**3GPP TSG-RAN WG4 Meeting #116 R4-25xxxxx**

**Bengaluru, India, August 25 – 29, 2025**

**Agenda item:** 7.17.1

**Source:** OPPO, CAICT, vivo, Nokia, Ericsson, Qualcomm, CMCC, CTC, Huawei, Hisilicon, Mediatek, CATT, Samsung, ZTE Corporation, Apple

**Title:** WF on updated simulation assumptions for AI based CSI prediction

**Document for:** Approval

# Introduction

In this contribution, according to companies’ inputs in RAN4 #116 meeting, updated simulation assumptions for AI/ML based CSI prediction are proposed.

# Updated simulation assumptions for AIML based CSI prediction

**For information**

* Regarding updates to the simulation assumptions for AIML-based CSI prediction:
* Introduce SGCS-1 and SGCS-3 as KPIs for Step-3 (under practical channel estimation, corresponding to 90% of maximum TP), to better align and understand companies’ simulation results.
* In addition to γ1\_AI/ML(already agreed), also provide γ2\_AI/ML:

γ1\_AI/ML：AI/ML based CSI prediction is compared with Rel-15 Type I random PMI

γ2\_AI/ML：AI/ML based CSI prediction is compared with Rel-16 eType II CB(sample and hold)

* Include MCS 17 and MCS 19 for Step-3
* Keep both 20Hz and 50Hz Doppler
* Keep 90% of maximum TP
* It is up to UE implementation whether to use one model for an SNR range or a separate model per SNR during simulations.
* Add beam steer approach for step-3. Randomization of the dual-cluster beam directions will be used as specified in AnnexB.2.3.2.3A in 38.101-4. The value of relative power ratio (p) shall be fixed as 1 during the test
* Note: companies are encouraged to clarify whether the SNR dataset for model training is per SNR or with an SNR range when providing the results of step-3 simulation

**Way forward for next step simulation for CSI prediction**

* + For step-2 and step-3,
    - Interested companies are encouraged to provide more CSI prediction simulation results in RAN4#116bis meeting.

**Table 1: Updated simulation assumptions for AIML based CSI prediction**

|  |  |
| --- | --- |
| Parameter | Value |
| Duplex, Waveform | FDD, TDD,  OFDM |
| Carrier frequency | 2GHz for FDD  4GHz for TDD |
| Subcarrier spacing | 15kHz for FDD, 30kHz for TDD |
| Bandwidth | 10MHz for FDD, 40MHz for TDD |
| Symbol | 1 symbol for step-1 and step-2 simulation |
| Number of subbands | 13 subbands, 4RB as a bundle for FDD  14 subbands, 8RB as a bundle for TDD |
| gNB TX antennas | Baseline: 16(N1,N2)=(4,2) as defined in Rel-18 CSI prediction requirements  Optional: 32(N1,N2)=(4,4) as defined in Rel-15 type1 |
| UE RX antennas | 4 |
| Channel model | TDLA30 with XP medium correlation as baseline |
| Doppler spread | 20Hz, 50Hz |
| Channel estimation for CSI prediction | Step-1:   * Ideal DL channel estimation, for the purpose of calibration and/or comparing intermediate results (e.g., accuracy of AI/ML output CSI, etc.).   Step-2:   * Ideal DL channel estimation, for the purpose of calibration and/or comparing intermediate results (e.g., to check SGCS after CSI feedback).   Step-3:   * Practical DL channel estimation, use a common CSI-RS configuration as in demodulation test (may need to define/choose a CSI-RS configuration) |
| CSI-RS configuration | For 16Tx   |  |  | | --- | --- | | Number of CSI-RS ports (*X*) | 16 | | CDM Type | CDM4 (FD2, TD2) | | Density (ρ) | 1 | | First subcarrier index in the PRB used for CSI-RS (k0, k1, k2, k3) | (2, 4, 6, 8) | | First OFDM symbol in the PRB used for CSI-RS (l0) | (5) |  * For 32Tx  |  |  | | --- | --- | | Number of CSI-RS ports (*X*) | 32 | | CDM Type | CDM4 (FD2, TD2) | | Density (ρ) | 1 | | First subcarrier index in the PRB used for CSI-RS (k0, k1, k2, k3) | (2, 4, 6, 8) | | First OFDM symbol in the PRB used for CSI-RS (l0, l1) | (5, 12) | |
| Rank per UE | Step-1: Rank 1 and 2 to do quick check  Step-2 and Step-3: Rank 2 as baseline |
| CSI feedback assumption | Step-1: check the CSI prediction (outputs Raw channel) performance, do not need to take CSI feedback into account |
| Step-2 and Step-3: take CSI feedback into account   * Use Rel-18 eTypeII-Doppler, N4 = 1， N4>1 can be further discussed in the future if needed |
| Test setup(timeline) | Only for step-3  For FDD test setup with Periodic CSI-RS configuration   * CSI-RS periodicity: 5 ms * CSI feedback periodicity: 5 ms * Scheduling delay (from CSI feedback to apply in scheduling): 4 slots   Note: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation using a CSI-RS resource set in which the last CSI-RS resource is transmitted at a downlink slot not later than slot#(n-4), this reported PMI cannot be applied at the gNB downlink before slot#(n+4)   * Test setup for FDD test setup with Periodic CSI-RS configuration is captured in Table2   For TDD test setup with Periodic CSI-RS configuration   * CSI-RS periodicity: 5 ms * CSI feedback periodicity: 5 ms * Scheduling delay (from CSI feedback to apply in scheduling): 6 slots   Note : If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation using a CSI-RS resource set in which the last CSI-RS resource is transmitted at a downlink slot not later than slot#(n-6), this reported PMI cannot be applied at the gNB downlink before slot#(n+6).   * Test setup for TDD test setup with Periodic CSI-RS configuration is captured in Table3   FFS test setup for aperiodic CSI-RS configuration |
| Beam steer approach | For step-3, randomization of the dual-cluster beam directions should be used as specified in AnnexB.2.3.2.3A in 38.101-4. The value of relative power ratio (p) shall be fixed as 1 during the test |
| SNR assumption | Only for step-3  Claimed by companies for step-3 first round simulation (TP as KPI)  FFS: other suggestions |
| CSI feedback overhead | PC7 as baseline |
| Baseline | ~~FFS~~   * Random PMI with Rel-15 Type I single panel codebook if needed (e.g., for Step-3 or performance requirements) |
| KPI | Step-1:   * check SGCS1 before CSI feedback * SGCS1 is calculated by comparing the SVD of model output (before feedback) with the SVD of the ground truth Raw channel * Average of SGCS for intermediate results over all subbands per layer (e.g. for rank 2),   Step-2:   * check SGCS2 and SGCS3 * SGCS2: Compares the PMI feedback-derived based on Rel-18 eType II-Doppler CB with the model output against the ground-truth raw channel’s SVD   SGCS3: Compares the PMI feedback-derived based on Rel-18 eType II-Doppler CB with the model output against the PMI -derived based on Rel-18 eType II-Doppler CB with the ground truth   * Average of SGCS for intermediate results over all subbands per layer (e.g. for rank 2)   Step-3:   * check SGCS1 and SGCS3, under practical channel estimation, corresponding to 90% of maximum TP with follow PMI using AI/ML-based CSI prediction * SGCS1: Compares the SVD of model output (before feedback) with the SVD of the ground truth Raw channel * SGCS3: Compares the PMI feedback-derived based on Rel-18 eType II-Doppler CB with the model output against the PMI -derived based on Rel-18 eType II-Doppler CB with the ground truth * Average of SGCS for intermediate results over all subbands per layer (e.g. for rank 2) * check TPs after CSI feedback for both AI based CSI prediction and Random PMI with Rel-15 Type I single panel codebook, as well as the SNR value corresponding to 90% of maximum TP of the AI based CSI prediction   γ1\_AI/ML: AI/ML based CSI prediction is compared with Rel-15 Type I random PMI   * check TPs after CSI feedback for both AI based CSI prediction and Rel-16 eType II codebook(sample and hold), as well as the SNR value corresponding to 90% of maximum TP of the AI based CSI prediction   γ2\_AI/ML: AI/ML based CSI prediction is compared with Rel-16 eType II CB(sample and hold)   * Companies are also encouraged to provide the TP curve with corresponding SNRs. * The test parameters for TPs simulation can be referred as 38.101-4 section of 6.3   + FDD with 16Tx4Rx: Table 6.3.3.1.8-1   + FDD with 32Tx4Rx: Table 6.3.3.1.4-1:   + TDD with 16Tx4Rx: Table 6.3.3.2.8-1   + TDD with 32Tx4Rx: Table 6.3.3.2.4-1: |
| Model input type | Raw channel matrix |
| Model out type | Raw channel matrix |
| Observation window | Observation window (number/distance): 5/5ms as baseline  Optional for 10/5ms |
| Prediction window | Prediction window (number/distance between prediction instances/distance from the last observation instance to the 1st prediction instance): 1/5ms/5ms |
| Training data and test data | Use following combinations:   |  |  | | --- | --- | | Training dataset  (TDLA30) | Test on  (TDLA30) | | 20Hz Doppler spreads | 20Hz Doppler spreads | | 50Hz Doppler spreads | 50Hz Doppler spreads | | Mixed Doppler spreads  (20Hz, 50Hz,) | 20Hz Doppler spreads | | 50Hz Doppler spreads | |
| Companies can provide the model complexity information (e.g., flops, backbone) of their AI/ML CSI prediction models  Companies are encouraged to clarify whether the SNR dataset for model training is per SNR or with an SNR range when providing the results of step-3 simulation | |
| Clarifications on the SGCS calculation:  SGCS1: Compares the SVD of model output (before feedback) with the SVD of the ground truth Raw channel  SGCS2: Compares the PMI feedback-derived based on Rel-18 eType II-Doppler CB with the model output against the ground-truth raw channel’s SVD.  SGCS3: Compares the PMI feedback-derived based on Rel-18 eType II-Doppler CB with the model output against the PMI -derived based on Rel-18 eType II-Doppler CB with the ground truth.  A diagram of a software project  AI-generated content may be incorrect. | |

Table2: Test setup for FDD test setup with Periodic CSI-RS configuration (based on R.PDSCH.1-24.1 FDD)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Value | | | | |
| Reference channel |  | MCS13 | MCS17 | MCS19 |  |  |
| Channel bandwidth | MHz | 10 | 10 | 10 |  |  |
| Subcarrier spacing | kHz | 15 | 15 | 15 |  |  |
| Number of allocated resource blocks | PRBs | 52 | 52 | 52 |  |  |
| Number of consecutive PDSCH symbols |  | 12 | 12 | 12 |  |  |
| Allocated slots per 2 frames | Slots | 16 | 16 | 16 |  |  |
| MCS table |  | 64QAM | 64QAM | 64QAM |  |  |
| MCS index |  | 13 | 17 | 19 |  |  |
| Modulation |  | 16QAM | 64QAM | 64QAM |  |  |
| Target Coding Rate |  | 0.48 | 0.43 | 0.50 |  |  |
| Number of MIMO layer |  | 2 | 2 | 2 |  |  |
| Number of DMRS REs (Note 3) |  | 24 | 24 | 24 |  |  |
| Overhead for TBS determination |  | 0 | 0 | 0 |  |  |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For CSI Slots i, if mod (i, 5) = {0}, i={0,…,19} |  | N/A | N/A | N/A |  |  |
| For Non CSI-RS Slot | Bits | 24072 | 32264 | 37896 |  |  |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For CSI Slots i, if mod (i, 5) = {0}, i={0,…,19} |  | N/A | N/A | N/A |  |  |
| For Non CSI-RS Slot | Bits | 24 | 24 | 24 |  |  |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For CSI Slots i, if mod (i, 5) = {0}, i={0,…,19} |  | N/A | N/A | N/A |  |  |
| For Non CSI-RS Slot | CBs | 3 | 4 | 5 |  |  |
|  |  |  |  |  |  |  |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames  Note 3: Number of DMRS REs includes the overhead of the DM-RS CDM groups without data  An example for FDD test setup with Periodic CSI-RS configuration | | | | | | |

Table3: Test setup for TDD test setup with Periodic CSI-RS configuration (based on R.PDSCH.2-38.1 TDD)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Value | | | | |
| Reference channel |  | MCS13 | MCS17 | MCS19 |  |  |
| Channel bandwidth | MHz | 40 | 40 | 40 |  |  |
| Subcarrier spacing | kHz | 30 | 30 | 30 |  |  |
| Number of allocated resource blocks | PRBs | 106 | 106 | 106 |  |  |
| Number of consecutive PDSCH symbols |  | 12 | 12 | 12 |  |  |
| Allocated slots per 2 frames | Slots | 24 | 24 | 24 |  |  |
| MCS table |  | 64QAM | 64QAM | 64QAM |  |  |
| MCS index |  | 13 | 17 | 19 |  |  |
| Modulation |  | 16QAM | 64QAM | 64QAM |  |  |
| Target Coding Rate |  | 0.48 | 0.43 | 0.50 |  |  |
| Number of MIMO layer |  | 2 | 2 | 2 |  |  |
| Number of DMRS REs (Note 3) |  | 24 | 24 | 24 |  |  |
| Overhead for TBS determination |  | 0 | 0 | 0 |  |  |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39} | Bits | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i, 10) = {0} for i from {0,…,39} | Bits | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i, 10) = {1,2,3,4,5,6} for i from {1,…,39} |  | 49176 | 65576 | 77896 |  |  |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39} | Bits | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i, 10) = {0} for i from {0,…,39} | Bits | N/A | N/A | N/A |  |  |
| For Non CSI-RS Slot i | Bits | 24 | 24 | 24 |  |  |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For Slot i, if mod(i, 10) = {7,8,9} for i from {0,…,39} | CBs | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i, 10) = {0} for i from {0,…,39} | CBs | N/A | N/A | N/A |  |  |
| For Non CSI-RS Slot | CBs | 6 | 8 | 10 |  |  |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames  Note 3: Number of DMRS REs includes the overhead of the DM-RS CDM groups without data  An example for TDD test setup with Periodic CSI-RS configuration | | | | | | |