**3GPP TSG RAN Meeting #94e RP-21xxxx**

**Electronic Meeting, Dec. 6 - 17, 2021** (revision of RP-212708)

**Source: Qualcomm (Moderator)**

**Title: New SID on AI/ML for NR Air Interface**

**Document for: Approval**

**Agenda Item: 8.6.1**

3GPP™ Work Item Description

Information on Work Items can be found at <http://www.3gpp.org/Work-Items>
See also the [3GPP Working Procedures](http://www.3gpp.org/specifications-groups/working-procedures), article 39 and the TSG Working Methods in [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm)

# Title: SID on AI/ML for NR Air Interface

## Acronym: NR\_AI/ML

## Unique identifier:

NOTE: For new WIs/SIs leave the Unique identifier empty and make a proposal for an Acronym.

 For a revised WI/SI: Take Unique identifier and acronym as shown in 3GPP workplan.

 If this is a RAN WID including Core and Perf. part, then Title, Acronym and Unique identifier refer to the feature WI.

 Please tick (X) the applicable box(es) in the table below:

 Either:

|  |  |
| --- | --- |
| **This WID includes a Core part** |  |
| **This WID includes a Performance part** |  |

 or:

|  |  |
| --- | --- |
| **This WID includes a Testing part** |  |
| **and it addresses the following 3GPP work area:** | **Radio Access** |  |
| **Core Network** |  |
| **Services** |  |

Potential target Release: Rel-18

Note that this field above indicates the proposed Release at the time of submission of the WID to TSG approval. It can later be changed without a need to revise the WID. The updated target Release is indicated in the Work Plan. NOTE: In case of contradiction with the target dates of clause 5, clause 5 determines the target release.

## 1 Impacts

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Affects:** | UICC apps | ME | AN | CN | Others (specify) |
| **Yes** |  | X | X |  |  |
| **No** | X |  |  | X |  |
| **Don't know** |  |  |  |  |  |

## 2 Classification of the Work Item and linked work items

### 2.1 Primary classification

This work item is a …

|  |  |
| --- | --- |
|  | Feature |
|  | Building Block |
|  | *Work Task* |
| X | Study Item |

NOTE: Normally, Core/Perf./Testing parts in RAN WIDs are Building Blocks. Only if they are under an SA or CT umbrella, they are defined as work tasks. If you are in doubt, please contact MCC.

### 2.2 Parent Work Item

|  |
| --- |
| Parent Work / Study Items  |
| Acronym | Working Group | Unique ID | Title (as in 3GPP Work Plan) |
|  |  |  |  |

NOTE: RAN agreed some time ago, that it describes the feature WI + Core/Perf. part WI or Testing part WI in one WID. Therefore the table above should just include the feature WI data (In case the feature covers Core and Perf. part, please list under Working Group the leading WG of the Core part).

### 2.3 Other related Work Items and dependencies

|  |
| --- |
| Other related Work Items (if any) |
| Unique ID | Title | Nature of relationship |
| 880076 | Study on enhancement for data collection for NR and ENDC | Related study for RAN intelligence.  |

NOTE: Also related or dependent WIs/SIs in other TSGs should be indicated.

## 3 Justification

The application of AI/ML to wireless communications has been thus far limited to implementation-based approaches, both, at the network and the UE sides. A study on enhancement for data collection for NR and ENDC (*FS\_NR\_ENDC\_data\_collect*) has examined the *functional framework for RAN intelligence enabled by further enhancement of data collection through use cases, examples etc. and identify the potential standardization impacts on current NG-RAN nodes and interfaces*. In SA WG2 AI/ML related study, a network functionality NWDAF (Network Data Analytics Function) was introduced in Rel-15 and has been enhanced in Rel-16 and Rel-17.

In this study, we explore the benefits of augmenting the air-interface with features enabling improved support of AI/ML based algorithms for enhanced performance and/or reduced complexity/overhead. Enhanced performance here depends on the use cases under consideration and could be, e.g., improved throughput, robustness, accuracy or reliability, etc.

Through studying a few carefully selected use cases, assessing their performance in comparison with traditional methods and the associated potential specification impacts that enable their solutions, this SI will lay the foundation for future air-interface use cases leveraging AI/ML techniques.

