**3GPP TSG-RAN Meeting #89-e Revised RP-201588**

**Electronic Meeting, 14 - 18 September, 2020**

**Agenda item:** 9.1.2

**Source:** Moderator (China Telecom)

**Title:** Email discussion summary for RAN4 Rel-17 demodulation scope

**Document for:** Discussion

# Introduction

**Scope:**

According to the work areas of RAN4 R17 non-spectrum related WI/SIs endorsed at RAN #88e [1], this email thread will discuss the RAN4 Rel-17 demodulation scope, based on the initial inputs from [2] - [6].

Meanwhile, the way forward on NR Application Layer Throughput Performance was endorsed at RAN #88e [7], and the detailed objectives and scope on RAN4 study for VRC will also be discussed in this thread.

**Target and time schedule:**

* Companies are invited to provide comments in section 1.2, 2.2, 3.2 4.2, 5.1 and 5.2 (till Sept. 3)
  + - An intermediate summary will be submitted to the August RAN4 meeting.
    - The final summary will be submitted to RAN#89e.
* The corresponding WID and SID update will be submitted to RAN#89e.

# UE advanced receivers

## Companies’ proposals summary

Candidate objectives for UE advanced receivers [2] - [6]:

* Scenario a): Inter-cell interference
  + - Target frequency: FR1 and/or FR2
    - Reference receiver:
* MMSE-IRC with DMRS based interference covariance estimation
* MMSE-IRC with data based interference covariance estimation
  + - Type of requirements: PDSCH and the corresponding CQI reporting requirement
    - Rx antenna number: 2Rx; 4Rx (for FR1 only)
    - Interference profile: LTE interference profiles can be used as a starting point for NR FR1 scenarios
    - Discuss if additional network assistance is required
* Scenario b): Inter-layer interference for SU-MIMO
  + - Target frequency: FR1 and FR2
    - Reference receiver: soft IC
    - Type of requirements: PDSCH and the corresponding CQI reporting requirement
    - Number of data layers: up to 4 for FR1, 2 for FR2
    - Rx antenna number: 2Rx; 4Rx (for FR1 only)
* Scenario c): Intra-cell inter-user interference for MU-MIMO
  + - Target frequency: FR1 and/or FR2
    - Reference receiver: RML, SLIC
    - Type of requirements: PDSCH and the corresponding CQI reporting requirement
    - Rx antenna number: 2Rx; 4Rx (for FR1 only)
    - Discuss if additional network assistance is required

