ETSI TS 128 105 V18.3.0 (2024-05)

5G;
Management and orchestration;
Artificial Intelligence/ Machine Learning (AI/ML) management
(3GPP TS 28.105 version 18.3.0 Release 18)

Reference
RTS/TSGS-0528105vi30

Keywords
5G

ETSI

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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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where:

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2 presented to TSG for approval;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

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

shall indicates a mandatory requirement to do something

shall not indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

should indicates a recommendation to do something

should not indicates a recommendation not to do something

may indicates permission to do something

need not indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

can indicates that something is possible

cannot indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

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

will not indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

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.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[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".

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 entity: a manageable artifact of an ML model.

NOTE 1: An ML entity may contain metadata related to the model. Metadata may include e.g. the applicable runtime context for the ML model.

ML model: mathematical algorithm that can be "trained" by data and human expert input as examples to replicate a decision an expert would make when provided that same information.

NOTE 2: The ML models are proprietary and not in scope for standardization.

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

ML initial training: the ML model training that generates the initial version of an ML entity.

ML re-training: The process of training of a previously trained ML model.

NOTE 3: A new version of a trained ML entity supports the same type of inference as the previous version of the ML entity, i.e., the data type of inference input and data type of inference output remain unchanged between the two versions of the ML entity, but parameter values might be different for the re-trained model.

ML joint training: the ML training for a group of ML models that are trained and targeted for inference.

ML training: refers to the end-to-end processes to enable an ML training function to perform ML model initial training or re-training (as defined above).

NOTE 4: ML training may include interaction with other parties to collect and format the data required for ML model training.

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

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

AI/ML inference function: a logical function that employs an ML model to conduct inference.

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 means the input and output parameters are explicitly labelled for each training data example.				

- **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**
  - 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 AI/ML management related capabilities and services, which include the followings:

- ML training.

4a AI/ML management functionality and service framework

4a.0 AI/ML operational workflow

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

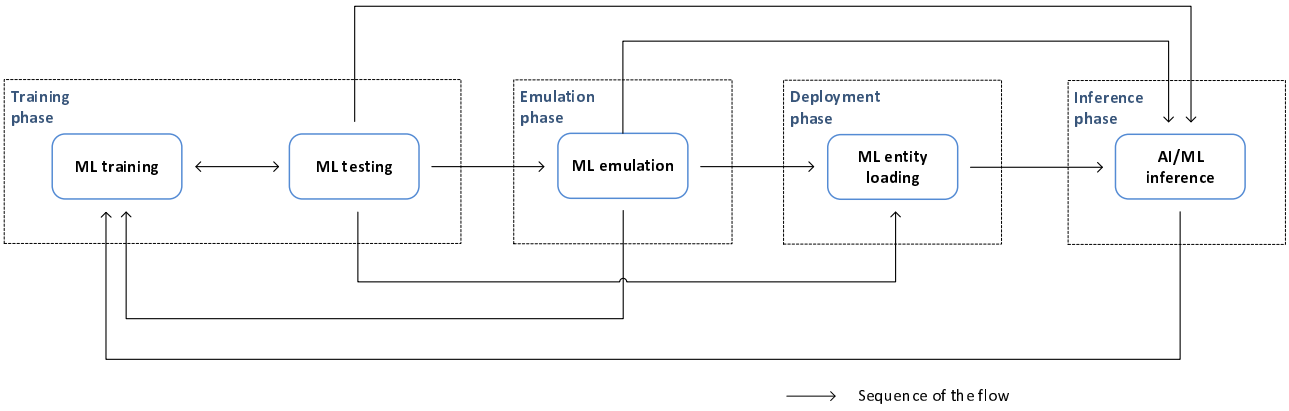


Figure 4a.0-1: AI/ML operational workflow

The workflow involves 4 main operational phases; namely training, emulation, deployment, and inference phase. The main tasks for each phase are briefly described below:

Training phase:

- **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 entity to evaluate the performance when the ML entity performs on the training data and validation data. If the validation result does not meet the expectation (e.g., the variance is not acceptable), the ML model associated with that entity needs to be re-trained. The ML model training is the initial phase of the workflow.

- **ML testing:** testing of the validated ML entity to evaluate the performance of the trained ML model when it performs on testing data. If the testing result meets the expectation, the ML entity may proceed to the next phase, otherwise the ML model associated with that entity may need to be re-trained.

Emulation phase:

- **ML emulation:** running an ML entity for inference in an emulation environment. The purpose is to evaluate the inference performance of the ML entity in the emulation environment prior to applying it to the target network or system.

  NOTE: The emulation phase is considered optional and can be skipped in the AI/ML operational workflow.

Deployment phase:

- **ML entity loading:** the process (a.k.a. a sequence of atomic actions) of making a trained ML entity available for use at the target AI/ML inference function.

  The deployment phase may not be needed in some cases, for example when the training function and inference function are co-located.

Inference phase:

- **AI/ML inference:** performing inference using a trained ML entity by the AI/ML inference function.

4a.1 Functionality and service framework for ML training

An ML training Function playing the role of ML training MnS producer, may consume various data for ML training purpose.

As illustrated in Figure 4a.1-1 the ML training capability is provided via ML training MnS in the context of SBMA to the authorized consumer(s) by ML training MnS producer.

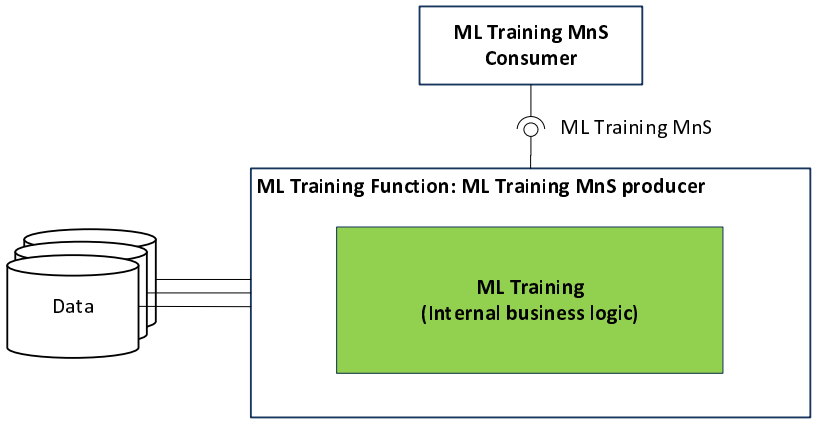


Figure 4a.1-1: Functional overview and service framework for ML training

The internal business logic of ML training leverages the current and historical relevant data, including those listed below to monitor the networks and/or services where relevant to the ML model, prepare the data, trigger and conduct the training:

- Performance Measurements (PM) as per 3GPP TS 28.552 [4], 3GPP TS 32.425 [5] and Key Performance Indicators (KPIs) as per 3GPP TS 28.554 [6].
- Trace/MDT/RLF/RCEF data, as per 3GPP TS 32.422 [7].
- QoE and service experience data as per 3GPP TS 28.405 [9].
- Analytics data offered by NWDAF as per 3GPP TS 23.288 [3].
- Alarm information and notifications as per 3GPP TS 28.532 [11].
- CM information and notifications.
- MDA reports from MDA MnS producers as per 3GPP TS 28.104 [2].
- Management data from non-3GPP systems.
- Other data that can be used for training.

4a.2 AI/ML functionalities management scenarios

The ML training function and/or AI/ML inference function can be located in the RAN domain MnS consumer (e.g. cross-domain management system) or the domain-specific management system (i.e. a management function for RAN or CN), or Network Function.

For MDA, the ML training function can be located inside or outside of MDAF. The AI/ML inference function is in the MDAF.

For NWDAF, the ML training function can be located in NWDAF or management system, the AI/ML inference function is in the NWDAF.

For RAN, the ML training function and AI/ML inference function can both be located in the gNB, or the ML training function can be located in the management system and AI/ML inference function is located in the gNB.

Therefore, there might exist several location scenarios for ML training function and AI/ML inference function.

Scenario 1:

The ML training function and AI/ML inference function are both located in the 3GPP management system (e.g. RAN domain management function). For instance, for RAN domain-specific MDA, the ML training function and AI/ML inference functions for MDA can be located in the RAN domain-specific MDAF. As depicted in figure 4a.2-1.

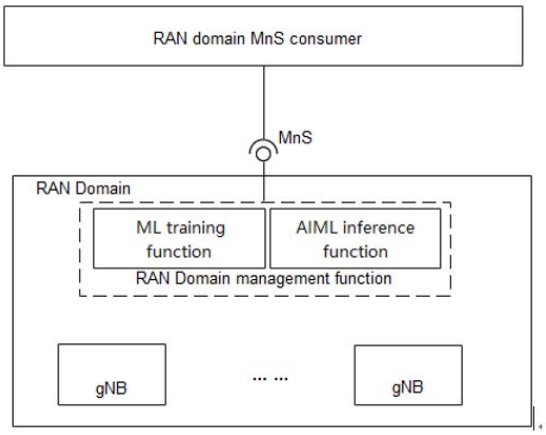


Figure 4a.2-1: Management for RAN domain analytics

Similarly, for CN domain-specific MDA the ML training function and AI/ML inference function can be located in CN domain-specific MDAF or in the cross-domain MDAF.

Scenario 2:

The ML training function is located in the 3GPP RAN domain-specific management function while the AI/ML inference function is located in gNB. See figure 4a.2-2.

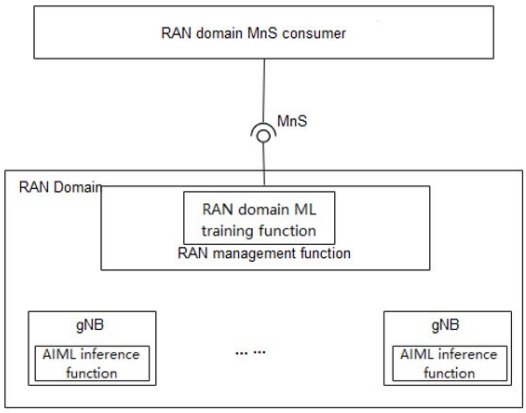


Figure 4a.2-2: Management where the ML training is located in RAN domain management function and AI/ML inference is located in gNB

Scenario 3:

The ML training function and AI/ML inference function are both located in the gNB. See figure 4a.2-3.

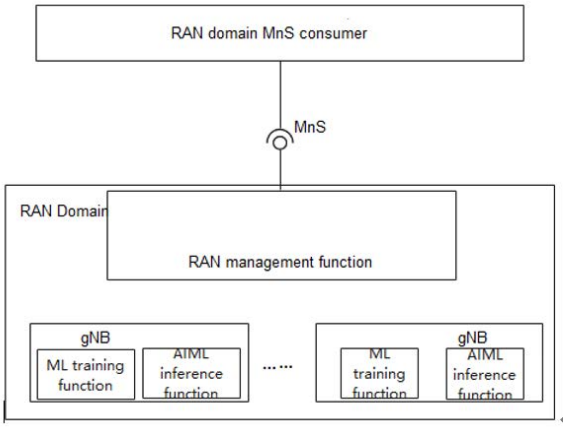


Figure 4a.2-3: Management where the ML training and AI/ML inference are both located in gNB

5 Void

6 AI/ML management use cases and requirements

6.1 General

Each operational step in the workflow (see clause 5.0) is supported by one or more AI/ML management capabilities as depicted below for each of the operational phases.

Management capabilities for ML training

- **ML training management**: allowing the MnS consumer to request the ML training, consume and control the producer-initiated training, and manage the ML training/re-training process. The training management capability may include training performance management and setting a policy for the producer-initiated ML training.
- **ML validation**: ML training capability also includes validation to evaluate the performance of the ML entity when performing on the validation data, and to identify the variance of the performance on the training and validation data. If the variance is not acceptable, the ML entity would need to be tuned (re-trained) before being made available for the next step in the operational workflow (e.g., ML entity testing).
- **ML testing management**: allowing the MnS consumer to request the ML entity testing, and to receive the testing results for a trained ML entity. It may also include capabilities for selecting the specific performance metrics to be used or reported by the ML testing function. MnS consumer may also be allowed to trigger ML re-training based on the ML entity testing performance requirements.

Management capabilities for ML emulation phase:

- **AI/ML inference emulation:** a capability allowing an MnS consumer to request an ML inference emulation for a specific ML entity or entities (after the training, validation, and testing) to evaluate the inference performance in an emulation environment prior to applying it to the target network or system.

Management capabilities for ML entity deployment phase:

- **ML entity loading management**: allowing the MnS consumer to trigger, control and/or monitor the ML entity loading process.

Management capabilities for AI/ML inference phase:

- **AI/ML inference management:** allowing an MnS consumer to control the inference, i.e., activate/deactivate the inference function and/or ML entity/entities, configure the allowed ranges of the inference output parameters. The capabilities also allow the MnS consumer to monitor and evaluate the inference performance and when needed trigger an update of an ML entity or an AI/ML inference function.

The use cases and corresponding requirements for AI/ML management capabilities are specified in the following clauses for each phase of the operational workflow.

6.2 Void

6.2a ML training phase

6.2a.1 ML training

6.2a.1.1 Description

Before an ML entity is deployed to conduct inference, the ML model associated with the ML entity needs to be trained. The ML model training can be an initial training or the re-training of an already trained ML entity.

The ML model is trained by the ML training MnS producer, and the training can be triggered by request(s) from one or more ML training MnS consumer(s), or initiated by the ML training MnS producer (e.g., as a result of model performance evaluation).

