sub-PRB resource allocation * Align the MPR simulation results for NB-IoT UL 16QAM and agree on the MPR values * Continue to discuss any other UE RF or BS RF issues in the support of 16QAM for NB-IoT * Continue the discussion on specifying the requirements for the new signaling for neighbor cell measurements before RLF   **RAN4#100bis:**   * Continue discussion on the feasibility of power reduction for PRACH, PUCCH, and full-PRB PUSCH for UEs supporting PUSCH sub-PRB resource allocation * Continue to discuss any remaining UE RF or BS RF issues in the support of 16QAM for NB-IoT * Continue the discussion on specifying the requirements for the new signaling for neighbor cell measurements before RLF   **RAN4#101:**   * Discuss any remaining issues in RF and RRM core requirements * Start discussion on the demod performance requirements for NB-IoT DL/UL 16QAM as well as 14-HARQ for LTE-MTC DL, align simulation assumptions if necessary * Start discussion on extending the NB-IoT channel quality reporting based on the framework of Rel-14-16, to support 16-QAM in DL   **RAN4#102:**   * Finalize the core parts CRs * Continue the discussion on the demod performance requirements for NB-IoT DL/UL 16QAM as well as 14-HARQ for LTE-MTC DL * Continue the discussion on extending the NB-IoT channel quality reporting based on the framework of Rel-14-16, to support 16-QAM in DL   **RAN4#102bis:**   * Continue the discussion on the demod performance requirements for NB-IoT DL/UL 16QAM as well as 14-HARQ for LTE-MTC DL * Continue the discussion on extending the NB-IoT channel quality reporting based on the framework of Rel-14-16, to support 16-QAM in DL   **RAN4#103:**   * Discuss any remaining issues in the demod performance requirements   **RAN4#104:**   * Finalize the performance parts CRs, complete the work in RAN4 |

## Open issues

*As per the latest TU allocation for this WI in RAN#91-e, the RAN4 core work (RF+RRM) starts from RAN4#98bis-e and finishes at RAN4#102; the RAN4 performance work starts from RAN4#101and finishes at RAN4#104.A detailed breakdown is proposed in the work plan R4-2107255, which is subject to discussion in the group.*

### Sub-topic 1-1 RAN4 Work Plan

*A breakdown of the RAN4 work is proposed in the work plan. Companies are encouraged to share their views on the proposal. The work plan may be revised before approval.*

#### Companies views’ collection for 1st round

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | Ok with provisional work plan, but may need to update depending on RAN1 progress and decisions. |
| Huawei | To Nokia: Yes, it could be updated when necessary. |

#### Summary for 1st round

|  |
| --- |
| No objections received, the proposed work plan seems agreeable. |

**Suggested proposals from Moderator for 2nd round** (if applicable)

* Recommended WF
  + No further discussion is needed.

#### Companies views’ collection for 2nd round (if applicable)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| YYY |  |

#### Summary for 2nd round (if applicable)

|  |
| --- |
|  |

# Topic #2: NB-IoT

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2104458 | Nokia, Nokia Shanghai Bell | Proposal 1: All NB-IoT BS RF requirements that are specified agnostic to the modulation order in TS 36.104 and TS 38.104 should be reused for NB-IoT BS supporting 16QAM.  Proposal 2: The current NB-IoT RB power dynamic range for QPSK RB transmission in NB-IoT should apply to 16QAM RB for in-band or guard band operation or NB-IoT operation in NR in-band.  Proposal 3: A EVM limit of 12.5% should be specified for NB-IoT 16QAM transmission.  Proposal 4: To define the new uplink FRC for 16QAM as shown in table 3 above. |
| R4-2107245 | Ericsson | Proposal-1: Adding 16QAM support on EVM fo TX signal quality for NB.  Proposal-2: 16QAM has no impact on receiver dynamic range impact. |
| R4-2104651 | Nokia | Proposal: Make the NB-IoT IBE mask dependent on EVM limit the same way as in E-UTRA and NR. |
| R4-2107246 | Ericsson | Proposal-1: Consider the two TX requirements as RF working scope for UE specification.  Proposal 2: Considering 16QAM is not supported for single tone, MPR shall remain equal to 0 for single tone transmission.  Proposal-3: 16QAM EVM should be reuse the LTE UE EVM requirement. |
| R4-2107258 | Huawei, HiSilicon | Proposal 1: Study and specify MPR for 16QAM for NB-IoT UL.  Proposal 2: The 16QAM MPR study should reuse the simulation assumptions for QPSK. Companies are encouraged to provide simulation results in the following meetings. |

