**3GPP TSG RAN WG1 #122 R1-250XXXX**

**Bengaluru, India, Aug 25th – 29th, 2025**

Agenda Item: 10.1

Source: Ad-Hoc Chair (Ericsson)

Title: Session notes for 10.1 Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface enhancements

Document for: Discussion, Decision

## Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface enhancements

*Please refer to RP-251870 for detailed scope of the WI.*

[122-R20-AI/ML] Email discussion on Rel-20 AI/ML – xxx

* To be used for sharing updates on online/offline schedule, details on what is to be discussed in online/offline sessions, tdoc number of the moderator summary for online session, etc

**R1-2506206** Work plan for NR\_AIML\_air\_Ph2 Qualcomm Incorporated

### CSI spatial/frequency compression without temporal aspects (“Case 0”)

R1-2506375 Enhancements for Case-0 CSI Compression in Rel-20 Rakuten Mobile, Inc

#### 10.1.1.1 Inference related aspects

*Including target CSI type, measurement and report configuration, CQI RI determination, payload determination, quantization configuration codebook, UCI mapping, CSI processing criteria and timeline, priority rules for CSI reports.*

**R1-2505148** Discussion on inference related aspects for CSI spatial/frequency compression without temporal aspects (“Case 0”) FUTUREWEI

**R1-2505239** AI/ML CSI Spatial/Frequency Compression: Inference Aspects InterDigital, Inc.

R1-2505133 Inference related aspects of AI/ML for CSI compression Ericsson

R1-2505161 Discussion on AIML for CSI compression inference related aspects Spreadtrum, UNISOC

R1-2505199 Inference related aspects for CSI compression Huawei, HiSilicon

R1-2505260 Inference for AI/ML based CSI Compression Google

R1-2505299 Specification support on inference related aspects of AI/ML-based CSI compression CATT

R1-2505405 Discussion on inference related aspects for CSI compression vivo

R1-2505452 Discussion on inference related aspects of two-sided AI/ML model based CSI feedback Xiaomi

R1-2505477 Discussion on interference related aspects for CSI compression TCL

R1-2505491 Discussion on inference related aspects of CSI compression ZTE Corporation, Sanechips

R1-2505573 Views on inference related aspects of CSI compression Samsung

R1-2505617 Discussion on inference related aspects for CSI compression KT Corp.

R1-2505670 Discussion on Inference related aspects for AI CSI compression Ofinno

R1-2505687 Inference related aspects for CSI compression Lenovo

R1-2505699 Discussion on inference aspects for AI/ML-based CSI compression Panasonic

R1-2505746 Inference related aspects for AI/ML CSI compression OPPO

R1-2505802 CSI Compression: Inference Related Aspects Nokia

R1-2505819 Discussion on inference related aspects for CSI compression LG Electronics

R1-2505902 On inference related aspects for AI based CSI spatial/frequency domain compression Apple

R1-2505935 Discussion on inference aspects of CSI compression NEC

R1-2505944 Discussions on Inference Related Aspects for CSI Compression Sharp

R1-2505945 Discussion on inference of AI/ML CSI compression Transsion Holdings

R1-2505962 Discussion on inference related aspects in CSI compression with AI/ML Fujitsu

R1-2506029 CSI spatial/frequency compression without temporal aspects (“Case 0”)- Inference related aspects MediaTek Inc.

R1-2506057 Discussion on inference related aspects of CSI compression ETRI

R1-2506088 Discussion on inference related aspects of CSI compression CMCC

R1-2506122 Discussion on inference aspects of CSI compression KAIST

R1-2506149 Discussion on Inference related aspects for AI/ML based CSI compression ITL

R1-2506207 Specification of inference aspects of AIML CSI compression Qualcomm Incorporated

R1-2506294 Discussion on the inference-related aspects of AI/ML CSI compression NTT DOCOMO, INC.

R1-2506353 Discussion on AI/ML CSI Compression inference aspects CEWiT

R1-2506377 Discussion on Inference-Related Aspects of Case-0 CSI Compression Rakuten Mobile, Inc

**R1-2506496**

Agreement:

For CSI feedback via two-sided model, support at least precoding matrix as target CSI type.