6.2a.1.2 Use cases

6.2a.1.2.1 ML training requested by consumer

The ML training capabilities are provided by an ML training MnS producer to one or more consumer(s).

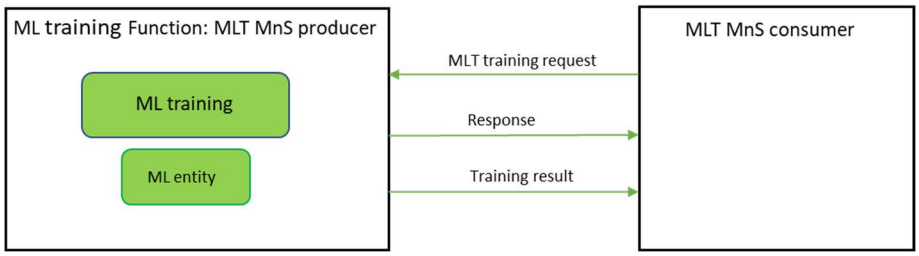


Figure 6.2a.1.2.1-1: ML training requested by ML training MnS consumer

The ML training may be triggered by the request(s) from one or more ML training MnS consumer(s). The consumer may be for example a network function, a management function, an operator, or another functional differentiation. Figure 6.2a.1.2.1-1 highlights the high-level overview of the process and the relevant sequence.

To trigger an initial ML training, the MnS consumer needs to specify in the ML training request the inference type which indicates the function or purpose of the ML entity, e.g. CoverageProblemAnalysis [see TS 28.104 [2]]. The ML training MnS producer can perform the initial training according to the designated inference type. To trigger an ML re-training, the MnS consumer needs to specify in the ML training request the identifier of the ML entity to be re-trained.

The consumer may provide the data source(s) that contain(s) the training data which are considered as inputs candidates for training. To obtain the valid training outcomes, consumers may also designate their requirements for model performance (e.g. accuracy, etc) in the training request.

The performance of the ML entity depends on the degree of commonality between the distribution of the data used for training and the distribution of the data used for inference. As time progresses, the distribution of the input data used for inference might change as compared to the distribution of the data used for training. In such a scenario, the performance of the ML entity degrades over time. The ML training MnS producer may re-train the ML model associated to the entity if the inference performance of the ML entity falls below a certain threshold, which needs to be configurable by the MnS consumer.

Following the ML training request by the M training MnS consumer, the ML training MnS producer provides a response to the consumer indicating whether the request was accepted.

If the request is accepted, the ML training MnS producer decides when to start the ML training with consideration of the request(s) from the consumer(s). Once the training is decided, the producer performs the following:

- selects the training data, with consideration of the consumer provided candidate training data. Since the training data directly influences the algorithm and performance of the trained ML entity, the ML training MnS producer may examine the consumer's provided training data and decide to select none, some or all of them. In addition, the ML training MnS producer may select some other training data that are available;
- trains the ML model using the selected training data;
- provides the training results (including the identifier of the ML entity generated from the initially trained ML model or the version number of the ML entity associated with the re-trained model, training performance results, etc.) to the ML training MnS consumer(s).

6.2a.1.2.2 ML training initiated by producer

The ML training or re-training may be initiated by the ML training MnS producer, for instance as a result of performance evaluation of the ML entity or based on feedback or new training data received from the consumer, or when new training data, which are not from the consumer, describing the new network status/events become available.

Therefore, there is a need to monitor the performance and/or the KPIs of the ML entity and use the thresholds that the ML training MnS consumer configured for the ML training MnS producer to trigger the training or re-training.

When the ML training MnS producer decides to start the ML training, the producer performs the followings:

- selects the training data;
- trains the ML model using the selected training data;
- provides the training results (including the identifier of the ML entity generated from the initially trained ML model or the version number of the ML entity associated with the re-trained model, training performance, etc.) to the ML training MnS consumer(s) who have subscribed to receive the ML training results.

6.2a.1.2.3 ML entity selection

For a given machine learning-based use case, different entities that apply the respective ML model or AI/ML inference function may have different inference requirements and capabilities. For example, one consumer with specific responsibility wishes to have an AI/ML inference function supported by an ML model or entity trained for city central business district where mobile users move at speeds not exceeding 30 km/hr. On the other hand, another consumer, for the same use case may support a rural environment and as such wishes to have an ML model and AI/ML inference function fitting that type of environment. The different consumers need to know the available versions of ML entities, with the variants of trained ML models or entities and to select the appropriate one for their respective conditions.

Besides, there is no guarantee that the available ML models/entities have been trained according to the characteristics that the consumers expect. As such the consumers need to know the conditions for which the ML models or ML entities have been trained to then enable them to select the models that are best fit to their conditions and needs.

The models that have been trained may differ in terms of complexity and performance. For example, a generic comprehensive and complex model may have been trained in a cloud-like environment, but such a model cannot be used in the gNB and instead, a less complex model, trained as a derivative of this generic model, could be a better candidate. Moreover, multiple less complex models could be trained with different levels of complexity and performance which would then allow different relevant models to be delivered to different consumers depending on operating conditions and performance requirements. The consumers need to know the alternative models available and interactively request and replace them when needed and depending on the observed inference-related constraints and performance requirements.

6.2a.1.2.4 Managing ML training processes

This relates to the management and controlling of the ML training processes.

To achieve the desired outcomes of any machine learning relevant use-case or task, the ML model applied for such use case or task, needs to be trained with the appropriate data. The training may be undertaken in a managed function or in a management function.

In either case, the network management system not only needs to have the required training capabilities but needs to also have the means to manage the training process of the ML models. The consumers need to be able to interact with the training process, e.g., to suspend or restart the process; and also need to manage and control the requests related to such training process.

6.2a.1.2.5 Handling errors in data and ML decisions

Ideally, the ML models/entities (e.g., ML entity1 and ML entity2 in figure 6.2a.1.2.5-1) are trained on good quality data, i.e. data that was collected correctly and reflected the real network status to represent the expected context in which the ML entity is meant to operate. However, this is not always the case in real world as data cannot be completely error-free. Good quality data is void of errors, such as:

- Imprecise measurements
- Missing values or records
- Records which are communicated with a significant delay (in case of online measurements).

Without errors, an ML entity can depend on a few precise inputs, and does not need to exploit the redundancy present in the training data. However, during inference, the ML entity is very likely to come across these inconsistencies. When this happens, the ML entity shows high error in the inference outputs, even if redundant and uncorrupted data are available from other sources.

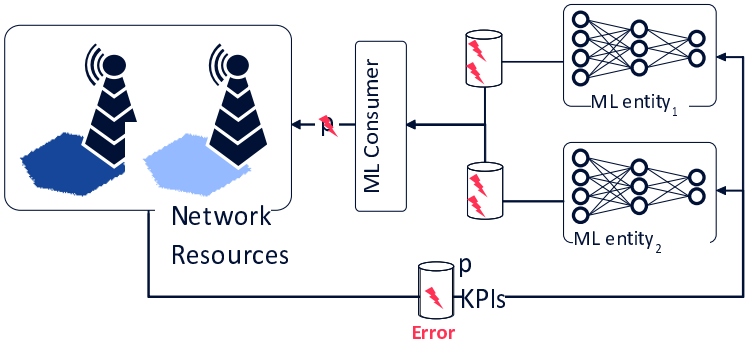


Figure 6.2a.1.2.5-1: The propagation of erroneous information

As such, the training function should attempt to identify errors in the input data. If an entity has been trained on erroneous or inconsistent data, the consumer should be made aware of such.

6.2a.1.2.6 ML entity joint training

Each ML entity supports a specific type of inference. An AI/ML inference function may use one or more ML entities to perform the inference(s). When multiple ML entities are employed, these ML entities may operate together in a coordinated way, such as in a sequence, or even in a more complicated structure. In this case, any change in the performance of one ML entity may impact another, and consequently impact the overall performance of the whole AI/ML inference function.

There are different ways in which the group of ML entities may coordinate. An example is the case where the output of one ML entity can be used as input to another ML entity forming a sequence of interlinked ML entities. Another example is the case where multiple ML entities provide the output in parallel (either the same output type where outputs may be merged (e.g., using weights), or their outputs are needed in parallel as input to another ML entity. The group of ML entities needs to be employed in a coordinated way to support an AI/ML inference function.

Therefore, it is desirable that the ML models associated with these coordinated ML entities can be trained or re-trained jointly, so that the group of these ML entities can complete a more complex task jointly with better performance.

The ML entity joint training may be initiated by the ML training MnS producer or the ML training MnS consumer, with the grouping of the ML entities shared by the ML training MnS producer with the ML training MnS consumer.

6.2a.1.2.7 ML entity validation performance reporting

During the ML training process, the generated ML entity needs to be validated. The purpose of ML validation is to evaluate the performance of the ML entity when performing on the validation data, and to identify the variance of the performance on the training data and the validation data. The training data and validation data are of the same pattern as they normally split from the same data set with a certain ratio in terms of quantity of the data samples.

In the ML training, the ML entity is generated based on the learning from the training data and validated using the validation data. The performance of the ML entity has tight dependency on the data (i.e., training data) from which the ML entity is generated. Therefore, an ML entity performing well on the training data may not necessarily perform well on other data e.g., while conducting inference. If the performance of ML entity is not good enough according to the result of ML validation, the ML entity will be tuned (i.e., the model associated with it be re-trained) and validated again. The process of ML entity tuning and validation is repeated by the ML training function, until the performance of the ML entity meets the expectation on both training data and validation data. The MnS producer subsequently selects one or more ML entities with the best level of performance on both training data and validation data as the result of the ML training, and reports accordingly to the consumer. The performance of each selected ML entity on both training data and validation data also needs to be reported.

The performance result of the validation may also be impacted by the ratio of the training data and the validation data. MnS consumer needs to be aware of the ratio of training data and the validation data, coupled with the performance score on each data set, in order to be confident about the performance of ML entity.

6.2a.1.2.8 Training data effectiveness reporting

Training data effectiveness refers to the process of evaluating the contribution of a single data instance or a type of input training data (e.g., one measurement type among all types of input training data) to ML model training process.

To efficiently train a ML model, high quality and large volume of training data instances are considered essential. The open use of all available data can be costly, both in terms of data collection process and from a computational resources perspective since the data also contains the unnecessary data samples that are computed through the ML model. It is better that the training function evaluates the usefulness of different data samples and indicates that level of usefulness to the consumer so that the data used for re-training can be further enhanced/optimized.

The 3GPP management system needs to support means to report the extent of effectiveness of the different training data samples used in ML training based on insight of how the different portion of data contribute differently to the trained model accuracy.

6.2a.1.3 Requirements for ML training

Table 6.2a.1.3-1

Requirement label	Description	Related use case(s)
REQ-ML_TRAIN-FUN-01	The ML training MnS producer shall have a capability allowing an authorized ML training MnS consumer to request ML training.	ML training requested by consumer (clause 6.2a.1.2.1)
REQ- ML_TRAIN-FUN-02	The ML training MnS producer shall have a capability allowing the authorized ML training MnS consumer to specify the data sources containing the candidate training data for ML training.	ML training requested by consumer (clause 6.2a.1.2.1)
REQ- ML_TRAIN-FUN-03	The ML training MnS producer shall have a capability allowing the authorized ML training MnS consumer to specify the inference type of the ML entity to be trained.	ML training requested by consumer (clause 6.2a.1.2.1)
REQ- ML_TRAIN-FUN-04	The ML training MnS producer shall have a capability to provide the training result to the ML training MnS consumer.	ML training requested by consumer (clause 6.2a.1.2.1), ML training initiated by producer (clause 6.2a.1.2.2)
REQ- ML_TRAIN-FUN-05	The ML training MnS producer shall have a capability allowing an authorized ML training MnS consumer to configure the thresholds of the performance measurements and/or KPIs to trigger the re-training of an ML entity. (See Note)	ML training initiated by producer (clause 6.2a.1.2.2)