## Open issues

### Sub-topic 2-1 BS RF Requirements

*BS RF related issues are discussed here. It’s reasonable to assume that all modulation agnostic BS RF requirements defined in TS 36.104 and TS 38.104 should apply for 16QAM. Hence only modulation related requirements are open for discussion. So far three issues have been identified.*

#### Issue 2-1-1: NB-IoT RB power dynamic range for in-band or guard band operation or NB-IoT operation in NR in-band

* Proposals
  + Option 1: Reuse the existing QPSK requirements
  + Option 2: FFS
* Recommended WF
  + TBA

#### Issue 2-1-2: EVM limit for 16QAM DL

* Proposals
  + Option 1: same as E-UTRA, i.e. 12.5%
  + Option 2: FFS
* Recommended WF
  + TBA

#### Issue 2-1-3: 16QAM FRC for BS Rx Characteristics

* Proposals
  + Option 1: Adopt the 16QAM FRC as proposed in R4-2104458 Table 3
  + Option 2: New FRC for 16QAM is not needed
  + Option 3: FFS
* Recommended WF
  + TBA

#### Companies views’ collection for 1st round

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | Issue 2-1-1: Support option 1.  Issue 2-1-2: Support option 1.  Issue 2-1-3: Refsens / demod requirements will be needed with 12 tones 16QAM FRC to verify performance, even if receiver dynamic range would continue to be tested with single tone QPSK FRC (which is questionable in itself as 12 tones FRC could generate more IMD products in the receiver). |
| Huawei | Issue 2-1-1: We’d like more time to check. Hence option 2.  Issue 2-1-2: ~~Option 1~~ This issue is related to issue 2-1-1. We’d like more time to check. Hence option 2.  Issue 2-1-3: REFSENS tests typically use QPSK modulation and demod tests would define their own FRCs. For receiver dynamic tests, new FRC with 16QAM might be needed. We need further check. |
| Ericsson | Issue 2-1-1: option 1.  Issue 2-1-2: option 1.  Issue 2-1-3: Option 3. The demod discussion will be starting at RAN4#101. Refesens only for QPSK. The single tone is chosen for dynamic range is the same reason for the single tone NB-IoT REFSENS. |

#### Summary for 1st round

|  |
| --- |
| Issue 2-1-1 NB-IoT RB power dynamic range  Two companies support reusing the existing requirement and one company supports FFS.  Issue 2-1-2 EVM limit for 16QAM DL  Two companies support 12.5% and one company supports FFS.  Issue 2-1-3 16QAM FRC for BS Rx Characteristics  Most companies think 16QAM is not applicable for REFSENS tests and the demod 16QAM FRC will be defined in the dedicated demod session. Whether 16QAM FRC is needed for BS RF tests such as Rx dynamic range is FFS.  The moderator recommends further discussion is focused on building the WF. Huawei will be the sourcing company and lead the WF discussions. |

**Suggested proposals from Moderator for 2nd round** (if applicable)

* Recommended WF
  + WF on BS RF requirements for R17 NB-IoT 16QAM, Huawei, HiSilicon

#### Companies views’ collection for 2nd round (if applicable)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| YYY |  |

#### Summary for 2nd round (if applicable)

|  |
| --- |
|  |

### Sub-topic 2-2 UE RF Requirements

*The impact of 16QAM on UE RF is discussed here. It has been identified that the specs on transmit power and transmit signal quality are to be affected by the introduction of 16QAM. Moreover, the simulation assumptions need to be agreed before aligning simulation results and deciding the MPR values for 16QAM.*