## Companies views’ collection

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| Company | Comments |
| Intel | Scenario A): Inter-cell interference:  Support to define the requirements. The NR systems are characterized by interference-limited conditions and inter-cell interference suppression using IRC is required to ensure proper performance in the field. IRC processing is a common approach used on all chipsets for a long time and a limited set of requirements will be beneficial to ensure proper UE implementations. Same time, in comparison to LTE, PDSCH mapping in NR is more flexible (e.g. support of multiple SCS, support of non-slot based transmissions) and can result in specific interference conditions (e.g. time-selective interference). Therefore, different algorithms for covariance matrix estimation can be considered to ensure good IRC performance under various NR scenarios. Requirements can be defined at least for scenarios with time-selective interference, for which receive processing can be different in comparison to typical IRC processing for LTE-like scenarios.  Also, FR1 scenarios can be prioritized given that initial FR2 deployments are expected to be less interference limited due to Tx/Rx analog beamforming applies at gNB and UE sides and more analysis on interference conditions in FR2 is needed.  Scenario B): Inter-layer interference for SU-MIMO  In NR Rel-15, demodulation requirements with R-ML receiver were introduced for SU-MIMO scenarios. Performance benefits of Soft IC receiver over R-ML are not clear. Therefore, we suggest to study Soft IC performance, first. The outcome of this study will be used to decide whether to define performance requirements for Soft IC receiver.  Scenario C): Intra-cell inter-user interference for MU-MIMO  Using of R-ML or SLIC receiver for MU-MIMO scenarios requires information on dynamic PDSCH parameters of co-scheduled UEs (e.g. resource allocation, modulation and coding scheme). Such network assistance may require changes in DCI (e.g. similar to LTE MUST Case 3) and requires RAN1 involvement and analysis. Before such work is triggered need to check on available time budget in RAN1.  Overall, we recommend RAN4 to prioritize Scenario A) and B) for Rel-17 work. |
| Qualcomm | a)MMSE-IRC receiver requirements were already proposed for Rel.16 enhancements but were deprioritized because UE vendors already implement more advanced receivers in modems available today. These would just become paper specifications that everyone is already compliant to.  b) NR specifications already have requirements for advanced receivers, proposal should be clarified. If this is about specifying codeword level IC, this would introduce too much complexity in our view.  c) UEs that are multiplexed in a MU-MIMO scheme should already be orthogonal or quasi-orthogonal(there should be enough spatial isolation between them for the scheduler to multiplex them in the first place). As such, the gain from interference cancelation or some sort of advanced receiver will be very limited while implementing such complicated receiver introduced a lot of complexity since they have to rely on some sort of blind detection of interference. The trade-off complexity vs. system gain does not justify defining these requirements. |
| Ericsson | Scenario A: Inter-cell interference  Support to define the requirements. We also propose that this scenario should include the case TRS/CSI-RS are collided among cells considering the realistic deployment scenario.  Scenario B: Inter-layer interference for SU-MIMO  RAN4 need the study first the benefit of Soft-IC over R-ML first.  Scenario C: Intra-cell inter-user interference for MU-MIMO  RAN4 has not defined the PDSCH requirement for the MU-MIMO transmission (other UE scheduled simultaneously) with the MMSE-IRC receiver (Rel-15 baseline receiver). RAN4 should also define the requirements. if RAN4 will specify the requirements with advanced receiver.  Network signalling  We understand the network assigned signalling could help UE to improve the receiver performance, but it does not work if gNB does not support the it. We prefer to specify the advanced receiver without any network assisted signalling or minimize the number of network assigned signalling, especially for MU-MIMO advanced receiver. |
| MTK | Scenario a): Inter-cell interference   * OK to this scenario * Prefer to focus on FR1 only * Some study on the uncertainty neighboring cell PRB bundling size and DMRS patten is needed. Network signalling may need to be introduced, if necessary * Suggest to remove CQI reporting requirement unless it can be guaranteed that the CSI-RS for CQI can always experience the same interference condition as PDSCH * Suppression or cancellation on neighboring cell’s CSI-RS/TRS can be considered. * Data-based interference covariance estimation is not preferred. If UE is already successfully decodes the data, it makes not much sense to re-estimation the interference covariance matrix again in the same slot unless it is guaranteed that the interference condition keeps the same in the next slots.   Scenario b): Inter-layer interference for SU-MIMO   * Not OK with this scenario * FR2 should not be considered. * CW-IC receiver is too complex from UE implementation point of view. * The feasibility of CW-IC is not clear because NR has more stringent HARQ feedback timing than LTE   Scenario c): Intra-cell inter-user interference for MU-MIMO   * More study is needed * How network pairs 2 UE in MU-MIMO is critical. Good pairing (e.g., orthogonal UEs) would require no extra effort for interference cancellation at UE side. System-level evaluation is needed to justify the benefit. * Feasibility on blind detection for modulation order, PRB bundle, OFDM symbol bundle, DMRS scrambling sequence need to be studied. Network signalling may be needed if concluded to be infeasible. |
| CMCC | In general, we support to define the UE advanced receivers. Considering the limited time and resource, some prioritizations may be needed.  For scenario b), R-ML receiver is defined for SU-MIMO in Rel-15. The soft IC receiver need to be studied first.  For scenario c), the network assistance information should be minimized or avoided in order to avoid RAN1 workload. |
| ORANGE | For all scenarios FR1 should be prioritized where the spectral efficiency is more crucial and where the number of SU-MIMO spatial layers can reach 4.  Scenario A): Inter-cell interference  This is the most complicated scenario in terms of acquiring the interference parameters. Ensuring that the interference covariance estimate is sufficiently accurate, enabling reference signal cancellation on colliding TRS/CSI-RS as proposed by Ericsson could be the main targets.   * Scenario B): Inter-layer interference for SU-MIMO   Here, the UE has full knowledge of the interference parameters. In this scenario (iterative) soft-IC should be carefully evaluated and compared to R-ML detection, particularly, in the case of more than 2 spatial layers and/or high order modulation. A special care should be taken to reflect the spatial covariance of the MIMO channel at Tx and Rx encountered in practice for the comparison for FR1.  Scenario C): Intra-cell inter-user interference for MU-MIMO  Here, the paired UE can estimate the channel and blind detect the modulation of other UEs more easily than in Scenario A. Interference aware receiver (R-ML/Symbol level IC) provides better performance than IRC. Some low overhead assistance from the network may be needed and should be investigated.  Note that MU-MIMO pairing opportunity greatly depends on the number of users active at the same time and, thus, on the users’ traffic, it is not possible to always ensure low interference between MU-MIMO users. |
| Apple | Scenario A:   * MMSE-IRC is Rel-15 baseline receiver. IRC is already widely implemented. We do not see the need to specify a R17 demodulation test for MMSE-IRC with LTE based interference profile. * Due to dynamic nature of inter-cell interference, and large number of antennas at gNB, new interference profile should be studied first. * Baseline receiver should be DMRS based, not data based. * For CSI feedback, no requirement should be specified unless network can ensure CSI-RS for reporting experience similar interference as PDSCH scheduling. * FR2 is low priority, with reduced inter-cell interference due to gNB/UE beamforming   Scenario B: Performance and complexity tradeoff for soft IC (iterative receiver) needs to be studied, e.g. starting as a study item or with study phase.  Scenario C: Realistic MU MIMO paring needs to be modelled. Network assisted information needs to be studied, e.g. starting as a study item or with study phase. |
| China Telecom | * Scenario a): Inter-cell interference   It is also our understanding that MMSE-IRC receiver has been implemented in the chipsets, and Rel-15 PDSCH requirements are defined based on MMSE-IRC receiver. However, a minimum set of requirements with explicit modelling of inter-cell interference is necessary to ensure the proper implementation and performance requirements. For FR1, with interference profile and reference receiver reused from LTE, we do not expect much RAN4 effort on this.  We also have some follow-up discussion on the above comments:  On interference profile & dynamic/time-selective interference (to Intel and Apple):  Regarding the dynamic/time-selective interference, if it is going to be considered, the DMRS based interference estimation may not work properly, due to different interference level in DMRS and data REs. We are open to it, but think the DMRS based interference estimation with slot-based transmission and aligned SCS among cells can be given with higher priority.  In addition, massive MIMO is deployed for some frequency bands; while for some frequency bands at around 2GHz or lower, the BS antenna configuration is the same as LTE.  On TRS/CSI-RS configuration (to Ericsson, MediaTek and Orange):  Regarding the TRS/CSI-RS configuration in serving and neighboring cells, we think it can be decided in the WI. We would like to ask will this impact the receiver structure assumption in E///’s view? As MediaTek and Orange mentioned, suppression or cancellation on neighboring cell’s CSI-RS/TRS can be considered.  On uncertainty neighboring cell PRB bundling size and DMRS pattern (to MediaTek):  For the uncertainty in neighbouring cell PRB bundling size, if the interference covariance is estimated at per PRB basis, the neighboring cell PRB bundling size may not impact the receiver implementation.  For the uncertainty in neighbouring cell DMRS pattern, considering that FDM is applied between DMRS and data in the symbols with DMRS (which is the assumption in Rel-15/16 PDSCH demod test), this may not impact the receiver implementation in our understanding.  In general, for inter-cell IRC receiver, we do not prefer to introduce network signalling unless the necessity is confirmed by the whole group.  On CQI reporting (to MediaTek and Apple):  Regarding the different interference condition for CSI-RS and PDSCH, we understand the issue may happen in some cases. But if we do not introduce CQI requirement, the gain by IRC receiver is only on reducing BLER, but not achieving a higher MCS. In other words, the throughput improvement will be limited to some extend.  On interference covariance estimation:  Regarding the interference covariance estimation scheme, based on the LTE experience, we also think DMRS based interference covariance estimation can be used as baseline.  Scenario B): Inter-layer interference for SU-MIMO  Support to include soft IC for SU-MIMO in Rel-17. In general, since the UE has full knowledge of the interference parameters, the gain by soft IC is expected to be stable in real network.  We are also ok to have a study phase to confirm the reference receiver structure and performance gain, given that we do not have sufficient experience on it in LTE. Also, the MIMO layer, modulation order and spatial correlation level need to be carefully taken into account in the study phase as mentioned by Orange.  Scenario C): Intra-cell inter-user interference for MU-MIMO  Firstly, we believe MU-MIMO operation will be much more popular for NR, considering the widely deployment of massive MIMO in some major NR bands.  There is a debate on whether network should guarantee the orthogonality among paired UEs, or the UE should also be enable to cancel or suppress the interference. We think it is not easy to quickly draw any conclusion for this debate. But it does worth more investigation in 3GPP to ensure a NR system with good MU-MIMO performance.  We are ok to have some study before move to define any enhanced requirements based on the advanced MU-MIMO receiver. |
| Samsung | For scenario c), the necessity of introducing advanced receivers for MU-MIMO is related to current Rel-16 discussion for (enhanced) type II codebook test cases. As important deployment scenario MU-MIMO, if RAN4 fail to specify the test cases for type II codebook in Rel-16, more considerations including assuming advanced receivers for MU-MIMO in Rel-17 shall be considered. We also noted that the work scope of introducing advanced receiver for MU-MIMO can be large considering the potential analysis for interference profile from system level, the choice of baseline receiver and so on. |
| Vodafone | Scenario A) This seems beneficial if we use realistic interference profiles. Clearly FR1 is the priority, and probably more useful for lower bands with limited number of BS Tx beams possible.  Scenario B) Unclear if better than what we already have.  Scenario C) Agree with Ericsson that basic performance needs to be properly testable first. Gains from any enhancements are unclear and would need proper study before specifying anything. |
| Huawei | Scenario A): Inter-cell interference  Support to define the requirements.  MMSE-IRC receiver can provide the significant gain by suppressing the inter-cell interference especially when 4Rx is available. But there is no corresponding NR performance requirements and thus conformance testing to verify the IRC performance. For LTE, such performance requirements are specified.  Compared to LTE, the NR design is more complicated and flexible, such as the different SCS or/and different symbol length would be used by two cells. In RAN4 we should discuss how to deal with those scenario. The network assistance information and/or network restriction would be needed to help UE have knowledge of the resource allocation, PDSCH RE mapping information and PRB bundling size of neighbouring cell to do the proper IRC cancellation algorithm.  Besides, for LTE the IRC is conducted mainly based on the CRS-based interference matrix estimation, while for NR it may be mainly conducted based on DMRS. And the case where DMRS is colliding with TRS/CSI-RS of interfering cell should also be considered in WI.  So based on the above difference from LTE, it would be better to investigate and specify the performance requirements for NR MMSE IRC requirements.  Target frequency: We prefer to focus on FR1 only. In FR2 scenario, the beam is narrow and the interference from neighbouring cell is limited.  Reference receiver: We prefer to consider MMSE-IRC with DMRS based interference covariance estimation as it is more commonly used for most scenarios.  Type of requirements: We prefer to focus on PDSCH demodulation firstly and further study whether to introduce the requirements for CQI reporting.  RX antenna number: We prefer to consider both 2RX and 4RX.  Interference profile: LTE interference profiles can be reused for NR. In our view, the purpose of the requirements is to verify the IRC performance gain. If the existing LTE interference profile works well for that purpose, then we may not need to re-run the system simulation campaign to achieve the interference profile as we did for LTE. And at least one of the scenarios together with the set of parameters for system simulations in NR is similar to LTE.  Scenario B: Inter-layer interference for SU-MIMO  Support to define the requirements. Although R-ML has been introduced for SU-MIMO, the benefit of Soft IC over R-ML can be achieved under the scenario with imbalance SNR between two layers and the same MCS on two layers.  We would like to elaborate on it more. One of the difference between NR and LTE is that one codeword is mapped to two layers for NR while two codewords are mapped to two layers separately. When the channel is medium or high correlated, one layer will observe much lower SNR than the other. For LTE, UE can do link adaptation and apply different MCS to match the available SNRs on two layers. But for NR, since one codeword is used across two layer, UE cannot adjust MCS separately for two layer. According to our simulation, we observe the gain under such scenario. Thus we would like to consider such softIC advanced receiver on top of RLM receiver.  Besides, such advanced receiver is optional. UE which can support softIC can fulfil all the existing performance requirements. Compared to MMSE or RLM receiver, such receiver can help addressing the inter-stream efficient SNR imbalance issue.  Target frequency: We prefer to consider FR1 firstly and deprioritise FR2.  Type of requirements: We prefer to focus on PDSCH demodulation firstly and further study whether to introduce the requirements for CQI reporting.  Rx antenna number: We prefer to consider both 2RX and 4RX.  To MTK and QC: For NR scenarios, one codeword can schedule up to 4-layer which has the same MCS. It is not feasible to reuse CWIC for SU-MIMO.  Scenario C: Intra-cell inter-user interference for MU-MIMO  According to companies’ comments, we would like to split the discussion for MU-MIMO into two parts.  Firstly, we saw the interest from operators and companies on MU-MIMO scenario especially for eType-II codebook in Rel-16. But unfortunately there is no final agreement for it in Rel-16. Secondly, to investigate eType-II codebook performance, RAN1 assumes at least IRC receiver for it. In our understanding, without advanced receiver, there seems less gain for eType-II. In this regard, it is better for us to consider MU-MIMO scenario in Rel-17.  Secondly, BS cannot guarantee the perfect paring multiple users in the real life, because the available users are not perfectly spatially orthogonal. The advanced receiver is expected to suppress or cancel the interference. So it would better to define the advanced receiver to better support MU-MIMO scenario in Rel-17.  Regarding the reference receiver, there would be a number of candidates   * MMSE-IRC receiver, which can suppress the interference from the paired users as well as from the neighbour cell * R-ML, which treats the paired user as another layer and needs some modulation parameters for the paired users be informed or blindly detected. * SLIC, which decode the interferer user first and then cancel it, and needs the modulation parameters for the paired users be informed or blindly detected.   In general for the last two receiver, to reduce UE effort for blind detection, we prefer to specify the network assistant information to inform UE the demodulation parameters for the paired user.  Target frequency: We prefer to consider FR1 firstly and deprioritise FR2  Type of requirements: We prefer to focus on PDSCH demodulation firstly and further study whether to introduce the requirements for CQI reporting.  Rx antenna number: We prefer to consider both 2RX and 4RX. |