Requirement label	Description	Related use case(s)
REQ- ML_TRAIN-FUN-06	The ML training MnS producer shall have a capability to provide the version number of the ML entity and the time when it is generated by ML re-training to the authorized ML training MnS consumer.	ML training requested by consumer (clause 6.2a.1.2.1), /ML training initiated by producer (clause 6.2a.1.2.2)
REQ- ML_TRAIN-FUN-07	The ML training MnS producer shall have a capability allowing an authorized ML training MnS consumer to manage the training process, including starting, suspending, or resuming the training process, and configuring the ML context for ML training.	ML training requested by consumer (clause 6.2a.1.2.1), ML training initiated by producer (clause 6.2a.1.2.2), ML entity joint training (clause 6.2a.1.2.6)
REQ- ML_TRAIN-FUN-08	The ML training MnS producer should have a capability to provide the grouping of ML entities to an authorized ML training MnS consumer to enable coordinated inference.	ML entity joint training (clause 6.2a.1.2.6)
REQ- ML_TRAIN-FUN-09	The ML training MnS producer should have a capability to allow an authorized ML training MnS consumer to request joint training of a group of ML entities.	ML entity joint training (clause 6.2a.1.2.6)
REQ- ML_TRAIN-FUN-10	The ML training MnS producer should have a capability to jointly train a group of ML entities and provide the training results to an authorized consumer.	ML entity joint training (clause 6.2a.1.2.6)
REQ-ML_SELECT-01	3GPP management system shall have a capability to enable an authorized ML training MnS consumer to discover the properties of available ML entities including the contexts under which each of the models associated with the ML entities were trained.	ML model and ML entity selection (clause 6.2a.1.2.3)
REQ-ML_SELECT-02	3GPP management system shall have a capability to enable an authorized ML training MnS consumer to select an ML entity to be used for inference.	ML models and ML entity selection (clause 6.2a.1.2.3)
REQ-ML_SELECT-03	3GPP management system shall have a capability to enable an authorized ML training MnS consumer to request for information and be informed about the available alternative ML entities of differing complexity and performance.	ML model and ML entity selection (clause 6.2a.1.2.3)
REQ-ML_SELECT-04	The 3GPP management system shall have a capability to provide a selected ML entity to the authorized ML training MnS consumer.	ML model and ML entity selection (clause 6.2a.1.2.3)
REQ-ML_TRAIN- MGT-01	The ML training MnS producer shall have a capability allowing an authorized consumer to manage and configure one or more requests for the specific ML training, e.g. to modify the request or to delete the request.	ML training requested by consumer (clause 6.2a.2.1), Managing ML Training Processes (clause 6.2a.1.2.4)
REQ-ML_TRAIN- MGT-02	The ML training MnS producer shall have a capability allowing an authorized ML training MnS consumer to manage and configure one or more training processes, e.g. to start, suspend or restart the training.	ML training requested by consumer (clause 6.2a.1.2.1), Managing ML training processes (clause 6.2a.1.2.4)
REQ-ML_TRAIN- MGT-03	3GPP management system shall have a capability to enable an authorized ML training MnS consumer (e.g. the function/entity different from the function that generated a request for ML training) to request for a report on the outcomes of a specific training instance.	Managing ML training processes (clause 6.2a.1.2.4)
REQ-ML_TRAIN- MGT-04	3GPP management system shall have a capability to enable an authorized ML training MnS consumer to define the reporting characteristics related to a specific training request or training instance.	Managing ML training processes (clause 6.2a.1.2.4)
REQ-ML_TRAIN- MGT-05	3GPP management system shall have a capability to enable the ML training function to report to any authorized ML training MnS consumer about specific ML training process and/or report about the outcomes of any such ML training process.	Managing ML training processes (clause 6.2a.1.2.4)

Requirement label	Description	Related use case(s)
REQ-ML_ERROR-01	The 3GPP management system shall enable an authorized consumer of data services (e.g. an ML training function) to request from a producer of data services a Value Quality Score of the data, which is the numerical value that represents the dependability/quality of a given observation and measurement type.	Handling errors in data and ML decisions (clause 6.2a.1.2.5)
REQ-ML_ERROR-02	The 3GPP management system shall enable an authorized consumer of AI/ML decisions (e.g. a controller) to request ML decision confidence score which is the numerical value that represents the dependability/quality of a given decision generated by an AI/ML inference function.	Handling errors in data and ML decisions (clause 6.2a.1.2.5)
REQ-ML_ERROR-03	The 3GPP management system shall enable a producer of data services (e.g. a gNB) to provide to an authorized consumer (e.g. an ML training function) a Value Quality Score of the data, which is the numerical value that represents the dependability/quality of a given observation and measurement type.	Handling errors in data and ML decisions (clause 6.2a.1.2.5)
REQ-ML_ERROR-04	The 3GPP management system shall enable a producer of ML decisions (e.g. an AI/ML inference function) to provide to an authorized consumer of ML decisions (e.g. a controller) an AI/ML decision confidence score which is the numerical value that represents the dependability/quality of a given decision generated by the AI/ML inference function.	Handling errors in data and ML decisions (clause 6.2a.1.2.5)
REQ-ML_VLD-01	The ML training MnS producer should have a capability to validate the ML entities during the ML training process and report the performance of the ML entities on both the training data and validation data to the authorized consumer.	ML entity validation performance reporting (clause 6.2a.1.2.7)
REQ-ML_VLD-02	The ML training MnS producer should have a capability to report the ratio (in terms of quantity of data samples) of the training data and validation data used during the ML training and validation process.	ML entity validation performance reporting (clause 6.2a.1.2.7)
REQ-TRAIN_EFF-01	The 3GPP management system should have the capability to allow an authorized consumer to configure an ML training function to report the effectiveness of data used for model training.	Training data effectiveness reporting (clause 6.2a.1.2.8)
NOTE: The performance measurements and KPIs are specific to each type (i.e., the inference type that the ML entity supports) of ML entity.		

6.2a.2 Performance management for ML training and testing

6.2a.2.1 Description

In the ML model training phase (including training and validation), the performance of ML entity needs to be evaluated. The performance is the degree to which the ML entities fulfil the objectives for which they were trained and can be evaluated for training data as training performance or for testing data as testing performance. The related performance indicators need to be collected and analyzed.

6.2a.2.2 Use cases

6.2a.2.2.1 Performance indicator selection for ML training and testing

The ML model training function may support training for single or different kinds of ML models and may support the capability to evaluate each kind of ML entity by one or more performance indicators.

The MnS consumer may prefer to use some performance indicator(s) over others to evaluate one kind of ML entity. The performance indicators for training mainly include the following aspects:

- ML training process monitors performance indicators: the performance indicators of the system that trains the ML entity, including training duration indicator.

- ML training model performance indicators: performance indicators of the ML entity itself, including but not limited to:
  - Accuracy indicator,
  - Precision indicator,
  - Recall indicator,
  - F1 score indicator,
  - MSE (Mean Squared Error) indicator, and
  - MAE (Mean Absolute Error) indicator,
  - RMSE (Root Mean Square Error) indicator.

The MnS consumer may prefer to use some performance indicator(s) over others to evaluate one kind of ML entity. The performance indicators for testing mainly include the following aspects:

- ML testing model performance indicators: performance indicators of the ML entity itself, including but not limited to:
  - Accuracy indicator,
  - Precision indicator,
  - Recall indicator,
  - F1 score indicator,
  - MSE(Mean Squared Error) indicator,
  - MAE(Mean Absolute Error) indicator, and
  - RMSE(Root Mean Square Error) indicator.

Therefore, the MnS producer for ML training and testing needs to provide the name(s) of supported performance indicator(s) for the MnS consumer to query and select for ML entity performance evaluation. The MnS consumer may also need to provide the performance requirements of the ML entity using the selected performance indicators.

The MnS producer for ML training and testing uses the selected performance indicators for evaluating ML training and testing, and reports with the corresponding performance score in the ML training report or ML testing report when the training or testing is completed.

6.2a.2.2.2 ML entity performance indicators query and selection for ML training and testing

The ML entity performance evaluation and management is needed during training and testing. The related performance indicators need to be collected and analyzed. The MnS producer of ML training or testing should determine which indicators are needed, i.e., select some indicators based on the use case and use these indicators for performance evaluation.

The ML MnS consumer or testing may have different requests on AI/ML performance, depending on its use case and requirements, which may imply that different performance indicators may be relevant for performance evaluation. The MnS producer for ML training/testing can be queried to provide the information on supported performance indicators referring to ML training/testing. Such performance indicators in training phase may be for example accuracy/precision/recall/F1-score/MSE/MAE, and in test phase may be data drift in data statistics. Based on supported performance indicators in different phase as well as based on consumer's requirements, the MnS consumer for ML training or ML testing may request a sub-set of supported performance indicators to be monitored and used for performance evaluation. Management capabilities are needed to enable the MnS consumer for ML training or ML testing to query the supported performance indicators and select a sub-set of performance indicators in training phase to be used for performance evaluation.

6.2a.2.2.3 MnS consumer policy-based selection of ML entity performance indicators for ML training and testing

ML entity performance evaluation and management is needed during ML training phase. The related performance indicators need to be collected and analysed. The MnS producer for ML training should determine which indicators are needed or may be reported, i.e., select some indicators based on the service and use these indicators for performance evaluation.

The MnS consumer for ML training or testing may have differentiated levels of interest in the different performance dimensions or metrics. Thus, depending on its use case, the AI/ML MnS consumer may indicate the preferred behaviour and performance requirement that needs to be considered during training or testing of/from the ML entity by the ML MnS producer for ML training or testing. These performance requirements need not indicate the technical performance indicators used for ML training, testing or inference, such as "accuracy" or "precision" or "recall" or "MSE" or "MAE" or “F1 score" etc. The ML MnS consumer for ML training or testing may not be capable enough to indicate the performance metrics to be used for training or testing.

6.2a.2.3 Requirements for ML training and testing performance management

Table 6.2a.2.3-1

Requirement label	Description	Related use case(s)
REQ-ML_TRAIN_PM-1	The ML Training or Testing MnS producer shall have a capability to allow an authorized consumer to get the capabilities about what kind of ML models the ML training function or ML testing function is able to train or test.	Performance indicator selection for ML training (clause 6.2a.2.2.1)
REQ-ML_TRAIN_PM-2	The ML Training or Testing MnS producer shall have a capability to allow an authorized consumer to query what performance indicators are supported by the ML training function or ML testing function for each kind of ML entity.	Performance indicator selection for ML training (clause 6.2a.2.2.1)
REQ-ML_TRAIN_PM-3	The ML Training or Testing MnS producer shall have a capability to allow an authorized consumer to select the performance indicators from those supported by the ML training function or ML testing function for reporting the training or testing performance for each kind of ML entity.	Performance indicator selection for ML training (clause 6.2a.2.2.1)
REQ-ML_TRAIN_PM-4	The ML Training MnS producer shall have a capability to allow an authorized consumer to provide the performance requirements for the ML model training using the selected the performance indicators from those supported by the ML training function.	Performance indicator selection for ML training (clause 6.2a.2.2.1)

6.2a.3 ML testing

6.2a.3.1 Description

During ML training phase, after the training and validation, the ML entity needs to be tested to evaluate the performance of the ML entity when it conducts inference using the testing data. Testing may involve interaction with third parties (besides the developer of the ML training function), e.g., the operators may use the ML training function or third-party systems/functions that may rely on the inference results computed by the ML entity for testing.

If the testing performance is not acceptable or does not meet the pre-defined requirements, the consumer may request the ML training producer to re-train the ML model with specific training data and/or performance requirements.

6.2a.3.2 Use cases

6.2a.3.2.1 Consumer-requested ML entity testing

After receiving an ML training report about a trained ML entity from the ML training MnS producer, the consumer may request the ML testing MnS producer to test the ML entity before applying it to the target inference function.

The ML testing is to conduct inference on the tested ML entity using the testing data as inference inputs and produce the inference output for each testing dataset example.

The ML testing MnS producer may be the same as or different from the ML training MnS producer.

After completing the ML testing, the ML testing MnS producer provides the testing report indicating the success or failure of the ML testing to the consumer. For a successful ML testing, the testing report contains the testing results, i.e., the inference output for each testing dataset example.

The ML testing MnS producer needs to have the capabilities to provide the services needed to enable the consumer to request testing and receive results on the testing of an ML entity.

6.2a.3.2.2 Producer-initiated ML entity testing

The ML entity testing may also be initiated by the MnS producer, after the ML entity is trained and validated. A consumer (e.g., an operator) may still need to define the policies (e.g., allowed time window, maximum number of testing iterations, etc.) for the testing of a given ML entity. The consumer may pre-define performance requirements for the ML entity testing and allow the MnS producer to decide on whether re-training/validation need to be triggered. Re-training may be triggered by the testing MnS producer itself based on the performance requirements supplied by the MnS consumer.

6.2a.3.2.3 Joint testing of multiple ML entities

A group of ML entities may work in a coordinated manner for complex use cases. In such cases an ML entity is just one step of the inference processes of an AI/ML inference function, with the inference outputs of an ML entity as the inputs to the next ML entity.

The group of ML entities is generated by the ML training function. The group, including all contained ML entities, needs to be tested. After the ML testing of the group, the MnS producer provides the testing results to the consumer.

NOTE: This use case is about the ML entities testing during the training phase and is irrelevant to the testing cases that the ML entities have been deployed.

6.2a.3.3 Requirements for ML testing

Table 6.2a.3.3-1

Requirement label	Description	Related use case(s)
REQ-ML_TEST-1	The ML testing MnS producer shall have a capability to allow an authorized consumer to request the testing of a specific ML entity.	Consumer-requested ML entity testing (clause 6.2a.3.2.1)
REQ-ML_TEST-2	The ML testing MnS producer shall have a capability to trigger the testing of an ML entity and allow the MnS consumer to set the policy for the testing.	Producer-initiated ML entity testing (6.2a.3.2.2)
REQ-ML_TEST-3	The ML testing MnS producer shall have a capability to report the performance of the ML entity when it performs inference on the testing data.	Consumer-requested ML entity testing (clause 6.2a.3.2.1), and producer-triggered ML entity testing (clause 6.2a.3.2.2)
REQ-ML_TEST-4	The ML testing MnS producer shall have a capability allowing an authorized consumer to request the testing of a group of ML entities.	Joint testing of multiple ML entities (clause 6.2a.3.2.3)

6.3 AI/ML emulation phase

6.3.1 Description

Before the ML entity is applied in the production network, the MnS inference consumer may want to receive results of inference in one or more environments that emulate (to different extents) the expected inference characteristics, in a process that may be termed as Inference emulation. The Inference emulation phase enables this.

6.3.2 Use cases

6.3.2.1 AI/ML Inference emulation

After the ML entity is validated and tested during development, the MnS consumer may wish to receive information from an inference emulation process that indicates if the ML entity or the associated ML inference function is working correctly under certain runtime context.

