**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-210XXXX**

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

**Agenda item:** 8.14.1, 8.14.2

**Source:** Moderator (China Telecom)

**Title:** Email discussion summary for [98-bis-e][323] NR\_perf\_enh2\_Demod\_Part1

**Document for:** Information

# Introduction

This email thread discusses the general and UE parts for Rel-17 demodulation performance enhancement WI in AI 8.14.1 and 8.14.2.

List of candidate target of email discussion for 1st round and 2nd round:

* 1st round: Invite companies to review the recommended WF in section 1~3, and provide comments (if any) in section 1.3, 2.3 and 3.3.
* 2nd round: TBA

# Topic #1: General

## Companies’ contributions summary

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2104951 | China Telecom | Work plan for Further enhancement on NR demodulation performance WI |
| R4-2104952 | China Telecom | TR skeleton (V0.0.1) for Inter-user interference suppression for NR Multiple-User Multiple-Input Multiple-Output (MU-MIMO) |

## Open issues summary

### Sub-topic 1-1: Work plan

**Issue 1-1: Work plan**

* Proposals
	+ Initial work plan in R4-2104951
* Recommended WF
	+ Encourage comments if any

### Sub-topic 1-2: TR skeleton

**Issue 1-2: TR skeleton**

* Proposals
	+ TR skeleton in R4-2104952: According to the approved WID, the TR skeleton (V0.0.1) is proposed to capture Phase I outcome of Inter-user interference suppression for NR MU-MIMO.
		- Note: With the new objective on LTE CRS-IM performance evaluation added at RAN #91e, the TR title in the WID would probably be updated in the June RAN #92e meeting.
* Recommended WF
	+ Encourage comments if any

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company A | Issue 1-1: Work planIssue 1-2: TR skeleton |
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## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

## Discussion on 2nd round

# Topic #2: MMSE-IRC receiver for inter-cell interference

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2104606 | CMCC | Proposal 1: Introduce the Micro-cell (victim cell) and Macro-cell (interfering cell) scenario for R17 demodulation enhancements inter-cell interference suppressing. Proposal 2: the following scenarios should be considered:* FR1, FDD sync scenario;
* FR1, FDD async scenario;
* FR1, TDD sync scenario;

Proposal 3: the following SCS and bandwidth combination should be considered:* FDD
* 10MHz/15kHz
* 50MHz/15kHz
* TDD
* 40MHz/30kHz
* 100MHz/30kHz

Proposal 4: For TDD 30kHz, use typical 7D1S2U(S=6D+4G+4U) for TDD configuration.Proposal 5: * For victim cell, first consider rank-1 transmission.
* For MIMO rank transmission probability on the interference cells, take rank-1 transmission probability 70% as the starting point.

Proposal 6:* For victim cell, take 2Tx as the baseline.
* For interference cells, consider both 4Tx and 2Tx.

Proposal 7: SSB configuration for victim cells and interference cells can be aligned. * SSB position in burst: first SSB in Slot#0
* SSB periodicity: 20ms.

Proposal 8: Use throughput vs SNR as the test metric for MMSE-IRC receiver demodulation performance requirements, and consider 70% relative throughput for the test points. |
| R4-2104846 | Apple | Observation #1: DMRS based interference covariance estimation suffers degradation when there is no interference on DMRS REs.Proposal #1: For requirements with DMRS based interference covariance estimation, limit scenarios to cases where interference can be rejected with DMRS based covariance estimation.Proposal #2: Introduce requirements with ICI for QPSK and 16QAM.Proposal #3: Further discuss interference model for NR.  |
| R4-2104953 | China Telecom | The following proposals were made w.r.t. the network scenario:Proposal 1: Cover both sync and async network scenarios for FDD, and sync network scenario for TDD.Proposal 2: For the SCS, cover at least 15kHz SCS for FDD and 30kHz SCS for TDD.Proposal 3: For the channel bandwidth, cover 10 MHz and 40 MHz channel bandwidth for FDD 15kHz SCS, 40MHz and 100MHz channel bandwidth for TDD 30kHz SCS.Proposal 4: Consider two TDD configurations for 30kHz SCS:* Configuration 1: 7D1S2U, S = 6D:4G:4U
* Configuration 2: DDDSUDDSUU, S1=10G: 2G: 2U, S2 = 10G: 2G: 2U

Proposal 5: Only consider PDSCH to PDSCH interference. Use symbols #0 and #1 of each slot for control channel in all the considered cells.The following observation and proposals were made w.r.t. the reference receiver:Observation 1: It is unknown whether the precoding matrix in any two contiguous PRBs in the neighboring/interfering cell(s) is the same.Proposal 6: The estimation of interference covariance matrix can be performed at per PRB and per slot basis.Proposal 7: Reuse the interference profiles for LTE MMSE-IRC receiver, i.e., assume target geometry of -2.5dB, use DIP1/2= -1.73/-8.66 dB for synchronous network, and use DIP1/2= -2.23/-8.06 dB for asynchronous network.Proposal 8: The number of explicit interferers can be 2 or 1 for different tests, by considering the tradeoff between test complexity and the gain of MMSE-IRC over MMSE receiver.Proposal 9: Assume 70% and 30% probability for rank 1 and rank 2 transmission in the interfering cell(s).Proposal 10: For the interferers, assume random precoding per slot and per PRB bundling granularity, with PRB bundling size of 2.Proposal 11: Assume 16QAM randomly modulated symbols in the interfering PDSCH.The following proposals were made w.r.t. the target PDSCH parameters:Proposal 12: Use rank 1 for target PDSCH.Proposal 13: As baseline, choose MCS for which the resulting geometry value falls in the range ~[-2.5dB, 0dB] with typical margin considered.Proposal 14: For the precoding model of target PDSCH, further discuss whether to use random precoding or follow PMI.Proposal 15: For the throughput test point, use 70% of max TP as baseline.Proposal 16: Re-use the Rel-15 assumptions on HARQ process number, i.e., 4 for FDD 15kHz SCS and 8 for TDD 30kHz SCS.The following proposals were made w.r.t. the common parameters for target and interfering PDSCH:Proposal 17: For the antenna configuration, use 2Tx as baseline, and cover both 2Rx and 4Rx.Proposal 18: For the propagation condition, include both TDLA30-10 and TDLC300-100 at this early phase, and decide whether down-selection is needed later. Use ULA low for the antenna correlation.Proposal 19: In both target and interfering PDSCH, assume PDSCH mapping type A with full PRB allocation, use DMRS Type 1 with single symbol front loaded and 1 additional DMRS, with FDM applied between DMRS and data.Proposal 20: For SSB in both target and interfering cells, reuse the Rel-15 assumptions , i.e., configure the first SSB in slot #0 in every 20 slots, and the slot #0 in every 20 slots is not scheduled for PDSCH transmission.Proposal 21: Use Physical cell ID of 0 for the serving cell, and cell ID 1 and 2 for the two interfering cellsProposal 22: Further discuss whether TRS/CSI-RS are collided among cells, as well as whether DMRS and TRS/CSI-RS are collided among cells.The following observation and proposals were made w.r.t. the CQI reporting requirements:Observation 2: Two categories of scenarios can be considered for further discussion on CQI reporting requirement:* A) Interference is precoded as data, i.e., in serving cell’s NZP CSI-RS REs, DMRS and/or data is transmitted in interfering cell. For these scenarios, MMSE-IRC based CQI calculation is beneficial for the PDSCH performance.
* B) Interference is not precoded as data, i.e., in serving cell’s NZP CSI-RS REs, NZP CSI-RS or ZP CSI-RS is transmitted in interfering cell. For these scenarios, check the performance benefits brought by MMSE-IRC based CQI calculation over MMSE based CQI calculation if needed.