## Summary

### Scenario a: Inter-cell interference

**Companies’ position:**

* Support (Intel, E///, MTK, CMCC, Orange, Apple, China Telecom, Vodafone, Huawei)
  + A limited set of requirements with explicit modelling of inter-cell interference is necessary to ensure the proper implementation and performance requirements.
  + NR design is more complicated and flexible compared to LTE. The DMRS/TRS/CSI-RS configurations, SCS and slot duration among cells need to be considered.
* Not support (QC)
  + MMSE-IRC has been widely implemented in chipsets/UEs.

**Summary of comments on the detailed objectives:**

* Target frequency
  + Prioritize FR1 (Intel, MTK, Orange, Apple, Vodafone, HW)
    - FR2 deployments are expected to be less interference limited due to Tx/Rx analog beamforming applies at gNB and UE sides
    - The spectral efficiency is more crucial in FR1
* Reference receiver
  + Use DMRS based interference covariance estimation (MTK, Apple, HW, CTC)
  + Consider different algorithms for interference covariance estimation (DMRS based and Data based) (Intel)
* CQI reporting requirement
  + Focus on PDSCH demodulation firstly and further study whether to introduce the requirements for CQI reporting (MTK, Apple, HW)
    - The interference condition for CSI-RS and PDSCH can be different.
  + Define PDSCH and the corresponding CQI reporting requirement (CTC)
    - If we do not introduce CQI requirement, the gain by IRC receiver is only on reducing BLER, but not achieving a higher MCS.
* TRS/CSI-RS/DMRS configuration
  + Consider colliding TRS/CSI-RS among cells (E///, Orange)
  + Consider DMRS is colliding with TRS/CSI-RS of interfering cell (HW)
  + Consider suppression or cancellation on neighboring cell’s CSI-RS/TRS (MediaTek, Orange)
* SCS and slot duration
  + Consider non-slot based transmissions and different SCSs among cells (Intel, Apple)
  + Slot-based transmission and aligned SCS among cells can be given with higher priority (CTC)
* Interference profile
  + Reuse LTE interference profile to avoid additional system simulation efforts (HW, CTC)
  + Also consider interference profile based on realistic NR deployment scenario (Intel, Apple)
* Network assistance/restriction
  + May be needed if justified (MTK, HW)
    - MTK: uncertainty in neighboring cell PRB bundling size and DMRS pattern
    - HW: resource allocation, PDSCH RE mapping information and PRB bundling size of neighbouring cell
  + Should be avoided or minimized for IRC receiver (E///, CTC)
    - E///: the network assigned signalling could help UE to improve the receiver performance, but it does not work if gNB does not support it.

**Recommended updated objective in the WID:**

* Scenario a): Inter-cell interference
  + - Type of requirements:
    - Define PDSCH demodulation requirements
    - Further decide whether to introduce the corresponding CQI reporting requirements during the WI
    - Reference receiver:
    - Option 1:
      * MMSE-IRC with DMRS based interference covariance estimation
      * MMSE-IRC with Data based interference covariance estimation
    - Option 2:
      * MMSE-IRC. Interference covariance estimation method is FFS
    - Target frequency: FR1
    - Rx antenna number: 2Rx and 4Rx
    - On SCS and slot duration
    - Scenario 1: Slot-based transmission and aligned SCS among cells
    - Scenario 2: Non-slot-based transmission and/or different SCSs among cells
    - Further discuss the assumptions for requirements definition
    - Interference profile
    - Reuse LTE interference profiles as a starting point
    - Other interference profiles are not precluded
    - TRS/CSI-RS/DMRS configuration
    - Further discuss and decide whether TRS/CSI-RS are collided among cells during the WI
    - Further discuss and decide whether DMRS is colliding with TRS/CSI-RS of interfering cell during the WI
    - Further discuss and decide whether suppression or cancellation on interfering cell’s CSI-RS/TRS is needed during the WI
    - As baseline, avoid network assistance and/or restriction.

Note: Prioritization of different objectives will be discussed during the RAN plenary.

### Scenario b: SU-MIMO inter-layer interference

**Companies’ position:**

* Support (Orange, CTC, HW)
  + Orange, CTC: the UE has full knowledge of the interference parameters, and (iterative) soft-IC should be carefully evaluated and compared to R-ML detection.
  + HW: one codeword is mapped to two layers for NR, and one layer will observe much lower SNR than the other with medium or high correlated channel. Compared to MMSE or RML receiver, such receiver can help addressing the inter-stream efficient SNR imbalance issue. Performance gain over R-ML has been observed in our simulation.
* A study phase is needed (Intel, E///, CMCC, Orange, Apple, China Telecom, VDF)
  + Study on the reference receiver structure and performance benefit over R-ML
  + Take into account the trade-off between complexity
* Not support (MTK, QC)
  + Too much complexity

**Summary of comments on the detailed objective:**

* Target frequency
  + Prioritize FR1 (MTK, HW)
* HARQ feedback timing
  + Consider the processing delay and impact on HARQ feedback timing (MTK)
* MIMO layer, modulation order and spatial correlation level
  + Consider more than 2 spatial layers and/or high order modulation, reflect the spatial covariance of the MIMO channel at Tx and Rx (Orange)
* CQI reporting requirement
  + Focus on PDSCH demodulation firstly and further study whether to introduce the requirements for CQI reporting (HW)

**Recommended updated objective in the WID:**

* Scenario b): Inter-layer interference for SU-MIMO
  + Study on the reference receiver structure for (iterative) soft IC and evaluate the performance benefit over R-ML, by taking into account the implementation complexity and processing delay
    - Target frequency: FR1, FFS for FR2
    - Number of data layers: up to 4 for FR1; 2 for FR2(if applicable)
    - Rx antenna number: 2Rx and 4Rx for FR1; 2Rx for FR2 (if applicable)
    - Modulation order and spatial correlation level: further discuss and decide during the WI

Note: Prioritization of different objectives will be discussed during the RAN plenary.

