**3GPP TSG-RAN WG4 Meeting #112 R4-2411180**

**Maastricht, NL, 19-23 Aug 2024**

**Agenda item:** 8.16.4

**Source:** Moderator (China Telecom)

**Title:** Topic summary for [112][328] NR\_demod\_Ph5

**Document for:** Information

# Introduction

This contribution summarizes the open issues, candidate options as well as the recommended WF for the Rel-19 NR demodulation performance: Phase 5 WI under agenda item 8.16.

# Topic #1: Work Plan

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2411182 | China Telecom, NTT DOCOMO | Work plan for NR demodulation performance: Phase 5 |

## Open issues summary

**Issue 1-1: Work plan**

* Recommended WF
  + Companies to provide comments to R4-2411182.

# Topic #2: UE performance requirements for 8Rx

*Objectives in the approved WID RP-241297*

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| * *Define the following UE performance requirements for 8Rx CPE/FWA/vehicle/industrial devices:*   + *PDSCH demodulation and CQI reporting requirements with inter-cell interference with MMSE-IRC receiver*     - *Reuse the Rel-17 interference model for 2/4Rx UE as a baseline*   + *PDSCH demodulation requirements with intra-cell inter-user interference with MMSE-IRC receiver*     - *Reuse the existing interference model for 2/4Rx UE as a baseline* |