The management system should have the capabilities enabling an MnS consumer:

- request an inference emulation function to provide emulation reports; and
- to receive the results from running inference through an AI/ML inference emulation environment available at the emulation MnS producer.

6.3.3 Requirements for Managing AI/ML Inference emulation

Table 6.3.3-1

Requirement label	Description	Related use case(s)
REQ-AI/ML_EMUL-1:	The MnS producer for AI/ML inference emulation should have a capability enabling an authorized MnS consumer to receive reporting about the ML inference emulation.	AI/ML Inference emulation (clause 6.3.2.1)
REQ-AI/ML_EMUL-2:	The MnS producer for AI/ML inference emulation should have a capability enabling an authorized MnS consumer to request an inference emulation function to provide inference emulation reports on an ML entity or inference Function.	AI/ML Inference emulation (clause 6.3.2.1)

6.4 ML entity deployment phase

6.4.1 ML entity loading

6.4.1.1 Description

ML entity loading refers to the process of making an ML entity available for use in the inference function . After a trained ML entity meets the performance criteria per the ML entity testing and optionally ML emulation, the ML entity could be loaded into the target inference function(s) in the system. The way for loading the ML entity is not in scope of the present document.

6.4.1.2 Use cases

6.4.1.2.1 Consumer requested ML entity loading

After a trained ML entity or the coordination group of ML entities are tested and optionally emulated, if the performance of the ML entity or the coordination group of ML entities meet the MnS consumer’s requirements, the MnS consumer may request to load the one or more ML entities to one or more target inference function(s) where the ML entity will be used for conducting inference. Once the ML entity loading request is accepted, the MnS consumer (e.g., operator) needs to know the progress of the loading and needs to be able to control (e.g., cancel, suspend, resume) the loading process. For a completed ML entity loading, the ML entity instance loaded to each target inference function needs to be manageable individually, for instance, to be activated/deactivated individually or concurrently.

6.4.1.2.2 Control of producer-initiated ML entity loading

To enable more autonomous AI/ML operations, the MnS producer is allowed to load the ML entity or the coordination group of ML entities without the consumer's specific request.

In this case, the consumer needs to be able to set the policy for the ML loading, to make sure that ML entities loaded by the MnS producer meet the performance target. The policy could be, for example, the threshold of the testing performance of the ML entities, the threshold of the inference performance of the existing ML model, the time schedule allowed for ML entity loading, etc.

ML models are typically trained and tested to meet specific requirements for inference, addressing a specific use case or task. The network conditions may change regularly, for example, the gNB providing coverage for a specific location is scheduled to accommodate different load levels and/or patterns of services at different times of the day, or on different days in a week. One or more ML entities may be loaded per the policy to adapt to a specific load/traffic pattern.

6.4.1.2.3 ML entity registration

After multiple iterations, there could be a large number of ML entities with different versions, deployment environments, performance levels, and functionalities. ML entity registration refers to the process of recording, tracking, controlling those trained ML entities enabling future retrieval, reproducibility, sharing and loading in the target inference functions across different environments. For example, the inference MnS consumer could recall the most applicable version dealing with a sudden changed deployment environment of the target inference function by tracking the registration information.

The ML training MnS producer should register the ML entity along with its loading information, e.g., ML entity metadata and relevant information (e.g., description, version, version date, target inference function, deployment environment, etc.).

6.4.1.3 Requirements for ML entity loading

Table 6.4.1.3-1

Requirement label	Description	Related use case(s)
REQ- ML_LOAD-FUN-01	The MnS producer for ML entity loading shall have a capability allowing an authorized consumer to request to trigger loading of an ML entity or a group of ML entities.	Consumer requested ML entity loading (clause 6.4.1.2.1)
REQ- ML_LOAD-FUN-02	The MnS producer for ML entity loading shall have a capability allowing an authorized consumer to provide a policy for the MnS producer to trigger loading of an ML entity or a group of ML entities.	Producer-initiated ML entity loading (clause 6.4.1.2.2)
REQ- ML_LOAD-FUN-03	The MnS producer for ML entity loading shall be able to inform an authorized consumer about the progress of ML entity loading.	Consumer requested ML entity loading (clause 6.4.1.2.1) and Producer-initiated ML entity loading (clause 6.4.1.2.2)
REQ- ML_LOAD-FUN-04	The MnS producer for ML entity loading shall have a capability allowing an authorized consumer to control the process of ML entity loading.	Consumer requested ML entity loading (clause 6.4.1.2.1) and Producer-initiated ML entity loading (clause 6.4.1.2.2)
REQ- ML_REG-01	The ML training MnS producer should have a capability to register an ML entity to record the relevant information that may be used for loading.	ML entity registration (Clause 6.4.1.2.3)
REQ- ML_REG-02	The ML training MnS producer should have a capability to allow an authorized consumer (e.g., an AI/ML inference function) to acquire the registration information of ML entities.	ML entity registration (Clause 6.4.1.2.3)

6.5 AI/ML inference phase

6.5.1 AI/ML inference performance management

6.5.1.1 Description

In the AI/ML inference phase, the performance of the AI/ML inference function and ML entity need to be evaluated against the MnS consumer's provided performance expectations/targets, to identify and timely fix any problem. Actions to fix any problem would be e.g., to trigger the ML re-training, ML testing, or re-deployment.

6.5.1.2 Use cases

6.5.1.2.1 AI/ML inference performance evaluation

In the AI/ML inference phase, the AI/ML inference function (including e.g., MDAF, NWDAF or RAN functions) uses one or more ML entities for inference to generate the AI/ML inference output. The performance of a running ML entity may degrade over time due to changes in network state, which will affect the related network performance and service. Thus, it is necessary to evaluate performance of the ML entity during the AI/ML inference process. If the inference output is executed, the network performance related to each AI/ML inference function also needs to be evaluated.

The consumer (e.g., a Network or Management function) may take some actions according to the AI/ML inference output provided by the AI/ML inference function. If the actions are taken accordingly, the network performance is expected to be optimized. Each AI/ML inference function has its specific focus and will impact the network performance from different perspectives.

The consumer may choose to not take any actions for various reasons, e.g., lacking confidence in the inference output, avoiding potential conflict with other actions or when no actions are needed or recommended at all according to the inference output.

For evaluating the performance of the AI/ML inference function and ML entity, the MnS producer responsible for ML inference performance management needs to be able to get the inference output generated by each AI/ML inference function. Then, the MnS producer can evaluate the performance based on the inference output and related network measurements (i.e., the actual output).

Depending on the performance evaluation results, some actions (e.g., deactivate the running entity, start retraining, change the running entity with a new one, etc) can be taken to avoid generating the inaccurate inference output.

To monitor the performance in the AI/ML inference phase, the MnS producer responsible for AI/ML inference performance management can perform evaluation periodically. The performance evaluation period may be determined based on the network change speed. Besides, a consumer (e.g., an operator) may wish to control and manage the performance evaluation capability. For example, the operator may configure the performance evaluation period of a specified ML entity.

6.5.1.2.2 AI/ML performance measurements selection based on MnS consumer policy

Evaluation and management of the performance of an ML entity is needed during inference phase. The related performance measurements need to be collected and analysed. The MnS producer for inference should determine which measurements are needed or may be reported, i.e., select some measurements based on the service and use these measurements for performance evaluation.

The MnS consumer for inference may have differentiated levels of interest in the different performance dimensions or metrics. Thus, depending on its use case, the MnS consumer may indicate the preferred behaviour and performance requirement that needs to be considered during inference from the ML entity by the AI/ML inference MnS Producer. The AI/ML inference MnS consumer may not be capable enough to indicate the performance metrics. Instead, the AI/ML MnS consumer may indicate the requirement using a policy or guidance that reflects the preferred performance characteristics of the ML entity. Based on the indicated policy/guidance, the AI/ML MnS producer may then deduce and apply the appropriate performance indicators for inference. Management capabilities are needed to enable the MnS consumer to indicate the behavioural and performance policy/guidance that may be translated by the MnS producer into one or more technical performance measurements during inference.

6.5.1.3 Requirements for AI/ML inference performance management

Table 6.5.1.3-1

Requirement label	Description	Related use case(s)
REQ-AI/ML_INF_PE-01	The MnS producer responsible for AI/ML inference management shall have a capability enabling an authorized consumer to get the inference output provided by an AI/ML inference function (e.g., MDAF, NWDAF or RAN function).	AI/ML inference performance evaluation (clause 6.5.1.2.1)
REQ-AI/ML_INF_PE-02	The MnS producer responsible for AI/ML inference management shall have a capability enabling an authorized consumer to get the performance evaluation of an AI/ML inference output as measured by a defined set of performance metrics	AI/ML inference performance evaluation (clause 6.5.1.2.1)
REQ-AI/ML_INF_PE-03	The MnS producer responsible for AI/ML inference management shall have a capability enabling an authorized consumer to provide feedback about an AI/ML inference output expressing the degree to which the inference output meets the consumer's expectations.	AI/ML inference performance evaluation (clause 6.5.1.2.1)
REQ-AI/ML_INF_PE-04	The MnS producer responsible for AI/ML inference management shall have a capability enabling an authorized consumer to be informed about the executed actions that were triggered based on the inference output provided by an AI/ML inference function (e.g., MDAF, NWDAF or RAN function).	AI/ML inference performance evaluation (clause 6.5.1.2.1)
REQ-AI/ML_INF_PE-05	The MnS producer responsible for AI/ML inference management shall have a capability enabling an authorized consumer to obtain the performance data related to an ML entity or an AI/ML inference function (e.g., MDAF, NWDAF or RAN function).	AI/ML inference performance evaluation (clause 6.5.1.2.1)
REQ-AI/ML_PERF-SEL-1	The ML training MnS producer shall have a capability allowing an authorized MnS consumer to discover supported AI/ML performance measurements related to AI/ML inference and select some of the desired measurements based on the MnS consumer’s requirements.	AI/ML performance measurements selection based on MnS consumer policy (clause 6.5.1.2.2)
REQ-AI/ML_PERF-POL-1	The AI/ML MnS producer shall have a capability allowing the authorized MnS consumer to indicate a performance policy related to AI/ML inference phase.	AI/ML performance measurements selection based on MnS consumer policy (clause 6.5.1.2.2)

6.5.2 AI/ML update control

6.5.2.1 Description

In many cases, network conditions change makes the capabilities of the ML entity/entities decay, or at least become inappropriate for the changed conditions. In such cases, the MnS consumer should still be enabled to trigger updates, e.g., when the consumer realizes that the insight or decisions generated by the function are no longer appropriate for the observed network states, when the consumer observes the inference performance of ML entity/entities is decreasing.

The MnS consumer may request the AI/ML inference MnS producer to use an updated ML entity/entities for the inference with some specific performance requirements. This gives flexibility to the AI/ML inference MnS producer on how to address the requirements by for example getting ML entity/entities updated, which may be loading the already trained ML entity/entities or may lead to requesting to train/re-train the ML entity/entities by utilizing the ML training MnS.

6.5.2.2 Use cases

6.5.2.2.1 Availability of new capabilities or ML entities

Depending on their configurations, AI/ML inference functions may learn new characteristics during their utilization, e.g., if they are configured to learn through reinforcement learning or if they are configured to download new versions of their constituent ML entities. In such cases, the authorized consumer of AI/ML may wish to be informed by the AI/ML Inference MnS producer (e.g., the operator, a management function, or a network function) about their new capabilities.

6.5.2.2.2 Triggering ML entity update

When the inference capabilities of AI/ML inference functions degenerate, the typical action may be to trigger re-training of the constituent ML entities. It is possible, however, that the AI/ML inference MnS producer only offers inference capabilities and is not equipped with capabilities to update, train/re-train its constituent ML entities. Nevertheless, the authorized MnS consumer may still need to request for improvements in the capabilities of the AI/ML inference function. In such cases, the authorized MnS consumer may still wish to request for an improvement and may specify in its request e.g., a new version of the ML entities, i.e., to have the ML entities updated or re-trained. The corresponding internal actions taken by the AI/ML MnS inference producer may not be necessarily known by the consumer.

The AI/ML inference MnS consumer needs to request the AI/ML inference MnS producer to update its capabilities or its constituent ML entities and the AI/ML MnS producer should respond accordingly. For example, the AI/ML inference MnS producer may download new software that supports the required updates, download from a remote server a file containing configurations and parameters to update one or more of its constituent ML entities, or it may trigger one or more remote or local AI/ML-related processes (including training/re-training, testing, etc.) needed to generate the required updates. Related notifications for update can be sent to the AI/ML inference MnS consumer to indicate the information of the update process, e.g., the update is finished successfully, the maximum time taken to complete the update is reached but the performance does not achieve the requirements, etc.

Besides, an AI/ML inference MnS consumer may wish to manage the update process(es), e.g., to define policies on how often the update may occur, suspend or restart the update or adjust the update conditions or characteristics, the requirements could include, e.g., the times when the update may be executed, the expected achievable performance for updating, the expected time taken to complete the update, etc.