Proposal 23: For MMSE-IRC based CQI reporting, the interference covariance can be estimated and averaged among multiple PRBs, and the exact PRB number for interference covariance averaging needs further discussion.Proposal 24: As the starting point, model one inter-cell interferer with DIP of -0.41dB and static propagation condition.Proposal 25: Reuse the LTE test metric as a starting point, which include: 1) the relative increase of the throughput obtained when the transport format is that indicated by the reported CQI subject to an interference model compared to the case with a white Gaussian noise model, and 2) when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified DIP, the average BLER for the indicated transport formats shall be greater than or equal to 2%. |
| R4-2104977 | NTT DOCOMO, INC. | Proposal 1: For MMSE-IRC receiver for inter-cell interference test, the following test parameters are applied;

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| Parameters | Value |
| Duplex mode/SCS | FDD 15kHz, TDD 30kHz |
| Channel Bandwidth | FDD 10MHz, TDD 40MHz |
| TDD pattern | 7D1S2U (S= 6D:4G:4U) |
| Antenna configuration | 2x2, 2x4 |
| PDSCH mapping | Type A, Start symbol 2, Duration 12 |
| PDCCH allocation | Symbol 0,1 |
| Test metric | SNR @70% of maximum throughput |

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| R4-2106426 | Intel Corporation | Proposal 1: Define CQI reporting requirements for MMSE-IRC receiver for scenario with inter-cell interference.Proposal 2: Use the following LTE NAICS assumptions for interference modelling for initial alignment of NR MMSE-IRC performance: * Explicit modelling of 2 interference cells with INRs 13.91 and 3.34 dB or 7.77 and 2.29 dB
* Interference signal is transmitted in each slot with 16QAM randomly modulated symbols and with random rank (Rank 1 – 80% and Rank 2 – 20 %)

Proposal 3: Analyse the SINR and INRs distributions for “Urban macro” NR scenarios using methodology from TR 36.866 and system level assumptions from TR 38.913 and 38.901.Proposal 4: Consider the following simulation assumptions for Scenario 1 requirements: * SCS/CBW: 15 kHz / 10 MHz for FDD and 30 kHz / 40 MHz for TDD
* TDD pattern: 7D1S2U, S = 6D+4G+4U
* PDSCH configuration for serving and interference cells
	+ Type A PDSCH mapping with starting symbol 2 and duration 12
	+ DMRS Type 1 with 1 additional RS
	+ Number of PDSCH DMRS CDM group(s) without data = 1
* Serving PDSCH Rank 1, MCS 5 or 13 or 19.
* Channel model: TDL-A, 30 ns, 10 Hz
* Antenna configuration: 2x2 and 2x4 with ULA Low correlation
* Receiver assumptions: MMSE-IRC with DMRS based covariance matrix estimation and without time selective interference handling

Proposal 5: Consider the following simulation assumptions for Scenario 2 requirements: * SCS/CBW: 15 kHz / 10 MHz for FDD and 30 kHz / 40 MHz for TDD
* TDD pattern: 7D1S2U, S = 6D+4G+4U
* PDSCH configuration for serving cell
	+ Type A PDSCH mapping with starting symbol 2 and duration 12
	+ DMRS Type 1 with 1 additional RS
	+ Number of PDSCH DMRS CDM group(s) without data = 1
	+ RMC: Rank 1, MCS 5 or 13 or 19.
* PDSCH configuration for interference cells
	+ Option 1: Type A PDSCH mapping with starting symbol 2 and duration 5 for both cells
	+ Option 2:
		- Type A PDSCH mapping with starting symbol 2 and duration 5 for cell #1
		- Type B PDSCH mapping with starting symbol 7 and duration 7 for cell #2
	+ Option 3: Type B PDSCH mapping with starting symbol 4 and duration 7 for both cells
* Channel model: TDL-A, 30 ns, 10 Hz
* Antenna configuration: 2x2 and 2x4 with ULA Low correlation
* Receiver assumptions:
	+ Option 1: MMSE-IRC with DMRS based covariance matrix estimation and without time selective interference handling
	+ Option 2: MMSE-IRC with DMRS based covariance matrix estimation and with time selective interference handling
	+ Option 3: MMSE-IRC with DMRS and Data based covariance matrix estimation

Observation #1: MMSE-IRC allows to achieve ~3.5 dB performance benefits in comparison to MMSE-MRC for Scenario 1 with considered simulation assumptionsObservation #2: MMSE-IRC allows to achieve ~3-4 dB performance benefits in comparison to MMSE-MRC for Scenario 2-1 and 2-2 with considered simulation assumptions.Observation #3: No MMSE-IRC performance benefits in comparison to MMSE-MRC are observed for Scenario 2-3.Observation #4: MMSE-IRC processing with time selective interference handling allows to achieve additional ~1-2 dB performance benefits in comparisons to basic MMSE-IRC processing for Scenario 2-1 and 2-2 with considered simulation assumptions.Observation #5: MMSE-IRC processing with time selective interference handling allows to achieve additional ~6-8 dB performance benefits in comparison to MMSE-MRC or basic MMSE-IRC processing for Scenario 2-3 with considered simulation assumptions. |
| R4-2106833 | Huawei, HiSilicon | Proposal 1: We propose the following configurations for PDSCH and DMRS:* PDSCH configuration for serving cell and neighboring cell:
* PDSCH Mapping Type: Type A
* Starting symbol: 2
* Length: 12
* PDSCH DMRS configuration for serving cell and neighboring cell:
* DMRS Type: Type 1
* Number of additional DMRS: 1
* Scheduling with data multiplexed on the DMRS symbols

Proposal 2: We propose to define the requirements for 15 kHz/10 MHz for FDD and 30 kHz/40 MHz for TDD.Proposal 3: We propose to use DIP ratio to define the interference profiles.Proposal 4: We propose to consider two neighbour cells as the interference cells.Proposal 5: We propose to use TDLA30-10 as the propagation condition.Proposal 6: We propose to use 16QAM as the target MCS for inter-cell MMSE IRC requirements.Proposal 7: We propose to further discuss whether to introduce the corresponding CQI reporting test. |
| R4-2106867 | Ericsson | Proposal 1: RAN4 should agree with the inter-cell interference model before discussing the detailed simulation assumption for inter-cell interference scenario.Proposal 2: RAN4 defines the interference modes for NR performance enhanced requirements as follows, by reusing LTE interference model. Some values in [] in the texts below may be discussed further.

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| This subclause provides interference modelling for each explicitly modelled interfering cell in the requirement scenario. In each slot, each interfering cell shall transmit randomly modulated data over the entire PDSCH region and the full transmission bandwidth according to the probabilities of occurrence. Transmitted physical channels shall include SS/PBCH block. Probabilities of occurrence in each slot are as specified in the requirement scenario. If the probabilities of occurrence in each slot are not specified in the requirement scenario, as default, they are equal to 1.For each slot and each [smallest] subband as defined in subclause 5.2.1.4 of TS38.214, a transmission rank shall be randomly determined independently from other subbands as well as other interfering cells. Probabilities of occurrence of each possible transmission rank are as specified in the requirement scenario.For each slot and each subband, a precoding matrix for the number of layers v associated to the selected rank shall be selected randomly from [single panel type I].The generic beamforming model in subclause B.4 shall be applied assuming DM-RS and CSI reference signals as specified in the requirement scenario. Random precoding with selected rank and precoding matrices for each slot and each subband shall be applied to [16QAM] randomly modulated layer symbols including the DM-RS over antenna port [1000] when the rank is one and antenna ports [1000/1001] when the rank is two.For unallocated REs in the CORESET region, precoding of randomly selected from single panel type I, per slot with equal probability of each applicable i1, i2 combination, and with REG bundling granularity for number of Tx larger than 1, shall be applied to QPSK randomly modulated layer symbols. |

Proposal 3: Neighboring cell(s) schedule SSB at the same location as the serving cell.Proposal 4: Neighboring cell(s) schedule CSI reference signals (for both tracking and CSI acquisition) at the same location as the serving cell.Proposal 5: RAN4 use the dominant interference proportion (DIP) to specify the received signal powers from interfering cells:

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| $$DIP\_{i}=\frac{\hat{I}\_{or\left(i+1\right)}}{N\_{oc}^{'}}$$Where  $\hat{i}\_{or(i+1)}$ is the average received power spectral density from the i-th strongest interfering cell involved in the requirement scenario and $N\_{oc}^{'}=\sum\_{j=2}^{N}\hat{i}\_{oc(j)}+N\_{oc}$, where $N\_{oc}$ is the average power spectral density of a white noise source consistent with the definition provided in TS38.101-4 subclause 4.4.3, and $N$ is the total number of cells involved in a given requirement scenario. Note  $\hat{i}\_{or(1)}$ is assumed to be the power spectral density associated with the serving cell.  |

Proposal 6: RAN4 specify the NR UE demodulation requirements for MMSE-IRC suppressing the inter-cell interference with regard to SINR to achieve 70% of maximum throughput. Proposal 7: Define SINR (for FR1) as follows, and capture it in TS38.101-4 Clause 4.4.2.