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2411026 | MediaTek inc. | Proposal 1: Reuse test parameters of Table 5.2.2.1.15-2 and Table 5.2.2.2.16-2 in TS38.101-4 as a starting point to define 8Rx IRC receiver requirements in FDD mode and TDD mode, respectively.  Proposal 2: Use “2T8R ULA low” as MIMO correlation matrix and antenna configuration to define PDSCH requirements for 8Rx IRC receiver considering CPE/FWA/vehicle/industrial devices.  Proposal 3: Use TDLC300-100 (for the case of two interfering cells) and TDLA30-10 (for the case of one interfering cell) as a starting point to define 8Rx IRC receiver requirements.  Observation 1: Based on our initial evaluations, the gain of 8Rx MMSE-IRC receiver over 8Rx MMSE-MRC is larger than 5 dB when considering the same setting as RAN4 used in Rel-17.  Observation 2: The SINR for both one and two interfering cells scenarios are quite low if considering MCS13 used in Rel-17 MMSE-IRC requirements.  Proposal 4: Consider rank 1 and MCS16 as a starting point to define 8Rx MMSE-IRC requirements with inter-cell interference.  Proposal 5: Consider two sets of PDSCH requirements for 8Rx MMSE-IRC receiver with inter-cell interference.  Proposal 6: Use the following test metrics to define 8Rx CQI reporting requirements with inter-cell interference. The testing SINR point, throughput ratio  and BLER X% can be determined through simulation by using Table 6.2.2.1.2.3-1 and Table 6.2.3.1.2.3-1 with 2T8R ULA.  a) the ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified INR and that obtained when transmitting the transport format indicated by each reported wideband CQI index subject to a white Gaussian noise source shall be ≥ .  b) when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified INR, the average BLER for the indicated transport formats shall be greater than or equal to X%.  Proposal 7: Reuse test parameters of Table 5.2.3.1.16 and Table 5.2.3.2.17 in TS38.101-4 as a starting point to define 8Rx MMSE-IRC receiver MU-MIMO requirements in FDD mode and TDD mode, respectively.  Proposal 8: Consider two sets of requirements for 8Rx MMSE-IRC receiver with inter-user intra-cell interference. |
| R4-2411045 | Nokia | Proposal 1: RAN4 shall use a common set of parameters between both inter-cell and intra-cell deployments for 8Rx with MMSE-IRC.  Proposal 2: RAN4 to introduce UE demodulation requirements for both TDD and FDD for 8Rx  Observation 1: A spatial channel model, such as CDL, should be used for observing the spatial effects of a feature like 8Rx; however, as this is ongoing in Rel-19 it would not be possible to agree a SCM in this work item  Proposal 3: RAN4 shall use a TDL based model for performance requirements.  Proposal 4: RAN4 shall use TDLA 30-10 Low for FWA performance requirements.  Proposal 5: RAN4 shall that MCS 17 (table 2) for FWA use cases.  Proposal 6: RAN4 shall define requirements with 15 kHz SCS and 50 MHz CBW for FWA use cases.  Proposal 7: RAN4 shall define requirements with 30 kHz SCS and 100 MHz CBW for FWA use cases.  Observation 2: Due to a lack of spatial model in RAN4 currently, a rank 8 requirement may not be representative of a relevant deployment.  Proposal 8: RAN4 shall use a rank of 4 to define requirements for FWA.  Observation 3: RAN4 could choose any Rank 4 PMI index for FWA requirements if TLDA 30-10 Low is used..  Proposal 9: RAN4 shall use TDLB 100-400 Low for vehicular performance requirements.  Proposal 10: RAN4 shall that MCS 2 (table 1) for vehicular use cases.  Proposal 11: RAN4 shall define requirements with 15 kHz SCS and 5 MHz CBW for vehicular use cases.  Proposal 12: RAN4 shall define requirements with 30 kHz SCS and 10 MHz CBW for vehicular use cases.  Proposal 13: RAN4 shall use a rank of 2 to define requirements for vehicular deployments.  Proposal 14: RAN4 shall use TDLC 300-100 Low for industrial performance requirements.  Proposal 15: RAN4 shall that MCS 13 (table 2) for industrial use cases.  Proposal 16: RAN4 shall define requirements with 15 kHz SCS and 5 MHz CBW for industrial use cases.  Proposal 17: RAN4 shall define requirements with 30 kHz SCS and 10 MHz CBW for industrial use cases.  Proposal 18: RAN4 shall use a rank of 2 to define requirements for industrial deployments.  Proposal 19: RAN4 to include both PDSCH type A and type B requirements.  Observation 4: The Inter Cell Interference model is independent of the wanted cell link parameters.  Proposal 20: RAN4 shall use the Intercell Interference model, specified in Clause B.6.2 of TS 38.101-4.  Observation 5: There is no explicit method for intracell inter user interference modelling defined in TS 38.101-4.  Observation 6: The INR could be defined in accordance with clause B.6.1.  Proposal 21: RAN4 shall agree the exact method for Intra Cell Inter User Interference and look to include in a new clause of Annex B.6 of TS 38.101-4 |
| R4-2411183 | China Telecom | Proposal 1: RAN4 to discuss whether to cover PDSCH absolute physical layer throughput requirements for 8Rx.  Proposal 2: UE performance requirements under this WI should cover both Baseline SU-MIMO 8Rx receiver and Simplified SU-MIMO 8Rx receiver.  Proposal 3: The new requirements for 8Rx MMSE-IRC receiver should be mandatory requirements for all 8Rx UEs without additional test applicability rule.  Proposal 4: The new requirements for 8Rx should be release independent from Rel-18.  Proposal 5: Reuse the same interference power levels (i.e., INR values) defined for Rel-17 2/4Rx for 8Rx requirements with inter cell interference.  Observation 1: Under the same test configuration with 2/4Rx, the SNR requirement value for 8Rx may be reduced to around 2-3dB due to larger diversity gain and more MMSE-IRC performance gain.  Proposal 6: Investigate simulation results for rank 1 (2x8), 2 (2x8) and 4 (4x8) and choose a reasonable requirement value.  Observation 2: Currently there is no capability for 8Rx UE to support R-ML receiver.  Proposal 7: Consider MMSE-IRC for the receiver type for PDCSH requirements with intra cell inter user interference for 8Rx UE.  Proposal 8: RAN4 to check the possibility for 8Rx UE to support R-ML receiver for SU/MU-MIMO scenario. If so, new UE capabilities can be introduced in Rel-19 and have it tested.  Proposal 9: Reuse the same precoding method as MMSE-IRC, i.e., random precoding was used with rank 1+1 and orthogonal precoding was used for rank 2+2 tests, if we consider using the same test setting and PDSCH configuration as MMSE-IRC.  Proposal 10: The tested SINR value should be decided based on simulation results with reasonable performance gain.  Proposal 11: For the other parameters for 8Rx UE new requirements, we propose to reuse the same configuration for Rel-17 2/4Rx as summarized in Table 1. |
| R4-2411391 | Apple | Observation #1: RAN4 defined requirements for inter-cell and intra-cell inter-user interference cancellation with 2RX and 4RX in R17.  Observation #2: RAN4 defined requirements with 8RX in R18 with MMSE-IRC but didn’t include requirements for inter-cell and intra-cell inter-user interference cancellation  Observation #3: RAN4 introduces requirements for the same scenario for 2RX and 4RX and it aligns with the applicability rule of skipping 2RX requirements if UE supports 4RX  Proposal #1: RAN4 to define requirements for 8RX for same test scenarios/configurations as 2RX/4RX and introduce applicability rules to reduce UE testing burden.  Observation #4: For inter-cell interference cancellation, we have agreed to use the same interference profile as Rel-17 for 8RX requirements  Observation #5: A different test scenario would not be feasible with the same interference profile.  Proposal #2: For PDSCH demodulation and CQI reporting requirements with 8RX for inter-cell interference cancellation use the same test configuration as Rel-17 with 2RX/4RX.  Observation #6: There is a potential to increase the number of TX and MIMO layer combination with 8RX for MU-MIMO.  Observation #7: Performance with random precoder and 8TX would be degraded compared to follow PMI which is more realistic.  Observation #8: It would not be suitable to define requirements for a test setup that is not practical and doesn’t give good performance.  Proposal #3: For PDSCH demodulation with 8RX for intra-cell inter-user interference cancellation use the same interference profile and test configuration as Rel-17 with 2RX/4RX. |
| R4-2411759 | CMCC | Proposal 1: Introduce both Homogeneous and Heterogeneous network deployment, reuse the Rel-17 interference model as a baseline.  Proposal 2: reuse Rel-17 network type and SCS/CBW setup, which are:   FR1 FDD sync network, 15kHz/10MHz   FR1 TDD sync network, 30kHz/40MHz  Proposal 3: For serving cell, consider Rank 2 and Rank 4 transmission as the starting point.  Proposal 4: For serving cell propagation condition, consider TDLA30-10 as the starting point, and further decide whether to cover TDLC300-100 by simulating interference suppressing gain.  Proposal 5: For TDD pattern, MCS, PDSCH configuration, DMRS configuration, TRS configuration, HARQ, precoding, Tx EVM, Test metric and other parameters, reuse the configuration from 8Rx requirement as the baseline.  Proposal 6: For PCI and SSB configuration of serving cell and interference cell(s), Rank/MCS, precoding, timing and frequency offset, and other interference cell modeling parameters, reuse the configuration from R17 2/4Rx inter-cell interference suppressing requirement as the baseline.  Proposal 7: the requirement should be released independent from Rel-18 if no new signalling or UE capability introduced.  Proposal 8: Use AWGN static channel as the baseline, further study whether to involve fading channel.  Proposal 9: Consider 4T8R and no RI restriction configured for simulation.  Proposal 10: For other serving cell configuration, the setup from 8Rx CQI reporting requirement can be reused for simulation.  Proposal 11: Reuse INR 10.04dB for initial simulation.  Proposal 12: For CSI-IM and NZP CSI-RS assumption, reuse agreement from R17 2/4Rx inter-cell interference suppressing requirement for simulation, which are:   CSI-IM on serving cell overlapping with PDSCH from interference cell   NZP CSI-RS on serving cell overlapping with NZP CSI-RS from interference cell  Proposal 13: Use 1 target UE + 1 interference UE as starting point for initial simulation.  Proposal 14: For 8Tx, further study whether interference suppressing gain can be achieved by MMSE-IRC receiver in more than one paired UE scenario.  Proposal 15: Use FDD 15kHz/10MHz and TDD 30kHz/40MHz 7D1S2U for initial simulation  Proposal 16: For propagation condition, consider TDLA30-10 as the starting point, and further decide whether to cover TDLC300-100 by simulating interference suppressing gain.  Proposal 17: Following rank and antenna configuration can be used for initial simulation   Rank 2+2 for 2T8R   Rank 4+4 for 4T8R   Rank 8+8 for 8T8R when 1 paired UE scheduled  Proposal 18: Following MCS configuration can be used for initial simulation   For target UE, MCS19 Table 1 for Rank 2, MCS17 Table 1 for Rank 4 and MCS 17 Table 1 for Rank 8   For paired UE, random 16QAM  Proposal 19: For initial simulation, use following configuration as the baseline:   single Panel Type I codebook   precoding granularity and PRB bundling size set as 2PRBs   for target UE, random precoder selection updated per slot, with equal probability of each applicable i1, i2 combination   for co-scheduled UE, select the precoding matrix to ensure orthogonality with target UE |
| R4-2412143 | Ericsson | Proposal 1: RAN4 should first reach agreements on the interference model before dig into the detailed parameter assumption.  Proposal 2: Propose RAN4 to discuss and agree at least on the configurations of the following interference model aspects for inter-cell interference mitigation  • Number of interfering cell  • Interference profile  o Whether to reuse the DIP method and INR level  • Transmission rank  • Time/frequency offset  • SSB configuration  Proposal 3: Propose RAN4 to discuss and agree at least on the configurations of the following interference model aspects for intra-cell inter-user interference cancellation:  • Number of paired UE  • Rank for target and interference  • Codebook type  • PMI selection and precoding  • MCS for interference  • DMRS configurations |
| R4-2412144 | Ericsson | Proposal 1: Assume the following as the interference model:  • Number of interference cell: 2  • Frequency shift to the target cell: 300Hz for interference cell 1, -100Hz for interference cell 2  • Interference model: Reuse the assumption of the Rel-17 inter-cell interference requirement (as specified in B.6.2)  • INR: 7.77 for interference cell 1, 2.29 for interference cell 2  • SSB configuration: First SSB in Slot #0 for all interference cells (Same as serving cell)  • Transmission rank: Random rank with 70% and 30% probability for rank 1 and rank 2 for all interference cells  Proposal 2: Consider following parameter assumptions for inter-cell interference scenario  • Duplex CBW/SCS  o FDD 10MHz/15kHz  o TDD 40MHz/30kHz, TDD DL/UL configuration for 30kHz SCS: 7D1S2U(S=6D+4G+4U)  • Antenna configuration  o 2T8R ULA medium B  o 4T8R ULA low  o 8T8R ULA low  • Rank SCS  o Rank 2, MCS19  o Rank 4, MCS17  o Rank 8, MCS17  • Channel model  o TDLA30-10  • PDCCH and PDSCH allocation in time domain  o Use symbols #0 and #1 of each slot for PDCCH  o PDSCH mapping type A, Start symbol 2, Duration 12  • PDSCH allocation in frequency domain  o Full PRB  • DMRS configuration  o For both serving and interfering cells, DMRS Type 1 with single symbol front loaded and 1 additional DMRS, with FDM applied between DMRS and data (number of CDM groups without data is equal to 1), i.e., overlapped DMRS between target and interference  Proposal 3: Consider the assumption assumed for Rel-17 CQI reporting fading tests with inter-cell interference as baseline  Proposal 4: Consider only 1 co-schedule UE in the interference model  Proposal 5: Consider following rank configuration for initial evaluations  • For 2 layers  o Target UE + interference UE:   1+1  • For 4 layers  o Target UE + interference UE:   2+2  • For 8 layers  o Target UE + interference UE:   2+6   4+4  Proposal 6: Consider following antenna configurations:  • 2T8R  o For rank 1+1  • 4T8R  o For rank 2+2  • 8T8R  o For rank 2+6 and/or 6+6  Proposal 7: Consider Type I Single Panel only  Proposal 8: Reuse the PDSCH & PDSCH DMRS Precoding configuration of Rel-18 NR demodulation performance evolution WI  Proposal 9: 2PRBs for PRB bundling size and precoding granularity  Proposal 10: Assume Random 16QAM symbols for interfering PDSCH  Proposal 11: Consider following parameter assumptions for intra-cell inter-user interference scenario  • Duplex CBW/SCS  o For FDD 15kHz SCS: Cover 10MHz CBW  o For TDD 30kHz SCS: Cover 40MHz CBW, TDD DL/UL configuration for 30kHz SCS: 7D1S2U(S=6D+4G+4U)  • Antenna configuration  o 2T8R ULA low  o 4T8R ULA low  o 8T8R ULA low  • MCS for target UE for evaluation  o MCS17, MCS13  • Channel model  o TDLA30-10  • PDCCH and PDSCH allocation in time domain  o Use symbols #0 and #1 of each slot for PDCCH  o PDSCH mapping type A, Start symbol 2, Duration 12  • PDSCH allocation in frequency domain  o Full PRB |
| R4-2412464 | QUALCOMM Europe Inc. - Spain | Proposal 1: RAN4 to define requirements only for SU-MMO baseline receiver.  Proposal 2: RAN4 to use MCS13 (Table1) for simulation studies as a starting point.  Proposal 3: For inter-cell interference, RAN4 to use rank4 for target UE for both TDD and FDD.  Proposal 4: RAN4 to use TDLA30-10 as the propagation model with 4 x 8 configuration for initial simulations.  Proposal 5: For MU-MIMO, RAN4 to use 8 x 8 antenna configuration with rank4 for target UE for both FDD and TDD.  Proposal 6: RAN4 to consider rank4 with 4 x 8 antenna configuration for wideband CQI fading reporting with inter-cell interference for both FDD and TDD.  Proposal 7: RAN4 to use Rel-17 interference models for initial simulation studies.  Proposal 8: Rel-19 8Rx performance requirements shall be independent from Rel-18. |
| R4-2412763 | Huawei,HiSilicon | For PDSCH requirements with inter-cell interference:  Observation 1: The most complicated step which should be mainly verified for MMSE-IRC is Ruu calculation, 4x4 Ruu matrix calculation has been verified in R17 MMSE-IRC 4Rx requirements definition.  Proposal 1: RAN4 shall define 8Rx requirements with interference with joint 8Rx processing. I.e. Baseline receiver.  Proposal 2: Reference receiver should be MMSE-MRC, RAN4 should guarantee the gain of MMSE-IRC over reference receiver for test setup selection. Furthermore, test SINR should be higher than -6dB  Proposal 3: 8Rx MMSE-IRC requirements with inter-cell and intra-cell inter user interference should be mandatory from Rel-18  Proposal 4: RAN4 to only reuse Rel-17 interference model specified for 2 interference cells for 8Rx MMSE-IRC requirements definition.  Observation 1: For Rank1 with 8Rx, the SINR is lower than -6dB, which is infeasible for requirements definition.  Observation 2: For Rank4, UE can perform interference covariance calculation with 2CDM groups and the target SINR range is reasonable.  Proposal 5: RAN4 to consider following test setup as start point:   TDLA30-10   Rank4+Low correlation   MCS13  For CQI requirements with inter-cell interference:  Observation 3: 4x4 interference covariance matrixes calculation has been verified in Rel-17 4Rx requirements MMSE-IRC requirements definition, which means CSI calculation based on 4Rx joint processing is pointless to be considered for requirements definition.  Proposal 6: RAN4 to define CQI requirements with 8Rx joint processing based CQI calculation.  Proposal 7: RAN4 to discuss how to handle the issue that there is no 8Rx CQI requirements with fading channel in the spec.  Observation 4: Case of rank2 has more SINR points with higher gain, which looks more reasonable than rank4.  Proposal 8: RAN4 to use following test setup for 8Rx CQI requirements with interference as start point for evaluation:   Serving cell:   Rank2   2T8R   TDLA30-5, Low   Others: Reuse test setup of Rel-18 8Rx CQI requirements   Interference cell:   INR=10.04dB   Rank1   1T8R   AWGN   Others: Reuse test setup of Rel-17 2Rx/4Rx CQI requirements with inter-cell interference  Proposal 9: RAN4 to reuse following test metric for Rel-17 2Rx/4Rx CQI requirements:   a) the ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified INR and that obtained when transmitting the transport format indicated by each reported wideband CQI index subject to a white Gaussian noise source shall be ≥ where is specified in Table 6.2.2.1.2.3-2;   b) when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified INR, the average BLER for the indicated transport formats shall be greater than or equal to 0.02.  For PDSCH requirements with intra cell inter user interference:  Proposal 10: RAN4 to consider following test setup for 8Rx requirements with intra-cell inter user interference:   Rank 2+2+2   Serving UE: Antenna Port 1000, 1001   Co-scheduled UE1: Antenna Port 1002,1003,   Co-scheduled UE2: Antenna Port 1006, 1007   Rank 4+4   Serving UE: Antenna Port 1000, 1001,1004,1005   Co-scheduled UE: Antenna Port 1002,1003,1006,1007   Channel: TDLA30-10, Low   MCS:   Rank 2+2+2：MCS19   Rank 4+4：MCS13.   Precoder:   Single Panel Type 1 for all UEs, any column of matrix of any serving UE or co-scheduled UE is orthogonal to any column of matrix of any other UE |
| R4-2412790 | ZTE Corporation, Sanechips | Observation1. Rank 4+4 can be introduced, which is different from legacy requirements and also can verify the processing capability of 8Rx.  Proposal 1. Rel-17 INR values can be as a start point, e.g. INR1= 7.77dB and INR2=2.29dB or INR=7.58dB.  Proposal 2. Propose to consider 2layers, 4layers and 6layers for inter cell scenario.  Proposal 3. Propose to consider MCS 19 and MCS 17 for rank 2 and rank 4 for PDSCH demodulation requirements.  Proposal 4. Propose to consider TDLA/ TDLC low correlation as starting point.  Proposal 5. Propose to consider FDD/TDD, 10M/15kHz and 40M/30kHz for demodulation requirements.  Proposal 6. Rel-17 INR values can be reused, e.g. INR= 10.04dB.  Proposal 7. Propose to consider rank 4 to define CQI requirements under fading channel conditions.  Proposal 8. RAN4 can follow the approach of Rel-17 as start point, e.g. duplex model, bandwidth and subcarrier spacing, etc.  Proposal 9. Propose to consider rank 2+2 and rank 4+4 to define requirements.  Proposal 10. Propose to consider MCS 13 and MCS 17 as starting point. |
| R4-2412878 | Samsung | Observation 1: For 2Rx and 4Rx antennas scenario, 2x2 and 2x4 antenna configurations with rank1 are used by the serving cell separately.  Observation 2: 16QAM based randomly modulated data for each interfering cell over the entire PDSCH region and over the full transmission bandwidth of the specified reference measurement channel are defined in the interference model for PDSCH requirements.  Proposal 1: Clarify the antenna configurations for UE performance requirements for 8Rx in the inter-cell interference with MMSE-IRC receiver scenario, 2x8 or more configuration options.  Proposal 2: Clarify the rank value of the serving cell for UE performance requirements for 8Rx in the inter-cell interference with MMSE-IRC receiver scenario, rank1 or more configuration options.  Proposal 3: Clarify the modulation order based randomly modulated data for each interfering cell over the entire PDSCH region and over the full transmission bandwidth of the specified reference measurement channel, whether 16QAM is still suitable or not.  Proposal 4: Reuse Rel-17 interference model and simulation assumptions for 2/4Rx UE as a starting point for 8Rx PDSCH demodulation requirements.  Proposal 5: Clarify if CQI reporting requirements are needed for 8Rx UE antennas with inter-cell interference with MMSE-IRC receiver scenario.  Proposal 6: Clarify the antenna configurations for UE performance requirements for 8Rx in the intra-cell inter-user interference with MMSE-IRC receiver scenario, 2x8, 8x8 or more configuration options.  Proposal 7: Clarify the rank value of the target UE and co-scheduled UE(s) for UE performance requirements for 8Rx in the intra-cell inter-user interference with MMSE-IRC receiver scenario, rank1 or more configuration options.  Proposal 8: Clarify whether PDSCH demodulation requirements are needed or not for intra-cell inter-user interference with Enhanced receiver Type 2. |

