

3GPP TSG RAN Rel-19 Workshop
Taipei, June 15 – 16, 2023
Agenda Item: 5

RWS-230004

AI/ML for Air Interface for Release 19

Futurewei Technologies, Inc.



AI/ML for Air Interface: R18 SI Status

- Rel-18 Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR Air Interface (*FS_NR_AIML_Air*) has made some high-level progress in many fronts, including
 - Identification and definitions on common notation and terminology for AI/ML related functions, procedures and interfaces pertinent to *FS_NR_AIML_Air*.
 - 3 major training collaboration types between NW side and UE side
 - 6 model transfer/delivery cases for UE-side models and UE-part of two-sided models depending on model training/storage location and model delivery/transfer format combinations
 - Evaluation methodology and KPI development/agreement for 3 identified use cases and 6 associated sub-use cases.
 - Evaluation results and common observations for all 3 use cases collected across companies.
 - Identification of some areas/topics that have potential specification impacts at high-level for all 3 use cases and 6 associated sub use cases.

AI/ML for Air Interface: R19 WI (1)

- There are still many remaining open issues for each agenda item in *FS_NR_AIML_Air*, further progress is needed before starting normative work in Rel-19 with limited and more focused scope.
 - Start with a SI followed by a WI in Rel-19
- Given that AI/ML use cases are new in RAN1 and based on the lessons learned during Rel-18, we call for more focused discussions in Rel-19.
 - A small number of sub use cases to be selected from the 6 sub use cases of the 3 R18 SI use cases (CSI, BM, POS).
 - Performance benefits of the selected sub use case need to be significant to justify the efforts of standardization, implementation, and deployment.
 - As an example, for CSI reporting sub use case, CSI codebook/look-up-table generated via AI/ML autoencoder model and vector quantization can reduce the feedback overall to less than 10-20% of that of Type-II codebook without performance loss, that is 80-90% overhead saving! (See later pages for details)

AI/ML for Air Interface: R19 WI (2)

- Standards impacts considerations
 - Option 1: only support the selected use case(s) with minimum framework augmentation
 - Option 2: support the selected use case(s) with (limited) consideration on extendibility to other use cases in future release(s)
 - Option 3: design framework that can support lots of potential use cases with the selected use case(s) as the first few in R19
- Option 2 is preferred considering the workload and the upcoming 6G work

AI/ML for Air Interface: R19 WI (3)

- Areas for general specification work:

- Specifications to support the development of general life cycle management (LCM) framework for AI/ML-based features/functions and AI/ML operations across interacting entities and interfaces.
- Specifications to support the development of model/functionality identification and AI-enabled UE features/functionalities.
- Specifications to support data collection and delivery/transfer needed at various stages, including AI/ML model training/update, inference and performance monitoring for identified use cases and associated sub use cases.
- Specifications to support AI/ML model delivery/transfer cases based on the agreement for each (sub) use case (note: not necessarily all model deliver/transfer cases need to be supported).
- Specifications to enable the realization of AI/ML based approaches/solutions and required AI/ML operations for each agreed (sub) use case while not revealing vendor-specific implementation details.

Selected Use Case: An Example

- For CSI feedback use case, CSI codebook/look-up-table (LUT) is generated via AI/ML autoencoder model and vector quantization
 - UE selects an entry from the LUT that has the highest performance (e.g., SGCS) and reports the index to gNB
- CSI feedback overhead is of 10+ bits instead of 100+ bits for Type-II codebook and without performance degradation (next page)
- See R1-2304371 for more details