6.5.2.3 Requirements for AIML update control

Table 6.5.2.3-1

Requirement label	Description	Related use case(s)
REQ-AIML_UPDATE-1	The AI/ML Inference MnS producer should have a capability to inform an authorized MnS consumer of the availability of AI/ML capabilities or ML entities or versions thereof (e.g., as learned through a training process or as provided via a software update) and the readiness to update the AI/ML capabilities of the respective network function when triggered	Availability of new capabilities or ML entities (clause 6.5.2.2.1)
REQ-AIML_UPDATE-2	The AI/ML Inference MnS producer should have a capability to inform an authorized MnS consumer of the expected performance gain if/when the AI/ML capabilities or ML entities of the respective network function are updated with/to the specific set of newly available AI/ML capabilities	Availability of new capabilities or ML entities (clause 6.5.2.2.1)
REQ-AIML_UPDATE-3	The AI/ML Inference MnS producer should have a capability to allow an authorized MnS consumer to request the AI/ML MnS producer to update its ML entities using a specific version of newly available AI/ML capabilities or ML entities or using AI/ML capabilities or ML entities with requirements (e.g., the minimum achievable performance after updating, the maximum time taken to complete the update, etc)..	Triggering ML entity update (clause 6.5.2.2.2)
REQ-AIML_UPDATE-4	The AI/ML Inference MnS producer should have a capability for the AI/ML MnS producer to inform an authorized MnS consumer about of the process or outcomes related to any request for updating the AI/ML capabilities or ML entities	Triggering ML entity update (clause 6.5.2.2.2)
REQ-AIML_UPDATE-5	The AI/ML Inference MnS producer should have a capability for the AI/ML MnS producer to inform an authorized MnS consumer about of the achieved performance gain following the update of the AI/ML capabilities of a network function with/to the specific newly available ML entities or set of AI/ML capabilities	Triggering ML entity update (clause 6.5.2.2.2)
REQ-AIML_UPDATE-6	The AI/ML Inference MnS producer should have a capability for an authorized MnS consumer (e.g., an operator or the function/entity that generated the request for updating the AI/ML capabilities) to manage the request and subsequent process, e.g. to suspend, re-activate or cancel the request or process; or to adjust the characteristics of the capability update; or to define how often the update may occur, suspend, restart or cancel the request or to further adjust the requirements of the update.	Triggering ML entity update (clause 6.5.2.2.2)

6.5.3 AI/ML inference capabilities management

6.5.3.1 Description

A network or management function that applies AI/ML to accomplish specific tasks may be considered to have one or more ML entities, each having specific capabilities.

Different network functions, e.g., MDA Functions, may need to rely on existing AI/ML capabilities to accomplish the desired inference. However, the details of such ML-based solutions (i.e., which ML entities are applied and how) for accomplishing those inference functionalities is not obvious. The management services are required to identify the capabilities of the involved ML entities and to map those capabilities to the desired logic.

6.5.3.2 Use cases

6.5.3.2.1 Identifying capabilities of ML entities

Network functions, especially network automation functions, may need to rely on capabilities of ML entities that are not internal to those network functions to accomplish the desired automation (inference). For example, as stated in TS 28.104 [2], “An MDA Function may optionally be deployed as one or more AI/ML inference function(s) in which the relevant ML entities are used for inference per the corresponding MDA.” Similarly, owing to the differences in the kinds and complexity of intents that need to be fulfilled, an intent fulfillment solution may need to employ the capabilities of existing AI/ML inference functions to fulfill the intents. In any such case, management services are required to identify the capabilities of those existing ML entities that are employed by AI/ML inference functions.

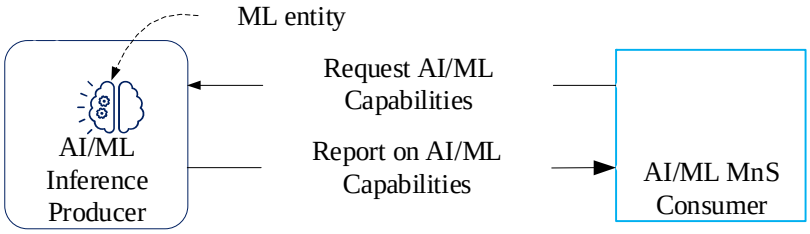


Figure 6.5.3.2.1-1: Request and reporting on AI/ML inference capabilities

Figure 6.5.3.2.1-1 shows that the consumer may wish to obtain information about the available AI/ML inference capabilities to determine how to use them for the consumer's needs, e.g., for fulfillment of intent targets or other automation targets.

6.5.3.2.2 Mapping of the capabilities of ML entities

Besides the discovery of the capabilities of ML entities, services are needed for mapping the ML entities and capabilities. In other words, instead of the consumer discovering specific capabilities, the consumer may want to know the ML entities that can be used to achieve a certain outcome. For this, the producer should be able to inform the consumer of the set of available ML entities that together achieve the consumer's automation needs.

In the case of intents for example, the complexity of the stated intents may significantly vary - from simple intents which may be fulfilled with a call to a single ML entity to complex intents that may require an intricate orchestration of multiple ML entities. For simple intents, it may be easy to map the execution logic to one or multiple ML entities. For complex intents, it may be required to employ multiple ML entities along with a corresponding functionality that manages their interrelated execution. The usage of the ML entities requires the awareness of their capabilities and interrelations.

Moreover, given the complexity of the required mapping to the multiple ML entities, services should be supported to provide the mapping of ML entities and capabilities.

6.5.3.3 Requirements for AI/ML inference capabilities management

Table 6.5.3.3-1

Requirement label	Description	Related use case(s)
REQ-ML_CAP-01	The AI/ML inference MnS Producer shall have a capability allowing an authorized MnS consumer to request the capabilities of existing ML entities available within the AI/ML inference producer.	Identifying capabilities of ML entities (clause 6.5.3.2.1)
REQ- ML_CAP-02	The AI/ML inference MnS Producer shall have a capability to report to an authorized MnS consumer the capabilities of an ML entity as a decision described as a triplet <object(s), parameters, metrics> with the entries respectively indicating: the object or object types for which the ML entity can undertake optimization or control; the configuration parameters on the stated object or object types, which the ML entity optimizes or controls to achieve the desired outcomes; and the network metrics which the ML entity optimizes through its actions.	Identifying capabilities of ML entities (clause 6.5.3.2.1)
REQ-ML_CAP-03	The AI/ML inference MnS Producer shall have a capability to report to an authorized MnS consumer the capabilities of an ML entity as an analysis described as a tuple <object(s), characteristics> with the entries respectively indicating: the object or object types for which the ML entity can undertake analysis; and the network characteristics (related to the stated object or object types) for which the ML entity produces analysis	Identifying capabilities of ML entities (clause 6.5.3.2.1)
REQ-ML_CAP-04	The AI/ML inference MnS Producer shall have a capability allowing an authorized MnS consumer to request a mapping of the consumer's inference targets to the capabilities of one or more ML entities.	Mapping of the capabilities of ML entities (clause 6.5.3.2.2)

6.5.4 AI/ML inference capability configuration management

6.5.4.1 Description

The AI/ML inference function and the associated ML entity may need to be managed and configured to conduct inference in the 5G system to align with the consumer´s expectation, e.g., to enable the AI/ML inference function to perform inference.

The MnS producer for AI/ML inference management needs to provide a capability for configuration of the AI/ML inference function.

6.5.4.2 Use cases

6.5.4.2.1 Managing NG-RAN AI/ML-based distributed Network Energy Saving

An NG-RAN AI/ML-based distributed Network Energy Saving capability may use one or more ML entities to derive energy saving recommendations.

This NG-RAN AI/ML-based distributed Network Energy Saving capability needs to be managed. The MnS consumer monitors the network performance and determines whether to, and when to activate or deactivate an AI/ML-based Distributed Network Energy Saving function. The activation and deactivation actions for AI/ML-based Distributed Network Energy Saving conducted by the MnS producer may also be triggered by some defined policies provided by the consumer.

6.5.4.2.2 Managing NG-RAN AI/ML-based distributed Mobility Optimization

An AI/ML-based distributed Mobility Optimization capability may use one or more ML entities to derive handover recommendations.

This NG-RAN AI/ML-based distributed Mobility Optimization capability needs to be managed. The MnS consumer monitors the network performance and determines whether to, and when to activate or deactivate an AI/ML-based Distributed Mobility Optimization function. The activation and deactivation actions for AI/ML-based Distributed Mobility Optimization conducted by the MnS producer may also be triggered by some defined policies provided by the consumer.

6.5.4.2.3 Managing NG-RAN AI/ML-based distributed Load Balancing

An NG-RAN AI/ML-based distributed Load Balancing capability may use one or more ML entities to derive load balancing recommendations.

This NG-RAN AI/ML-based distributed Load Balancing capability needs to be managed. The MnS consumer monitors the network performance and determines whether to, and when to activate or deactivate an AI/ML-based Distributed Load balancing function. The activation and deactivation actions for AI/ML-based Distributed Load balancing conducted by the MnS producer may also be triggered by some defined policies provided by the consumer.

6.5.4.3 Requirements for AI/ML inference management

Table 6.5.4.3-1

Requirement label	Description	Related use case(s)
REQ- AI/ML_INF-01	The MnS producer of NG-RAN AI/ML-based distributed Network Energy Saving should enable an authorized MnS consumer to request to manage the Network Energy Saving inference capability	Managing AI/ML-based for NG-RAN distributed Network Energy Saving (clause 6.5.4.2.1)
REQ- AI/ML_INF-02	The MnS producer of NG-RAN AI/ML-based distributed Mobility Optimization should enable an authorized MnS consumer to request to manage the Mobility Optimization inference capability	Managing AI/ML-based for NG-RAN distributed Mobility Optimization (clause 6.5.4.2.2)
REQ- AI/ML_INF-03	The MnS producer of NG-RAN AI/ML-based distributed Load Balancing should enable an authorized MnS consumer to request to manage the Load Balancing inference capability	Managing AI/ML-based for NG-RAN distributed Load Balancing (clause 6.5.4.2.3)
REQ-AIML_ INF_ACT-1	The MnS producer for AI/ML inference management should have a capability allowing an authorized MnS consumer to activate and deactivate an ML inference function.	Managing AI/ML-enabled for Distributed Network Energy Saving (clause 6.5.4.2.1) Managing AI/ML-enabled for distributed Mobility Optimization (clause 6.5.4.2.2) Managing AI/ML-enabled for distributed Load balancing (clause 6.5.4.2.3)
REQ-AIML_ INF_ACT-2	The MnS producer for AI/ML inference management should have a capability to allow an authorized MnS consumer to provide the policy for activating and deactivating inference function. Note: The policies instructing the ML MnS producer on how or/and when to activate which ML capabilities.	Managing AI/ML-enabled for Distributed Network Energy Saving (clause 6.5.4.2.1) Managing AI/ML-enabled for distributed Mobility Optimization (clause 6.5.4.2.2) Managing AI/ML-enabled for distributed Load balancing (clause 6.5.4.2.3)

6.5.5 Executing AI/ML Inference

6.5.5.1 Description

Different functionalities in the network or management domains may utilize AI/ML inference techniques to conduct their tasks under different contexts. Depending on the contexts, the outcome of the ML entity at inference might be different. The history of such inference outcome and the corresponding context within which they were taken may be of interest to different consumers.

6.5.5.2 Use cases

6.5.5.2.1 AI/ML Inference History - tracking inferences and context

For different automation requirements in specific network domain, management/automation functions (e.g., MDAS, SON) may apply ML functionality to make the appropriate inferences in different contexts. The context is the set of appropriate conditions under which the inference was made including network conditions, traffic characteristics, time of day, weather, and climate, etc. And depending on the contexts, the different inferences may have different outcomes. The inference history, which is the history of such inferences and the contexts within which they are taken, may be of interest to different consumers. The AI/ML inference history includes recommendations and insights derived by the ML entity and the contexts, e.g., network resources, time periods, traffic conditions, etc. under which those recommendations and insights were derived.

The inferences (need to be tracked for future reference, e.g., to evaluate the appropriateness/effectiveness of the inference outcome for those contexts or to evaluate degradations in the ML entity's performance. For this, the network not only needs to have the required inference capabilities but needs also to have the means to track and enable usage of the history of the inferences made by the ML entity. The MnS producer, i.e., a specific AI/ML inference function should also provide the capability for AI/ML inference history Control, the means to control the process of compiling and reporting on AI/ML inference history.

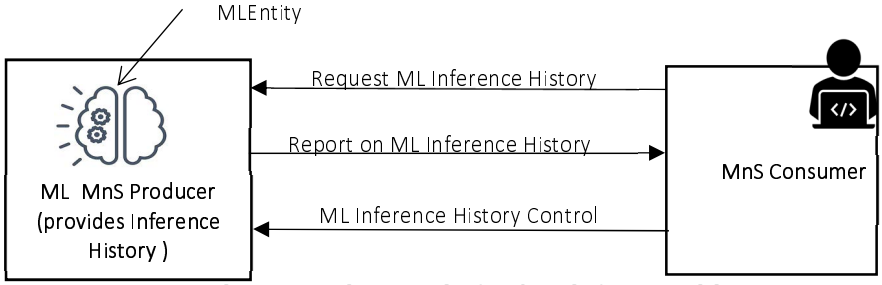


Figure 6.5.5.2.1-1: Example use and control of AI/ML inference history request and reporting.