## Open issues summary

### Sub-topic 2-1 General

**Issue 2-1-1: Test scope**

* Proposals:
  + Proposal 1: RAN4 to introduce UE demodulation requirements for both TDD and FDD for 8Rx (Nokia, China Telecom, CMCC, Qualcomm)
  + Proposal 2: RAN4 to discuss whether to cover PDSCH absolute physical layer throughput requirements for 8Rx (China Telecom)
* CTC: PDSCH absolute physical layer throughput requirements are mandatory requirements for 2/4Rx.
  + Proposal 3: Clarify if CQI reporting requirements are needed for 8Rx UE antennas with inter-cell interference (Samsung)
* HW: Only AWGN is covered for 8Rx CQI requirements in current spec. It seems strange that RAN4 skip fading channel requirements and jump directly to requirements with interference.
* Recommended WF
  + It is recommended to cover both TDD and FDD.
  + Encourage feedback on Proposal 2 and Proposal 3.

**Issue 2-1-2: 8Rx UE MMSE-IRC receiver assumption**

* UE receiver capability definition in Rel-18:

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| *SU-MIMO 8Rx receiver*  *- Baseline SU-MIMO 8Rx receiver: 8Rx receivers for SU-MIMO transmissions with support of up to 8 layers with joint 8Rx MIMO detector in FR1*  *- Simplified SU-MIMO 8Rx receiver: 8Rx receivers for SU-MIMO transmissions with support of up to 4 layers with two joint 4Rx MIMO detectors in FR1.* |

* Proposals:
  + Option 1: Cover both Baseline SU-MIMO 8Rx receiver and Simplified SU-MIMO 8Rx receiver (China Telecom, MTK)
* MTK: The gap between 8Rx MMSE-IRC baseline receiver and 8Rx MMSE-IRC simplified receiver is over 1dB.
  + Option 2: Define requirements only for SU-MIMO baseline receiver (Qualcomm, Huawei)
* QC, HW: Requirements with 4Rx are already defined in 38.101.
* Recommended WF
  + Need discussion.

**Issue 2-1-3: Channel model**

* Proposals:
  + Proposal 1: Only consider TDL channel model (Nokia)
* Recommended WF
  + It is recommended to agree proposal 1.

**Issue 2-1-4: Test parameters for different devices with 8Rx**

* Proposals:
  + Proposal 1: Define different parameters for FWA, Vehicular and Industrial deployments respectively (Nokia)

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| * For FWA performance requirements   + TDLA 30-10 Low   + MCS 17 (table 2)   + 15 kHz SCS and 50 MHz CBW   + 30 kHz SCS and 100 MHz CBW   + Rank 4 * For vehicular performance requirements   + TDLB 100-400 Low   + MCS 2 (table 1)   + 15 kHz SCS and 5 MHz CBW   + 30 kHz SCS and 10 MHz CBW   + Rank 2 * For industrial performance requirements   + TDLC 300-100 Low   + MCS 13 (table 2)   + 15 kHz SCS and 5 MHz CBW   + 30 kHz SCS and 10 MHz CBW   + Rank 2 |

* Recommended WF
  + Encourage feedback on Proposal 1.