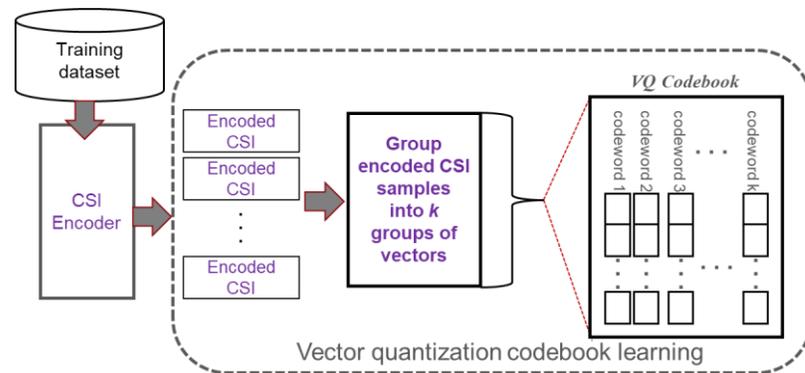


Figure 1: Vector quantization codebook learning

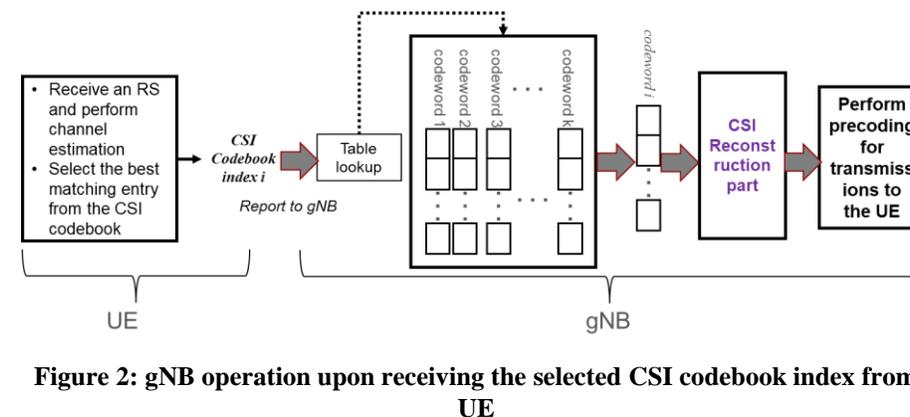
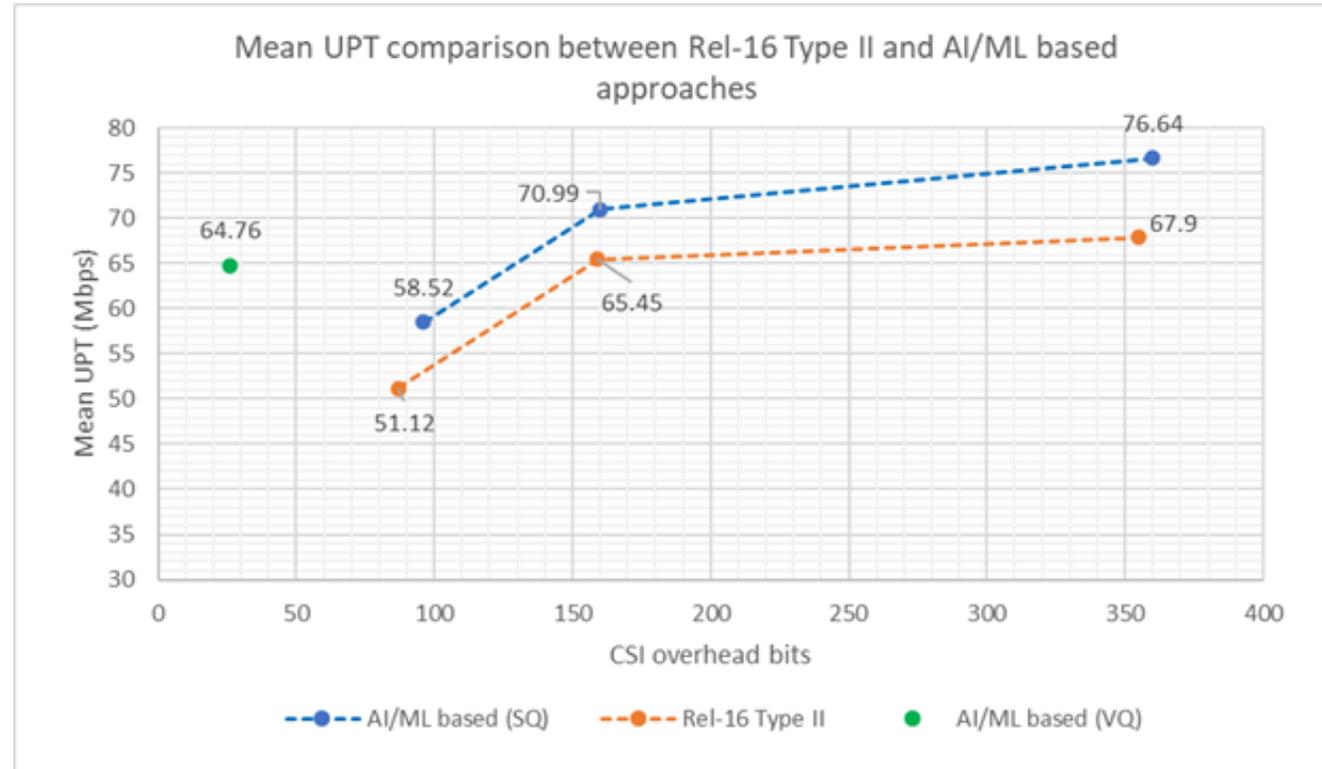
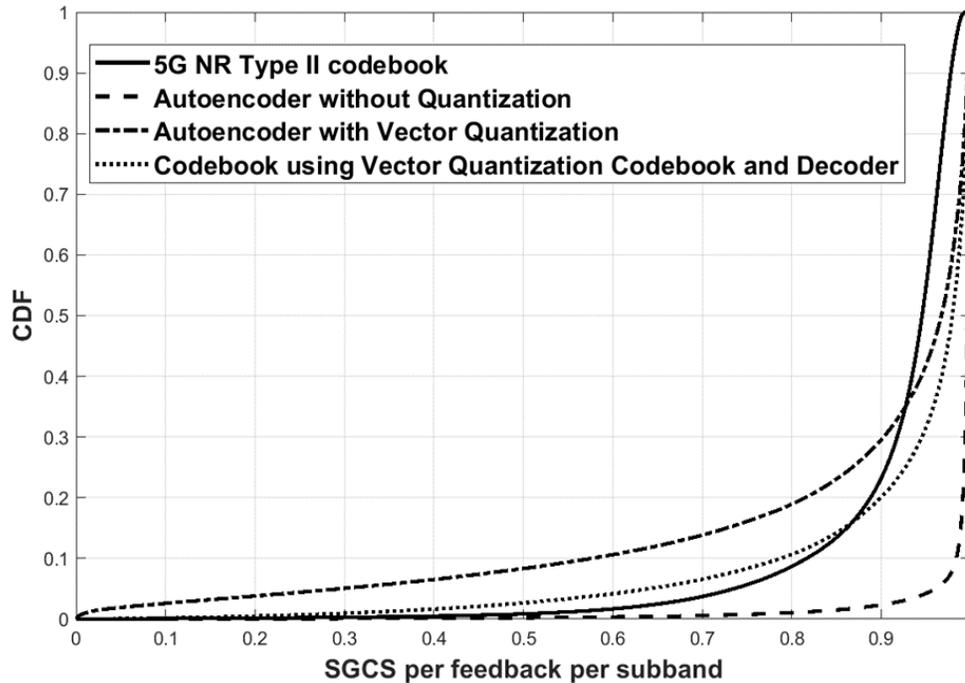