The goal is that sufficient use cases will be considered to enable the identification of a common AI/ML framework, including functional requirements of AI/ML architecture, which could be used in subsequent projects. The study should also identify areas where AI/ML could improve the performance of air-interface functions.

The study will serve identifying what is required for an adequate AI/ML model characterization and description establishing pertinent notation for discussions and subsequent evaluations. Various levels of collaboration between the gNB and UE are identified and considered.

Evaluations to exercise the attainable gains of AI/ML based techniques for the use cases under consideration will be carried out with the corresponding identification of KPIs with the goal to have a better understanding of the attainable gains and associated complexity requirements.

Finally, specification impact will be assessed in order to improve the overall understanding of what would be required to enable AI/ML techniques for the air-interface.

For the study on AI/ML for air-interface, the basic framework and principles agreed for *FS\_NR\_ENDC\_data\_collect*,as captured in section 4 of TR 37.817, should be taken into consideration for possible applicability.

## 4 Objective

### 4.1 Objective of SI or Core part WI or Testing part WI

Study the 3GPP framework for AI/ML for air-interface corresponding to each target use case regarding aspects such as performance, complexity, and potential specification impact.

Use cases to focus on:

* Initial set of use cases includes:
	+ CSI feedback enhancement, e.g., overhead reduction, improved accuracy, prediction [RAN1]
	+ Beam management, e.g., beam prediction in time, and/or spatial domain for overhead and latency reduction, beam selection accuracy improvement [RAN1]
	+ Positioning accuracy enhancements for different scenarios including, e.g., those with heavy NLOS conditions [RAN1]
* Finalize representative sub uses cases for each use case for characterization and baseline performance evaluations by RAN#98
	+ The AI/ML approaches for the selected sub use cases need be diverse enough to support various requirements on the gNB-UE collaboration levels

Note: the selection of use cases for this study solely targets the formulation of a framework to apply AI/ML to the air-interface for these and other use cases. The selection itself does not intend to provide any indication of the prospects of any future normative project.

AI/ML model, terminology and description to identify common and specific characteristics for framework investigations:

* Characterize the defining stages of AI/ML related algorithms and associated complexity:
	+ Model generation, e.g., model training (including input/output, pre-/post-process, online/offline as applicable), model validation, model testing, as applicable
	+ Inference operation, e.g., input/output, pre-/post-process, as applicable
* Identify various levels of collaboration between UE and gNB pertinent to the selected use cases, e.g.,
	+ No collaboration: implementation-based only AI/ML algorithms without information exchange [for comparison purposes]
	+ Various levels of UE/gNB collaboration targeting at separate or joint ML operation.
* Characterize lifecycle management of AI/ML model: e.g., model training, model deployment , model inference, model monitoring, model updating
* Data set(s) for training, validation, testing, and inference
* Identify common notation and terminology for AI/ML related functions, procedures and interfaces
* Note: Consider the work done for *FS\_NR\_ENDC\_data\_collect* when appropriate

For the use cases under consideration:

1. Evaluate performance benefits of AI/ML based algorithms for the agreed use cases in the final representative set:
	* Methodology based on statistical models (from TR 38.901 and TR 38.857 [positioning]), for link and system level simulations.
		+ Extensions of 3GPP evaluation methodology for better suitability to AI/ML based techniques should be considered as needed.
		+ Whether field data are optionally needed to further assess the performance and robustness in real-world environments should be discussed as part of the study.
		+ Need for common assumptions in dataset construction for training, validation and test for the selected use cases.
		+ Consider adequate model training strategy, collaboration levels and associated implications
		+ Consider agreed-upon base AI model(s) for calibration
		+ AI model description and training methodology used for evaluation should be reported for information and cross-checking purposes
	* KPIs: Determine the common KPIs and corresponding requirements for the AI/ML operations. Determine the use-case specific KPIs and benchmarks of the selected use-cases.
		+ Performance, inference latency and computational complexity of AI/ML based algorithms should be compared to that of a state-of-the-art baseline
		+ Overhead, power consumption (including computational), memory storage, and hardware requirements (including for given processing delays) associated with enabling respective AI/ML scheme, as well as generalization capability should be considered.
2. Assess potential specification impact, specifically for the agreed use cases in the final representative set and for a common framework:
	* PHY layer aspects, e.g., (RAN1)
		+ Consider aspects related to, e.g., the specification of the AI Model lifecycle management, and dataset construction for training, validation and test for the selected use cases
		+ Use case and collaboration level specific specification impact, such as new signalling, means for training and validation data assistance, assistance information, measurement, and feedback
	* Protocol aspects, e.g., (RAN2) - RAN2 only starts the work after there is sufficient progress on the use case study in RAN1
		+ Consider aspects related to, e.g., capability indication, configuration and control procedures (training/inference), , and management of data and AI/ML model, per RAN1 input
		+ Collaboration level specific specification impact per use case
	* Interoperability and testability aspects, e.g., (RAN4) - RAN4 only starts the work after there is sufficient progress on use case study in RAN1 and RAN2
		+ Requirements and testing frameworks to validate AI/ML based performance enhancements and ensuring that UE and gNB with AI/ML meet or exceed the existing minimum requirements if applicable
		+ Consider the need and implications for AI/ML processing capabilities definition