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| $$SINR=\frac{\sum\_{j=1}^{N\_{RX}}E\_{s}^{\left(j\right)}}{\sum\_{j=1}^{N\_{RX}}N'\_{oc}^{\left(j\right)}} $$Where $E\_{s}^{(j)}$ is the averaged received energy per Hz of the wanted signal during the useful part of the symbol, i.e. excluding the cyclic prefix, at the j-th UE receiver antenna connector ; average power is computed within a set of REs used for the transmission of physical, divided transmission bandwidth within the set.And $N\_{oc}^{'(j)}$ is the power spectral density (average power per RE normalised to the subcarrier spacing) of the summation of the received power spectral densities of the strongest interfering cells explicitly defined in a test procedure plus $N\_{oc}^{(j)}$, as measured at the j-th UE receiver antenna connector. The respective power spectral density of each interfering cell relative to $N\_{oc}^{(j)}$ is defined by its associated DIP value, or the respective power spectral density of each interfering cell relative to $N\_{oc}^{(j)}$ is defined by its associated Es/Noc value.  |

Proposal 8: RAN4 should study first the MMSE-IRC receiver performance with interfering cell(s) whether it shows the gain compared with the case without neighboring interfering cell(s), i.e., AWGN-only scenario.Proposal 9: Use Rel-11 LTE DIP settings as the starting point, i.e., (DIP Cell 2, DIP Cell 3) = (-2.23, -8.06), (-2.23, -Inf), (-1.73, -8.66), (-1.73, -Inf). Proposal 10: In Rel-17, MMSE-IRC receiver performance requirements with interference cell condition is defined only for single carrier scenario.Proposal 11: For the Rel-17 MMSE-IRC receiver performance evaluation, RAN4 should assume the following parameters as the starting point:

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| Parameters | FDD | TDD |
| CBW | 10MHz (single carrier only) | 40MHz (single carrier only) |
| TDD configuration | N/A | 7DS2U,S=6D+4G+4USchedule PDSCH in special slots |
| SCS | 15kHz | 30kHz |
| PDSCH configuration | Type A, Start symbol 2, Duration 12​ | Type A, Start symbol 2, Duration 12​ |
| PRB bundling size  | 2 | 2 |
| PDSCH DMRS configuration | Type 1, 1+1 | Type 1, 1+1 |
| MCS | MCS 4 (QPSK, CR=0.3)MCS 13 (16QAM, CR=0.5) | MCS 4 (QPSK, CR=0.3)MCS 13 (16QAM, CR=0.5) |
| Rank | 1 | 1 |
| PDSCH precoder | Single Panel Type I, Random precoder selection updated per slot,with equal probability of each applicable i1, i2 combination, and with PRB bundling granularity | Single Panel Type I, Random precoder selection updated per slot,with equal probability of each applicable i1, i2 combination, and with PRB bundling granularity |
| Antenna configuration | 2x2, 2x4 | 2x2, 2x4 |
| Propagation condition | TDLA30-10TDLC300-100 | TDLA30-10TDLC300-100 |
| DIP | (DIP1, DIP2) = (-2.23, -8.06)(DIP1, DIP2) = (-2.23, -Inf)(DIP1, DIP2) = (-1.73, -8.66)(DIP1, DIP2) = (-1.73, -Inf) | (DIP1, DIP2) = (-2.23, -8.06)(DIP1, DIP2) = (-2.23, -Inf)(DIP1, DIP2) = (-1.73, -8.66)(DIP1, DIP2) = (-1.73, -Inf) |
| Time Offset relative to serving cell | 0 us | 0 us |
| Metric  | SINR to achieve 70% of maximum throughput | SINR to achieve 70% of maximum throughput |

Proposal 12: RAN4 defines the CSI reporting tests with neighboring cell(s) interference condition. Proposal 13: RAN4 discuss whether the UE demodulation and CQI reporting requirements with inter-cell interference is released independent from Rel-15 or not, after RAN4 agree with the detailed simulation assumption. |
| R4-2107093 | MediaTek inc. | Proposal 1: Determine the number of interferers and the corresponding interference profiles first.Proposal 2: Regarding CQI report, discuss the assumption of interference for DM-RS and PDSCH first.  |

## Open issues summary

**Note:** The issues in sub-topic 2-1 to 2-5 are for scenario 1 with slot-based transmission and aligned SCS among cells.

### Sub-topic 2-1: Interference model for scenario 1

**Issue 2-1-1: Sync and async network for FR1**

* Proposals
	+ Option 1: (CMCC, China Telecom)
		- FDD sync scenario
		- FDD async scenario
		- TDD sync scenario
	+ Option 2: FDD and TDD sync scenario (E///)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-1-2: Interference profile**

* Proposals
	+ Option 1: Reuse the DIP based interference profiles from LTE MMSE-IRC receiver (China Telecom, Huawei, E///, [MediaTek])
		- China Telecom:
			* Assume target geometry of -2.5dB, use DIP1/2= -1.73/-8.66 dB for synchronous network, and use DIP1/2= -2.23/-8.06 dB for asynchronous network.
			* The number of explicit interferers can be 2 or 1 for different tests, by considering the tradeoff between test complexity and the gain of MMSE-IRC over MMSE receiver.
		- HW: Consider two neighbour cells as the interference cells
		- E///: Use Rel-11 LTE DIP settings as the starting point, i.e., (DIP Cell 2, DIP Cell 3) = (-2.23, -8.06), (-2.23, -Inf), (-1.73, -8.66), (-1.73, -Inf).
	+ Option 2: In addition to the Macro cell scenario considered for LTE MMSE-IRC receiver, introduce the Micro-cell (victim cell) and Macro-cell (interfering cell) scenario (CMCC)
		- CMCC: we observe the interference in realistic deployment
	+ Option 3: (Intel)
		- Use the following LTE NAICS assumptions for interference modelling for initial alignment of NR MMSE-IRC performance
			* Explicit modelling of 2 interference cells with INRs 13.91 and 3.34 dB or 7.77 and 2.29 dB
		- Analyse the SINR and INRs distributions for “Urban macro” NR scenarios using methodology from TR 36.866 and system level assumptions from TR 38.913 and 38.901.
* Recommended WF
	+ Encourage more discussion

**Issue 2-1-3: Transmission rank of interfering PDSCH**

* Proposals
	+ Option 1: Reuse LTE MMSE-IRC assumption for DMRS-based transmission mode, i.e., random rank with 70% and 30% probability for rank 1 and rank 2 transmission in the interfering cell(s), as the starting point (CMCC, China Telecom)
	+ Option 2: Reuse LTE NAICS assumption, i.e., random rank with 80% and 20% probability for rank 1 and rank 2 transmission in the interfering cell(s) (Intel)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-1-4: Precoding of interfering PDSCH**

* Proposals
	+ Option 1: Random precoding (China Telecom, Ericsson)
		- Option 1A: Random precoding per slot and per PRB bundling granularity, with PRB bundling size of 2 (China Telecom)
		- Option 1B: Random precoding per slot and per [smallest] subband as defined in subclause 5.2.1.4 of TS38.214; [single panel type I] codebook (Ericsson)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-1-5: Modulation order of interfering PDSCH**

* Proposals
	+ Option 1: Reuse LTE assumption for MMSE-IRC receiver, i.e., 16QAM randomly modulated symbols (China Telecom, [E///], Intel)
* Recommended WF
	+ Encourage feedback from more companies

### Sub-topic 2-2: DMRS configuration and reference receiver for scenario 1

**Issue 2-2-1: DMRS configuration**

* Proposals
	+ Option 1: limit scenarios to cases where interference can be rejected with DMRS based covariance estimation. (Apple)
		- Apple: DMRS based interference covariance estimation suffers degradation when there is no interference on DMRS REs.
	+ Option 2: 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 (China Telecom, Intel, Huawei)
	+ Option 3: DMRS Type 1 with single symbol front loaded and 1 additional DMRS (E///)
* Recommended WF
	+ Encourage more discussion

**Issue 2-2-2: Interference covariance estimation granularity**

* Proposals
	+ Option 1: The estimation of interference covariance matrix can be performed at per PRB and per slot basis (China Telecom, Intel)
		- China Telecom: It is unknown whether the precoding matrix in any two contiguous PRBs in the neighboring/interfering cell(s) is the same.
* Recommended WF
	+ Encourage feedback from more companies

### Sub-topic 2-3: Target PDSCH parameters for scenario 1

**Issue 2-3-1: Transmission rank**

* Proposals
	+ Option 1: rank 1 (CMCC, China Telecom, Intel, E///)
* Recommended WF
	+ Use rank 1 as baseline

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

* Proposals
	+ Option 1: QPSK and 16QAM (Apple, E///)
		- Option 1A: MCS 4 (QPSK, CR=0.3), MCS 13 (16QAM, CR=0.5) (E///)
	+ Option 2: choose MCS for which the resulting geometry value falls in the range ~[-2.5dB, 0dB] with typical margin considered (China Telecom)
	+ Option 3: MCS 5 or 13 or 19 (Intel)
	+ Option 4: 16QAM (HW)
* Recommended WF
	+ Encourage more discussion