* FFS whether consider ~~raw~~ channel matrix as further improvement, starting with evaluations, e.g. potential fusion with SRS measurement (SRS period/hopping, DL/UL reciprocity), frequency granularity of channel matrix, number of Rx antennas, etc.

Agreement

Specify the precoding matrix feedback via two-sided model as follows: For a certain ~~layer and~~ rank ,



* A precoding matrix is mapped with a latent message , with l = 1, ..., v where l is the layer index.



* + The mapping is subject to [at least] a pairing ID configured by high-layer signalling.
  + FFS is common or specific for different layers or ranks



* + Note: the terminology “latent message” is used for discussion purposes, the detailed name can be discussed further
* is quantized and mapped to bit sequence before reporting.



R1-256497

Agreement

For precoding matrix feedback, for a certain layer of rank , the latent message contains real values



* If scalar quantization (SQ) supported, it refers to the quantization of each real value independently,
  + The payload size for layer and rank is determined by , where is the number of bits per scalar.



* If vector quantization (VQ) is supported, it refers to the quantization of a segment of L (L>1) consecutive real values jointly, and the segment(s) are separately quantized.
  + The payload size for layer and rank is determined by , where is the length of the vector segment, is the number of bits per segment



* + Note: Combining two real-values as a complex value and performing amplitude-phase quantization is precluded.

Agreement:

For precoding matrix feedback, consider the following aspects for payload determination

* Support only SQ, or only VQ or both
* and / or and / or are fixed values or determined from multiple values based on NW configuration or UE reporting.



* and / or is layer-common or layer-specific, rank-common or rank-specific.



* If configured, and / or and / or above are configured separately from pairing ID, or configured by Pairing ID.



* + The configuration may be via other parameters which are used to derive , L and .



Note: Consider limiting the total number of possible payload sizes considering the inter-vendor training challenges.

Note: , and are independent on subband and port configurations,



* FFS each combination of , and is applicable to a certain set of subband and port configurations



R1-2506498

Agreement:

For inference report configuration, support separate configuration of subband, Tx port and payload size from pairing ID.

Agreement:

For quantization codebook used for quantizing the feedback,

* For inter-vendor collaboration Direction A, select one of the following:
  + Alt1: Exchange quantization codebook from NW-side to UE-side along with each exchanged dataset or model parameters
  + Alt2: Use a standardized quantization codebook decided by RAN1.

#### 10.1.1.2 Other aspects

*Including NW and UE data collection for training, performance monitoring, as well as model pairing related issues.*

**R1-2505700** Discussion on other aspects for AI/ML-based CSI compression Panasonic

**R1-2505574** Views on other aspects of CSI compression Samsung

R1-2505134 Other aspects of AI/ML for CSI compression Ericsson

R1-2505149 Discussion on other aspects for CSI spatial/frequency compression without temporal aspects (“Case 0”) FUTUREWEI

R1-2505162 Discussion on AIML for CSI compression other aspects Spreadtrum, UNISOC

R1-2505200 Other aspects for CSI compression Huawei, HiSilicon

R1-2505240 AI/ML CSI Spatial/Frequency Compression: Other Aspects InterDigital, Inc.

R1-2505261 Other Aspects for AI/ML based CSI Compression Google

R1-2505300 Specification support on other aspects of AI/ML-based CSI compression CATT

R1-2505406 Discussion on other aspects for CSI compression vivo

R1-2505453 Discussion on other aspects of CSI spatial/frequency compression Xiaomi

R1-2505478 Discussion on other aspects for CSI compression TCL

R1-2505492 Discussion on other aspects of CSI compression ZTE Corporation, Sanechips

R1-2505685 Other aspects Tejas Network Limited

R1-2505688 Other aspects for CSI compression Lenovo

R1-2505747 Other aspects for AI/ML CSI compression OPPO

R1-2505803 CSI Compression: Other Aspects Nokia

R1-2505820 Discussion on other aspects for CSI compression LG Electronics

R1-2505903 On other aspects for AI based CSI spatial/frequency domain compression Apple

R1-2505930 Discussion on other aspects of CSI compression NEC

R1-2505963 Discussion on other aspects of CSI compression Fujitsu

R1-2506030 CSI spatial/frequency compression without temporal aspects (“Case 0”)- Other aspects MediaTek Inc.