6.5.5.3 Requirements for Executing AI/ML Inference

Table 6.5.5.3-1

Requirement label	Description	Related use case(s)
REQ-AI/ML_INF-HIST-01	The MnS producer for AI/ML inference management should have a capability allowing an authorized consumer to request the inference history of a specific ML entity.	AI/ML Inference History - tracking inferences and context (clause 6.5.5.2.1)
REQ-AI/ML-INF-HIST-02	The MnS producer for AI/ML inference management should have a capability enabling an authorized consumer to define the reporting characteristics (e.g., reporting period) related to a specific instance of ML inference history or the reporting thereof.	AI/ML Inference History - tracking inferences and context (clause 6.5.5.2.1)

7 Information model definitions for AI/ML management

7.1 Imported and associated information entities

7.1.1 Imported information entities and local labels

Table 7.1.1-1

Label reference	Local label
3GPP TS 28.622 [12], IOC, Top	Top
3GPP TS 28.622 [12], IOC, SubNetwork	SubNetwork
3GPP TS 28.622 [12], IOC, ManagedElement	ManagedElement
3GPP TS 28.622 [12], IOC, ManagedFunction	ManagedFunction
3GPP TS 28.622 [12], IOC, ThresholdMonitor	ThresholdMonitor
3GPP TS 28.541 [18], IOC, GNBCUCPFunction	GNBCUCPFunction
3GPP TS 28.104 [2], IOC, MDAFunction	MDAFunction
3GPP TS 28.622 [12], dataType, TimeWindow	TimeWindow
3GPP TS 28.622 [12], dataType, GeoArea	GeoArea
3GPP TS 28.622 [12], dataType, ThresholdInfo	ThresholdInfo
3GPP TS 28.622 [12], dataType, ProcessMonitor	ProcessMonitor

7.1.2 Associated information entities and local labels

Table 7.1.2-1

Label reference	Local label
3GPP TS 28.104 [2], IOC, MDAFunction	MDAFunction
3GPP TS 28.541 [18], IOC, NWDAFFunction	NWDAFFunction

7.2 Void

7.2a Common information model definitions for AI/ML management

7.2a.1 Class diagram

7.2a.1.1 Relationships

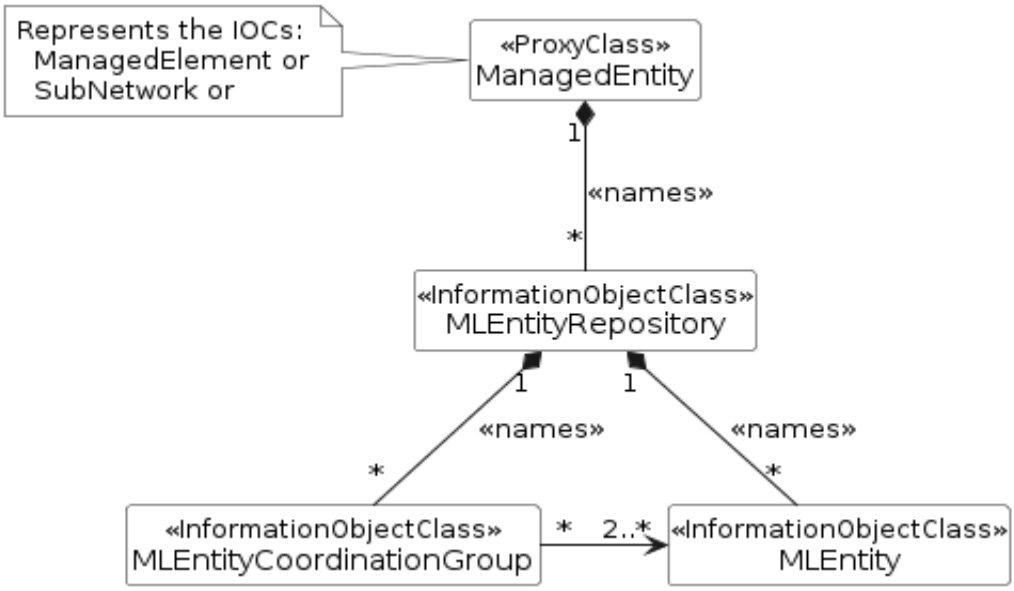


Figure 7.2a.1.1-1: Relations for common information models for AI/ML management

7.2a.1.2 Inheritance

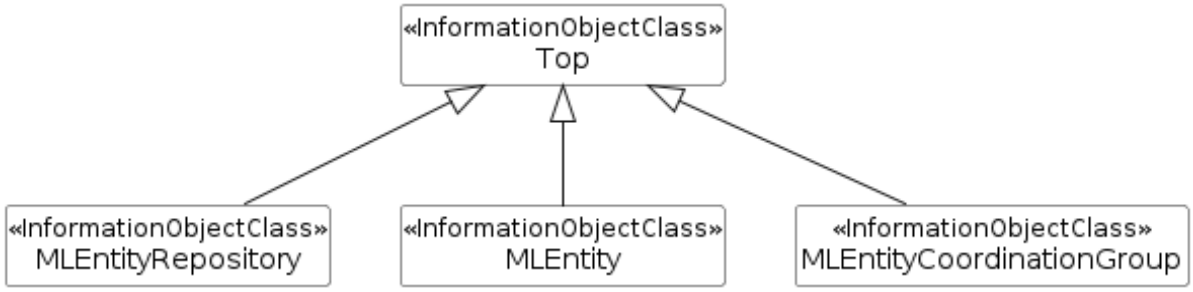


Figure 7.2a.1.2-1: Inheritance Hierarchy for common information models for AI/ML management

7.2a.2 Class definitions

7.2a.2.1 `MLEntity`

7.2a.2.1.1 Definition

This IOC represents the ML entity. ML model or ML entity are not subjects for standardization.

The MLEntity may contain 3 types of contexts - TrainingContext, ExpectedRunTimeContext and RunTimeContext which represent status and conditions of the MLEntity. These contexts are of mLContext <<dataType>>, see clauses 7.4.3 and 7.5.1 for details.
It also contains a reference named retrainingEventsMonitorRef which is a pointer to ThresholdMnonitor MOI. This indicates the list of performance measurements and the corresponding thresholds that are monitored and used to identify the need for re-training by the MnS Producer. After the MLEntity MOI has been instantiated, the MnS Consumer can request MnS producer to instantiate a ThresholdMonitor MOI and update the reference in the MLEntity MOI that can be used by the MnS producer to decide on the re-training of the MLEntity. The MnS producer can be ML Training MnS producer or ML Inference MnS Producer.

7.2a.2.1.2 Attributes

Table 7.2a.2.1.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
mLEntityId	M	T	F	F	T
inferenceType	M	T	F	F	T
mLEntityVersion	M	T	F	F	T
expectedRunTimeContext	M	T	T	F	T
trainingContext	CM	T	F	F	T
runTimeContext	O	T	F	F	T
supportedPerformanceIndicators	O	T	F	F	T
mLCapabilitiesInfoList	M	T	F	F	T
Attribute related to role					
retrainingEventsMonitorRef	O	T	T	F	T
sourceTrainedMLEntityRef	CM	T	F	F	T

7.2a.2.1.3 Attribute constraints

Table 7.2a.2.1.3-1

Name	Definition
trainingContext Support Qualifier	Condition: The trainingContext represents the status and conditions related to training and should be added when training is completed.
sourceTrainedMLEntityRef Support Qualifier	Condition: The MLEntity MOI containing this attribute represents an ML entity loaded to an inference function.

7.2a.2.1.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.2a.2.2 MLEntityRepository

7.2a.2.2.1 Definition

The IOC MLEntityRepository represents the repository that contains the ML entities .

The MLEntityRepository MOI may contain one or more MLEntity(s).

7.2a.2.2.2 Attributes

Table 7.a.2.2.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
mlEntityRef	M	T	F	F	F

7.2a.2.2.3 Attribute constraints

None.

7.2a.2.2.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.2a.2.3 `MLEntityCoordinationGroup`

7.2a.2.3.1 Definition

This IOC represents the group of ML entities, which can be trained and tested jointly and used to perform inference in a coordinated way.

One ML entity may have dependencies on one or more of the other ML entities of the same group.

One group is associated with at least two ML entities.

7.2a.2.3.2 Attributes

Table 7.2a.2.3.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
Attribute related to role					
`memberMLEntityRefList`	M	T	F	F	T

7.2a.2.3.3 Attribute constraints

None.

7.2a.2.3.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3 Void

7.3a Information model definitions for AI/ML operational phases

7.3a.1 Information model definitions for ML Training

7.3a.1.1 Class diagram

7.3a.1.1.1 Relationships

This clause depicts the set of classes (e.g. IOCs) that encapsulates the information relevant to ML model training. For the UML semantics, see TS 32.156 [13].