**Issue 2-3-3: Precoding model**

* Proposals
	+ Option 1: Further discuss whether to use random precoding or follow PMI (China Telecom)
	+ Option 2: Single Panel Type I, Random precoder selection (E///)
* Recommended WF
	+ Encourage more discussion

**Issue 2-3-4: PRB bundle size**

* Proposals
	+ Option 1: 2 (E///)
* Recommended WF
	+ Encourage more discussion

**Issue 2-3-5: Performance measurement point**

* Proposals
	+ Option 1: 70% relative throughput(CMCC, China Telecom, DCM, E///)
		- Option 1A: S**I**NR (not SNR) at 70% TP (E///)
* Recommended WF
	+ Use Option 1 + Option 1A as baseline

**Issue 2-3-6: HARQ process number**

* Proposals
	+ Option 1: Re-use the Rel-15 assumptions on HARQ process number, i.e., 4 for FDD 15kHz SCS and 8 for TDD 30kHz SCS (China Telecom)
* Recommended WF
	+ Use Option 1 as baseline

### Sub-topic 2-4: Other parameters for target and interfering PDSCH for scenario 1

**Issue 2-4-1: SCS**

* Proposals
	+ Option 1: FDD 15kHz, TDD 30kHz (CMCC, China Telecom, DCM, Intel, Huawei, E///)
* Recommended WF
	+ Agree Option 1

**Issue 2-4-2: Channel bandwidth**

* Proposals
	+ Option 1 (CMCC)
		- FDD 15kHz: 10MHz, 50MHz
		- TDD 30kHz: 40MHz, 100MHz
			* CMCC: We also support to consider the maximum bandwidth for FDD and TDD, which is 50MHz for FDD and 100MHz for TDD.
	+ Option 2 (China Telecom)
		- FDD 15kHz: 10MHz, 40MHz
		- TDD 30kHz: 40MHz, 100MHz
	+ Option 3 (DCM, Intel, Huawei, E///)
		- FDD 15kHz: 10MHz
		- TDD 30kHz: 40MHz
* Recommended WF
	+ Encourage more discussion

**Issue 2-4-3: TDD DL/UL configuration for 30kHz SCS**

* Proposals
	+ Option 1: 7D1S2U(S=6D+4G+4U) (CMCC, DCM, Intel)
	+ Option 2: Consider two TDD configurations(China Telecom)
		- Configuration 1: 7D1S2U, S = 6D:4G:4U
		- Configuration 2: DDDSUDDSUU, S1=10G: 2G: 2U, S2 = 10G: 2G: 2U
* Recommended WF
	+ Encourage more discussion

**Issue 2-4-4: Number of carriers**

* Proposals
	+ Option 1: In Rel-17, MMSE-IRC receiver performance requirements with interference cell condition is defined only for single carrier scenario. (E///)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-4-5: PDCCH and PDSCH allocation**

* Proposals
	+ Option 1: for serving and interfering cells (China Telecom, Intel, DCM, Huawei, E///)
		- Use symbols #0 and #1 of each slot for PDCCH
		- PDSCH Start symbol 2, Duration 12
* Recommended WF
	+ Agree Option 1

**Issue 2-4-6: Tx antenna number**

* Proposals
	+ Option 1: 2Tx as baseline for serving cell, both 4Tx and 2Tx for interfering cells (CMCC)
	+ Option 2: 2Tx as baseline for serving cell and interfering cells (China Telecom, DCM, Intel, E///)
* Recommended WF
	+ Encourage more discussion

**Issue 2-4-7: Propagation condition**

* Proposals
	+ Option 1: Include both TDLA30-10 and TDLC300-100 at this early phase (China Telecom, E///)
	+ Option 2: TDLA30-10 (Intel, HW)
* Recommended WF
	+ Encourage more discussion

**Issue 2-4-8: Antenna correlation**

* Proposals
	+ Option 1: ULA low (China Telecom, Intel)
* Recommended WF
	+ Can we use Option 1 as baseline?

**Issue 2-4-9: PDSCH mapping type**

* Proposals
	+ Option 1: PDSCH mapping type A for serving and interfering PDSCH (China Telecom, DCM, Huawei)
* Recommended WF
	+ Can we agree Option 1?

**Issue 2-4-10: PRB allocation**

* Proposals
	+ Option 1: Full PRB allocation for serving and interfering PDSCH (China Telecom)
* Recommended WF
	+ Can we agree Option 1?

**Issue 2-4-11: SSB configuration for serving and interfering cells**

* Proposals
	+ Option 1: Aligned SSB configuration for serving and interference cells(CMCC, China Telecom, E///)
		- Option 1A: (CMCC, China Telecom)
			* SSB position in burst: first SSB in Slot#0; SSB periodicity: 20ms.
			* The slot #0 in every 20 ms is not scheduled for PDSCH transmission
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-4-12: Physical cell ID**

* Proposals
	+ Option 1: Physical cell ID of 0 for the serving cell, and cell ID 1 and 2 for the two interfering cells (China Telecom)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-4-13: TRS/CSI-RS among cells**

* Proposals
	+ Option 1: Further discuss whether TRS/CSI-RS are collided among cells (China Telecom)
	+ Option 2: Neighboring cell(s) schedule CSI reference signals (for both tracking and CSI acquisition) at the same location as the serving cell (E///)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-4-14: DMRS and TRS/CSI-RS among cells**

* Proposals
	+ Option 1: Further discuss whether DMRS and TRS/CSI-RS are collided among cells (China Telecom)
* Recommended WF
	+ Encourage feedback from more companies

### Sub-topic 2-5: CQI reporting requirements for scenario 1

**Issue 2-5-1: Whether to define CQI reporting requirements**

* Proposals
	+ Option 1: Yes (China Telecom, Intel, E///)
	+ Option 2: Further discuss (Huawei, MediaTek)
		- MediaTek: Enhancement on CQI can be considered only if network can guarantee same interference is experienced by CSI-RS and PDSCH.
* Recommended WF
	+ Encourage more discussion

**Issue 2-5-2: Interference covariance estimation granularity for CQI reporting**

* Proposals
	+ Option 1: the interference covariance can be estimated and averaged among multiple PRBs, and the exact PRB number for interference covariance averaging needs further discussion (China Telecom)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-5-3: Interference model for CQI reporting**

* Proposals
	+ Option 1: As the starting point, model one inter-cell interferer with DIP of -0.41dB and static propagation condition (China Telecom)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 2-5-4: Test metric for CQI reporting**

* Proposals
	+ Option 1: Reuse the LTE test metric as a starting point, which include (China Telecom)
		- 1) the relative increase of the throughput obtained when the transport format is that indicated by the reported CQI subject to an interference model compared to the case with a white Gaussian noise model, and
		- 2) when transmitting the transport format indicated by each reported wideband CQI index subject to an interference source with specified DIP, the average BLER for the indicated transport formats shall be greater than or equal to 2%.
* Recommended WF
	+ Encourage feedback from more companies

### Sub-topic 2-6: Scenario 2 with non-slot-based transmission

**Issue 2-6-1: Test parameters**

* Proposals
	+ Option 1 (Intel)
		- SCS/CBW: 15 kHz / 10 MHz for FDD and 30 kHz / 40 MHz for TDD
		- TDD pattern: 7D1S2U, S = 6D+4G+4U
		- PDSCH configuration for serving cell
			* Type A PDSCH mapping with starting symbol 2 and duration 12
			* DMRS Type 1 with 1 additional RS
			* Number of PDSCH DMRS CDM group(s) without data = 1
			* RMC: Rank 1, MCS 5 or 13 or 19.
		- PDSCH configuration for interference cells
			* Option 1: Type A PDSCH mapping with starting symbol 2 and duration 5 for both cells
			* Option 2:
		- Type A PDSCH mapping with starting symbol 2 and duration 5 for cell #1
		- Type B PDSCH mapping with starting symbol 7 and duration 7 for cell #2
			* Option 3: Type B PDSCH mapping with starting symbol 4 and duration 7 for both cells
		- Channel model: TDL-A, 30 ns, 10 Hz
		- Antenna configuration: 2x2 and 2x4 with ULA Low correlation
		- Receiver assumptions:
			* Option 1: MMSE-IRC with DMRS based covariance matrix estimation and without time selective interference handling
			* Option 2: MMSE-IRC with DMRS based covariance matrix estimation and with time selective interference handling
			* Option 3: MMSE-IRC with DMRS and Data based covariance matrix estimation
* Recommended WF
	+ Encourage feedback from more companies