*Open issues and candidate options before e-meeting:*

#### Issue 2-2-1: EVM limit for 16QAM UL

* Proposals
  + Option 1: same as E-UTRA, i.e. 12.5%
  + Option 2: FFS
* Recommended WF
  + TBA

#### Issue 2-2-2: In-band Emission limit for 16QAM UL

* Proposals
  + Option 1: Include the EVM limit in the IBE mask the same way as E-UTRA and NR
  + Option 2: Reuse the existing IBE mask, i.e., no changes
  + Option 3: FFS
* Recommended WF
  + TBA

#### Issue 2-2-3 MPR simulation assumptions for 16QAM

There’re three contribution papers involved with this issue. Two of them cited the simulation assumptions agreed in Rel-13. The assumption below seems to have consensus if no objections in this meeting.

* + I/Q image: 25 dB, Carrier leakage: 25 dBc, CIM3: 60 dB

Among the proposals, there’s a small difference on the PA calibration point. Additionally, one company proposes to add EVM and IBE as extra constraints in MPR simulations for 16QAM. One company indicates the exclusion of 12-tone allocation and proposes three power classes to be studied, i.e. PC3, PC5 and PC6.

* Proposals
  + PA calibration point
    - Option 1: MPR=0 for single-tone QPSK allocations
    - Option 2: MPR=0 for single-tone (worst case among 3.75 kHz pi/2 BPSK and pi/4 QPSK, 15 kHz pi/2 BPSK and pi/4 QPSK)
    - Option 3: TBD (i.e. open for proposal)
  + Whether to include EVM limit: YES/NO/FFS
  + Whether to include IBE mask: YES/NO/FFS
  + Whether to include 12-tone allocation: YES/NO
  + Power classes to be considered
    - Option 1: PC3, PC5 and PC6
    - Option 2: PC3 and PC5
    - Option 3: TBD
* Recommended WF
  + TBA

#### Companies views’ collection for 1st round

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Nokia | Issue 2-2-1: Option 1  Issue 2-2-2: Option 1  Issue 2-2-3: **- PA calibration point**: Option 2 for PC3 and PC5. For PC6, the proposed calibration references seem not to work. According to our simulations, extreme compression (amplitude becomes constant) of a single-tone QPSK signal with full 14 dBm TX power does not violate the spectrum emission mask and ACLR. Thus, a different calibration reference is needed for PC6. **Proposal**: For PC6, calibrate the PA so that specified MPR suffices for QPSK, all allocation sizes, with allocation at channel edge.  **- Whether to include EVM limit**: **Yes** (if not, 16-QAM would dictate the dimensioning of the PA, compromising the PA power efficiency)  **- Whether to include IBE mask**: **Yes** (same reason as above)  **- Whether to include 12-tone allocation**: **Yes** It seems there is some confusion regarding RAN1 agreements. RAN1#103-e agreed that at least the 12-tone allocation is included. RAN1#104-e then agreed that also 3 and 6 tones can be used.  **- Power classes to be considered**: 3, 5, 6 |
| Huawei | Issue 2-2-1: ~~option 1~~ We’d like to run some simulations first, hence option 2.  Issue 2-2-2: option 1 seems reasonable, but we’d like to perform some study first before making the decision. Hence option 3.  Issue 2-2-3:   * PA calibration: option 2 for PC3 and PC5. PC6 targets wearable devices powered by small batteries, for which different PA model and hence different calibration are needed. Moreover, the peak current consumption was a key factor when deciding the PC6 MPR for QPSK. * Whether to include EVM limit: we’d like to perform some simulations to verify the EVM effect first. * Whether to include IBE mask: same as EVM. * Whether to include 12-tone: Yes, agree with Nokia. * Power classes to be considered: 3, 5, 6 |
| Qualcomm | Issue 2-2-1: Option 1  Issue 2-2-2: Option 1  Issue 2-2-3:  Option 2 for PA calibration point  EVM limit: Yes  IBE mask: Yes  12-tone allocation: Yes  Power class: Option 2 |
| Ericsson | Issue 2-2-1: Option 1 ok.  Issue 2-2-2: option 1 ok.  Issue 2-2-3:  Option 2 reasonable  EVM limit: Yes  IBE mask: Yes  12-tone allocation: Yes  Power class: option 1 |