**Issue 2-1-5: PDSCH mapping type**

* Proposals:
  + Option 1: Include both PDSCH type A and type B requirements. (Nokia)
* Nokia: 1) PDSCH mapping type B is a mandatory UE feature; 2) The industrial use case assumes a very reliable environment with low latency transmissions.
  + Option 2: Reuse the same configuration for Rel-17 2/4Rx, i.e., PDSCH mapping type A only (China Telecom)
* Recommended WF
  + Encourage feedback

### Sub-topic 2-2 PDSCH requirements with inter cell interference

**Issue 2-2-1: Interference modelling and power levels**

* Proposals:
  + Option 1: Use the Intercell Interference model, specified in Clause B.6.2 of TS 38.101-4 (MTK, Nokia, China Telecom, Apple, CMCC, Ericsson, Qualcomm, Huawei, ZTE)
* Option 1A: Reuse the same interference profiles (i.e., cover HomNet and Hetnet scenarios) and same power levels (i.e., INR values) defined for Rel-17 2/4Rx (China Telecom, MTK, Apple, CMCC, Qualcomm, ZTE, Samsung)
* Option 1B: Only consider HomNet scenario with 2 interference cells and reuse the same power levels (i.e., INR values) defined for Rel-17 2/4Rx (Ericsson, Huawei)
  + Option 2: RAN4 to discuss if it is still reasonable to use 16QAM based randomly modulated data for each interfering cell (Samsung)
* Recommended WF
  + Encourage feedback on option2.

**Issue 2-2-2: Network Type and SCS/CBW**

* Proposals:
  + Option 1: Reuse the same propagation condition defined for Rel-17 2/4Rx, i.e., 15kHz/10MHz for FDD, and 30kHz/40MHz for TDD with 7D1S2U(S=6D+4G+4U), (China Telecom, Apple, CMCC, Ericsson, ZTE, Samsung)
  + Option 2: Define different parameters for FWA, Vehicular and Industrial deployments respectively (Nokia)
* Recommended WF
  + First discuss Issue 2-1-4.

**Issue 2-2-3: Propagation condition**

* Proposals:
  + Option 1: Reuse the same propagation condition defined for Rel-17 2/4Rx, i.e., TDLC300-100 for 2 interfering cells (HomNet) and TDLA30-10 for 1 interfering cell (HetNet) (China Telecom, MTK, Apple, Samsung)
  + Option 2: Consider TDLA30-10 as the starting point (CMCC, Ericsson, Qualcomm, Huawei)
* CMCC: For TDLC300ns delay spread model, the minimum coherence bandwidth is about 0.385MHz, which is smaller than 2PRB and larger than 1PRB in 30kHz scenario.
  + Option 3: Define different parameters for FWA, Vehicular and Industrial deployments respectively (Nokia)
* Recommended WF
  + First discuss Issue 2-1-4.

**Issue 2-2-4: Rank**

* Proposals:
  + Option 1: Consider higher rank for 8Rx (China Telecom, CMCC, Ericsson, Qualcomm, Huawei, ZTE)
* Option 1A: RAN4 to investigate rank 1, 2, 4 and choose a reasonable requirement value (China Telecom)
* Option 1B: Rank 2 and Rank 4 as the starting point (CMCC)
* Option 1C: Rank 2 and Rank 4 and Rank 8 (Ericsson)
* Option 1D: Rank 4 (Qualcomm, Huawei)
* Option 1E: Consider 2 layers, 4 layers and 6 layers (ZTE)
  + Option 2: Same as Rel-17 2/4Rx, i.e., Rank 1 (MTK, Apple)
  + Option 3: Define different parameters for FWA, Vehicular and Industrial deployments respectively (Nokia)
* Recommended WF
  + First discuss Issue 2-1-4.

**Issue 2-2-5: MCS**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., MCS 13 (China Telecom, Apple, CMCC, Qualcomm, Huawei)
  + Option 2: MCS 16 (MTK)
* MTK: the SINRs for MCS 13 are quite low.
  + Option 3: MCS 19 for rank 2, MCS 17 for rank 4 and 8 (Ericsson, ZTE without rank 8)
  + Option 4: Define different parameters for FWA, Vehicular and Industrial deployments respectively (Nokia)
* Recommended WF
  + First discuss Issue 2-1-4.

**Issue 2-2-6: Antenna and MIMO correlation**

* Proposals:
  + Option 1: 2T8R ULA low (MTK)
  + Option 2: 4T8R (Qualcomm, Huawei with Low correlation)
  + Option 2 (Ericsson)
* 2T8R ULA medium B
* 4T8R ULA low
* 8T8R ULA low
* Recommended WF
  + Encourage feedback

**Issue 2-2-7: Other parameters**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx (China Telecom, MTK, Apple, CMCC, Ericsson, Samsung)
* E///:
* SSB configuration: First SSB in Slot #0 for all interference cells (Same as serving cell)
* Transmission rank: Random rank with 70% and 30% probability for rank 1 and rank 2 for all interference cells
* Frequency shift to the target cell: 300Hz for interference cell 1, -100Hz for interference cell 2
* PDCCH and PDSCH allocation in time domain
  + Use symbols #0 and #1 of each slot for PDCCH
  + PDSCH mapping type A, Start symbol 2, Duration 12
* PDSCH allocation in frequency domain: Full PRB
* DMRS configuration
  + For both serving and interfering cells, DMRS Type 1 with single symbol front loaded and 1 additional DMRS, with FDM applied between DMRS and data (number of CDM groups without data is equal to 1), i.e., overlapped DMRS between target and interference
* Recommended WF
  + Can we take option 1 as baseline and companies are still able to bring different configurations in the next meeting?

### Sub-topic 2-3 PDSCH requirements with intra cell inter user interference

**Issue 2-3-1: Receiver type**

* Proposals:
  + Proposal 1: Consider MMSE-IRC and also check the possibility to support R-ML receiver in Rel-19 (China Telecom)
* Samsung: Clarify whether PDSCH demodulation requirements are needed or not for intra-cell inter-user interference with Enhanced receiver Type 2.
* Recommended WF
  + Encourage feedback

**Issue 2-3-2: Network Type and SCS/CBW**

* Proposals:
  + Option 1: Reuse the same propagation condition defined for Rel-17 2/4Rx, i.e., 15kHz/10MHz for FDD, and 30kHz/40MHz for TDD 7D1S2U, (China Telecom, Apple, CMCC, ZTE)
  + Option 2: Define different parameters for FWA, Vehicular and Industrial deployments respectively (Nokia)
* Recommended WF
  + First discuss Issue 2-1-4.

**Issue 2-3-3: Interference modelling**

* Proposals on MU-MIMO Beamforming Model:
  + Option 1: Reuse the same MU-MIMO Beamforming Model for Rel-17 2/4Rx in B.4.2 in TS38.101-4 (China Telecom, Qualcomm, ZTE, [MTK, Ericsson])
  + Option 2: Include in a new clause of Annex B.6 of TS 38.101-4 (Nokia)
* Proposals on co-UE number:
  + Option 1: Same as Rel-17 2/4Rx requirements, i.e., 1 target UE + 1 co-UE (China Telecom, CMCC, Ericsson, Qualcomm)
* CMCC: further study whether interference suppressing gain can be achieved by MMSE-IRC receiver in more than one paired UE scenario
  + Option 2: Consider 1 target UE and more than 1 co-UEs (Huawei, [CMCC])
* Recommended WF
  + TBA

**Issue 2-3-4: Propagation condition**

* Proposals:
  + Option 1: Reuse the same precoding method as MMSE-IRC, i.e., TDLC300-100 with rank 1+1 and TDLA30-10 with rank 2+2 (China Telecom)
  + Option 2: Consider TDLA30-10 (CMCC, Huawei)
* Recommended WF
  + Encourage feedback

**Issue 2-3-5: Precoding method for the co-scheduled UE**

* Proposals:
  + Option 1: Reuse the same precoding method as MMSE-IRC, i.e., random precoding with rank 1+1 and orthogonal precoding for rank 2+2 tests. (China Telecom, MTK)
  + Option 2: Orthogonal precoding with the target UE, i.e., any column of matrix of any serving UE or co-scheduled UE is orthogonal to any column of matrix of any other UE (CMCC, Ericsson, Huawei)
* Recommended WF
  + Encourage feedback

**Issue 2-3-6: Antenna, rank (target UE + co-scheduled UEs) configuration and MIMO correlation**

* Proposals:
  + Option 1: 2T8R ULA low (MTK)
  + Option 2: Rank 4+2 with 8T8R (Qualcomm)
  + Option 3 (CMCC)
* Rank 2+2 for 2T8R
* Rank 4+4 for 4T8R
* Rank 8+8 for 8T8R when 1 paired UE scheduled
  + Option 4 (Ericsson)
* Rank 1+1 for 2T8R
* Rank 2+2 for 4T8R
* Rank 2+6 or rank 6+6 for 8T8R
  + Option 5 (Huawei)
* Rank 2+2+2 for 8T8R
* Rank 4+4 for 4T8R
  + Option 6 (ZTE)
* Rank 2+2
* Rank 4+4
  + Option 7 (Apple) same as R17
* Rank 1+1 for 2T4R
* Rank 2+4 for 4T4R
* Recommended WF
  + Encourage feedback