### Sub-topic 2-7: Release independence

**Issue 2-7-1: Release independence**

* Proposals
	+ Option 1: RAN4 discuss whether the UE demodulation and CQI reporting requirements with inter-cell interference is released independent from Rel-15 or not, after RAN4 agree with the detailed simulation assumption (E///)
* Recommended WF
	+ Encourage feedback from more companies

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company A | Sub-topic 2-1: Interference modelIssue 2-1-1: Sync and async network for FR1Issue 2-1-2: Interference profileIssue 2-1-3: Transmission rank of interfering PDSCHIssue 2-1-4: Precoding of interfering PDSCHIssue 2-1-5: Modulation order of interfering PDSCHSub-topic 2-2: DMRS configuration and reference receiverIssue 2-2-1: DMRS configurationIssue 2-2-2: Interference covariance estimation granularitySub-topic 2-3: Target PDSCH parametersIssue 2-3-1: Transmission rank Issue 2-3-2: MCS Issue 2-3-3: Precoding model Issue 2-3-4: PRB bundle size Issue 2-3-5: Performance measurement point Issue 2-3-6: HARQ process numberSub-topic 2-4: Other parameters for target and interfering PDSCHIssue 2-4-1: SCSIssue 2-4-2: Channel bandwidthIssue 2-4-3: TDD DL/UL configuration for 30kHz SCSIssue 2-4-4: Number of carriers Issue 2-4-5: PDCCH and PDSCH allocationIssue 2-4-6: Tx antenna numberIssue 2-4-7: Propagation conditionIssue 2-4-8: Antenna correlationIssue 2-4-9: PDSCH mapping typeIssue 2-4-10: PRB allocationIssue 2-4-11: SSB configuration for serving and interfering cellsIssue 2-4-12: Physical cell IDIssue 2-4-13: TRS/CSI-RS among cellsIssue 2-4-14: DMRS and TRS/CSI-RS among cellsSub-topic 2-5: CQI reporting requirementsIssue 2-5-1: Whether to define CQI reporting requirementsIssue 2-5-2: Interference covariance estimation granularity for CQI reportingIssue 2-5-3: Interference model for CQI reportingIssue 2-5-4: Test metric for CQI reportingSub-topic 2-6: Scenario 2 with non-slot-based transmissionIssue 2-6-1: Test parametersSub-topic 2-7: Release independenceIssue 2-7-1: Release independence |
| Company B |  |
|  |  |
|  |  |
|  |  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

## Discussion on 2nd round

1. MMSE-IRC receiver for intra-cell inter-user interference

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2104607 | CMCC | Proposal 1: the following SCS and bandwidth combination should be considered:* FDD
	+ 10MHz/15kHz
	+ 50MHz/15kHz
* TDD
* 40MHz/30kHz
* 100MHz/30kHz

Proposal 2: For TDD 30kHz, use typical 7D1S2U(S=6D+4G+4U) for TDD configuration.Proposal 3: For Tx antenna number, we propose to consider 8 and 16 Tx antenna number.Proposal 4: For MIMO correlation, include XP High and XP Medium in this phase.Proposal 5: * For FDD, the number of HARQ processes set to 4;
* For TDD, the number of HARQ processes set to 8;

Proposal 6: For propagation channel, TDLA30-10 can be the baseline.Proposal 7: * SSB position in burst: first SSB in Slot#0
* SSB periodicity: 20ms.

Proposal 8: For the number of paired UEs, we propose to consider 1, 2, 3 paired UEs.Proposal 9: For Rank configuration, at least include Rank1 and further evaluate Rank2 in this phase.Proposal 10: * Target PDSCH MCS configuration:
	+ QPSK/0.30, 16QAM/0.48 and 64QAM/0.5 for Rank 1
	+ 64QAM for Rank 2
* Interference PDSCH MCS configuration
	+ 16QAM/0.48 as the baseline

Proposal 11: Use target UE’s throughput vs SNR as the test metric for MMSE-IRC receiver demodulation performance requirements, and consider 70% relative throughput for the test points. |
| R4-2104847 | Apple Inc. | Proposal #1: Transmit co-scheduled UE on different CDM group as target UE.Proposal #2: Use number of CDM groups without data on target UE as 2.Observation #1: ZF precoder is effective in nulling inter-user interference when UE reported PMI or actual channel is used rather than random PMI.Observation #2: 1.5 - 3dB performance improvement is observed with QRD orthogonalization over ZF precoding with randomly generated PMI.Proposal #3: Use QRD orthogonalization to generate precoders for MU-MIMO.Proposal #4: The total number of layers transmitted shall be less than or equal to the number of UE RX antenna.Proposal #5: Limit the study and evaluation for MU-MIMO to up to 16QAM for 2x2 and up to 64QAM for 4x4.Proposal #6: For 4x4 limit the layers combinations to [1,1], [1,2], [2,1] on target and co-scheduled UE respectively. |
| R4-2106427 | Intel Corporation | Proposal 1: Consider the following assumptions for MU-MIMO modelling:Explicit modelling of PDSCH+DMRS signal for one interference UERandom or feedback-based precoder selection of serving UESelection of precoder for interference UE to ensure orthogonality of serving and interference precodersRandom PDSCH signal generation for interference UE with 16QAM modulationProposal 2: Consider the following simulation assumptions for MMSE-IRC requirements for scenario with intra-cell inter-user interference:SCS/CBW: 15 kHz / 10 MHz for FDD and 30 kHz / 40 MHz for TDDType A PDSCH mapping with starting symbol 2 and duration 12Serving PDSCH Rank 1 or Rank 2, MCS 5 or 12 or 19Interference PDSCH Rank is same as for Serving PDSCHDMRS Type 1 with 1 additional RSDMRS AP mapping:Rank 1 – Option 1: Number of CDM groups without data is equal to 1, UE #1 uses AP 1000, UE #2 uses AP 1001.Rank 1 – Option 2: Number of CDM groups without data is equal to 2, UE #1 uses AP 1000, UE #2 uses AP 1002.Rank 2: Number of CDM groups without data is equal to 2, UE #1 uses APs 1000 and 1001, UE #2 uses AP 1002 and 1003.TDD pattern: 7D1S2U, S = 6D+4G+4UChannel model: TDL-A, 30 ns, 10 HzAntenna configuration: 2x2 or 4x2 and 2x4 or 4x4Candidate receivers:Option 1: MMSE-IRC processing with serving signal demodulationOption 2: MMSE-IRC processing with joint (serving + interference) signal demodulationObservation #1: MMSE-IRC does not allow to improve MU-MIMO performance for scenarios with QPSK modulation.Observation #2: MMSE-MRC cannot reach maximum throughput for scenarios with 16QAM modulation.Observation #3: Using of MMSE-IRC processing with interference-plus-noise covariance matrix estimation based on active serving DMRS positions leads to significant performance degradation for scenarios with 2 DMRS CDM groups. |
| R4-2104954 | China Telecom | Proposal 1: Cover 8Tx and 16 Tx antenna ports, 2Rx and 4Rx antennas.Proposal 2: Only measure the PDSCH throughput performance of one target UE, and use follow PMI in the PDSCH simulation.Proposal 3: Use random PMI selection for the paired UE(s).Proposal 4: Use Zero Forcing as the BS precoding algorithm if the feasibility can be confirmed by the TE vendor.Proposal 5: For 8Tx, use type I single panel codebook with wideband PMI for all the target and paired UEs, and the same BS precoding matrix is applied in the whole transmitted bandwidth.Proposal 6: For 16Tx, use Rel-15/16 (e)type II codebook for all the target and paired UEs, and use subband PMI if it is feasible for TE to calculate ZF precoding matrix per subband.Proposal 7: Assume low correlation among the co-scheduled UEs.Proposal 8: In the initial simulation, consider different options for the number of co-scheduled UEs an the number of layers per UE:* 2 co-scheduled UEs (1 target UE and 1 paired UEs) and 1 layer per UE.
* 2 co-scheduled UEs (1 target UE and 1 paired UEs) and 2 layers per UE.
* 4 co-scheduled UEs (1 target UE and 3 paired UEs) and 1 layer per UE.
* 4 co-scheduled UEs (1 target UE and 3 paired UEs) and 2 layers per UE.

