ETSI TS 128 105 V18.9.0 (2026-04)

TECHNICAL SPECIFICATION

5G;
Management and orchestration;
Artificial Intelligence/ Machine Learning (AI/ML) management
(3GPP TS 28.105 version 18.9.0 Release 18)

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Reference
RTS/TSGS-0528105vi90

Keywords
5G

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In the present document, modal verbs have the following meanings:

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will indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

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1 Scope

The present document specifies the Artificial Intelligence / Machine Learning (AI/ML) management capabilities and services for 5GS where AI/ML is used, including management and orchestration (e.g., MDA, see 3GPP TS 28.104 [2]) and 5G networks (e.g. NWDAF, see 3GPP TS 23.288 [3]) and NG-RAN (see TS 38.300 [16] and TS 38.401 [17]).

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

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[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 28.104: "Management and orchestration; Management Data Analytics".

[3] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[4] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[5] 3GPP TS 32.425: "Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)".

[6] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[7] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".

[8] Void

[9] 3GPP TS 28.405: "Telecommunication management; Quality of Experience (QoE) measurement collection; Control and configuration".

[10] Void

[11] 3GPP TS 28.532: "Management and orchestration; Generic management services".

[12] 3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[13] 3GPP TS 32.156: "Telecommunication management; Fixed Mobile Convergence (FMC) Model repertoire".

[14] 3GPP TS 32.160: "Management and orchestration; Management service template".

[15] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[16] 3GPP TS 38.300: "NR; NR and NG-RAN Overall description; Stage-2".

[17] 3GPP TS 38.401: "NG-RAN; Architecture description".

[18] 3GPP TS 28.541: " Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

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[19] 3GPP TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".

[20] 3GPP TS 29.520: "5G System; Network Data Analytics Services; Stage 3".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

ML model: a manageable representation of an ML model algorithm.

NOTE 1: an ML model algorithm is a mathematical algorithm through which running a set of input data can generate a set of inference output.

NOTE 2: ML model algorithm is proprietary and not in scope for standardization and therefore not treated in this specification.

NOTE 3: ML model may include metadata. Metadata may include e.g. information related to the trained model, and applicable runtime context.

ML model training: a process performed by an ML training function to take training data, run it through an ML model algorithm, derive the associated loss and adjust the parameterization of that ML model iteratively based on the computed loss and generate the trained ML model.

ML model initial training: a process of training an initial version of an ML model.

ML model re-training: a process of training a previously trained version of an ML model and generate a new version.

NOTE 4: a new version of a trained ML model supports the same type of inference as the previous version of the ML model, i.e., the data type of inference input and data type of inference output remain unchanged between the two versions of the ML model, but parameter values might be different for the re-trained model.

ML model joint training: a process of training a group of ML models.

ML training function: a logical function with ML model training capabilities.

ML model testing: a process of evaluating the performance of an ML model using testing data different from data used for model training and validation.

ML model joint testing: a process of evaluating the performance of a group of ML models using testing data different from data used for model training and validation.

ML testing function: a logical function with ML model testing capabilities.

AI/ML inference: a process of running a set of input data through a trained ML model to produce set of output data, such as predictions.

NOTE 5: the inference represents the process to realize the AI capabilities by utilizing a trained ML model and other AI enablers if needed, hence the AI/ML prefix is used when referring to inference as compared to training and testing.

AI/ML inference function: a logical function that employs trained ML model(s) to conduct inference.

AI/ML inference emulation: running the inference process to evaluate the performance of an ML model in an emulation environment before deploying it into the target environment.

ML model deployment: a process of making a trained ML model available for use in the target environment.

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ML model loading: a process of making a trained ML model available to an inference function.

AI/ML activation: a process of enabling the inference capability of an AI/ML inference function.

AI/ML deactivation: a process of disabling the inference capability of an AI/ML inference function.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and TS 28.533 [15]. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1] and TS 28.533 [15].

AI	Artificial Intelligence
ML	Machine Learning

4 Concepts and overview

4.1 Overview

The AI/ML techniques and relevant applications are being increasingly adopted by the wider industries and proved to be successful. These are now being applied to telecommunication industry including mobile networks.

Although AI/ML techniques in general are quite mature nowadays, some of the relevant aspects of the technology are still evolving while new complementary techniques are frequently emerging.