Note 1: specific AI/ML models are not expected to be specified and are left to implementation. User data privacy needs to be preserved.

Note 2: The study on AI/ML for air interface is based on the current RAN architecture and new interfaces shall not be introduced.

### 4.2 Objective of Performance part WI

NOTE: Leave empty if the WI proposal does not contain a RAN performance part.

### 4.3 RAN time budget request (not applicable to RAN5 WIs/SIs)

NOTE: For all new RAN related WIs/SIs which are not led by RAN WG5 the WI/SI rapporteur has to fill out the attached Excel table to request time budgets for corresponding RAN WG meetings.
The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI.
One time unit (TU) corresponds to ~ 2 hours in the meeting.
If no TU is needed, then leave the field empty otherwise enter a number >0 in the field.

 For revisions of already approved WI/SI descriptions: Please remove the Excel table from the WID/SID's zip file. The time budgets are already recorded. If you want to modify them, then this has to be done via the status report and not via a revised WID/SID.

 If this WID is covering Core and Performance part, then please fill out one line for each part in the attached Excel table.

**additional comments to the time budget request in the attached Excel table:**

## 5 Expected Output and Time scale

|  |
| --- |
| **New specifications** *{One line per specification. Create/delete lines as needed}* |
| Type  | TS/TR number | Title | For info at TSG#  | For approval at TSG# | Remarks |
| Internal TR | 38.xxx | Study on AI/ML for NR Air Interface | RAN#101 | RAN#102 | *{e.g. rapporteur: <FamilyName>, <GivenName>, <Company>, <email address>}* |

*{Note 1: Only TSs may contain normative provisions. Study Items shall create or impact only TRs.
"Internal TR" is intended for 3GPP internal use only whereas "External TR" may be transposed by OPs.}*

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
By default a new specs can only be new for one of both parts.

|  |
| --- |
| **Impacted existing TS/TR** *{One line per specification. Create/delete lines as needed}* |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
|  |  |  |  |

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
If an existing spec is affected by both (Core part and Perf. part), then it has to be listed twice with appropriate approval dates.

## 6 Work item Rapporteur(s)

*{Mandatory: <FamilyName>, <GivenName>, <Company>, <email address>.}*

*{Optional: <FamilyName>, <GivenName>, <Company>, <email address>: Secondary task(s).}*

*{The first listed Rapporteur is the work item primary Rapporteur. The role of a Rapporteur is further described in* [*www.3gpp.org/specifications-groups/delegates-corner/writing-a-new-spec*](http://www.3gpp.org/specifications-groups/delegates-corner/writing-a-new-spec)*. Secondary Rapporteur(s) are possible for specific secondary task(s)}*.

## 7 Work item leadership

Primary: RAN1

Secondary: RAN2, RAN4

## 8 Aspects that involve other WGs

None.

NOTE: For RAN WIs: Section 8 applies only toWGs outside of TSG RAN because RAN WG aspects have to be covered in section 4.

## 9 Supporting Individual Members

*{At least 4 supporting Individual Members are needed. There is an expectation that these companies will provide resources to progress the work. Note that having 4 supporting companies is a necessary but not sufficient condition: the usual TSG approval process by consensus is needed for the WID approval.}*

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| Supporting IM name |
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