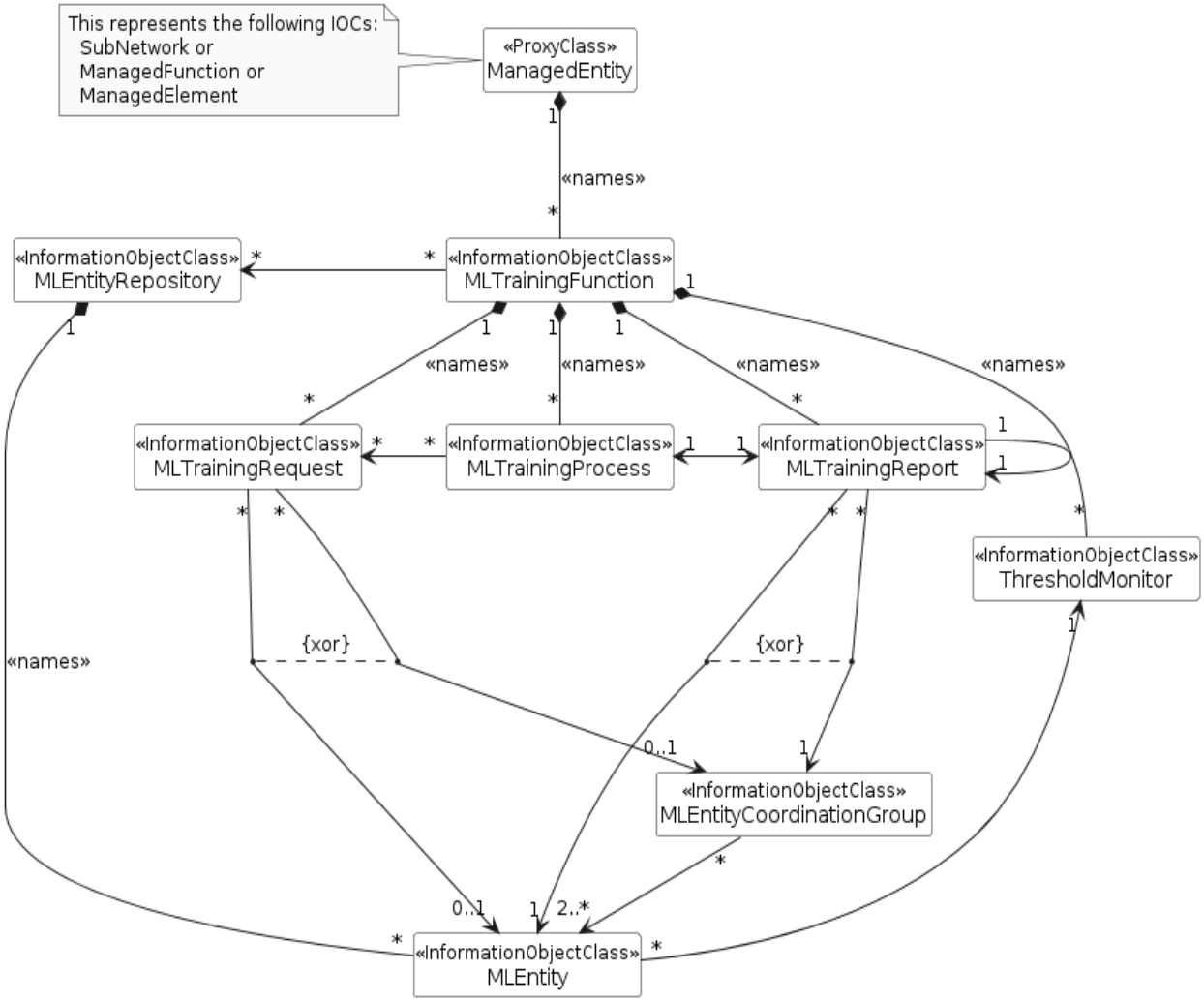


Figure 7.3a.1.1.1-1: NRM fragment for ML training

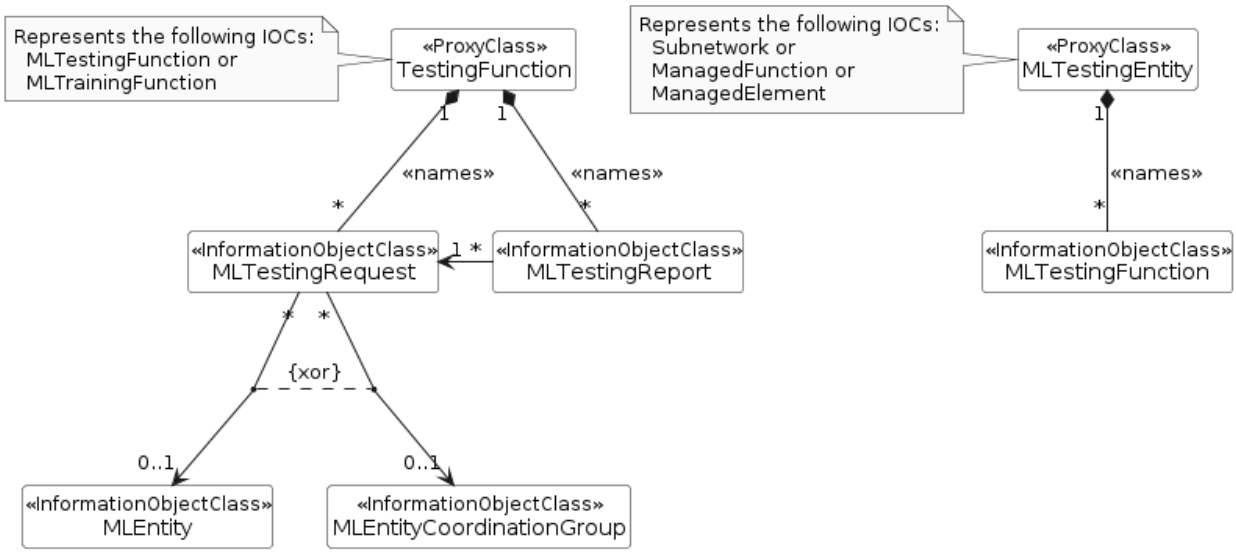


Figure 7.3a.1.1.1-2: NRM fragment for ML testing

7.3a.1.1.2 Inheritance

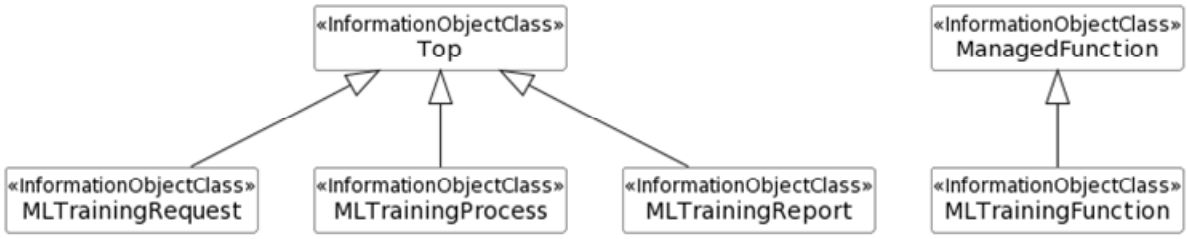


Figure 7.3a.1.1.2-1: Inheritance Hierarchy for ML training related NRMs

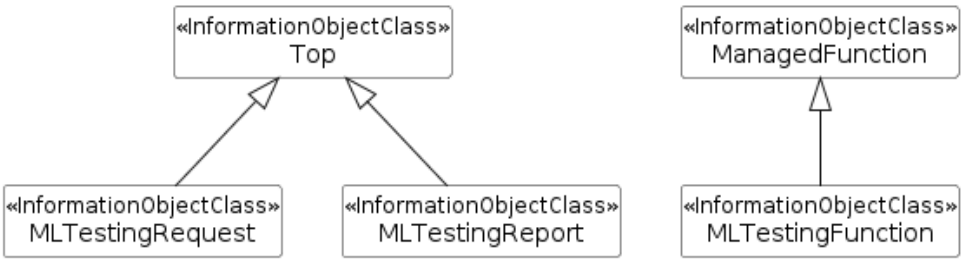


Figure 7.3a.1.1.2-2: Inheritance Hierarchy for ML testing related NRMs

7.3a.1.2 Class definitions

7.3a.1.2.1 `MLTrainingFunction`

7.3a.1.2.1.1 Definition

The IOC `MLTrainingFunction` represents the entity that undertakes ML training. The MOI of `MLTrainingFunction` is also the container of the `MLTrainingRequest` MOI(s).

The entity represented by `MLTrainingFunction` MOI supports training of one or more `MLEntity(s)`.

7.3a.1.2.1.2 Attributes

Table 7.3a.1.2.1.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
Attribute related to role					
`mLEntityRepositoryRef`	M	T	F	F	T

7.3a.1.2.1.3 Attribute constraints

None.

7.3a.1.2.1.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.1.2.2 MLTrainingRequest

7.3a.1.2.2.1 Definition

The IOC MLTrainingRequest represents the ML model training request that is created by the ML training MnS consumer.

The MLTrainingRequest MOI is contained under one MLTrainingFunction MOI.

The MLTrainingRequest MOI may represent the request for initial ML training or re-training. For ML re-training, the MLTrainingRequest is associated to one MLEntity for re-training a single ML entity, or associated to one MLEntityCoordinationGroup for re-training a group of coordinated ML entities.

The MLTrainingRequest may have a source to identify its origin, which may be used to prioritize the training resources for different sources. The sources may be for example the network functions, operator roles, or other functional differentiations.

Each MLTrainingRequest indicates the expectedRunTimeContext that describes the specific conditions for which the MLEntity should be trained.

In case the request is accepted, the ML training MnS producer decides when to start the ML training based on consumer requirements. Once the MnS producer decides to start the training based on the request, the ML training MnS producer instantiates one or more MLTrainingProcess MOI(s) that are responsible to perform the followings:

- collects (more) data for training, if the training data are not available or the data are available but not sufficient for the training;
- prepares and selects the required training data, with consideration of the consumer's request provided candidate training data if any. The ML training MnS producer may examine the consumer's provided candidate training data and select none, some or all of them for training. In addition, the ML training MnS producer may select some other training data that are available in order to meet the consumer's requirements for the MLentity training;
- trains the MLEntity using the selected and prepared training data.

The MLTrainingRequest may have a requestStatus field to represent the status of the specific MLTrainingRequest:

- The attribute values are "NOT_STARTED", " IN_PROGRESS", "SUSPENDED", "FINISHED", and "CANCELLED".
- When value turns to " IN_PROGRESS", the ML training MnS producer instantiates one or more MLTrainingProcess MOI(s) representing the training process(es) being performed per the request and notifies the MLT MnS consumer(s) who subscribed to the notification.

When all of the training process associated to this request are completed, the value turns to "FINISHED".

7.3a.1.2.2.2 Attributes

Table 7.3a.1.2.2.1-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceType	CM	T	F	F	T
candidateTrainingDataSource	O	T	T	F	T
trainingDataQualityScore	O	T	T	F	T
trainingRequestSource	M	T	T	F	T
requestStatus	M	T	F	F	T
expectedRuntimeContext	M	T	T	F	T
performanceRequirements	M	T	T	F	T
cancelRequest	O	T	T	F	T
suspendRequest	O	T	T	F	T
Attribute related to role					
mLEntityToTrainRef	CM	T	F	F	T
mLEntityCoordinationGroupToTrainRef	CM	T	F	F	T

7.3a.1.2.2.3 Attribute constraints

Table 7.3a.1.2.2.3-1

Name	Definition
inferenceType Support Qualifier	Condition: MLTrainingRequest MOI represents the request for initial ML training.
mLEntityToTrainRef Support Qualifier	Condition: MLTrainingRequest MOI represents the request for ML re-training.
mLEntityCoordinationGroupToTrainRef Support Qualifier	Condition: MLTrainingRequest MOI represents the request for joint training of a group of ML entities.

7.3a.1.2.2.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.1.2.3 MLTrainingReport

7.3a.1.2.3.1 Definition

The IOC MLTrainingReport represents the ML model training report that is provided by the training MnS producer.

The MLTrainingReport MOI is contained under one MLTrainingFunction MOI.

7.3.1.2.3.2 Attributes

Table 7.3a.1.2.3.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
areConsumerTrainingDataUsed	M	T	F	F	T
usedConsumerTrainingData	CM	T	F	F	T
modelConfidenceIndication	O	T	F	F	T
modelPerformanceTraining	M	T	F	F	T
areNewTrainingDataUsed	M	T	F	F	T
Attribute related to role					
trainingRequestRef	CM	T	F	F	T
trainingProcessRef	M	T	F	F	T
lastTrainingRef	CM	T	F	F	T
mLEnityGeneratedRef	M	T	F	F	T
mLEnityCoordinationGroupGeneratedRef	CM	T	F	F	T
mLEntityRef	M	T	F	F	T

7.3a.1.2.3.3 Attribute constraints

Table 7.3a.1.2.3.3-1

Name	Definition
`usedConsumerTrainingData` Support Qualifier	Condition: The value of `areConsumerTrainingDataUsed` attribute is ALL or PARTIALLY.
`trainingRequestRef` Support Qualifier	Condition: The `MLTrainingReport` MOI represents the report for the ML model training that was requested by the MnS consumer (via `MLTrainingRequest` MOI).
`lastTrainingRef` Support Qualifier	Condition: The `MLTrainingReport` MOI represents the report for the ML model training that was not initial training (i.e. the model has been trained before).
`mLEnityCoordinationGroupGeneratedRef` Support Qualifier	Condition: The MLTrainingReport MOI represents the report for a joint training of a group of ML entities.

7.3a.1.2.3.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.1.2.4 `MLTrainingProcess`

7.3a.1.2.4.1 Definition

The IOC `MLTrainingProcess` represents the ML training process.

One `MLTrainingProcess` MOI may be instantiated for each `MLTrainingRequest` MOI or a set of `MLTrainingRequest` MOIs.

For each `MLEntity` under training, a `MLTrainingProcess` is instantiated, i.e. an `MLTrainingProcess` is associated with exactly one `MLEntity`. The `MLTrainingProcess` may be associated with one or more `MLTrainingRequest` MOI.

The `MLTrainingProcess` does not have to correspond to a specific `MLTrainingRequest`, i.e. a `MLTrainingRequest` does not have to be associated to a specific `MLTrainingProcess`. The `MLTrainingProcess` may be managed separately from the `MLTrainingRequest` MOIs, e.g. the `MLTrainingRequest` MOI may come from consumers which are network functions while the operator may wish to manage the `MLTrainingProcess` that is instantiated following the requests. Thus, the `MLTrainingProcess` may be associated to either one or more `MLTrainingRequest` MOI.

Each `MLTrainingProcess` instance needs to be managed differently from the related `MLEntity`, although the `MLTrainingProcess` may be associated to only one `MLEntity`. For example, the `MLTrainingProcess` may be triggered to start with a specific version of the `MLEntity` and multiple `MLTrainingProcess` instances may be triggered for different versions of the `MLEntity`. In either case the `MLTrainingProcess` instances are still associated with the same `MLEntity` but are managed separately from the `MLEntity.`

Each `MLTrainingProcess` has a `priority` that may be used to prioritize the execution of different `MLTrainingProcess` instances. By default, the `priority` of the `MLTrainingProcess` may be related in a 1:1 manner with the `priority` of the `MLTrainingRequest` for which the `MLTrainingProcess` is instantiated.

Each `MLTrainingProcess` may have one or more termination conditions used to define the points at which the `MLTrainingProcess` may terminate.

The "`progressStatus`" attribute represents the status of the ML model training and includes information the ML training MnS consumer can use to monitor the progress and results. The data type of this attribute is "`ProcessMonitor`" (see 3GPP TS 28.622 [12]). The following specializations are provided for this data type for the ML training process:

- The "status" attribute values are "RUNNING", "CANCELLING", "SUSPENDED", "FINISHED", and "CANCELLED". The other values are not used.
- The "`timer`" attribute is not used.
- When the "status" is equal to "RUNNING" the "`progressStateInfo`" attribute shall indicate one of the following states: "COLLECTING_DATA", "PREPARING_TRAINING_DATA", "TRAINING".
- No specifications are provided for the "`resultStateInfo`" attribute. Vendor specific information may be provided though.

When the training is completed with "`status`" equal to "FINISHED", the MLT MnS producer provides the training report, by creating an MLTrainingReport MOI, to the MLT MnS consumer.

7.3a.1.2.4.2 Attributes

Table 7.3a.1.2.4.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
priority	M	T	T	F	T
terminationConditions	M	T	T	F	T
progressStatus	M	T	F	F	T
cancelProcess	O	T	T	F	T
suspendProcess	O	T	T	F	T
Attribute related to role					
trainingRequestRef	CM	T	F	F	T
trainingReportRef	M	T	F	F	T
mLEntityGeneratedRef	CM	T	F	F	T
mLEntityRef	M	T	F	F	T

7.3a.1.2.4.3 Attribute constraints

Table 7.3a.1.2.4.3-1

Name	Definition
`trainingRequestRef` Support Qualifier	Condition: The `MLTrainingReport` MOI represents the report for the ML model training that was requested by the training MnS consumer (via `MLTrainingRequest` MOI).
`mLEntityGeneratedRef` Support Qualifier	Condition: The `MLTrainingProcess` MOI is instantiated to retrain an existing `MLEntity`.

7.3a.1.2.4.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.1.2.5 `MLTestingFunction`

7.3a.1.2.5.1 Definition

The ML entity testing may be conducted by the ML training function, or by a separate function.

In case the ML entity testing is conducted by a function separate from the ML training function, the IOC `MLTestingFunction` is instantiated and represents the logical function that undertakes ML entity testing.

The entity represented by `MLTestingFunction MOI` supports testing of one or more `MLEntity(s)`.

7.3a.1.2.5.2 Attributes

Table 7.3a.1.2.5.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
mLEntityRef	M	T	F	F	F

7.3a.1.2.5.3 Attribute constraints

None.

7.3a.1.2.5.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.1.2.6 MLTestingRequest

7.3a.1.2.6.1 Definition

The IOC MLTestingRequest represents the ML entity testing request that is created by the ML testing MnS consumer.

The MLTestingRequest MOI is contained under one MLTestingFunction MOI or MLTrainingFunction MOI which represents the logical function that conducts the ML entity testing. Each MLTestingRequest is associated to at least one MLEntity.