### Scenario c: Intra-cell inter-user interference for MU-MIMO

**Companies’ position:**

* Support (E///, Samsung, VDF, HW, CMCC, Orange, CTC)
  + It is not possible to always ensure low interference between MU-MIMO users.
* A study phase is needed (MTK, CTC, Apple)
* Not support (Intel, QC)
  + - Intel: DCI change to signal the assistant information is required. Need to check RAN1 TU.
    - QC: UEs that are multiplexed in a MU-MIMO scheme should already be orthogonal or quasi-orthogonal.

**Summary of comments on the detailed objective:**

* Reference receiver
  + MMSE-IRC receiver (E///, VDF)
    - Work on baseline receiver at first
  + RML or SLIC (HW)
    - Without advanced receiver, there seems less gain for eType-II.
* Interference model
  + Realistic MU-MIMO interference profile from system level simulation (Samsung, Apple)
* Network assistant information
  + Network assistance information should be minimized or avoided in order to avoid RAN1 workload. (E///, CMCC)
  + Some low overhead assistance from the network may be needed and should be investigated. (Orange, HW)
  + Needs to be studied (Apple, MTK)
* Target frequency
  + Prioritize FR1 (HW)
* CQI reporting requirement
  + Focus on PDSCH demodulation firstly and further study whether to introduce the requirements for CQI reporting (HW)

**Recommended updated objective in the WID:**

* Scenario c): Intra-cell inter-user interference for MU-MIMO
  + - Evaluate the performance under practical MU-MIMO interference profile for the candidate reference receivers including MMSE-IRC, RML and SLIC.
    - Investigate the network assistant information required if it is concluded that blind detection on the necessary interference parameters is infeasible.
    - Other WG impact needs to be considered if network assistant information is required.
    - Target frequency: FR1, FFS for FR2
    - Rx antenna number: 2Rx and 4Rx for FR1; 2Rx for FR2 (if applicable)

Note: Prioritization of different objectives will be discussed during the RAN plenary.

# BS advanced receivers

## Companies’ proposals summary

Candidate objectives for BS advanced receivers [4] - [6]:

* Scenario a): Inter-cell interference
  + - Target frequency: FR1 and/or FR2
    - Reference receiver:
* MMSE-IRC with DMRS based interference covariance estimation
  + - Type of requirements: PUSCH requirement
    - Rx antenna number: 2Rx; 4Rx and 8Rx (for FR1 only)
    - Interference profile: LTE interference profiles can be used as a starting point for NR FR1 scenarios
    - Discuss if additional network assistance is required
* Scenario b): Inter-layer interference for SU-MIMO
  + - Target frequency: FR1 and FR2
    - Reference receiver: soft IC
    - Type of requirements: PUSCH requirement
    - Number of data layers: 2 for FR1 and FR2
    - Rx antenna number: 2Rx; 4Rx and 8Rx (for FR1 only)
* Scenario c): Intra-cell inter-user interference for MU-MIMO
  + - Target frequency: FR1 and/or FR2
    - Reference receiver: Hard-IC (hard L-CWIC), hybrid-IC (mixing hard-IC and soft-IC) as defined in NOMA TR 38.812
    - Type of requirements: PUSCH requirement
    - Rx antenna number: 2Rx; 4Rx and 8Rx (for FR1 only)

## Companies views’ collection

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| Company | Comments |
| Nokia, Nokia Shanghai Bell | It is our opinion that no specific receiver structures should be forced to be implemented via the WID. The detailed structure for any and all scenarios should be up to implementation.  For baseline evaluations we see it useful to aim for the LTE advanced receiver (MMSE-IRC + codeword-level interference cancellation), if such an alignment is found to be required.  The WID should make it clear that the inclusion of interference aware receivers is subject to consensus on the usefulness of such requirements. |
| Intel | Scenario A): Inter-cell interference  Similar to UE part, we support introduction of such requirements.   * Prefer to focus on FR1 scenarios since interference in FR2 is expected to be a less common scenario. * Number of RX antennas can be a part of WI discussion. * No need to discuss network assistance for gNB requirements.   Scenario B): Inter-layer interference for SU-MIMO  Similar to UE part, further studies on the performance/complexity trade-offs are required before making final conclusions on the proper receiver architecture and definition of requirements. Also, we suggest to include SL-IC receiver (Symbol level IC, Section 7.4, TR 36.866) as one of reference receivers for further study.  Scenario C): Intra-cell inter-user interference for MU-MIMO  We think that using of IC receivers is beneficial for MU-MIMO performance. More analysis is needed on performance benefits and complexity of different receiver designs before agreement on reference receiver for requirements definition. Study stage is recommended. |
| Ericsson | For FR2, it does not make sense to set requirements on inter-cell/user interference since testing is limited to 2 RX on orthogonal polarizations.  For FR1, we think that requirements on MMSE-IRC could make sense. Inter-layer cancellation could be studied further, although this would require significant time and effort in an already very loaded group. We should take care to understanding the gains before developing requirements relating to NOMA scenarios. |
| CMCC | Considering the limited time and resource, some prioritizations need to be considered among the scenarios. Scenario a) could be the baseline. |
| ORANGE | For all scenarios FR1 should be prioritized where the spectral efficiency is more crucial  For scenarios B) C), soft-IC (CW-IC) should be carefully investigated. Minimum performance of BS-IC for scenario C) is already there for LTE Rel. 15 and NR should try to propose tighter requirements than LTE in FR1.  Scenario A needs some coordination/signalling between cells. Soft-IC/CW-IC could be at least investigated for cell sectors belonging to the same site. |
| ZTE | Scenario a) Inter-cell interference model/property for FR2 may be very different from that for FR1  Scenario b): The inherent processing delay introduced by the IC-like advanced receivers may have more influence in NR compared with that in LTE. The impact might impose much restrictions on the choice of the advanced receivers.  Scenario c): Firstly one of the reference receivers should be selected for defining the possible requirements, i.e., the possible requirements should be based on only one of the reference receiver. |
| China Telecom | In general, we agree with Nokia that 3GPP will not enforce certain BS implementation. The reference receiver structure is only used for simulation to derive the requirements.   * Scenario a): Inter-cell interference   For inter-cell interference, we can start from DMRS based MMSE-IRC receiver.  For FR1, with interference profile and reference receiver reused from LTE, we do not expect much RAN4 effort on this.   * Scenario b): Inter-layer interference for SU-MIMO   This was not considered for LTE, since 2Tx UE with UL MIMO capability is not popular in LTE.  CW IC could not work since the two layers belong to the same CW. Support to include soft IC for SU-MIMO in Rel-17. We are also ok to have a study phase to confirm the reference receiver structure and performance gain.  To ZTE, for the inherent processing delay, in our understanding, for BS side, the HARQ timing is up to BS scheduling.   * Scenario c): Intra-cell inter-user interference for MU-MIMO   PUSCH requirements based on CWIC for intra-cell MU-MIMO was defined in LTE, which can be used as the starting point for NR. |
| Samsung | Scenario a: we support to define the requirement with MMSE-IRC for handling the inter-cell interference, similar as LTE. NR can support flexible configuration, such as SCS, PUSCH time domain resource allocation, DMRS configuration, which may result in the selective interference conditions that may impact the eventual performance and receiver design. Therefore, the proper deployment and interference profile should be further investigated  With targeting carrier frequency, at least FR2 shall not precluded for MMSE-IRC.  Scenario b: Different LTE, only 1 CW can be supported with NR for PUSCH. Maybe it seems that soft-IC can be not applied for NR, considering two layer generated within one CW. Meanwhile, the gain and complexity of soft-IC should be studied over the MMSE receiver  Scenario c: Regarding the hard IC to handle the intra cell inter user interference, generally, we are fine to introduce the hard IC in FR1, while we think the deployment and test scenario should be identified firstly, it maybe not appropriate to reuse the LTE approach, considering the flexible configuration in NR. The feasibility should be studied firstly to investigate the potential benefits based on the typical development.  As for hybrid-IC, the benefit of it is not clear considering the complexity and network deployment for achievable throughput. Since the new PHY for NoMA has not yet been introduced in RAN1, so, it seems too early to consider Hybrid-IC in Rel-17  For FR2, the beamforming can be used for mitigating the interference, our understanding it is not expected to achieve the obvious gain with IC receiver too much  Meanwhile, only 2 Rx can support in OTA for FR2 test, we are not clear whether the gain can be achieved with IC receiver |
| Vodafone | BS side work seems lower priority for us. |
| Huawei | For Scenario a) Inter-cell interference:  Target frequency: Similar to UE requirements, we prefer to consider FR1 only.  Interference profile: We prefer to reuse the LTE interference profile for NR.  Network assistance: Similar to the analysis in UE requirements, the network assistance is also needed for BS requirements such as PUSCH resource allocation, SCS of neighbouring cell in order to improve the performance. |