The AI/ML techniques can be generally characterized from different perspectives including the followings:

- **Learning methods**

The learning methods include supervised learning, semi-supervised learning, unsupervised learning and reinforcement learning. Each learning method fits one or more specific category of inference (e.g. prediction), and requires specific type of training data. A brief comparison of these learning methods is provided in table 4.1-1.

Table 4.1-1: Comparison of Learning methods

	Supervised learning	Semi-supervised learning	Unsupervised learning	Reinforcement learning
Category of inference	Regression (numeric), classification	Regression (numeric), classification	Association, Clustering	Reward-based behaviour
Type of training data	Labelled data (Note)	Labelled data (Note), and unlabelled data	Unlabelled data	Not pre-defined
NOTE: The labelled data refers to a set of training and testing data that have been assigned with one or more labels in order to add context and meaning.				

- **Learning complexity:**
  - As per the learning complexity, there are Machine Learning (i.e. basic learning) and Deep Learning.
- **Learning architecture**
  - Based on the topology and location where the learning tasks take place, the AI/ML can be categorized to centralized learning, distributed learning and federated learning.
- **Learning continuity**

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- From learning continuity perspective, the AI/ML can be offline learning or continual learning.

Artificial Intelligence/Machine Learning (AI/ML) capabilities are used in various domains in 5GS, including management and orchestration (e.g. MDA, see 3GPP TS 28.104 [2]) and 5G networks (e.g. NWDAF, see 3GPP TS 23.288 [3]).

The AI/ML inference function in the 5GS uses the ML model for inference.

Each AI/ML technique, depending on the adopted specific characteristics as mentioned above, may be suitable for supporting certain type/category of use case(s) in 5GS.

To enable and facilitate the AI/ML capabilities with the suitable AI/ML techniques in 5GS, the ML model and AI/ML inference function need to be managed.

The present document specifies the generic AI/ML management related capabilities and services without specifically taking any of the above-mentioned learning methods into consideration. The AI/ML management capabilities which include the followings:

- ML model training.
- ML model testing.
- AI/ML inference emulation.
- ML model deployment.
- AI/ML inference.

4a AI/ML management functionality and service framework

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4a.0 ML model lifecycle

AI/ML techniques are widely used in 5GS (including 5GC, NG-RAN, and management system), the generic AI/ML operational workflow shown in Figure 4a.0-1, highlights the main steps of an ML model lifecycle.

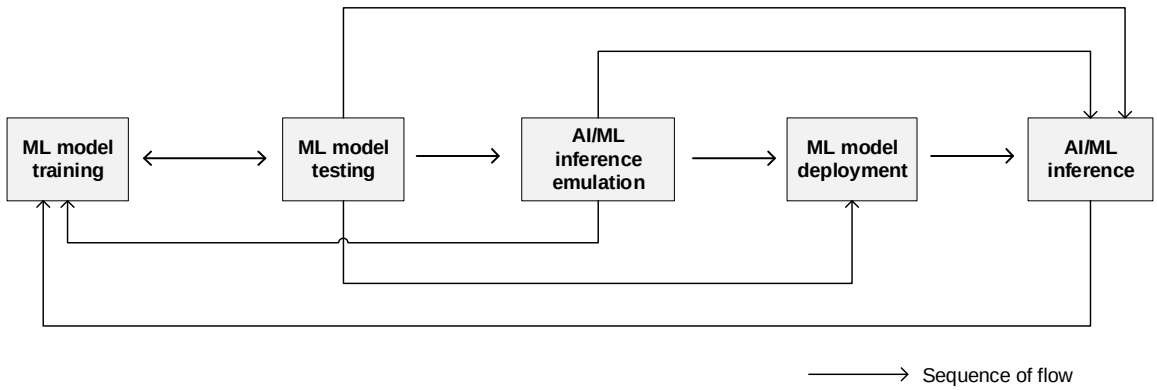

Figure 4a.0-1: ML model lifecycle

The ML model lifecycle includes training, testing, emulation, deployment, and inference. These steps are briefly described below:

- **ML model training:** training, including initial training and re-training, of an ML model or a group of ML models. It also includes validation of the ML model to evaluate the performance when the ML model performs on the training

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