**Issue 2-3-7: MCS**

* Proposals for the target UE:
  + Option 1: Same as Rel-17 2/4Rx requirements for MMSE-IRC, i.e., MCS 13 (China Telecom, Qualcomm)
  + Option 2: (CMCC)
* MCS 19 Table 1 for Rank 2
* MCS 17 Table 1 for Rank 4
* MCS 17 Table 1 for Rank 8
  + Option 3: Consider MCS 17 and MCS 13 (Ericsson, ZTE)
  + Option 4: MCS 19 for rank 2, MCS 13 for rank 4 (Huawei)
* Recommended WF
  + Encourage feedback

**Issue 2-3-8: Other parameters**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx for MMSE-IRC (China Telecom, MTK, Ericsson)
* E///:
* PMI: Type I Single Panel
* 2PRBs for PRB bundling size and precoding granularity
* Random 16QAM symbols for the co-scheduled UE
* PDCCH and PDSCH allocation in time domain
  + Use symbols #0 and #1 of each slot for PDCCH
  + PDSCH mapping type A, Start symbol 2, Duration 12
* PDSCH allocation in frequency domain: Full PRB
* CMCC:
* For the target UE, random precoder selection updated per slot, with equal probability of each applicable i1, i2 combination
* Recommended WF
  + Can we take option 1 as baseline and companies are still able to bring different configurations in the next meeting?

### Sub-topic 2-4 Wideband CQI reporting requirements with inter-cell interference

**Issue 2-4-1: Test metric**

* Proposals:
  + Option 1: Reuse the same test metric for Rel-17 2/4Rx (China Telecom, MTK, Apple, Ericsson, Huawei)

|  |
| --- |
| a) the ratio of the throughput obtained when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified INR and that obtained when transmitting the transport format indicated by each reported wideband CQI index subject to a white Gaussian noise source shall be ≥ **  b) when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified INR, the average BLER for the indicated transport formats shall be greater than or equal to X%. |

* Recommended WF
  + Option 1

**Issue 2-4-2: Propagation condition**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., TDLA30-5 for the serving cell and AWGN for the interference cell (China Telecom, Apple, Ericsson, Huawei)
  + Option 2: Use AWGN static channel as the baseline, further study whether to involve fading channel (CMCC)
* Recommended WF
  + Can we agree option 1?

**Issue 2-4-3: Interference power level**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., INR = 10.04dB with rank 1 (China Telecom, Apple, CMCC, Ericsson, Huawei, ZTE)
* HW: 1T8R for the interference cell
* Recommended WF
  + Can we agree option 1?

**Issue 2-4-4: Antenna configuration and MIMO correlation for the serving cell**

* Proposals:
  + Option 1: 2T8R ULA Low (MTK, Huawei)
  + Option 2: Consider 4T8R (CMCC, Qualcomm)
* CMCC: no RI restriction configured
* Recommended WF
  + Encourage feedback

**Issue 2-4-5: Rank**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., rank 1 (China Telecom)
  + Option 2: Rank 2 (Huawei)
  + Option 3: Rank 4 (ZTE)
* Recommended WF
  + Encourage feedback

**Issue 2-4-6: Tested SINR value, throughput ratio** ****and BLER X%**

* Proposals:
  + Proposal 1: Should be decided based on simulation results (China Telecom, MTK)
* Recommended WF
  + Can we agree option 1?

**Issue 2-4-7: CSI-IM and NZP CSI-RS configurations**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx (China Telecom, Apple, CMCC, Ericsson, Huawei)
* Recommended WF
  + Can we agree option 1?

**Issue 2-4-8: Other parameters**

* Proposals:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx (China Telecom, Apple, Ericsson)
  + Option 2: For the serving cell, reuse the setup from 8Rx CQI reporting requirement in Rel-18 (CMCC, Huawei)
* Recommended WF
  + Based on moderator’s check, the only difference between Rel-17 2/4Rx MMSE-IRC CQI reporting requirements and the Rel-18 8Rx CQI reporting requirement, is the NZP CSI-RS port and codebook configurations.
  + Therefore, it is recommended to first decide Issue 2-4-4.

### Sub-topic 2-5 Applicability rule and release independent

**Issue 2-5-1: Test applicability**

* Proposals:
  + Option 1: The new requirements for 8Rx MMSE-IRC receiver should be mandatory requirements for all 8Rx UEs without additional test applicability rule (China Telecom)
  + Option 2: Applicability rule to skip 2/4Rx requirements if 8Rx tests are passed, if same test scenarios/configurations as 2RX/4RX are defined (Apple)
* Recommended WF
  + Keep open and further discuss

**Issue 2-5-2: Release independent**

* Proposals:
  + Option 1: The new requirements for 8Rx should be release independent from Rel-18 (China Telecom, CMCC, Qualcomm, Huawei)
* Recommended WF
  + Encourage feedback

# Topic #3: BS demodulation performance requirements for MMSE-IRC

*Objectives in the approved WID RP-241297*

|  |
| --- |
| * *Define FR1 PUSCH performance requirements with inter-cell interference in homogeneous and heterogenous deployment based on the following assumption*    + *Receiver type: MMSE-IRC*   + *Scenarios:*     - *FDD synchronous deployments*     - *TDD synchronous deployments with aligned UL: DL configurations among cells*     - *Slot-based transmission and aligned SCS among cells* * *Reuse LTE based interference profile in TR 36.884 as a starting point. Other interference profiles are not precluded* |