## Summary

### Scenario a: Inter-cell interference

**Companies’ position:**

* Support (Nokia, Intel, E///, CMCC, Orange, CTC, Samsung)
* Low priority (VDF)

**Summary of comments on the detailed objectives:**

* Target frequency
  + Prioritize FR1 (Intel, E///, Orange, HW)
    - FR2 deployments are expected to be less interference limited due to Tx/Rx analog beamforming applies at gNB and UE sides.
    - For FR2, it does not make sense to set requirements on inter-cell/user interference since testing is limited to 2 RX on orthogonal polarizations.
    - Spectral efficiency is more crucial for FR1
  + FR2 shall not be precluded (Samsung)
* Rx antenna number
  + To be discussed in the WI (Intel)
* Reference receiver
  + Use DMRS based interference covariance estimation as starting point (CTC)
  + Soft-IC/CW-IC could be at least investigated for cell sectors belonging to the same site (Orange)
* Network assistance
  + Not needed (Intel, CTC)
  + Needs some coordination/signalling between cells (Orange, HW)
* Interference profile
  + Reuse LTE interference profile to avoid additional system simulation efforts (CTC, HW)
  + Interference profile should be further investigated (Samsung)

**Recommended updated objective in the WID:**

* Scenario a): Inter-cell interference
  + - Type of requirements: PUSCH requirement
    - Reference receiver:
    - As starting point, use MMSE-IRC with DMRS based interference covariance estimation
    - FFS Soft-IC/CW-IC for cell sectors belonging to the same site
    - Target frequency: FR1, FFS for FR2
    - Rx antenna number: further discuss and decide in the WI
    - Interference profile
    - Reuse LTE interference profiles as a starting point
    - Other interference profiles are not precluded
    - As baseline, avoid network assistance and/or restriction.

Note: Prioritization of different objectives will be discussed during the RAN plenary.

### Scenario b: SU-MIMO inter-layer interference

**Companies’ position:**

* Support (Orange, CTC)
* Further study is needed (Intel, E///, Samsung)
  + Study on the reference receiver structure and performance benefit
  + Take into account the trade-off between complexity
* Low priority (VDF)

**Summary of comments on the detailed objective:**

* Reference receiver
  + - Soft IC (Orange, CTC)
    - SL-IC (Intel)
* Target frequency
  + Prioritize FR1 (Orange)

**Recommended updated objective in the WID:**

* Scenario b): Inter-layer interference for SU-MIMO
  + - Type of requirements: PUSCH requirement
    - Candidate reference receiver:
    - Soft IC
    - SL-IC
  + Evaluate the performance gain for different reference receivers, by taking into account the implementation complexity
    - Target frequency: FR1, FFS for FR2
    - Number of data layers: 2 for FR1 and FR2
    - Rx antenna number: 2Rx, 4Rx and 8Rx for FR1; 2Rx for FR2

Note: Prioritization of different objectives will be discussed during the RAN plenary.

### Scenario c: Intra-cell inter-user interference for MU-MIMO

**Companies’ position:**

* Support (Orange, CTC, Nokia)
* A study phase is needed (Intel, E///, Samsung)
* Low priority (VDF)

**Summary of comments on the detailed objective:**

* Target frequency
  + Prioritize FR1 (Orange, Samsung)
    - For FR2, the beamforming can be used for mitigating the interference
* Reference receiver
  + Similar to LTE R15, use CWIC as the starting point (CTC, Samsung, Nokia)
  + Try to propose tighter requirements than LTE in FR1 (Orange)
  + One of the reference receivers should be selected for defining the possible requirements (ZTE)

**Recommended updated objective in the WID:**

* Scenario c): Intra-cell inter-user interference for MU-MIMO
  + - Type of requirements: PUSCH requirement
    - Reference receiver:
    - As starting point, use CWIC
    - FFS hybrid-IC (mixing hard-IC and soft-IC)
    - Target frequency: FR1, FFS for FR2
    - Rx antenna number: 2Rx, 4Rx and 8Rx for FR1; 2Rx for FR2

Note: Prioritization of different objectives will be discussed during the RAN plenary.

# BS FR1 PUSCH 256QAM

## Companies’ proposals summary

Candidate objective [4] [5]:

* Define PUSCH demodulation requirements for FR1 256QAM

## Companies views’ collection

|  |  |
| --- | --- |
| Company | Comments |
| Nokia, Nokia Shanghai Bell | We are positive towards the inclusion of FR1 256QAM PUSCH demodulation requirements. It is our understanding that minimal mobility is to be assumed, and realistic phase noise modelling is left up to the contributing entities. |
| Ericsson | We are also supportive towards inclusion of FR1 256QAM PUSCH requirements. |
| CMCC | We support to define PUSCH demodulation requirements for FR1 256QAM. |
| ZTE | We support to include 256QAM requirements for FR1 PUSCH |
| China Telecom | We support this work. PUSCH with 256QAM is quite helpful for increasing uplink throughput. In NR Rel-15, the RF requirements for FR1 256QAM has been introduced, but the PUSCH demodulation requirements are still absent even in Rel-16. |
| Samsung | We support to include 256QAM requirements for FR1 PUSCH |
| KDDI | We support to have FR1 PUSCH 256QAM requirements |
| Huawei | We support to include 256QAM for FR1 PUSCH. |

## Summary

**Companies’ position:**

* Support (Nokia, E///, CMCC, ZTE, CTC, Samsung, KDDI, Huawei)

**Summary of comments on the detailed objectives:**

* Mobility
  + - Minimal mobility is to be assumed (Nokia)
* Phase noise modelling
  + - Realistic phase noise modelling is left up to the contributing entities. (Nokia)

**Recommendation:**

* It is recommended to define PUSCH demodulation requirements for FR1 256QAM in Rel-17
  + - Further discuss and decide the test parameters during the WI.