Proposal 9: In both target and interfering PDSCH, assume PDSCH mapping type A with full PRB allocation.Proposal 10: Use Type 1 DMRS with 1 additional DMRS:* Use single symbol front loaded DMRS for cases with no more than 4 layers for all the considered UEs, and use double symbol front loaded DMRS for cases with 5-8 layers for all the considered UEs.
* Assume FDM between DMRS and data, i.e., the number of DMRS CDM groups without data as 1, for no more than 2 layers for all the considered UEs; and assume TDM between DMRS and data, i.e., the number of DMRS CDM groups without data as 2, for 3-8 layers for all the considered UEs.
* For the i-th UE with 2-layer transmission, DMRS port 2i-2 and 2i-1 (i = 1, 2,...) are used.

Proposal 11: The ratio of PDSCH EPRE to DM-RS EPRE is assumed as 0 dB and -3 dB when the number of DM-RS CDM groups without data is 1 and 2 respectively.Proposal 12: Assume 16QAM randomly modulated symbols in the interfering PDSCH.Proposal 13: Cover QPSK MCS 4, 16QAM MCS 13, and 64QAM MCS 19 in the initial simualtions.The following observation and proposals were made w.r.t. the reference receiver:Observation 1: It is unknown whether the precoding matrix in the multiple contiguous PRBs for the co-scheduled UE(s) is the same.Proposal 14: The estimation of interference covariance matrix can be performed at per PRB and per slot basis.Proposal 15: For cases with 2 DMRS CDM groups, the interference should be estimated based on the REs occupied by both of the two DMRS CDM groups.The following proposals were made w.r.t. other PDSCH simulation parameters:Proposal 16: Cover at least 15kHz SCS for FDD and 30kHz SCS for TDD.Proposal 17: Cover 10 MHz and 40 MHz channel bandwidth for FDD 15kHz SCS, 40MHz and 100MHz channel bandwidth for TDD 30kHz SCS.Proposal 18: Cover two TDD configurations for 30kHz SCS:* Configuration 1: 7D1S2U, S = 6D:4G:4U
* Configuration 2: DDDSUDDSUU, S1=10G: 2G: 2U, S2 = 10G: 2G: 2U

Proposal 19: Re-use the Rel-15 assumptions on HARQ process number, i.e., 4 for FDD 15kHz SCS and 8 for TDD 30kHz SCS.Proposal 20: For the propagation condition, include TDLA30-10 and TDLC300-100 in Phase I, and decide whether down-selection or adjustment is needed later. Use XP high or XP medium for the antenna correlation.Proposal 21: For SSB position, reuse the Rel-15 assumptions , i.e., configure the first SSB in Slot #0 in every 20 slots, and the slot #0 in every 20 slots is not scheduled for PDSCH transmission.Proposal 22: For TRS and ZP CSI-RS, reuse the Rel-15 assumptions for PDSCH demodulation requirement. For NZP CSI-RS, reuse the Rel-15 general assumptions for PDSCH demodulation requirement and extend the configuration for more than 4 ports. |
| R4-2106868 | Ericsson | Proposal 1: Specify intra-cell inter-user interference model as follows:

|  |
| --- |
| Precoded modulation symbols of an interference signal are randomly mapped onto one of the remaining DMRS antenna port. The update granularity for randomized mapping antenna port is PRB bundling size in frequency domain and slot in time domain.For each slot and each PRB bundling size, a precoding matrix for the number of layers, $v$, associated to the selected rank shall be selected randomly from [Single Panel Type I]. The selected precoding matrix shall not be identical to the precoding matrix applied for the UE under test. |

Proposal 2: For inter-user interference scenario, configure 2 DMRS CDM groups without data, that is, DMRS ports 1000/1001 are assigned for the UE under test and DMRS ports 1002/1003 are assigned for the co-scheduled UE.Proposal 3: For the MMSE-IRC receiver performance evaluation, RAN4 should assume the following parameters as the starting point.

|  |  |  |
| --- | --- | --- |
| Parameters | FDD | TDD |
| CBW | 10MHz | 40MHz |
| TDD configuration | N/A | 7DS2U,S=6D+4G+4USchedule PDSCH in special slots |
| SCS | 15kHz | 30kHz |
| PDSCH configuration | Type A, Start symbol 2, Duration 12​ | Type A, Start symbol 2, Duration 12​ |
| PRB bundling size  | 2 | 2 |
| PDSCH DMRS configuration | Type 1, 1+1 | Type 1, 1+1 |
| DMRS port assignment | 1000 for UE under test for rank 11000/1001 for UE under test for rank 21002 for co-scheduled UE for rank 11002/1003 for co-scheduled UR for rank 2 | 1000 for UE under test for rank 11000/1001 for UE under test for rank 21002 for co-scheduled UE for rank 11002/1003 for co-scheduled UR for rank 2 |
| MCS | MCS 4 (QPSK 0.3)MCS 13 (16QAM 0.48)MCS 19 (64QAM 0.5) | MCS 4 (QPSK 0.3)MCS 13 (16QAM 0.48)MCS 19 (64QAM 0.5) |
| Rank | 1 and 2 | 1 and 2 |
| PDSCH precoder | Single Panel Type I, Random precoder selection updated per slot,with equal probability of each applicable i1, i2 combination, and with PRB bundling granularity | Single Panel Type I, Random precoder selection updated per slot,with equal probability of each applicable i1, i2 combination, and with PRB bundling granularity |
| Antenna configuration | 2x2, 2x4 for rank 14x2, 4x4 for rank 2 | 2x2, 2x4 for rank 14x2, 4x4 for rank 2 |
| Propagation condition | TDLA30-10 | TDLA30-10 |
| Metric  | SNR to achieve 70% of maximum throughput | SNR to achieve 70% of maximum throughput |

Proposal 4: For evaluation RAN4 should compare the performance difference between the case with co-scheduled UE and without co-scheduled UE. |
| R4-2106834 | Huawei, HiSilicon | Observation 1: Intra-cell interference between paired UEs has significant impact on system performance Proposal 1: Define PDSCH demodulation requirement for intra-cell inter-user interference suppressingObservation 2: LTE MU-MIMO test case has verified one single-layer transmission companied by one interfering simultaneous transmission, which indicates two UEs a pairProposal 2: Take two Users as a pair and network does not need to ensure the perfect orthogonality between these two UEs Observation 3: LTE MU-MIMO test cases use randomly selected precoder for both paired UEsProposal 3: Reuse LTE precoding method of random selection without identical as a starting point for evaluation, fixed PMI for both UEs or at least one of them is not precluded Proposal 4: Use 4 as the precoding granularity for both UEsProposal 5: Use a multi-path fading channel with relative high frequency selective characteristic as channel model, take TDLC300 as a start to evaluateProposal 6: Consider low correlation level for defining requirementProposal 7: Not to consider any Null-forming method or any other interference suppression or scheduling schemes from BS sideProposal 8: RAN4 discusses and decides whether to introduce network assistance Proposal 9: Consider this draft interference model for further evaluationProposal 10: PDSCH mapping type: Type AProposal 11: Consider 2x2, 2x4 for antenna configurationProposal 12: Use same DMRS pattern and same sequence for both paired UEsProposal 13: The DUT and the co-scheduled UE can be either in the same CDM group or not, but with same PRG configurations |

## Open issues summary

### Sub-topic 3-1: Inter-user interference modeling for phase I evaluation

**Issue 3-1-1: Paired UE number**

* Proposals
	+ Option 1: Consider 1, 2, 3 paired UEs. (CMCC)
	+ Option 2: Consider both 1 and 3 paired UEs, make down-selections later based on the simulation outcome (CTC)
	+ Option 3: Only 1 paired UE (HW)
		- HW: Same with LTE MU-MIMO test cases.
* Recommended WF
	+ For initial evaluation, can we take option 2 as a compromise among different options?

**Issue 3-1-2: Rank for target and interference PDSCH**

* Proposals
	+ Option 1: At least cover rank 1 (CMCC)
	+ Option 2: Rank 1 or rank 2 for target UE, and the rank for interference UE is same with that for target UE (Intel)
	+ Option 3: Cover both rank 1 and rank 2 per UE (CTC, E///)
	+ Option 4: Limit the rank combinations to [1,1], [1,2], [2,1] on target and co-scheduled UE for 4x4 (Apple)
		- Apple: The total number of layers transmitted shall be less than or equal to the number of UE RX antenna.
* Recommended WF
	+ For initial evaluation, can we include both rank 1 and rank 2 per UE (with the same rank for target and interference UEs)?

**Issue 3-1-3: Correlation between the propagation channel of the paired UEs**

* Proposals
	+ Option 1: Low (CTC, HW)
* Recommended WF
	+ For initial evaluation, can we take option 1 as starting point to simplify the simulation setup?