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2411118 | CATT | Proposal 1: Reuse definition of DIP in sub-clause B.6.1 of TS 36.104 for NR BS MMSE-IRC demodulation.  Proposal 2: Define the SINR as below for conducted demodulation requirement for BS type 1-C and BS type 1-H:  For enhanced performance requirements type A, the SINR used in this clause is specified based on a single carrier and defined as:  Where:  is the total signal energy of one intra-cell UE in the subframe on a single antenna connector (for BS type 1-C) or on a single TAB connector (for BS type 1-H).  is the summation of the received energy of the strongest inter-cell interferers explicitly defined in a test procedure plus the white noise energy N, in a bandwidth corresponding to the transmission bandwidth over the duration of a subframe on a single antenna connector (for BS type 1-C) or on a single TAB connector (for BS type 1-H). The respective energy of each inter-cell interferer relative to is defined by its associated DIP value.  Proposal 3: Define the SINR as below for conducted demodulation requirement for BS type 1-O:  For enhanced performance requirements type A, the SINR used in this clause is specified based on a single carrier and defined as:  Where:  is the total signal energy of one intra-cell UE in the subframe on a RIB.  is the summation of the received energy of the strongest inter-cell interferers explicitly defined in a test procedure plus the white noise energy N, in a bandwidth corresponding to the transmission bandwidth over the duration of a subframe on a RIB. The respective energy of each inter-cell interferer relative to is defined by its associated DIP value.  Proposal 4: Reuse the interference model for synchronous scenario in sub-clause B.6.2 of TS 36.104 for NR BS MMSE-IRC demodulation.  Proposal 5: Reuse the DIP set1 and set2 for LTE BS MMSE-IRC demodulation for NR BS MMSE-IRC demodulation as starting point.  Proposal 6: Use MCS 5(QPSK, R=379/1024), MCS 13(16QAM, R=490/1024) and MCS 24(64QAM, R=772/1024) for NR BS MMSE-IRC demodulation.  Proposal 7: Use the following antenna configuration for serving and interferers for NR BS MMSE-IRC demodulation.  MCS Antenna configuration for serving and interferers  MCS 5(QPSK, R=379/1024) 1x2 Low  MCS 13(16QAM, R=490/1024) 1x4 Low  MCS 24(64QAM, R=772/1024) 1x8 Low  Proposal 8: Define NR BS MMSE-IRC demodulation requirements for both CP-OFDM and DFT-s-OFDM waveform.  Proposal 9: 5/10/20MHz CBW for 15kHz SCS, and 10/20/40/100MHz CBW for 30KHz SCS can be reused for CP-OFDM for NR BS MMSE-IRC demodulation.  Proposal 10: Use the following parameters for CP-OFDM for NR BS MMSE-IRC demodulation for serving and interferers.  Parameter Value  Transform precoding Disabled  Default TDD UL-DL pattern (Note 1) 15 kHz SCS:  3D1S1U, S=10D:2G:2U  30 kHz SCS:  7D1S2U, S=6D:4G:4U  HARQ Maximum number of HARQ transmissions 4  RV sequence 0, 2, 3, 1  DM-RS DM-RS configuration type 1  DM-RS duration single-symbol DM-RS  Additional DM-RS position pos1  Number of DM-RS CDM group(s) without data 2  Ratio of PUSCH EPRE to DM-RS EPRE -3 dB  DM-RS port {0}, {0, 1}, {0, 1, 2, 3}  DM-RS sequence generation NID0=0, nSCID =0  Time domain PUSCH mapping type A, B  resource Start symbol 0  assignment Allocation length 14  Frequency domain resource RB assignment Full applicable test bandwidth  assignment Frequency hopping Disabled  Code block group based PUSCH transmission Disabled  NOTE 1: The same requirements are applicable to FDD and TDD with different UL-DL pattern.  Proposal 11: 5MHz CBW for 15kHz SCS, and 10MHz CBW for 30KHz SCS can be reused for DFT-s-OFDM for NR BS MMSE-IRC demodulation.  Proposal 12: Use the following parameters for DFT-s-OFDM for NR BS MMSE-IRC demodulation for serving and interferers.  Parameter Value  Transform precoding Enabled  Default TDD UL-DL pattern (Note 1) 15 kHz SCS:  3D1S1U, S=10D:2G:2U  30 kHz SCS:  7D1S2U, S=6D:4G:4U  HARQ Maximum number of HARQ transmissions 4  RV sequence 0, 2, 3, 1  DM-RS DM-RS configuration type 1  DM-RS duration single-symbol DM-RS  Additional DM-RS position pos1  Number of DM-RS CDM group(s) without data 2  Ratio of PUSCH EPRE to DM-RS EPRE -3 dB  DM-RS port(s) 0  DM-RS sequence generation NID0=0, group hopping and sequence hopping are disabled  Time domain PUSCH mapping type A, B  resource Start symbol 0  assignment Allocation length 14  Frequency domain resource assignment RB assignment 15 kHz SCS: 25 PRBs in the middle of the test bandwidth  30 kHz SCS: 24 PRBs in the middle of the test bandwidth  Frequency hopping Disabled  Code block group based PUSCH transmission Disabled  NOTE 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns.  Proposal 13: Use 70% of maximum throughput as metric for NR BS MMSE-IRC demodulation. |
| R4-2411184 | China Telecom | Proposal 1: Reuse the same receiver assumption for MMSE-IRC in TR36.884.  Proposal 2: Align with the same test scope for Rel-15 PUSCH requirements with transform precoding disabled:  • Cover the following SCS and TDD patterns:  - 15kHz SCS with TDD pattern 3D1S1U, S=10D:2G:2U  - 30 kHz SCS with TDD pattern 7D1S2U, S=6D:4G:4U  • Cover both PUSCH mapping Type A and Type B.  • Channel bandwidth:  - For 15kHz SCS, cover 5MHz, 10MHz, 20MHz channel bandwidth  - For 30kHz SCS, cover 10MHz, 20MHz, 40MHz, 100MHz channel bandwidth  Proposal 4: Consider the following scenario for BS MMSE-IRC requirement definition and discuss how to model the corresponding interference profile:  - Serving cell: DSUUU  - Neighbour cell: 7D3U  Proposal 5: Reuse the same interference modeling as captured in B.6.2 in TS36.104, to transmit random 16QAM symbol for the neighbor cell PUSCH.  Proposal 6: Reuse the same interference power level as in LTE, i.e., DIP -1.11dB and -10.91dB for HomNet scenario and DIP -0.43dB and -13.78dB for HetNet scenario.  Proposal 7: Use INR-based modeling + SNR-based requirement definition criteria and transfer the DIP value into INR value.  Proposal 8: Cover 2/4/8 Rx with 1Tx.  Proposal 9: Use TDLA30-10 and TDLC300-100 propagation channel model for the serving cell for HetNet and HomNet respectively.  Proposal 10: Introduce new propagation channel for testing with desired delay spread 1000ns for the nonboring cell, i.e., TDLC1000. |
| R4-2411517 | Qualcomm Germany | Observation 1: As high power UEs becomes more common, advanced base station receivers play a crucial role in reducing inter-cell uplink interference in densely populated urban areas.  Observation 2: LTE work in TR 36.884 considered passive antennas at the BS, PC3 UEs, and 2 GHz carrier frequency in its system level study to derive the different DIP levels. Such assumptions might need to be revisited for Rel-19 WI.  Proposal 1: RAN4 to discuss what are the different assumptions in the Rel-19 WI in terms of deployment scenarios (i.e., homogenous and heterogenous deployments) and system level assumptions compared to those adopted in TR 36.884.  Proposal 2: RAN4 to adopt the DIP-based methodology as a starting point to characterize the interference profiles based on realistic system scenarios and assumptions.  Proposal 3a: RAN4 to consider only 4RX and 8RX gNB for TDD and FDD scenarios.  Proposal 3b: RAN4 to consider two interferences for both 4Rx and 8Rx cases as an initial assumption.  Proposal 4: RAN4 to revisit the multi-path fading propagation conditions in TR 36.884 following the agreed scenarios for Rel-19 WI. |
| R4-2411760 | CMCC | Proposal 1: Extend the scope to also cover BS CLI problem in HetNet unaligned TDD pattern scenario.  Proposal 2: Reuse LTE based interference profile in TR 36.884 for initial simulation, that are DIP1 = -1.11 and DIP2 = -10.91 for Homogeneous network, DIP1 = -0.43 and DIP2 = -13.78 for Heterogeneous network.  Proposal 3: For initial simulation, take 10MHz/15kHz and 40MHz/30kHz as baseline.  Proposal 4: For initial simulation, use TDLA30-10 as the baseline, and further evaluate whether performance gain can be achieved under TDLC300-100 for Homogeneous network.  Proposal 5: Same antenna configuration can be applied among target and interferer(s), take 1T2R, 1T4R, and 1T8R as the starting point for initial simulation. |
| R4-2412143 | Ericsson | Observation 1: The DIP model and INR model could be expressed by each other. The INR model would be much easier for link level simulation.  Proposal 4: Use INR for NR BS MMSE-IRC interference model.  Proposal 5: Companies to check if artificial interference profile based on LTE MMSE-IRC BS interference profile is feasible for NR MMSE-IRC BS demodulation requirement derivation. |
| R4-2412319 | Ericsson | Observation 1 LTE BS MMSE-IRC profile is feasible for NR FDD band deployment.  Based on the discussion in the previous sections we propose the following:  Proposal 1: Only setup NR TDD deployment to check the interference distribution if system level simulation is agreed.  Proposal 2 Take PC2 UE (26dBm) as the start point for NR TDD SLS and further discuss how to consider 3 types of UE distribution in SLS.  Proposal 3 Take configurations in Table 2.1-1 to 2.1-3 as the start point for NR TDD system simulations if SLS is agreed.  Proposal 4 If SLS is agreed for NR MMSE-IRC BS interference profile evaluation, take worse case from LTE profile and NR profile.  Proposal 5 Only take 16QAM for interference profile of NR MMSE-IRC BS demodulation requirements.  Proposal 6 Consider 2/4/8 Rx antenna configurations for NR MMSE-IRC BS demodulation requirements.  Proposal 7 Consider 1 interferer case for 2 Rx antenna configuration and 2 interferers case for 4/8 Rx antenna configuration.  Proposal 8 Do not consider 256QAM requirements for NR MMSE-IRC PUSCH demodulation requirements.  Proposal 9 Start from MCS index 2, 12, 20 in MCS table for QPSK, 16QAM and 64QAM simulations separately.  Proposal 10 Use channel model configuration in Table 2.4-2 for serving signal and interferer as the start point for NR MMSE-IRC BS demodulation requirement discussion.  Proposal 11 Take the minimum channel bandwidth for the NR MMSE-IRC requirements as the start point. |
| R4-2412333 | Intel Corporation | Proposal #1: Study suitability of LTE interference profiles for NR interference modelling and whether adjustments or new profiles are necessary.  Proposal #2: INR interference modelling methodology shall be used if new NR interference profiles are agreed to be defined. DIP interference modelling methodology shall be used if LTE interference profiles are reused.  Proposal #3: Reuse LTE MMSE-IRC reference receiver assumptions defined in TR 36.884. |
| R4-2412764 | Huawei,HiSilicon | Proposal 1: RAN4 to reuse the current LTE interference model for evaluation to check the gain over baseline receiver (MMSE-MRC). RAN4 consider other interference profiles only if the gain is not sufficient.   LTE interference profile:   Homogeneous: DIP1=-1.11dB, DIP2=-10.91dB   Heterogeneous: DIP=-0.43dB, DIP2=-13.78dB  Proposal 2: For simplicity, serving PUSCH and interference PUSCH should have same wave type, PUSCH mapping type and DMRS port index.  Proposal 3: RAN4 to consider following parameters as start point:   Antenna configuration: 1T2R, 1T4R and 1T8R for serving PUSCH and interference PUSCH   Waveform:   CP-OFDM (1st priority),   DFT-S-OFDM (2nd priority)   MCS:   CP-OFDM: 2,16,20   DFT-S-OFDM: MCS2   Propagation conditions:   Serving PUSCH: TDLB100-400 low for MCS2, TDLC300-100 low for MCS16 and TDLA30-10 low for MCS20.   Interference PUSCH: TDLC300-100 low   SCS: 15kHz and 30kHz   Mapping type: Type A and B   Bandwidth for serving and interference PUSCH:   15kHz SCS: 5MHz, 10MHz, 20MHz.   30kHz SCS: 10MHz, 20MHz,40MHz,100MHz   Receiver Type:  - MMSE-IRC receiver: DMRS based interference covariance matrix estimation with granularity of per RB per TTI  - MMSE-MRC receiver |
| R4-2412791 | ZTE Corporation, Sanechips | Proposal 1. Propose to reuse legacy interference profile, DIP1= -1.11dB, DIP2=-10.91dB for homogeneous network and DIP1=-0.43dB, DIP2= -13.78dB for heterogeneous network.  Proposal 2. Propose to consider 2/4/8 Rx for demodulation requirements.  Proposal 3. Propose to consider different modulation orders for different receive antennas, e.g. MCS.  Proposal 4. Propose to consider all propagation conditions,e.g. TDLA/B/C. |
| R4-2412905 | Nokia | Observation 1: BS UL MMSE-IRC has been extensively studied in TR 36.884 and specified in TS 36.104 for LTE. A DMRS based MMSE-IRC receiver is assumed.  Observation 2: Intercell interference signals have been considered in TR 36.884 as the source of interference in the received signals. Hence, the estimated covariance matrix R used to compute the MMSE-IRC weight matrix W has already captured the considered intercell interference signals.  Observation 3: With the estimated covariance matrix R as in TR 36.884, no intra-network information exchange shall be forced to compute the MMSE-IRC weight matrix W.  Proposal 1: The signal model and MMSE-IRC receiver weight matrix with its corresponding estimated covariance matrix as in TR 36.884 should be used as references to define the FR1 PUSCH requirements in this WI.  Proposal 2: There should be no other specific receiver structures to be forced to be implemented and the detailed structure for any (and all) scenarios should be up to implementation.  Proposal 3: Similar as in LTE, there is no need to enforce intra-network information exchange, when using the reference receiver.  Observation 4: In TR 36.884, with 2 explicit interferers, only 4Rx and 8Rx are considered.  Observation 5: In TR 36.766, only 2Rx and 4Rx are considered.  Proposal 4: Based on previous studies documented in TR 36.884 and TR 36.766, RAN4 shall prioritize 4Rx case especially in the case of 2 explicit interferers.  Observation 6: For interference profile, Dominant Interference Proportion (DIP) was used in LTE BS demodulation performance requirements. Such a DIP as in LTE could be considered as a starting point in this WI,  Observation 7: In NR UE demodulation performance requirements, Interference-to-Noise Ratio (INR) was used.  Proposal 5: RAN4 to discuss using INR instead of DIP, as in NR UE demodulation performance requirements.  Observation 8: DIP1 and DIP2 in TR 38.884 have different levels of dominance, which could be interpreted as two different interferers with two different power levels, where the one with the highest power level represents the HPUE. Using such DIP1 and DIP2 will avoid the need to run system level simulation to generate different interference profile with interference coming from a mixed of HPUEs and normal UEs.  Proposal 6: RAN4 to use DIP1 and DIP2 in TR 38.884 as references to define corresponding INR1 and INR2, in which DIP1 shall be assumed as the interference from HPUE and DIP2 from a normal UE.  Observation 9: In LTE, the BS demodulation requirements are defined for all possible bandwidth (BW) sizes. Nonetheless, the performance difference of BS MMSE-IRC in those different bandwidth sizes are relatively small.  Proposal 7: RAN4 to prioritize 5/50MHz BW with 15KHz SCS and 10/100MHz BW with 30KHz SCS to cover both extremes and have all DUTs testable regardless of BW support declaration. |
| R4-2413444 | Samsung | Proposal 1: Define PUSCH requirement with MMSE-IRC receiver for both homogeneous and heterogeneous network scenario.  Proposal 2: Define PUSCH requirement with MMSE-IRC receiver for both FDD and TDD. The same TDD requirement are applicable to different UL-DL configuration.  Proposal 3: Define PUSCH requirement with only synchronous scenario.  Proposal 4: For target PUSCH and interference PUSCH, prioritize the 1Tx UE scenario. Deprioritize 2Tx UE scenario, and not cover 4Tx UE scenario.  Observation 1: Number of interferer UE modeling depending on number of Rx number. Further evaluation the feasible of number interferer UE modeling before specifying the PUSCH requirement with MMSE-IRC receiver.  Proposal 5: LTE interference profiles can be used for verifying the gain of MMSE-IRC compared with MMSE receiver as a starting point. FFS to derive the interference profile based on system level simulation with NR deployment for homogeneous and heterogeneous scenarios  Proposal 6: Apply the DM-RS of severed targeting UE’s PUSCH for interference covariance matrix estimation. The baseline assumption for estimation of interference covariance matrix is performed at per PRB and per TTI basis.  Proposal 7: FFS on Technical Report needed to capture interference profile modeling and number of interfered UE explicitly modeling evaluation and analysis results.  Proposal 8: Consider 1Tx and 2/4/8Rx antenna configuration for target UE and interference UE to evaluate the performance gain of MMSE-IRC  Proposal 9: FFS to differentiate the channel model used for target UE and interfered UE for performance evaluation with MMSE-IRC receiver.  Proposal 10: Consider 15KHz SCS, 10MHz CBW and 30KHz SCS, 40MHz CBW for initial performance evaluation with MMSE-IRC receiver.  Proposal 11: Consider MCS 16 for interfered UE, MCS 2, MCS 16 and MCS 20 as candidate for initial performance evaluation with MMSE-IRC receiver.  Proposal 12: Consider CP-OFDM for initial performance evaluation with MMSE-IRC receiver.  Proposal 13: Reusing the existing test parameter for target UE and interfered UEs for performance evaluation with MMSE-IRC receiver. |