# Link adaptation throughput requirements

## Companies’ proposals summary

Candidate objectives [7] [8]:

* Study the feasibility of defining requirements with link adaptation
  + - Analyze in which scenarios absolute physical layer throughput requirement can be defined
      * Use currently defined RI test setup in 38.101-4 as baseline
      * Use the parameters suggested by RAN5 in R5-195422 as baseline
        + Other scenarios are not precluded if above parameters are not found feasible
* Possible RAN4 work plan
  + - Initial Simulation Assumptions
      * Reuse test parameters used in existing Rank Indication test cases in 38.101-4 as much as possible.
    - Alignment of results
      * Companies to present simulation results, multiple rounds of simulation might be needed
      * Refinement of simulation assumptions if needed
    - Conclusion
      * Tests to be declared feasible for the scenarios in which there is good alignment between results
      * Feasibility to be concluded if results from multiple companies are within +/- X % (e.g. 5%) of average LA throughput

## Companies views’ collection

|  |  |
| --- | --- |
| Company | Comments |
| Intel | Agree that RAN4 needs to first assess feasibility of defining requirements with link adaptation. Test setup with PMI/CQI/RI adaptation can be used as a starting point to to identify whether it is feasible to achieve reasonable alignment among the companies for scenarios with variation of multiple CSI parameters. If it will be not feasible then we can consider fixing some of the parameters (e.g. fix RI).  Subject to the outcome of the studies, RAN4 can provide further inputs to RAN5 on feasibility of LA requirements.  The work can be started in RAN4 subject to available budget for Demod topics. Q4’20 is expected to be heavily loaded with R16 performance part. Recommend start this work in 2021. |
| Qualcomm | This work is needed so that there are standardized tests in 3gpp for application layer throughput. Otherwise, similar to LTE, each operator will have to come up with their own test cases and UE vendors will have to pass a long list of tests unnecessarily.  The scope of work is limited to defining few test cases as described in the Annex in our paper.  For link adaptation throughput simulation results alignment, we provided some examples of submitted simulation results for PMI reporting where we show that span of results is within 10% of average throughput. So, it is feasible to have simulation results alignment between companies for LA throughput. |
| MTK | We are OK to study in general, but more detail is needed in this discussion. |
| CMCC | We support this work |
| Apple | We see the motivation for this proposal. However, the scope of the study is not clear. For example, why RI test setup is picked up. We firstly need to understand the ultimate objectives/scope of link adaptation throughput requirements. With this, we can understand if the proposal study is sufficient and representative enough. |
| China Telecom | We support this work.  We agree with Intel that we can consider fixing some of the parameters, e.g. fix RI, since typically the RI does not change very frequently compared to CQI/PMI.  For the simulation result alignment, the criteria for alignment (e.g., the required SNR or absolute throughput) can be further confirmed based on the simulation results in the SI phase. |
| Huawei | We can work aiming at agreeing on a set of parameters for VRC testing now, since many operators are interested in this work.  Regarding candidate objective one, we would like to keep the general principle in RAN4 to define the minimum requirements. Thus we would like to say:   * Study the feasibility of defining requirements with link adaptation   + - Analyze in which scenarios absolute physical layer throughput ~~requirement~~ can be verified ~~defined~~       * Use currently defined RI test setup in 38.101-4 as baseline       * Use the parameters suggested by RAN5 in R5-195422 as baseline         + Other scenarios are not precluded if above parameters are not found feasible       * Target at defining the minimum demodulation performance requirements, if needed   Other comments on the possible RAN4 plan:   * + - Initial Simulation Assumptions       * Reuse test parameters used in existing Rank Indication test cases in 38.101-4 as a starting point~~much as possible~~.   [Huawei] We are not ready to reuse the RI parameters. Maybe that is OK but we would like to have more evaluation first. |
| Qualcomm | There were some questions about test setup and scope for Link Adaptation requirements. We would like to answer those. Below are our comments:   * We suggested to use RI setup as a baseline because RI test has all of CQI, PMI and RI reporting enabled. As the purpose of this SI is to study the feasibility of Absolute throughput requirements when CQI/PMI/RI reporting is enabled, we can use RI test setup as a starting point and modify some of the parameters as needed. This will save us time rather than trying to come up with all the parameters from scratch. That principle was also followed in the initial simulation assumptions proposed in RP-201001. * Based on LS (R5-195422) sent by RAN5 to RAN4 and also in TR 37.901, we only want to focus on few SNR points such as 20dB. So, to address the comment on fixing RI, we can just choose an SNR where rank doesn’t change much and keep RI enabled. For example, with 20dB SNR, it will most likely be Rank2 regime for 2Rx. We can also use the same SNR point as in existing RI tests. * So, we would like to have the following in the objective: “Use RI test setup as a starting point”. * To answer Apple’s question on scope of work, the scope of the RAN4 work will be limited to just defining 1-2 tests per duplex mode, per FR, per NRx, similar to other RAN4 features. |

## Summary

**Companies’ position:**

* OK to study the feasibility (Intel, QC, MTK, CMCC, CTC, Huawei)
* Scope of the study is not clear (Apple)
  + - For example, why RI test setup is picked up. We firstly need to understand the ultimate objectives/scope of link adaptation throughput requirements.

**Summary of comments on the detailed objectives:**

* PMI/CQI/RI adaptation
  + - Consider fixing some of the parameters, e.g. fix RI (Intel, CTC)
    - Why RI test setup is picked up (Apple)
    - Need further discussion on whether to reuse the RI parameters (Huawei)
* Simulation result alignment
  + - The criteria for alignment (e.g., the required SNR or absolute throughput) can be further confirmed based on the simulation results in the SI phase.
* General principle for defining requirements
  + - Keep the general principle in RAN4 to define the minimum requirements (Huawei)

**Recommended updated objective in the SID:**

* Study the feasibility of defining requirements with link adaptation
  + - Analyze in which scenarios absolute physical layer throughput can be verified
      * Use currently defined RI test setup in 38.101-4 as a starting point
        + Fixing the RI is not precluded if the RI test setup with PMI/CQI/RI adaptation is not feasible
        + Other parameters are not precluded based on the evaluation during the SI
      * Decide the criteria for simulation result alignment during the SI
      * Based on the status of the simulation result alignment, discuss the criteria to derive the requirements, if it is concluded as feasible to define the requirements
* Decide the detailed work plan in the first RAN4 meeting for this SI