#### Summary for 1st round

|  |
| --- |
| Issue 2-2-1: EVM limit for 16QAM UL  Three companies support 12.5% and one company supports FFS.  Issue 2-2-2: In-band Emission limit for 16QAM UL  Three companies support option 1: include the EVM limit in the IBE mask the same way as E-UTRA and NR. One company supports FFS.  Issue 2-2-3 MPR simulation assumptions for 16QAM  It seems there are consensuses on the following simulation assumptions: I/Q image, carrier leakage, CIM3, PA calibration point for PC3/PC5 (i.e. option 2) and include 12-tone allocation in the evaluation.  Most companies support to include EVM and IBE as constraints for 16QAM MPR. One company thinks further study is needed due to the uncertainty status of EVM and IBE limits.  For PC6, one company points out that it targets wearable devices powered by small batteries. Hence a different PA model as well as calibration method should be used. In addition, reducing peak current consumption should be considered. Another company also raises the calibration problem that the calibration for PC3/PC5 does not work for PC6 and proposes an alternative method.  The moderator recommends that further discussion is focused on building the WF, esp. on MPR simulation assumptions, so that companies can submit their simulation results based on aligned assumptions in future meetings.  Nokia will be the sourcing company and lead the WF discussions. |

**Suggested proposals from Moderator for 2nd round** (if applicable)

* Recommended WF
  + WF on UE RF requirements for R17 NB-IoT 16QAM, Nokia

#### Companies views’ collection for 2nd round (if applicable)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| YYY |  |

#### Summary for 2nd round (if applicable)

|  |
| --- |
|  |

# Topic #3: LTE-MTC

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2107244 | Ericsson | Observation#1: If the output power were kept the same for PUSCH sub-PRB but reduced for PRACH, PUCCH and full-PRB PUSCH, there will be an MCL loss for the channels subject to a power reduction which translates into a coverage loss.  Observation#2: If only PUSCH sub-PRB transmissions were boosted, there might not be benefits in terms of coverage since the MCL of full-PRB PUSCH and other physical channels would remain the same.  Observation#3: From a resource utilization perspective, simulation results showed that even if a 3dB power boosting were applied to sub-PRB using ℼ /2-BPSK no gain would be observed with respect to a non-boosted sub-PRB transmission using QPSK.  Proposal-1: RAN4 to investigate the potential gains and any foreseen drawbacks (e.g., on non-sub-PRB allocations) from boosting the power of the subPRB allocation for a certain power class UE.  Observation#4: reducing the full-PRB transmission power generally is against the UE rated power definition.  Proposal-2: Follow the framework of NR pi/2 BPSK power boosting if RAN4 decides that there is an overall gain from the subPRB boosting.  Observation#5: If RAN4 decided for the subPRB power boosting, it will be possible to boost power for 2 out 3 tone subPRB transmission thanks to low PAPR characteristic.  Proposal-3: Focus on PC5 CAT-M1 device for the potential power boosting to PC3 on subPRB transmission.  Proposal-4: RAN4 discuss and agree the workplan for Rel-17 LTE-M. |

## Open issues

### Sub-topic 3-1 Feasibility study on max power reduction for PRACH, PUCCH, and full-PRB PUSCH

*According to the WID, the objective is:*

*For UEs supporting PUSCH sub-PRB resource allocation, study and if found feasible, specify support power reduction for PRACH, PUCCH, and full-PRB PUSCH, with a maximum reduction of e.g. 3 dB below sub-PRB PUSCH power.*

*Two interpretations of the above text are proposed by one company and shall be discussed below.*

*A work plan on this sub-topic is also proposed. In order to avoid duplication, companies are encouraged to discuss it in Topic #1.*

#### Issue 3-1-1: Feasibility of max power reduction

One interpretation of the WID is to maintain the max output power for sub-PRB transmissions as per UE power class while relatively reducing the max output power for PRACH, PUCCH and full-PRB PUSCH transmissions. The impact on both network and UE including pros and cons shall be discussed.