Figure 2: gNB operation upon receiving the selected CSI codebook index from UE

AI/ML generated Codebook/LUT for CSI Compression and Report

SGCS comparison for CSI compression: Type II codebook vs. typical autoencoder vs. using the best VQ codebook entry



- When using the best CSI codebook entry, the CSI reconstruction accuracy improves and the percentage of samples with poor SGCS is significantly lower compared to typical autoencoder-based approach.
- Using LUT-based vector quantization, AI/ML approach can achieve comparable UPT performance as Rel-16 Type II codebook with only ~ 1/10 and 1/6 of overhead with max rank =1, 2 respectively.

Assessment of Other Use Cases

- Time-domain CSI prediction

- Based on companies' contributions, AI/ML based time-domain CSI prediction moderately outperforms nearest historical CSI benchmark in term of SGCS (intermediate KPI) from UE speed perspective. System level performance gain is less clear as not many companies submitted UPT result comparisons with benchmarks as of RAN1#113.

- Beam Management

- Companies have spent significant amount of time/effort in discussing the feasibility/benefit regarding DL Tx-Rx beam pair prediction while views from companies are still split. The main concern is it may require exposing vendor proprietary information at UE side.
- DL beam prediction can provide moderate benefit in term of performance (comparing to sparse sweeping baseline) or overhead and latency (comparing to exhaustive sweeping baseline)
- Temporal domain beam prediction is yet to reach performance observation

- UE Positioning

- Direct AI/ML positioning can significantly improve the positioning accuracy when the generalization aspects are not considered. Performance also depends on various factors like model input type, dataset size, model complexity and ground truth label errors.

Conclusions

- A small number of Use cases to be selected for specification work
 - Performance benefits need to be significant to justify the efforts.
 - For example, CSI codebook/look-up-table generated via AI/ML autoencoder model and vector quantization can achieve **80-90% overhead saving without performance loss**
- Support the selected use case(s) with (limited) consideration on extendibility to other use cases in future release(s)
- Potential Standards work to support the following functionalities:
 - General life cycle management (LCM) framework for AI/ML-based features/functions and AI/ML operations across interacting entities and interfaces.
 - Data collection and delivery/transfer needed at various stages, including AI/ML model training/update, inference and performance monitoring
 - AI/ML model delivery/transfer for selected (sub) use case
 - Define and indicate AI/ML features/functions in UE capability and potential enhancements

Thank You.

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