# Other new proposals

## New proposal on UE demodulation requirements

Moderator’s note: interested companies please add your comments to the new proposls directly below each of the proposals.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | We suggest to consider the following scenarios in the Rel-17 timeframe, which already supported from Rel-15 and Rel-16:   * Requirements for Rel-15 multi-TRP TX scheme. DPS (Dynamic Point Selection) scheme is supported from Rel-15. At current stage, DPS is considered for HST deployment. Also, more advanced Rel-16 multi-TRP TX schemes are considered under Rel-16 eMIMO WI. Same time, there are no requirements for DPS Tx scheme for normal propagation conditions. Therefore, we propose to include such requirements in Rel-17 scope for UE Demod. * Requirements for Rel-16 Multi-TRP TX scheme. At current stage, as a part of Rel-16 eMIMO WI, it was agreed to introduce requirements for Multi DCI and Single DCI based eMBB multi-TRP/panel Tx schemes. Same time, it is still under discussion whether to introduce requirements for single-DCI based URLLC multi-TRP Tx schemes 1a, 2a, 2b, 3 and 4. Therefore, if these Tx schemes will be not covered by Rel-16 eMIMO WI due to limited timelines then we suggest to include these schemes in the Rel-17 scope. * CRS-IC requirements for LTE-NR coexistence scenarios.   CSR-IC receiver is one of the advanced processing introduced for LTE deployment to cancel CRS interference which is observed in all subframes. Limited network assistance (cell ID, number of ports, MBSFN configuration) is required for CRS-IC processing.  In NR, CRS rate matching pattern was designed for LTE-NR coexistence scenarios and 15 kHz SCS NR transmission. Information about CRS pattern is available for serving cell transmission. CRS from neighboring cell may collide with serving Data resource. Therefore, CRS-IC receiver can also be used for NR to improve performance in LTE-NR coexistence scenarios. |
| Qualcomm | We are proposing to define performance requirements for 8Rx on the UE side similarly to what was done for LTE. The objectives of such work are listed below. We also included a draft WID proposal for information in the drafts folder:  Core part:  The work item has the following objectives for core requirements of downlink 8Rx antennas:   * Define the UE Rx RF requirements for 8Rx in single carrier and CA.   + Phase I: focus on the single carrier scenario   + Phase II: After finalizing the single carrier requirements, the following CA scenarios will be studied and specified, if feasible:     - Intra-band contiguous CA with 2CC and 8Rx with up to 8-layers supported per CC     - Inter-band CA with 8Rx/8-layers supported on one or two contiguous CCs on the identified operating bands in this work item, and with 2Rx or 4Rx supported on the other CC(s). * No new Tx requirement is expected. * Introduce operating bands to support 8Rx antennas. Define reference sensitivity for the bands supporting 8Rx antennas. * No new RRM/RLM core requirement is expected for 8Rx.   Performance part:  The work item has the following performance objectives for downlink 8Rx antennas:   * For UE RRM performance requirements   + No new RRM performance requirement is expected for 8Rx   + No new RLM performance requirement is expected for 8Rx     - UE is only required to pass the legacy 2Rx or 4Rx RLM testing   + In performance part, testing applicability rule will be defined for enabling 8Rx UE to pass the legacy 2Rx or 4Rx RLM test cases. * For UE demodulation/CSI requirements   + Define channel model for downlink 8Rx antennas     - Specify the antenna configuration and MIMO channel correlation matrices for 8Rx antennas;     - Specify the static channel model;   + Define test cases for the rank lower than or equal to 4.   + Define test cases for the rank higher than 4 in fading channel.     - Base on combinations of rank and MCS that can achieve the maximum configured throughput.   + Define SDR test for 8Rx in WI.   + Define CSI test for 8Rx.   + No PDCCH/PCFICH demodulation requirement is expected for 8Rx. * Considering the test coverage of 8Rx, test applicability rule is needed to define   + Define applicability rule of existing performance requirements for 8Rx capable UEs. * After finalizing the single carrier requirements, the following CA scenarios are included when the performance requirements are specified.   + Phase I: focus on the single carrier scenario   + Phase II: After finalizing the single carrier requirements, the following CA scenarios will be specified:     - Intra-band contiguous CA with 2CC and 8Rx with up to 8-layers supported per CC     - Inter-band CA with 8Rx/8-layers supported on one or two contiguous CCs on the identified operating bands in this work item, and with 2Rx or 4Rx supported on the other CC(s). |
| Samsung | We suggest to consider potential new objectives for Rel-16 performance left over issues in Dec RAN Plenary and/or 2021 March RAN-Plenary pending on Rel-16 performance progress. |
| SoftBank | As discussed in R4-2010122, we want to define performance requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77) in Rel-17, since we see the necessity from our practical deployments   * Extend the target MRTD to [10] us * Extend the target power imbalance   + to [25] dB assuming single Rx chain, and/or   + by introducing a UE capability report that indicates the support of dual Rx chain in a band of interest   The values with square brackets (and the refinements of the scope) can be discussed further considering UE complexity and requirements from other interested operators. |
| Huawei | To Intel proposals:  Regarding multi-TRP DPS requirement under normal propagation condition, we are open to investigation. But the key test purpose of the proposal is to verify the proper time/frequency tracking and channel estimation when UE is camped on one TP but demodulate the signal from the other TP. We wonder if such performance and functionality have already been verified by the Rel-16 potential requirements.  Regarding single DCI based URLLC multi-TRP Tx schemes, we would like to continue discussion in Rel-16 first. We are not sure if companies did not agree to introduce a certain test in Rel-16, they would agree to introduce them in Rel-17. But we are open.  Regarding CRS-IC, we have concern on introduction of LTE RRC signalling for NR UE. We are open to do CRS-IC purely based on UE implementation.  To Qualcomm 8Rx proposal:  We understood that in LTE there are such 8Rx requirements for certain TDD bands. But for NR, can we postpone specifying such requirement?  Compared to LTE, NR is mandated to support 100MHz and 256QAM for DL. Combining 8Rx with them, UE needs to support MIMO equalizer up to 8-layer in 100MHz channel bandwidth. Let alone that UE may need support RLM algorithm for up to 8-layer with 100MHz channel bandwidth. UE seems more complicated, the power consumption will be increased significantly, which is not linearly proportional to bandwidth or Rx antenna number, and UE would be over-heat.  And for smart phone, due to the limit of form factor, it seems difficult to guarantee the isolation between Rx antenna elements.  We wonder if 8Rx is such urgent in terms of meeting the DL service requirement in the real life at the current stage. Maybe 4Rx + 100MHz for downlink would be sufficient at the current stage.  To Samsung proposal  We are OK to the proposal for the potential leftover topics. We can update the scope of performance enhancement WI in December further according to the progress in Rel-16.  To Softbank proposal  We are positive to the proposal since we have related proposal in last RAN4 meeting to define the capability for UE to better support of intra-band EN-DC/NR-CA non-collocated scenario.  We have two comments:  1. It seems that we would discuss it in RF working area because the issue is related to UE RF architecture and it seems better to treat this topic in main session considering both RF and baseband would be involved. And this is some kind of common issue also applicable to other EN-DC band combination. So we would like to check if we can include this one in FR1 RF enhancement WI.  2. Regarding MRTD and power imbalance value, it is related to UE architecture, i.e., whether one RF chain or multiple RF chains and whether the single FFT or multiple FFT would be used. We should have investigation before agreeing on the number. For 25dB power imbalance, since LTE and NR CC are quite closed to each other, we are not sure if the AGC can handle such big number even with multiple RF chains, because the filter cannot fully remove the signal from the other RAT. So more study is preferred. |
|  |  |

## New proposal on BS demodulation requirements

Moderator’s note: interested companies please add your comments to the new proposls directly below each of the proposals.

|  |  |
| --- | --- |
| Company | Comments |
| Company A | xxxx |
| Company B | xxxx |
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## Initial Summary

**Summary of new proposals on UE demodulation requirements:**

* Requirements for Rel-15 multi-TRP TX scheme under normal propagation conditions (Intel)
* CRS-IC requirements for LTE-NR coexistence scenarios (Intel)
* Performance requirements for downlink 8Rx antennas (QC)
* Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78) (SoftBank)
* Rel-16 performance leftovers: In Dec and/or 2021 March RAN-Plenary, update the WID to further consider potential new objectives for Rel-16 performance left over issues if needed (Samsung, Huawei)
  + - Requirements for single-DCI based URLLC multi-TRP Tx schemes 1a, 2a, 2b, 3 and 4, if they will not be covered in Rel-16 (Intel)

**Recommendation:**

* Encourage more interested companies to review the new proposals, and provide feedback early next week (e.g., before 11:59h UTC Tuesday 15th September, which is the RAN plenary deadline for comments on Initial email discussions)
* For downlink 8Rx and non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA, if agreeable to be included in Rel-17 package, the RF impact needs to be included in the FR1 RF work area.
* For Rel-16 performance leftovers: In Dec and/or 2021 March RAN Plenary, update the WID to further consider potential new objectives for Rel-16 performance left over issues if justified

## Companies views’ collection on the new UE proposals

* Proposal 1: Requirements for Rel-15 multi-TRP TX scheme under normal propagation conditions (proposed by Intel)

[HW]: Regarding multi-TRP DPS requirement under normal propagation condition, we are open to investigation. But the key test purpose of the proposal is to verify the proper time/frequency tracking and channel estimation when UE is camped on one TP but demodulate the signal from the other TP. We wonder if such performance and functionality have already been verified by the Rel-16 potential requirements.

[QC] Which Rel.15 requirements is this proposal about? We believe this should be clarified first.

[Intel] To HW: Multi-TRP DPS transmission scheme is supported from Rel-15. Features, which are required for this scenario are 2-4 “TCI states for PDSCH” and 2-4a “Additional active TCI state for PDCCH”, which are mandatory with capability signalling. Same time, all requirements for Rel-16 Multi-TRP Tx schemes are optional.

To QC: We consider requirements similar to LTE CoMP DPS (sections 8.3.1.3.1- 8.3.1.3.4 of TS 36.101).

* Proposal 2: CRS-IC requirements for LTE-NR coexistence scenarios (proposed by Intel)

[HW]: Regarding CRS-IC, we have concern on introduction of LTE RRC signalling for NR UE. We are open to do CRS-IC purely based on UE implementation.

[QC] NR demodulation timeline is completely different compared to LTE so introducing IC is not a trivial change. Introducing this will probably require a new HARQ timeline which will have a much bigger impact than just some demodulation requirements. Also, this feature would become implementable in a few years when many networks will have moved entirely to NR so the practical gains will be very limited.