R1-2506058 Discussion on other aspects of CSI compression ETRI

R1-2506089 Discussion on other aspects of CSI compression CMCC

R1-2506108 Discussions on Performance Monitoring for AI/ML CSI Compression Sony

Withdrawn

R1-2506208 Specification of other aspects of AIML CSI compression Qualcomm Incorporated

R1-2506249 Discussions on other aspects for NR air interface enhancements Sharp

R1-2506295 Discussion on other aspects of AI/ML CSI compression NTT DOCOMO, INC.

R1-2506315 Other Aspects of CSI spatial/frequency compression Indian Institute of Tech (M)

R1-2506339 Discussion on AIML based CSI compression ASUSTeK

R1-2506354 Discussion on AI/ML CSI Compression other aspects CEWiT

R1-2506378 Discussion on Data-collection / Monitoring / Model-pairing Rakuten Mobile, Inc

R1-2506386 Other aspects for CSI compression IIT Kanpur

**R1-2506482**

**Agreement:**

For model pairing procedure for inference, consider the applicability report procedure of Rel-19 AI/ML beam management for UE side model as a starting point.

* Pairing ID(s) (i.e., ID for pairing related discussion) is indicated (e.g., in *CSI-reportConfig*) in Step 3.
  + FFS whether/how to link the Pairing ID with the inter-vendor collaboration
  + FFS whether/how Paring ID(s) are reported in Step 4
* FFS whether to support both Option A (*CSI-ReportConfig* for inference configuration) and Option B (sets of inference related parameters for applicability report only).
  + FFS CSI compression specific inference configuration or inference related parameters.

**Agreement:**

For NW side data collection of CSI compression, discuss the content and format of the collected data by assuming higher layer based signalling.

* Details on signaling is up to RAN2.

**Agreement:**

To enable UE side data collection, *CSI-ReportConfig* can be used for configuring the resources for data collection purpose without CSI report

* P-CSI-RS and ~~/~~SP CSI-RS are supported

R1-2506483

R1-2506484

Agreement:

For NW side data collection, study the solution for quantizing Target CSI, from the aspects of overhead, quantization loss/performance, and complexity. E.g.,:

* Option 0: Reusing legacy e-Type II codebook
* Option 1: Scalar quantization to the Target CSI. FFS number of bits for real/imaginary, whether coefficients for quantization are obtained from transformation of Target CSI.
* Option 2: Enhanced methods to reduce the SVD/EVD decomposition complexity, reduce frequency/spatial/beam domain basis searching, with potentially relaxed overhead, e.g., Type II like codebook with scalar quantized W2 similar to Option 1 scalar quantization.
* Option 3: Enhanced method for improved overhead saving, e.g., reporting the dominant eigenvalues/eigenvectors of per layer precoding matrix.
* Option 4: eType II like codebook with new parameter values (e.g. larger *L,* *pv*, *beta, amplitude, phase*)
* Note: the quantizaton format should consider the maximum payload size per reporting (e.g., 9KBytes) of the current higher layer signaling.
* Note: At least take precoding matrix as Target CSI type. FFS channel matrix.
* FFS: EVM, metric, benchmark (e.g., FP32, eT2 with PC6/8), by reusing R18 study EVM as baseline.

### Inter-vendor training collaboration for two-sided AI/ML models

*Including specification of standardized dataset format/content plus dataset exchange (“Direction A, sub-option 4-1”), as well as RAN4-triggered issues.*

**R1-2505964** Discussion on inter-vendor training collaboration for two-sided AI/ML models Fujitsu

**R1-2506090** Discussion on inter-vendor training collaboration for CSI compression CMCC

R1-2505135 Inter-vendor training collaboration for two-sided AI/ML models Ericsson

R1-2505150 Discussion on inter-vendor training collaboration for two-sided AI/ML models FUTUREWEI

R1-2505163 Discussion on Inter-vendor training collaboration for two-sided AI/ML models Spreadtrum, UNISOC

R1-2505201 Inter-vendor training collaboration for two-sided AI/ML models Huawei, HiSilicon

R1-2505241 AI/ML CSI Spatial/Frequency Compression: Inter-vendor Collaboration InterDigital, Inc.