**Issue 3-1-4: Antenna configuration**

* Proposals
	+ Tx antenna number:
		- Option 1: 8Tx and 16Tx (CMCC, CTC)
			* CMCC, CTC: Under MU-MIMO test setup, the number of transmit antenna will be larger than that of SU-MIMO test setup.
		- Option 2: 2Tx or 4Tx (Intel)
		- Option 3: 2Tx for rank 1 and 4Tx for rank 2 (E///)
		- Option 4: 2Tx only (HW)
			* HW: 2Tx was selected for LTE MU-MIMO test cases.
	+ Rx antenna number:
		- Option 1: Cover both 2Rx and 4Rx (CMCC, CTC, Intel, E///, HW)
* Recommended WF
	+ For Tx antenna number, companies’ views are divergent, encourage more discussion in the first round by taking into account the practical scenario and test complexity
	+ For Rx antenna number, agree option 1.

**Issue 3-1-5: Codebook type**

* Proposals
	+ Option 1: (CTC)
		- For 8Tx, use type I SP codebook with wideband PMI reporting for target and paired UEs.
		- For 16Tx, use Rel-15/16 (e)type II codebook for target and paired UEs. Use subband PMI if it is feasible for TE to calculate ZF precoding matrix per subband.
			* CTC: For 8Tx, type I single panel codebook with wideband PMI is a mandatory UE feature without capability.
	+ Option 2: For 2Tx and 4Tx, use Type I SP codebook. Type II precoder can also be applied for 4Tx (E///)
* Recommended WF
	+ Encourage more discussion in the first round.

**Issue 3-1-6: PMI selection and precoding matrix generation**

* Proposals
	+ Option 1: Random based target UE PMI selection (Apple, Intel, E///, HW)
		- Option 1A: Random selection based precoder generation with QRD orthogonalization processing as below (Apple)

|  |
| --- |
| 1. Choose precoders of the $N$ co-scheduled users randomly and horizontally concatenate them to get the overall precoder matrix $P$as follows:

$$P=\left[\begin{matrix}P\_{1}&\cdots &P\_{N}\end{matrix}\right]$$1. Compute the $l\_{2}$-norm squared of every column of $P$ as follows:

$$r=diag\left(P^{H}P\right) $$where $r$is a vector of length $N\_{L}≜\sum\_{i=1}^{N}N\_{L\_{i}}$1. Use QRD or SVD to get the orthonormal basis of $P$ as follows:

$$\left[Q,R\right]=qr(P)$$1. Keep only the first $N\_{L}$ columns of $Q$and scale every column using its corresponding value in $r$vector as follows

$$Q=Q\left(:,1:N\_{L}\right)×diag\left(\sqrt{r}\right)$$where $diag\left(\sqrt{r}\right)$ is a diagonal matrix with the square root of $r$entries of its diagonal. The purpose of this scaling is to preserve the power of every column such that the Frobenius norm of $P\_{i}^{'}$ is one for $i=1,2…,N$ as in the codebook.1. $P\_{1}^{'}$ is the first $N\_{L\_{1}}$ columns of $Q$; $P\_{2}^{'}$ is the next $N\_{L\_{2}}$ columns of $Q$, and so on., i.e.

$$P\_{i}^{'}=Q\left(:,\sum\_{j=1}^{i-1}N\_{L\_{j}}+1:\sum\_{j=1}^{i}N\_{L\_{j}}\right), i=1,2,…,N$$ |

* + - Option 1B: Random PMI selection for the target UE, and select the precoder for the interference UE to ensure orthogonality (Intel)
			* Intel: Feedback-based PMI selection mode is more preferable solution because it close to practical assumptions. However, we can check two PMI selection procedures and analyze pros and cons of each option.
		- Option 1C: Random PMI selection for both target and interference UE, with ensuring the selected PMI matrix shall not be identical to the precoding matrix applied for the UE under test. (E///, HW)
			* HW: 1) LTE MU-MIMO test cases use randomly selected precoder for both paired UEs; 2) Not to consider any Null-forming method or any other interference suppression or scheduling schemes from BS side
	+ Option 2: Feedback-based target UE PMI selection (CTC, Intel)
		- Option 2A: If the feasibility can be confirmed by the TE vendor, use ZF precoding based on the reported PMI from the target UE, and the randomly generated PMI from the interference UE(s). (CTC)
		- Option 2B: Feedback-based PMI selection for the target UE, select the precoder for the interference UE to ensure the orthogonality (Intel)
	+ Option 3: Fixed precoding matrix for one or both co-scheduled UEs (HW)
* Recommended WF
	+ For option 1A and 2A with QRD/ZF processing from Apple/CTC, invite the inputs from TE vendors on the test feasibility.
	+ For option 1B and 2B from Intel, it seems more details on how to ensure the orthogonality are needed.
	+ Encourage more discussion, aiming to come up with one baseline option for initial evaluation

**Issue 3-1-7: PRB bundling size and precoding granularity**

* Proposals
	+ Option 1: Per 2 PRBs for frequency domain and per slot for time domain (E///)
	+ Option 2: 4 for both target and interference UEs (HW)
	+ Option 3: (CTC)
		- Wideband for 8Tx for target and paired UEs.
		- For 16Tx, use subband precoding if it is feasible for TE to calculate ZF precoding matrix per subband.
* Recommended WF
	+ Encourage more discussion in the first round.

**Issue 3-1-8: MCS for interfering PDSCH**

* Proposals
	+ Option 1: Normal PDSCH with MCS 16QAM/0.48 as the baseline (CMCC)
	+ Option 2: Random 16QAM signal generation (Intel, CTC)
* Recommended WF
	+ Encourage more discussion in the first round.

### Sub-topic 3-2: DMRS configuration for phase I evaluation

**Issue 3-2-1: DMRS ports for target and interfering UEs**

* Proposals
	+ For rank 1 transmission per UE, with 1 target UE and 1 interference UE:
		- Option 1: DMRS port 0 for target UE, DMRS port 1 for the interference UE (China Telecom, Intel)
		- Option 2: DMRS port 0 for target UE, DMRS port 2 for the interference UE, i.e., different CDM groups (Intel, Apple, E///)
	+ For rank 1 transmission per UE, with 1 target UE and more than 1 interference UE:
		- Option 1: DMRS port 0 for target UE, DMRS port *i* for the *i*-th interference UE (*i* = 1, 2,...) (China Telecom)
	+ For rank 2 transmission per UE:
		- Option 1: DMRS port 0/1 for target UE, DMRS port 2*i* and 2*i*+1 for the *i*-th interference UE (*i* = 1, 2,...) (Intel, Apple, E///, CTC)
	+ When rank [1, 2] or rank [2, 1] transmission for the target and interference UEs:
		- Option 1: DMRS port 0 (and 1) for target UE, port 2 (and 3) for the interference UE, i.e., use different CDM groups for the target and interference UEs (Apple, E///)
* Recommended WF
	+ Encourage more discussion in the first round, aiming to come up with one baseline option for initial evaluation purpose

**Issue 3-2-2: DMRS type and DMRS additional position**

* Proposals
	+ Option 1: DMRS Type 1 with 1 additional DMRS (Intel, CTC, E///)
* Recommended WF
	+ Use option 1 if no objection during the first round discussion.

**Issue 3-2-3: Ratio of PDSCH EPRE to DM-RS EPRE**

* Proposals
	+ Option 1: 0 dB and -3 dB when the number of DM-RS CDM groups without data is 1 and 2 respectively (CTC)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 3-2-4: Whether to use the same DMRS pattern and the same sequence for all co-scheduled UEs**

* Proposals
	+ Option 1: Yes (HW)
		- HW: In real network deployment, same DMRS pattern for MU-MIMO paired UEs has been always used
* Recommended WF
	+ Encourage feedback from more companies

### Sub-topic 3-3: Reference receiver for phase I evaluation

**Issue 3-3-1: Candidate Receivers**

* Proposals
	+ Option 1: MMSE-IRC processing with serving signal demodulation (Intel)
		- $\hat{x}\_{S}=H\_{S}^{H}\left(H\_{S}H\_{S}^{H}+R\_{I+N}\right)^{-1}y$.
	+ Option 2: MMSE-IRC processing with joint (serving + interference) signal demodulation (Intel)
		- $\hat{x}\_{S+I}=H\_{S+I}^{H}\left(H\_{S+I}H\_{S+I}^{H}+R\_{N}\right)^{-1}y$, where $H\_{S+I}=\left[\begin{matrix}H\_{S}&H\_{I}\end{matrix}\right]$.
		- Intel: for MU-MIMO mode, UE has enough information to make channel estimation of interference signal and execute joint (serving + interference) demodulation processing.
* Recommended WF
	+ Encourage feedback from more companies

**Issue 3-3-2: Interference estimation for cases with 2 DMRS CDM groups**

* Proposals
	+ Option 1: For cases with 2 DMRS CDM groups, the interference should be estimated based on the REs occupied by both of the two DMRS CDM groups (CTC)
* Recommended WF
	+ Encourage feedback from more companies

**Issue 3-3-3: Interference estimation granularity**

* Proposals
	+ Option 1: Per PRB and per slot based interference covariance matrix estimation (CTC)
		- CTC: It is unknown whether the precoding matrix in the multiple contiguous PRBs for the co-scheduled UE(s) is the same.
* Recommended WF
	+ Encourage feedback from more companies

**Issue 3-3-4: Whether to introduce network assistance to assist the receiver**

* Proposals
	+ Option 1: RAN4 discusses and decides whether to introduce network assistance (HW)
		- HW: With network assistance, the tested UE can perform interference cancellation with less cost by detection.
* Recommended WF
	+ Encourage feedback from more companies.

### Sub-topic 3-4: PDSCH parameters for phase I evaluation

**Issue 3-4-1: SCS**

* Proposals
	+ Option 1: Cover both 15kHz SCS for FDD and 30kHz SCS for TDD. (CMCC, CTC, Intel, E///)
* Recommended WF
	+ Use option 1 if no objection during the first-round discussion.

**Issue 3-4-2: Channel Bandwidth**

* Proposals
	+ Option 1 (CMCC)
		- For FDD 15kHz SCS: Cover 10MHz and 50MHz CBW.
		- For TDD 30kHz SCS: Cover 40MHz and 100MHz CBW.
			* CMCC: We also support to consider the maximum bandwidth for FDD and TDD, which is 50MHz for FDD and 100MHz for TDD.
	+ Option 2: 10 MHz for FDD 15kHz SCS and 40 MHz for TDD 30kHz SCS (Intel, E///)
	+ Option 3: (CTC)
		- For FDD 15kHz SCS: Cover 10MHz and 40MHz CBW.
		- For TDD 30kHz SCS: Cover 40MHz and 100MHz CBW.
* Recommended WF
	+ Encourage more discussion during the first round.

**Issue 3-4-3: TDD Configuration**

* Proposals
	+ Option 1: 7D1S2U(6D+4G+4U) for 30kHz TDD (CMCC, Intel, E///)
	+ Option 2: Cover both of the TDD patterns below for 30kHz TDD (CTC)
		- 7D1S2U, S = 6D:4G:4U
		- DDDSUDDSUU, S1=10G: 2G: 2U, S2 = 10G: 2G: 2U
* Recommended WF
	+ Encourage more discussion during the first round.

**Issue 3-4-4: MIMO correlation for each UE**

* Proposals
	+ Option 1: Consider both XP High and XP Medium, and make further down-selection based on evaluation results (CMCC)
	+ Option 2: XP High or XP Medium (CTC)
* Recommended WF
	+ Encourage feedback from more companies.

**Issue 3-4-5: Propagation Condition**

* Proposals
	+ Option 1: TDLA30-10 as baseline (CMCC, Intel, E///)
		- CMCC: We are also support to evaluate other propagation channel in Phase1.
	+ Option 2: Cover both TDLA30-10 and TDLC300-100 in phase I, and decide whether down-selection or adjustment is needed later (CTC, [CMCC])
	+ Option 3: TDLC300 channel (HW)
		- HW: When transmitted signal is experiencing large time delay and frequency selective propagation condition, the precoding performance will have an obviously loss compared to flat channel, which is matched with real network scenario.
* Recommended WF
	+ Considering the different preferences on TDLA30/TDLC300, can we include both and take option 2 for initial evaluation?

**Issue 3-4-6: MCS for Target UE**

* Proposals
	+ Option 1: (CMCC)
		- QPSK MCS 4, 16QAM MCS 13 and 64QAM MCS 19 for Rank 1
		- 64QAM MCS 19 for Rank 2
	+ Option 2: MCS 5 or 12 or 19 (Intel)
	+ Option 3: Cover QPSK MCS 4, 16QAM MCS 13, and 64QAM MCS 19 for initial simulation (CTC, E///)
	+ Option 4: Up to 16QAM for 2x2 and up to 64QAM for 4x4 (Apple)
* Recommended WF
	+ Encourage suggestions on how to down-select a MCS set for initial evaluation.

**Issue 3-4-7: PDSCH Mapping Type**

* Proposals
	+ Option 1: Type A (Intel, CTC, E///, HW)
* Recommended WF
	+ Use option 1 if no objection during the first-round discussion.

**Issue 3-4-8: PDSCH Resource Allocation**

* Proposals
	+ Time Domain:
		- Option 1: Starting symbol 2 and duration 12 (Intel, E///)
	+ Frequency Domain:
		- Option 1: Full PRB allocation (CTC)
* Recommended WF
	+ Use option 1 for both time and frequency domain as baseline

**Issue 3-4-9: HARQ Process Number**

* Proposals
	+ Option 1: 4 for FDD 15kHz SCS and 8 for TDD 30kHz SCS (CMCC, CTC)
		- CMCC: Reuse the typical HARQ configuration in R16 PDSCH demodulation requirements.
* Recommended WF
	+ Use option 1 as baseline

**Issue 3-4-10: SSB Configuration**

* Proposals
	+ Option 1: (CMCC, CTC)
		- SSB position in burst: first SSB in Slot#0; SSB periodicity: 20ms.
		- The slot #0 in every 20 ms is not scheduled for PDSCH transmission
			* CMCC, CTC: Reuse the SSB configuration in NR PDSCH demodulation requirement.
* Recommended WF
	+ Use option 1 as baseline

**Issue 3-4-11: TRS, NZP CSI-RS and ZP CSI-RS Configuration**

* Proposals
	+ Option 1: (CTC)
		- For TRS and ZP CSI-RS, reuse the Rel-15 assumptions for PDSCH demodulation requirement.
		- For NZP CSI-RS, reuse the Rel-15 general assumptions for PDSCH demodulation requirement and extend the configuration for more than 4 ports
* Recommended WF
	+ Encourage feedback from more companies.

**Issue 3-4-12: Performance evolution metrics**

* Proposals
	+ Option 1: Measure the 70% max throughput performance of the target UE (CMCC, CTC, E///)
		- Evaluate the gain of MMSE-IRC over MMSE under the same simulation setup
* Recommended WF
	+ Encourage feedback from more companies.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Company A | Sub-topic 3-1: Inter-user interference modeling for phase I evaluationIssue 3-1-1: Paired UE numberIssue 3-1-2: Rank for target and interference PDSCHIssue 3-1-3: Correlation between the propagation channel of the paired UEsIssue 3-1-4: Antenna configurationIssue 3-1-5: Codebook typeIssue 3-1-6: PMI selection and precoding matrix generationIssue 3-1-7: PRB bundling size and precoding granularityIssue 3-1-8: MCS for interfering PDSCHSub-topic 3-2: DMRS configuration for phase I evaluationIssue 3-2-1: DMRS ports for target and interfering UEsIssue 3-2-2: DMRS type and DMRS additional positionIssue 3-2-3: Ratio of PDSCH EPRE to DM-RS EPREIssue 3-2-4: Whether to use the same DMRS pattern and the same sequence for all co-scheduled UEsSub-topic 3-3: Reference receiver for phase I evaluationIssue 3-3-1: Candidate ReceiversIssue 3-3-2: Interference estimation for cases with 2 DMRS CDM groupsIssue 3-3-3: Interference estimation granularityIssue 3-3-4: Whether to introduce network assistance to assist the receiverSub-topic 3-4: PDSCH parameters for phase I evaluationIssue 3-4-1: SCSIssue 3-4-2: Channel BandwidthIssue 3-4-3: TDD ConfigurationIssue 3-4-4: MIMO correlation for each UEIssue 3-4-5: Propagation ConditionIssue 3-4-6: MCS for Target UEIssue 3-4-7: PDSCH Mapping TypeIssue 3-4-8: PDSCH Resource AllocationIssue 3-4-9: HARQ Process NumberIssue 3-4-10: SSB ConfigurationIssue 3-4-11: TRS, NZP CSI-RS and ZP CSI-RS ConfigurationIssue 3-4-12: Performance evolution metrics |
|  |  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

## Discussion on 2nd round

1. Recommendations for Tdocs
	1. 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
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Notes:

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

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

Notes:

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