[Intel] To HW: We think that necessity of network assistance signalling can be discussed during WI based on analysis from companies. We are open to discuss purely CRS-IC based implementation.

To QC: The impact on HARQ timeline is unclear and it would be good to have clarifications. We don’t expect that the complexity will boost substantially comparing to the existing NR SU-MIMO receivers based on R-ML. The functionality can be introduced as an optional feature and vendors will have flexibility whether to support it. Regarding the migration to NR only - in our understanding it may be difficult to predict whether all the networks will migrate entirely to NR which indeed requires that 100% of cellular devices will have NR support. Use of DSS allows flexible resource sharing between the LTE and NR and is expected to be an efficient approach to balance the resources between different types of devices.

[China Telecom] We support to define the requirement for CRS-IC of neighboring cell CRS. For DSS scenario, in LTE non-MBSFN sub-frame, the LTE CRS from neighboring cell will impact the NR PDSCH performance. For LTE, CRS-IC requirement has already defined in Rel-13.

* Proposal 3: Performance requirements for downlink 8Rx antennas (proposed by QC)

[HW]: We understood that in LTE there are such 8Rx requirements for certain TDD bands. But for NR, can we postpone specifying such requirement?

Compared to LTE, NR is mandated to support 100MHz and 256QAM for DL. Combining 8Rx with them, UE needs to support MIMO equalizer up to 8-layer in 100MHz channel bandwidth. Let alone that UE may need support RLM algorithm for up to 8-layer with 100MHz channel bandwidth. UE seems more complicated, the power consumption will be increased significantly, which is not linearly proportional to bandwidth or Rx antenna number, and UE would be over-heat.

And for smart phone, due to the limit of form factor, it seems difficult to guarantee the isolation between Rx antenna elements.

We wonder if 8Rx is such urgent in terms of meeting the DL service requirement in the real life at the current stage. Maybe 4Rx + 100MHz for downlink would be sufficient at the current stage.

[SoftBank] We support the proposal by Qualcomm. We want to consider 8Rx in Rel-17.

[QC] Replies to Huawei: Rel.15 NR already introduced 800MHz with 2 layers for FR2, the processing requirements should be at least comparable with 8Rx with 100MHz. We are also talking about Rel.17 UEs so we do not see the argument that power consumption or UE over-heat would be an issue. The antenna implementation issue should be the same for LTE and our understanding is that there are already commercial devices with 8Rx for LTE. The main target does not necessarily have to be smartphones, this can be useful for other form factors such as CPEs or laptops/tablets. We do see a need for such requirements.

[Intel] Based on our analysis for LTE 8Rx WI, the performance benefits from the support of > 4 MIMO layers are rather questionable since the performance becomes very sensitive to the RX antenna correlation. For instance, the LTE 8 layer requirements are defined for low correlation only which does not represent a very practical use case. Also, SNR operating point can be rather unpractical (i.e. higher than 30 dB). Therefore, LTE requirements were defined for scenario with 16QAM modulation.

* Proposal 4: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78) (proposed by SoftBank)

[HW]: We are positive to the proposal since we have related proposal in last RAN4 meeting to define the capability for UE to better support of intra-band EN-DC/NR-CA non-collocated scenario.

We have two comments:

1. It seems that we would discuss it in RF working area because the issue is related to UE RF architecture and it seems better to treat this topic in main session considering both RF and baseband would be involved. And this is some kind of common issue also applicable to other EN-DC band combination. So we would like to check if we can include this one in FR1 RF enhancement WI.

2. Regarding MRTD and power imbalance value, it is related to UE architecture, i.e., whether one RF chain or multiple RF chains and whether the single FFT or multiple FFT would be used. We should have investigation before agreeing on the number. For 25dB power imbalance, since LTE and NR CC are quite closed to each other, we are not sure if the AGC can handle such big number even with multiple RF chains, because the filter cannot fully remove the signal from the other RAT. So more study is preferred.

[QC] We believe that such large MRTD and power imbalance will lead to performance issues. For the power imbalance issue, it would be good to see how the 25dB was derived. With such large number, one of the links should have very low SINR so the usefulness of EN-DC is questionable as this is considered for Rel.17 when we believe SA will be available. MRTD larger than CP will also introduce performance degradation for demod.

[Intel] Agree with QC that 25dB power imbalance with current assumptions on RX image rejection (25dBc) will results in < 0 dB SINR for one of the carriers which does not look a reasonable scenario. Recommend to further discuss in the RF room on power imbalance aspects. The MRTD assumptions need to be handled in the RRM scope to identify the feasibility.

* Proposal 5: Rel-16 performance leftovers: Requirements for single-DCI based URLLC multi-TRP Tx schemes 1a, 2a, 2b, 3 and 4 (proposed by Intel)

[HW]: Regarding single DCI based URLLC multi-TRP Tx schemes, we would like to continue discussion in Rel-16 first. We are not sure if companies did not agree to introduce a certain test in Rel-16, they would agree to introduce them in Rel-17. But we are open.

[Samsung]: We suggest to consider potential new objectives for Rel-16 performance left over issues in Dec RAN Plenary and/or 2021 March RAN-Plenary pending on Rel-16 performance progress.

[QC] We agree with previous comments that this should be considered after Rel.16 discussion outcome is clear.

[Intel]: We are fine to come back to this topic once coverage of Rel-16 eMIMO requirements will be stable. Based on feedback above, we hope companies will be open to discuss this in Dec or March plenary.

## Updated summary based on commpanies’ views

* Proposal 1: Requirements for Rel-15 multi-TRP TX scheme under normal propagation conditions (proposed by Intel)

*Moderator’s recommendation:*

Update the objective to clarify the requirement is for DPS scheme.

* Proposal 2: CRS-IC requirements for LTE-NR coexistence scenarios (proposed by Intel)

*Moderator’s recommendation*:

Update the objective to clarify that the CRS-IC is for neighbouring cell CRS, and leave the discussion on whether the network assistance information is required in the WI phase.

* Proposal 3: Performance requirements for downlink 8Rx antennas (proposed by QC)

*Moderator’s recommendation*:

For PDSCH with > 4 MIMO layers, further discuss and decide whether to define the requirements in the WI phase.

The RF requirements need to be included in the FR1 RF work area.

* Proposal 4: Requirements for non-colocated scenario for intra-band non-contiguous EN-DC/NR-CA (e.g. band 42, n77/n78) (proposed by SoftBank)

*Moderator’s recommendation*:

Update the objective to further investigate the applicable MRTD in RRM session and power imbalance level in RF session, by considering the network deployment scenario and UE implementation feasibility.

* Proposal 5: Rel-16 performance leftovers: Requirements for single-DCI based URLLC multi-TRP Tx schemes 1a, 2a, 2b, 3 and 4 (proposed by Intel)

*Moderator’s recommendation*:

In Dec and/or 2021 March RAN Plenary, update the WID to further consider potential new objectives for Rel-16 performance left over issues if justified.

# Conclusions

* For UE advanced receiver, BS advanced receiver, BS FR1 PUSCH 256QAM and other new UE proposals:
  + Based on the summary in section 1.3, 2.3, 3.3 and 5.5, update the objectives in Rel-17 demodulation performance enhancement WID, and further discuss the prioritization of different objectives during the RAN plenary.
  + /RRM/RRMs
* For link adaptation throughput requirements
  + Based on the summary in section 4.3, update the objectives in 5G NR UE Application Layer Data SID.
* For Rel-16 performance leftovers: In Dec and/or 2021 March RAN Plenary, update the WID to further consider potential new objectives for Rel-16 performance left over issues if justified

# References

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3. RP‑200616, New WID proposal: Performance requirements for UE advanced receiver in Rel-17, Huawei Technologies Japan K.K, RAN #88e, 29 June - 3 July 2020.
4. RP‑200729, Motivation for further enhancement on NR demodulation performance requirements, China Telecom, RAN #88e, 29 June - 3 July 2020.
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