R1-2505262 Inter-Vendor Collaboration for AI/ML based CSI Compression Google

R1-2505301 Discussion on Inter-vendor training collaboration for CSI compression CATT

R1-2505407 Discussion on inter-vendor training collaboration for two-sided AI/ML models vivo

R1-2505454 Discussion on inter-vendor training collaboration for two-sided AI/ML models Xiaomi

R1-2505479 Discussion on inter-vendor collaboration for CSI compression TCL

R1-2505493 Discussion on inter-vendor training collaboration for two-sided AI/ML models ZTE Corporation, Sanechips

R1-2505575 Views on inter-vendor training collaboration for two-sided AI/ML models Samsung

R1-2505642 Discussion on Inter-vendor Training Collaboration for AI/ML models NEC

R1-2505689 Inter-vendor training collaboration for two-sided AI/ML models Lenovo

R1-2505701 Discussion on inter-vendor training collaboration for two-sided AI/ML models Panasonic

R1-2505748 Inter-vendor training collaboration for AI/ML CSI compression OPPO

R1-2505804 Inter-vendor training collaboration for two-sided AI/ML models Nokia

R1-2505806 Reference Model for Data Generation NTU

R1-2505821 Discussion on Inter-vendor training collaboration for two-sided models LG Electronics

R1-2505904 Inter-vendor training collaboration for two sided AI/ML models Apple

R1-2506012 Discussions on Inter-vendor training collaboration Sharp

R1-2506031 Inter-vendor training collaboration for two-sided AI/ML models MediaTek Inc.

R1-2506059 Discussion on inter vendor training collaboration for two-sided AI/ML models ETRI

R1-2506109 Discussion on Inter-Vendor Training collaboration for Two-Side AI/ML Models Sony

R1-2506209 Inter-vendor training collaboration for two-sided CSI compression use case Qualcomm Incorporated

R1-2506296 Discussion on the inter-vendor training collaborations for two-sided AI/ML models NTT DOCOMO, INC.

**R1-2506468**

**Agreement:**

For Option 4-1 under Direction A in AI/ML based CSI compression, support at least target CSI and CSI feedback in the exchanged dataset(s).

* FFS: Target CSI type and format
* FFS: CSI feedback type and format
* FFS: Association between Target CSI and CSI feedback, including mapping for different number of Tx port, number of sub bands, and CSI payload size.

**Agreement:**

For Option 4-1 under Direction A in AI/ML based CSI compression, consider the following methods for performance target in the exchanged dataset,

* SGCS
  + FFS: Average SGCS
  + FFS: SGCS values at X-percentiles
* NMSE:
  + FFS: When the exchanged CSI feedback is the floating-point values at the input of quantization
  + FFS: When the exchanged CSI feedback is the binary bit sequence at the output of quantization, the binary sequence will be mapped back to the floating-point values via quantization codebook
* FFS: Multiple performance targets for different layer when the target CSI type is precoding matrix, different configurations such as antenna ports, subband configuration and payload size configuration

**R1-2506469**

**R1-2506470**

Agreement:

For Option 4-1 under Direction A in AI/ML based CSI compression, for CSI feedback type and format, down select one of the following options:

* Option 1: The exchanged CSI feedback is the latent message before quantization.
* Option 2: The exchanged CSI feedback is the binary sequence at the output of quantization.
* Note: Quantization codebook is exchanged in addition if not specified in the spec.
* Note: Whether or not using the Quantization codebook for model training, is up to UE implementation.

**Agreement:**

For Option 4-1 under Direction A in AI/ML based CSI compression, support exchange of single pairing ID along with dataset exchange~~.~~

* One pairing ID is assigned to one dataset.
  + The dataset can have different number of Tx port, number of subbands, and CSI payload size configurations (including different quantization codebooks if needed).
* From RAN1 perspective, the uniqueness of the pairing ID needs further studied.
* FFS: the impact on pairing ID(s) when additional data samples are added to an exchanged dataset, if supported.

**Agreement:**

For Option 4-1 under Direction A in AI/ML based CSI compression, if the quantization codebook for CSI feedback is not fixed by the specification, support exchange of quantization codebook along with dataset exchange~~,~~

* FFS: Quantization codebook exchange method (e.g, look up table, , or how to exchange quantization codebook related information~~,~~ or other methods)
* FFS: Common or different quantization codebook for different CSI payload size
* Note: leveraging the discussion in agenda item 10.1.1.1 when applied