#### Issue 3-1-2: Feasibility of max power boost

The other interpretation of the WID is to maintain the max output power for PRACH, PUCCH and full-PRB PUSCH transmissions as per UE power class while relatively boost the max output power for sub-PRB transmissions. The validity of this interpretation should be checked across companies. If agreed, the impact on both network and UE shall be discussed.

#### Companies views’ collection for 1st round

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | To us, power reduction in the WID means reduction from the max power defined by the power class. And no channel has been allowed to transmit more power. Hence the interpretation in issue 3-1-1 matches the WI objective, while issue 3-1-2 is out of the scope of the WI. |
| Qualcomm | Interpretation 3-1-1 is our understanding of what is meant by the WID. the question is whether this will be a new power class. |
| Ericsson | Issue 3-1-1: Not pursue this direction as it does not give any network benefit and also against the UE power class definition.  Issue 3-1-2: Recommend RAN4 investigate this option and keep the UE power class as the legacy at the same time power boosting the sub-PRB transmission. System simulation however is needed to justify the network gain of this before starting to analysis the RF impact on UE specification. |

#### Summary for 1st round

|  |
| --- |
| Two companies support the interpretation of the WID as described in issue 3-1-1 and one company supports the interpretation described in issue 3-1-2.  No consensus is reached on the WI objective. Moderator recommends further discussions in the 2nd round. |

**Suggested proposals from Moderator for 2nd round** (if applicable)

* Recommended WF
  + Continue to discuss Issue 3-1-1 and 3-1-2

#### Companies views’ collection for 2nd round (if applicable)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | In WID it states:   * For UEs supporting PUSCH sub-PRB resource allocation, study and if found feasible, specify support power reduction for PRACH, PUCCH, and full-PRB PUSCH, with a maximum reduction of e.g. 3 dB below sub-PRB PUSCH power. [LTE-MTC] [RAN4]   The max power reduction and max power boosting both meet the WID objective as the statement only says the relative power relation between sub-PRB power and full-PRB power. However, the max power reduction interpretation of the objective will impact the legacy UE power class definition as the UE power class has strong correlation with the cell coverage in terms of the PRACH, PUCCH transmitted power. Clearly such UE with “new” power class definition will have less coverage than normal LTE-MTC UE with the same power class and thus not preferred from network perspective. The further impact of such “new power class” definition on RAN1 specification needs to be further evaluated.  On the other hand, max power boosting interpretation fits in the current NR power class framework where BPSK is boosted with “negative MPR” concept. However, as the objective indicated, RAN4 still needs study on the feasibility both from network gain and implementation aspects.  As there is only one paper in this meeting discussing this topic, we are open to more discussion in this meeting and next meeting to set the RAN4 scope on this WID. |
| YYY |  |

#### Summary for 2nd round (if applicable)

|  |
| --- |
|  |

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on BS RF requirements for R17 NB-IoT 16QAM | Huawei, HiSilicon |  |
| WF on UE RF requirements for R17 NB-IoT 16QAM | Nokia |  |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-2107255 | Work plan of Rel-17 enhancements for NB-IoT and LTE-MTC | Huawei, HiSilicon, Ericsson | Agreeable |  |
| R4-2104458 | Proposals on BS RF requirements for support of 16QAM in NB-IoT | Nokia, Nokia Shanghai Bell | Noted |  |
| R4-2107245 | BS RF impact analysis on R17 NB\_IoT | Ericsson | Noted |  |
| R4-2104651 | MPR for NB-IoT 16-QAM | Nokia | Noted |  |
| R4-2107246 | UE RF impact analysis on R17 NB\_IoT | Ericsson | Noted |  |
| R4-2107258 | MPR Simulation Assumptions for 16QAM NB-IoT Uplink | Huawei, HiSilicon | Noted |  |
| R4-2107244 | RF impact analysis on Rel-17 eMTC WID | Ericsson | Noted |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents