**3GPP TSG-RAN WG4 Meeting #112 R4-24xxxxx**

**Maastricht, Netherlands, 19th Aug 2024 - 23rd Aug 2024**

**Agenda item:** 8.16.4

**Source:** China Telcom

**Title:** WF on NR demodulation performance: Phase 5

**Document for:** Approval

# Introduction

This document provides the way forward on the Rel-19 NR demodulation performance: Phase 5 WI.

# <Topic #1: UE performance requirements for 8Rx>

### Sub-topic 1-1 General

**Test scope**

* RAN4 to introduce UE demodulation requirements for both TDD and FDD
* Not to cover PDSCH absolute physical layer throughput requirements for 8Rx
* Candidate options on whether to cover CQI requirements for ICI scenario:
  + Option 1: CQI reporting requirements under ICI should be cover for 8Rx
  + Option 2: No need to cover such requirements

**8Rx UE MMSE-IRC receiver assumption**

* Interested companies are encouraged to bring simulation results to show the gap between the two types of receivers.

**Channel model**

* Only consider TDL channel model

**Test parameters for different devices with 8Rx**

* Not to define different set of requirements for different device types.

**PDSCH mapping type**

* Candidate options:
  + Option 1: Include both PDSCH type A and type B requirements.
  + Option 2: Reuse the same configuration for Rel-17 2/4Rx, i.e., PDSCH mapping type A only

### Sub-topic 1-2 PDSCH requirements with inter cell interference

**Interference modelling and power levels**

* Candidate options:
  + Option 1: Use the Intercell Interference model, specified in Clause B.6.2 of TS 38.101-4
* 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
* 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
  + Option 2: RAN4 to discuss if it is still reasonable to use 16QAM based randomly modulated data for each interfering cell

**Network Type and SCS/CBW**

* Candidate options:
  + 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)
  + Other options are not precluded

**Propagation condition**

* Candidate options:
  + 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)
  + Option 2: Consider TDLA30-10 as the starting point

**Rank**

* Candidate options:
  + Option 1: Consider higher rank for 8Rx
* Option 1A: RAN4 to investigate rank 1, 2, 4 and choose a reasonable requirement value
* Option 1B: Rank 2 and Rank 4 as the starting point
* Option 1C: Rank 2 and Rank 4 and Rank 8
* Option 1D: Rank 4
* Option 1E: Consider 2 layers, 4 layers and 6 layers
  + Option 2: Same as Rel-17 2/4Rx, i.e., Rank 1

**MCS**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., MCS 13
  + Option 2: MCS 16
  + Option 3: MCS 19 for rank 2, MCS 17 for rank 4 and 8
  + Option 4: Define different parameters for FWA, Vehicular and Industrial deployments respectively

**Antenna and MIMO correlation**

* Candidate options:
  + Option 1: 2T8R ULA low
  + Option 2: 4T8R
  + Option 3:
* 2T8R ULA medium B
* 4T8R ULA low
* 8T8R ULA low

**Other parameters**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx
  + Other options are not precluded

### Sub-topic 1-3 PDSCH requirements with intra cell inter user interference

**Receiver type**

* Only consider MMSE-IRC

**Network Type and SCS/CBW**

* Candidate options:
  + 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
  + Other options are not precluded

**Interference modelling**

* Candidate options 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
  + Option 2: Include in a new clause of Annex B.6 of TS 38.101-4
* Candidate options on co-UE number:
  + Option 1: Same as Rel-17 2/4Rx requirements, i.e., 1 target UE + 1 co-UE
  + Option 2: Consider 1 target UE and more than 1 co-UEs

**Propagation condition**

* Candidate options:
  + 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
  + Option 2: Consider TDLA30-10

**Precoding method for the co-scheduled UE**

* Candidate options:
  + 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.
  + 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

**Antenna, rank (target UE + co-scheduled UEs) configuration and MIMO correlation**

* Candidate options:
  + Option 1: 2T8R ULA low
  + Option 2: Rank 4+2 with 8T8R
  + Option 3:
* Rank 2+2 for 2T8R
* Rank 4+4 for 4T8R
* Rank 8+8 for 8T8R when 1 paired UE scheduled
  + Option 4:
* Rank 1+1 for 2T8R
* Rank 2+2 for 4T8R
* Rank 2+6 or rank 6+6 for 8T8R
  + Option 5:
* Rank 2+2+2 for 8T8R
* Rank 4+4 for 4T8R
  + Option 6:
* Rank 2+2
* Rank 4+4

**MCS**

* Candidate options for the target UE:
  + Option 1: Same as Rel-17 2/4Rx requirements for MMSE-IRC, i.e., MCS 13
  + Option 2:
* 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
  + Option 4: MCS 19 for rank 2, MCS 13 for rank 4

**Other parameters**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx for MMSE-IRC
  + Other options are not precluded

### Sub-topic 1-4 Wideband CQI reporting requirements with inter-cell interference

**CQI calculation algorithm**

* Candidate options:
  + Option 1: RAN4 to consider whether to introduce two CQI calculation assumptions to match two 8Rx receiver assumptions.
    - Baseline CQI calculation: UE perform CQI calculation with 8Rx joint processing
    - Simplified CQI calculation: UE perform CQI calculation with separate 4Rx processing

**Test metric**

* Candidate options:
  + Option 1: Reuse the same test metric for Rel-17 2/4Rx

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| 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%. |

* + Other options are not precluded

**Propagation condition**

* Candidate options:
  + 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
  + Option 2: Use AWGN static channel as the baseline, further study whether to involve fading channel

**Interference power level**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., INR = 10.04dB with rank 1
  + Other options are not precluded

**Antenna configuration and MIMO correlation for the serving cell**

* Candidate options:
  + Option 1: 2T8R ULA Low
  + Option 2: Consider 4T8R

**Rank**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx, i.e., rank 1
  + Option 2: Rank 2
  + Option 3: Rank 4

**Tested SINR value, throughput ratio** ****and BLER X%**

* Candidate options:
  + Option 1: Should be decided based on simulation results
  + Other options are not precluded

**CSI-IM and NZP CSI-RS configurations**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx
  + Other options are not precluded

**Other parameters**

* Candidate options:
  + Option 1: Reuse the same configuration for Rel-17 2/4Rx
  + Option 2: For the serving cell, reuse the setup from 8Rx CQI reporting requirement in Rel-18

### Sub-topic 1-5 Applicability rule and release independent

**Test applicability**

* Candidate options:
  + Option 1: The new requirements for 8Rx MMSE-IRC receiver should be mandatory requirements for all 8Rx UEs without additional test applicability rule
  + Option 2: Applicability rule to skip 2/4Rx requirements if 8Rx tests are passed, if same test scenarios/configurations as 2RX/4RX are defined

**Release independent**

* Candidate options:
  + Option 1: The new requirements for 8Rx should be release independent from Rel-18
  + Other options are not precluded

# <Topic #2: BS demodulation performance requirements for MMSE-IRC >

### Sub-topic 2-1 General

**MMSE-IRC Receiver assumption**

* Reuse the same receiver model for MMSE-IRC in TR36.884 as below:

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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. |

**Baseline receiver assumption (for performance gain study only)**

* MMSE receiver as defined in TR36.884:

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| 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 . |

**Test scenarios**

* Proposals:
  + Proposal 1: Cover HomNet and HetNet scenarios, i.e., DIP set1 and set2 in TS36.104
  + Proposal 2: Consider the scenario with different TDD patterns between BS and discuss how to model the corresponding interference profile

### Sub-topic 2-2 Interference modelling

**Signalling model**

* Reuse the same signalling model in TR36.884 with agnostic to the waveform

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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. |

**Interference modelling criteria**

* Candidate options on interference modelling criteria:
  + Option 1: Use INR-based modelling + SNR-based requirement definition criteria and transfer the DIP value into INR value
  + Option 2: DIP-based modelling
* Candidate options on DIP definition:
  + Option 1: Reuse definition of DIP in sub-clause B.6.1 of TS 36.104
* Candidate options on SINR definition:
  + Option 1:

|  |
| --- |
| **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. |

**Interference profile**

* Candidate options 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
  + Other options not precluded
* On interference power level:
  + Reuse the LTE interference power level as a start point, and check performance gain of MMSE-IRC over baseline MMSE.
  + It is not precluded for companies to bring system level simulation on other profiles.
  + FFS how to account for HPUE in existing LTE profiles.

**Number of interferers**

* Candidate options:
  + Option 1: Consider 1 interferer case for 2 Rx antenna and 2 interferers case for 4/8 Rx antenna
  + Other options not precluded

**Network type**

* Only synchronous scenario

### Sub-topic 2-3 Test parameters and simulation assumptions

**Test scope**

* Candidate options:
  + Option 1: Cover the following SCS and TDD patterns
* 15kHz SCS FDD and TDD with pattern 3D1S1U, S=10D:2G:2U
* 30 kHz SCS TDD with pattern 7D1S2U, S=6D:4G:4U
  + Other options not precluded

**Channel bandwidth**

* Candidate options for CP-OFDM:
  + Option 1:
* 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
  + Option 3: Minimum channel bandwidth for each SCS, i.e., 5MHz for 15kHz SCS and 10MHz for 30kHz
  + Option 4: Minimum/Maximum channel bandwidth for each SCS, i.e., 5/50MHz for 15kHz SCS and 10/100MHz for 30kHz
* Candidate options for DFT-s-OFDM:
  + Option 1:
* For 15kHz SCS, 5MHz
* For 30kHz SCS, 10MHz

**Antenna configuration**

* Candidate options:
  + Option 1: Cover 2/4/8 Rx with 1Tx
  + Option 2: Consider only 4RX and 8RX gNB
  + Option 3: Cover 2/4/8 Rx with 1/2/4 Tx
  + Option 4: Prioritize 4Rx case especially in the case of 2 explicit interferers
  + Option 5: Prioritize 1Tx

**Propagation condition**

* Candidate options:
  + Option 1:
* 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
* Option 2A:
* Cover TDLA30-10, TDLB100-400 and TDLC300-100
* Same propagation condition for serving and interference PUSCH
* Option 2B:
* For the serving PUSCH, use TDLA30-10 for HetNet and TDLB100-100 for HomNet
* For the interference PUSCH, use TDLC300-100
* Option 2C:
* Cover TDLB100-400, TDLC300-100 and TDLA30-10 low for study purpose, select one for requirement definition
* For the interference PUSCH, use TDLC300-100

**MCS**

* Candidate options:
  + Option 1: Cover QPSK/16QAM/64QAM
* Option 1A: Use MCS 5(QPSK, R=379/1024), MCS 13(16QAM, R=490/1024) and MCS 24(64QAM, R=772/1024)
* Option 1B: MCS index 2, 12, 20 in MCS table 1
* Option 1C: Cover MCS 2, 16, 20

**Waveform**

* Candidate options:
  + Option 1: Cover both CP-OFDM and DFT-s-OFDM waveform
  + Option 2: Cover CP-OFDM only

**DMRS configuration**

* Candidate options:
  + Option 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 |

* + Other options not precluded

**PUSCH mapping type**

* Candidate options:
  + Option 1: Cover both PUSCH mapping Type A and Type B
  + Other options not precluded

**Test metric**

* Candidate options:
  + Option 1: Use 70% of maximum throughput as metric for NR BS MMSE-IRC demodulation
  + Other options not precluded