**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

Proposed conclusion:

Companies are encouraged to consider the following guidelines for discussions and preparation of contributions:

**Target CSI:**

* Target CSI type is about what to report, e.g., channel or precoder, antenna-port-subband representation or angular-delay representation. It will be mainly discussed in 10.1.1.1.
* Target CSI format is a method to quantize the target CSI. Target CSI in such format will be delivered from UE to NW in data collection / monitoring or exchanged from NW to UE for inter-vendor collaboration. The former will be discussed in 10.1.1.2. The latter will be discussed in 10.1.2 and may leverage the discussion in 10.1.1.2 if applicable.

**Pairing ID:**

* Pairing ID will be used in dataset exchange, applicability enquiry / model pairing, data collection, inference configuration. It can be discussed in all three agendas whenever necessary / applicable. The three agendas will try to leverage the discussion results each other.

**Quantization method / codebook:**

* Quantization method such as SQ or VQ, number of quantization bits, etc, will be discussed in 10.1.1.1. The necessity of adopting exchanged codebook can be discussed in both 10.1.1.1 and 10.1.2, while the codebook exchange will be discussed in 10.1.2. Other details, such as common or specific codebooks are needed for different configuration, can be discussed in these two agendas whenever necessary / applicable. The two agendas will try to leverage the discussion results each other.

### 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



#### 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

Proposal 2.5:

**Approve the following Rel-19 agreement to Rel-20 agreement, i.e., Pairing ID associated with the exchanged dataset of Option 4-1, model parameters of Option 3a-1, and fully standardized reference model of Direction C, ~~can be used~~ is considered for UE side data collection, model pairing procedure for inference (i.e., applicability inquiry and reporting), ~~inference configuration, and NW-sided data collection~~.**

* **FFS mandatory or optional**
* **FFS NW-sided data collection**

|  |
| --- |
| Agreement(#120bis)  In Options 3a-1 and 4-1, the exchanged dataset or the model parameters can be associated with an ID for pairing related discussion, then   * The same ID can be used for UE to collect UE-side target CSI for UE-side training * The same ID can be used for applicability inquiry and reporting * The same ID can be used for inference configuration * The same ID can be used for NW-side data collection * FFS: whether ID/even same ID is needed for monitoring configuration * FFS: where the ID is assigned * Note: whether the purpose for pair will be specified will be discussed separately.   Agreement(#120bis)  In Direction C, the fully standardized reference model is associated with an ID for pairing related discussion, then   * The same ID can be used for UE to collect UE-side target CSI for UE-side training * The same ID can be used for applicability inquiry and reporting * The same ID can be used for inference configuration * The same ID can be used for NW-side data collection * FFS: whether ID/even same ID is needed for monitoring configuration * FFS: where the ID is assigned or how the ID is specified * Note: whether the purpose for pair will be specified will be discussed separately. |

### 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