## Open issues

### Sub-topic 3-1 General

**Issue 3-1-1: MMSE-IRC Receiver assumption**

* Proposals:
  + Option 1: Reuse the same receiver assumption for MMSE-IRC in TR36.884 (China Telecom, Intel, Huawei, Nokia, Samsung)

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| --- |
| MMSE-IRC receiver The MMSE-IRC receiver weight matrix is usually defined as  The MMSE-IRC receiver weight matrix is usually defined as    where and denote the estimated channel matrix and covariance matrix, respectively.  To obtain the MMSE-IRC receiver weight matrix, the covariance matrix including the sources of inter-cell interference needs to be estimated. The covariance matrix is estimated at DM-RS REs by following equations:  , ,  where the DM-RS symbols are used to estimate the covariance matrix, and *Nsp* is the number of sampling DM-RS REs.  The estimation of interference covariance matrix is performed at per PRB and per TTI basis. |

* Recommended WF
  + Option 1?

**Issue 3-1-2: Baseline receiver assumption (for performance gain study only)**

* Proposals:
  + Option 1: MMSE receiver as defined in TR36.884 (Samsung, [Huawei])

|  |
| --- |
| Baseline receiver: MMSE receiver The MMSE receiver weight matrix is expressed as follow:  ,  where and denote the estimated channel matrix and noise power, respectively. *P*1 is the transmission power of UE scheduled by the serving cell and is equal to . |

* Recommended WF
  + Option 1?

**Issue 3-1-3: Test scenarios**

* Proposals:
  + Proposal 1: Cover HomNet and HetNet scenarios, i.e., DIP set1 and set2 in TS36.104 (China Telecom, CATT, Samsung)
  + Proposal 2: Consider the scenario with different TDD patterns between BS and discuss how to model the corresponding interference profile (China Telecom, CMCC)
* Recommended WF
  + Encourage feedback.

### Sub-topic 3-2 Interference modelling

**Issue 3-2-1: Signalling model**

* Proposals:
  + Option 1: Reuse the same signalling model in TR36.884 (Nokia)

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| --- |
| 4.1 Signal model  For PUSCH, the receiver equations are provided as the reference receiver for evaluation purpose.  Assume that  is the  frequency domain representation of the *k*-th subcarrier in the -th DFT-OFDM symbol for the -th UE scheduled by its serving BS.  is obtained with DFT operation of the time-domain modulating symbol, denoted as , where , with DFT size of . The *NRx*-dimensional received signal vector  of the *k*-th subcarrier and the *l*-th DFT-OFDM symbol by the serving BS of the 1st UE is assumed to be expressed as a sum of the signal from the 1st UE, the interference signals  (*j*>1) from other UEs and the white noise , as    where ,  represent the *(NRx* x *NStream)* effective channel matrix between the -th UE and the serving BS of the 1st UE, containing the contribution from all receiver branches.  is the total number of UEs scheduled by their corresponding BSs in the network.  The recovered *NStream* x 1 signal vector  for the 1st UE at its serving BS is detected as follows:    where the (*NStream* x *NRx*) receiver weight matrix  is determined according to the type of PUSCH receiver, as discussed in the following sections. The detected time-domain modulating symbol, denoted as , can be obtained with a IDFT operation for .  There will be two types of PUSCH receiver, as MMSE receiver and MMSE-IRC receiver. The equalization is assumed to be performed in the frequency domain. |

* Recommended WF
  + Option 1?

**Issue 3-2-2: Interference modelling criteria**

* Proposals on interference modelling criteria:
  + Option 1: Use INR-based modelling + SNR-based requirement definition criteria and transfer the DIP value into INR value (China Telecom, Ericsson, Nokia, Intel if new profile can be agreed)
  + Option 2: DIP-based modelling (CATT, Qualcomm, CMCC, Huawei, ZTE, Intel if the LTE profile is reused)
* Proposals on DIP definition:
  + Option 1: Reuse definition of DIP in sub-clause B.6.1 of TS 36.104 (CATT)
* Proposals on SINR definition:
  + Option 1: (CATT)

|  |
| --- |
| **For BS type 1-C and BS type 1-H:**  For enhanced performance requirements type A, the SINR used in this clause is specified based on a single carrier and defined as:    Where:  is the total signal energy of one intra-cell UE in the subframe on a single *antenna connector* (for *BS type 1-C*) or on a single *TAB connector* (for *BS type 1-H*).  is the summation of the received energy of the strongest inter-cell interferers explicitly defined in a test procedure plus thewhite noise energy *N*, in a bandwidth corresponding to the transmission bandwidth over the duration of a subframe on a single *antenna connector* (for *BS type 1-C*) or on a single *TAB connector* (for *BS type 1-H*). The respective energy of each inter-cell interferer relative to  is defined by its associated DIP value.  **For BS type 1-O:**  For enhanced performance requirements type A, the SINR used in this clause is specified based on a single carrier and defined as:    Where:  is the total signal energy of one intra-cell UE in the subframe on a RIB.  is the summation of the received energy of the strongest inter-cell interferers explicitly defined in a test procedure plus thewhite noise energy *N*, in a bandwidth corresponding to the transmission bandwidth over the duration of a subframe on a RIB. The respective energy of each inter-cell interferer relative to  is defined by its associated DIP value. |

* Recommended WF
  + Encourage feedback.

**Issue 3-2-3: Interference profile**

* Proposals on interference modelling:
  + Option 1: Reuse the same interference modelling as captured in B.6.2 in TS36.104, to transmit random 16QAM symbol for the neighbour PUSCH (China Telecom, CATT, Ericsson, Huawei, Samsung)
* Samsung: FFS to derive the interference profile based on system level simulation with NR deployment for homogeneous and heterogeneous scenarios
* Proposals on interference power level:
  + Option 1: Reuse the same interference power level as in LTE, i.e., DIP -1.11dB and -10.91dB for HomNet scenario and DIP -0.43dB and -13.78dB for HetNet scenario (China Telecom, CATT, CMCC, ZTE, Nokia, Huawei for performance study)
  + Option 2: System level simulation can be performed to check the SINR and interference distribution (Intel, Huawei if performance gain is not enough, Ericsson for TDD only)
* Qualcomm: RAN4 to discuss what are the different assumptions in the Rel-19 WI in terms of deployment scenarios
* E///: Proposed system level simulation assumptions can be found in Table 2.1-1 to 2.1-3 in R4-2412319
* Intel: Deployments, CHBW, Traffic model, precoding and UE Tx power are different from LTE study
* Samsung: Open to discuss. Technical Report may be needed.
  + Option 3: Check if artificial interference profile is feasible (Ericsson)
* E///: For example, INR could take 7dB or 3dB higher than LTE to reflect PC1 or PC2 HPUE in NR.
* Recommended WF
  + Encourage feedback.

**Issue 3-2-4: Number of interferers**

* Proposals:
  + Option 1: Consider 1 interferer case for 2 Rx antenna and 2 interferers case for 4/8 Rx antenna (Ericsson)
* Recommended WF
  + Encourage feedback.

**Issue 3-2-5: Network type**

* Proposals:
  + Option 1: Only synchronous scenario (Samsung)
* Recommended WF
  + Option 1 can be confirmed since it is aligned with the objectives in the approved WID.

### Sub-topic 3-3 Test parameters and simulation assumptions

**Issue 3-3-1: Test scope**

* Proposals:
  + Option 1: Cover the following SCS and TDD patterns (China Telecom, Samsung )
* 15kHz SCS FDD and TDD with pattern 3D1S1U, S=10D:2G:2U
* 30 kHz SCS TDD with pattern 7D1S2U, S=6D:4G:4U
* Recommended WF
  + Encourage feedback.

**Issue 3-3-2: Channel bandwidth**

* Proposals for CP-OFDM:
  + Option 1: (China Telecom, CATT)
* For 15kHz SCS, cover 5MHz, 10MHz, 20MHz
* For 30kHz SCS, cover 10MHz, 20MHz, 40MHz, 100MHz
  + Option 2: 10MHz/15kHz and 40MHz/30kHz for initial simulation purpose (CMCC, Samsung)
  + Option 3: Minimum channel bandwidth for each SCS, i.e., 5MHz for 15kHz SCS and 10MHz for 30kHz (Ericsson, Huawei)
  + Option 4: Minimum/Maximum channel bandwidth for each SCS, i.e., 5/50MHz for 15kHz SCS and 10/100MHz for 30kHz (Nokia)
* Proposals for DFT-s-OFDM:
  + Option 1: (CATT)
* For 15kHz SCS, 5MHz
* For 30kHz SCS, 10MHz
* Recommended WF
  + TBA

**Issue 3-3-3: Antenna configuration**

* Proposals:
  + Option 1: Cover 2/4/8 Rx with 1Tx (China Telecom, CATT, CMCC, Ericsson, Huawei, ZTE)
  + Option 2: Consider only 4RX and 8RX gNB (Qualcomm)
  + Option 3: Cover 2/4/8 Rx with 1/2/4 Tx (Intel)
  + Option 4: Prioritize 4Rx case especially in the case of 2 explicit interferers (Nokia)
  + Option 5: Prioritize 1Tx, deprioritize 2Tx UE scenario, and not cover 4Tx UE scenario (Samsung)
* Recommended WF
  + It is recommended to cover 2/4/8 Rx for simulation evaluation purpose and further down-select if needed.
  + Need discuss whether to cover 1/2/4 Tx.

**Issue 3-3-4: Propagation condition**

* Proposals:
  + Option 1: (China Telecom)
* For the serving PUSCH, use TDLA30-10 and TDLC300-100 propagation channel model for HetNet and HomNet respectively
* Introduce new propagation channel for testing with desired delay spread 1000ns for the interference PUSCH, i.e., TDLC1000.
  + Option 2: Select among legacy TDLA30, TDLB100, TDLC300 (CATT, Ericsson, Intel, Huawei, [ZTE])
* Option 2A: (CATT)
* Cover TDLA30-10, TDLB100-400 and TDLC300-100
* Same propagation condition for serving and interference PUSCH
* Option 2B: (Ericsson)
* For the serving PUSCH, use TDLA30-10 for HetNet and TDLB100-100 for HomNet
* For the interference PUSCH, use TDLC300-100
* Option 2C: (Huawei)
* Cover TDLB100-400, TDLC300-100 and TDLA30-10 low for study purpose, select one for requirement definition
* For the interference PUSCH, use TDLC300-100
  + Option 3: FFS to differentiate the channel model used for target UE and interfered UE for performance evaluation with MMSE-IRC receiver. (Samsung)
* Recommended WF
  + Encourage feedback.

**Issue 3-3-5: MCS**

* Proposals:
  + Option 1: Cover QPSK/16QAM/64QAM (Intel, CATT, Ericsson, Huawei, [ZTE])
* Option 1A: Use MCS 5(QPSK, R=379/1024), MCS 13(16QAM, R=490/1024) and MCS 24(64QAM, R=772/1024) (CATT)
* Option 1B: MCS index 2, 12, 20 in MCS table 1 (Ericsson)
* Option 1C: Cover MCS 2, 16, 20 (Huawei)
  + Option 2: Consider MCS 16 for interfered UE, MCS 2, MCS 16 and MCS 20 as candidate for initial performance evaluation with MMSE-IRC receiver. (Samsung)
* Recommended WF
  + Encourage feedback.

**Issue 3-3-6: Waveform**

* Proposals:
  + Option 1: Cover both CP-OFDM and DFT-s-OFDM waveform (CATT)
  + Option 2: Cover CP-OFDM only (Intel, Huawei)
* Intel: FFS DFT-s-OFDM
  + Option 3: Consider CP-OFDM for initial performance evaluation (Samsung)
* Recommended WF
  + Encourage feedback.

**Issue 3-3-7: DMRS configuration**

* Proposals:
  + Option 1: (Intel)

|  |  |  |
| --- | --- | --- |
| DM-RS | DM-RS configuration type | 1 |
|  | DM-RS duration | single-symbol DM-RS |
|  | Additional DM-RS position | pos1 |
|  | Number of DM-RS CDM group(s) without data | 2 |
|  | Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB |
|  | DM-RS port(s) | 0 |
|  | DM-RS sequence generation | NID0=0, group hopping and sequence hopping are disabled |

* Recommended WF
  + Encourage feedback.

**Issue 3-3-8: PUSCH mapping type**

* Proposals:
  + Option 1: Cover both PUSCH mapping Type A and Type B. (China Telecom, Huawei)
* Recommended WF
  + Encourage feedback.

**Issue 3-3-9: Test metric**

* Proposals:
  + Option 1: Use 70% of maximum throughput as metric for NR BS MMSE-IRC demodulation (CATT)
* Recommended WF
  + Option 1?