In case the request is accepted, the ML testing MnS producer decides when to start the ML testing. Once the MnS producer decides to start the testing based on the request, the ML testing MnS producer:

- collects (more) data for testing, if the testing data are not available or the data are available but not sufficient for the testing;
- prepares and selects the required testing data;
- tests the MLEntity by performing inference using the selected testing data, and
- reports the performance of the MLEntity when it performs on the selected testing data.

The MLTestingRequest may have a requestStatus field to represent the status of the request:

- The attribute values are "NOT_STARTED", "IN_PROGRESS", "SUSPENDED", "FINISHED", and "CANCELLED".

7.3a.1.2.6.2 Attributes

Table 7.3a.1.2.6.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
requestStatus	M	T	F	F	T
cancelRequest	O	T	T	F	T
suspendRequest	O	T	T	F	T
Attribute related to role					
mLEntityToTestRef	CM	T	F	F	T
mLEntityCoordinationGroupToTestRef	CM	T	F	F	T

7.3a.1.2.6.3 Attribute constraints

Table 7.3a.1.2.6.3-1

Name	Definition
`mLEntityToTestRef` Support Qualifier	Condition: The `MLTestingRequest` MOI represents the request for testing of a single ML entity.
`mLEntityCoordinationGroupToTestRef` Support Qualifier	Condition: The `MLTestingRequest` MOI represents the request for joint testing of a group of ML entities.

7.3a.1.2.6.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.1.2.7 `MLTestingReport`

7.3a.1.2.7.1 Definition

The IOC `MLTestingReport` represents the ML testing report that is provided by the ML testing MnS producer.

The `MLTestingReport` MOI is contained under one `MLTestingFunction` MOI or `MLTrainingFunction` MOI which represents the logical function that conducts the ML entity testing.

For the joint testing of a group of ML entities, the ML testing report contains the testing results for every ML entity in the group.

7.3a.1.2.7.2 Attributes

Table 7.3a.1.2.7.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
`modelPerformanceTesting`	M	T	F	F	T
`mLTestingResult`	M	T	F	F	T
Attribute related to role					
`testingRequestRef`	CM	T	F	F	T

7.3a.1.2.7.3 Attribute constraints

Table 7.3a.1.2.7.3-1

Name	Definition
`testingRequestRef` Support Qualifier	Condition: The `MLTestingReport` MOI represents the report for the ML model testing that was requested by the MnS consumer (via `MLTestingRequest` MOI).

7.3a.1.2.7.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.2 Information model definitions for ML emulation Phase

7.3a.2.1 Class diagram

7.3a.2.1.1 Relationships

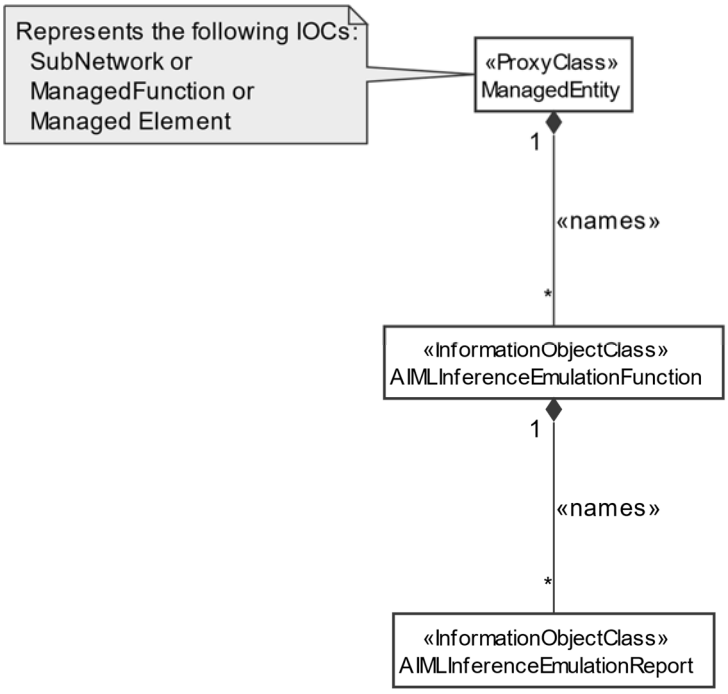


Figure 7.3a.2.1.1-1: NRM fragment for AI/ML inference emulation Control

7.3a.2.1.2 Inheritance

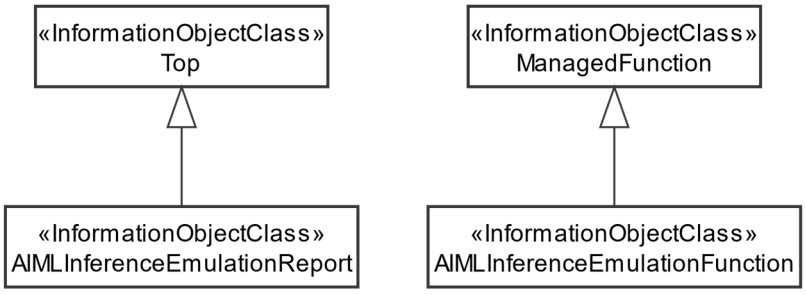


Figure 7.3a.2.1.2-1: AI/ML inference emulation Inheritance Relations

7.3a.2.2 Class definitions

7.3a.2.2.1 `AIMLInferenceEmulationFunction`

7.3a.2.2.1.1 Definition

This IOC represents the properties of a function that undertakes AI/ML Inference Emulation. An `AIMLInferenceEmulationFunction` may be associated with one or more `MLEntity(s)`. `AIMLInferenceEmulationFunction` is name contained with `AIMLInferenceEmulationReport(s)` that delivers the outcomes of the emulation processes.

NOTE: The way of triggering of an AI/ML inference emulation and the instantiation of the related AI/ML inference emulation process is not in the scope of the present document.

7.3a.2.2.1.2 Attributes

The `AIMLInferenceEmulationFunction` IOC includes attributes inherited from `ManagedFunction` IOC (defined in TS 28.622[30]) and the following attributes:

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
`aIMLInferenceEmulationFunctionId`	M	T	F	F	F
Attributes related to Role					
`aIMLInferenceEmulationReportRef`	M	T	F	F	F

7.3a.2.2.1.3 Attribute constraints

None.

7.3a.2.2.1.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.3 Information model definitions for ML deployment phase

7.3a.3.1 Class diagram

7.3a.3.1.1 Relationships

This clause depicts the set of classes (e.g. IOCs) that encapsulates the information relevant to ML deployment phase. For the UML semantics, see TS 32.156 [13].

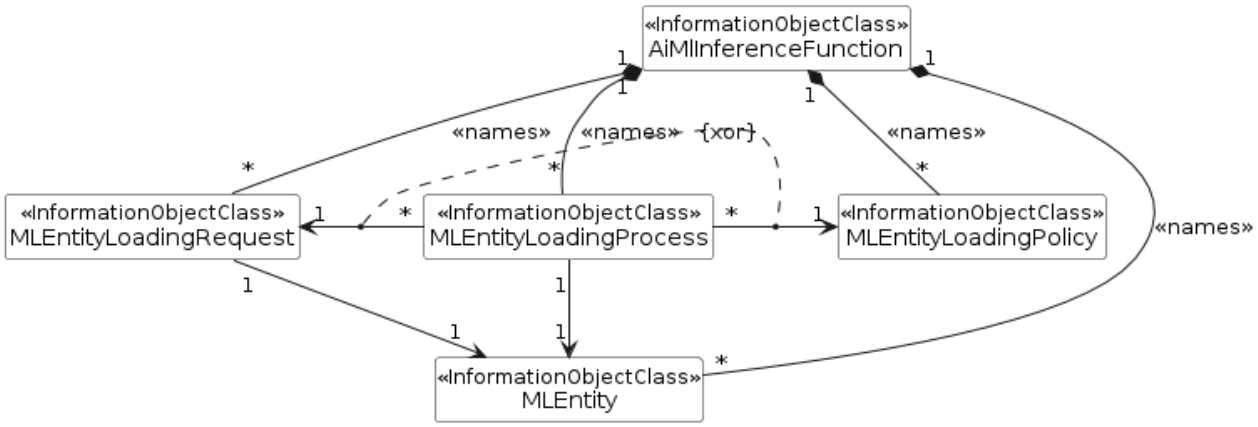


Figure 7.3a.3.1.1-1: NRM fragment for ML entity loading

7.3a.3.1.2 Inheritance

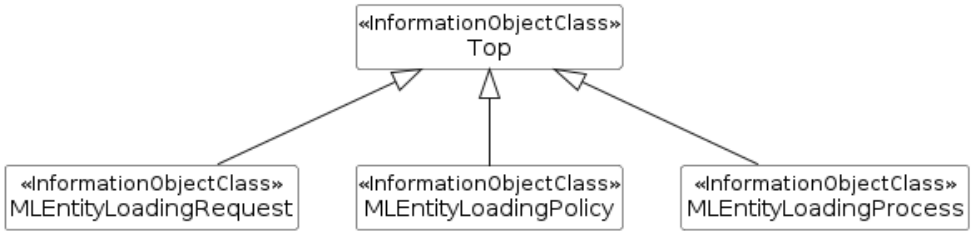


Figure 7.3a.3.1.2-1: Inheritance Hierarchy for ML entity loading related NRMs

7.3a.3.2 Class definitions

7.3a.3.2.1 `MLEntityLoadingRequest`

7.3a.3.2.1.1 Definition

This IOC represents the ML entity loading request that is created by the MnS consumer. Using this IOC, the MnS consumer requests the MnS producer to load an ML entity to the target inference function.

This `IOC` has a `requestStatus` field to represent the status of the request:

- The attribute value is one of "NOT_STARTED", "IN_PROGRESS", "SUSPENDED", "FINISHED_SUCCESS ", FINISHED_FAILED" and "CANCELLED".
- When value turns to "IN_PROGRESS", the MnS producer instantiates one or more `MLEntityLoadingProcess` MOI(s) representing the loading process(es) being performed per the request and notifies the MnS consumer(s) who subscribed to the notification.

7.3a.3.2.1.2 Attributes

Table 7.3a.3.2.1.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
`requestStatus`	M	T	T	F	T
`cancelRequest`	O	T	T	F	T
`suspendRequest`	O	T	T	F	T
Attribute related to role					
`mLEntityToLoadRef`	M	T	F	F	T

7.3a.3.2.1.3 Attribute constraints

None.

7.3a.3.2.1.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.3.2.2 `MLEntityLoadingPolicy`

7.3a.3.2.2.1 Definition

This IOC represents the ML entity loading policy set by the MnS consumer to the producer for loading an ML entity to the target inference function(s).

This IOC is used for the MnS consumer to set the conditions for the producer-initated ML entity loading. The MnS producer is only allowed to load the ML entity when all of the conditions are met.

7.3a.3.2.2.2 Attributes

Table 7.3a.3.2.2.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceType	CM	T	T	F	T
policyForLoading	M	T	T	F	T
Attribute related to role					
mLEntityRef	CM	T	F	F	F

7.3a.3.2.2.3 Attribute constraints

Table 7.3a.3.2.2.3-1

Name	Definition
inferenceType Support Qualifier	Condition: The ML entity loading policy is related to an initially trained ML entity.
mLEntityRef Support Qualifier	Condition: The ML entity loading policy is related to a re-trained ML entity.

7.3a.3.2.2.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.3.2.3 MLEntityLoadingProcess

7.3a.3.2.3.1 Definition

This IOC represents the ML entity loading process.

For the consumer requested ML entity loading, one or more MLEntityLoadingProcess MOI(s) may be instantiated for each ML entity loading request presented by the MLEntityLoadingRequest MOI.

For the producer-initiated ML entity loading, one or more MLEntityLoadingProcess MOI(s) may be instantiated and associated with each MLEntityLoadingPolicy MOI.

One MLEntityLoadingProcess MOI represent the ML entity loading process(es) corresponding to one or more target inference function(s).

The "progressStatus" attribute represents the status of the ML entity loading process and includes information the MnS consumer can use to monitor the progress and results. The data type of this attribute is "ProcessMonitor" (see 3GPP TS 28.622 [12]). The following specializations are provided for this data type for the ML entity loading process:

- The "status" attribute values are "RUNNING", "CANCELLING", "SUSPENDED", "FINISHED", and "CANCELLED". The other values are not used.
- The "timer" attribute is not used.
- When the "status" is equal to "RUNNING" the "progressStateInfo" attribute shall indicate one of the following state: "LOADING".
- No specifications are provided for the "resultStateInfo" attribute. Vendor specific information may be provided though.

When the loading is completed with "status" equal to "FINISHED", the MnS producer creates the MOI(s) of loaded MLEntity under each MOI of the target inference function(s).

7.3a.3.2.3.2 Attributes

Table 7.3a.3.2.3.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
progressStatus	M	T	F	F	T
cancelProcess	O	T	T	F	T
suspendProcess	O	T	T	F	T
resumeProcess	O	T	T	F	T
Attribute related to role					
MLEntityLoadingRequestRef	CM	T	F	F	T
MLEntityLoadingPolicyRef	CM	T	F	F	T
LoadedMLEntityRef	M	T	F	F	T

7.3a.3.2.3.3 Attribute constraints

Table 7.3a.3.2.3.3-1

Name	Definition
MLEntityLoadingRequestRef Support Qualifier	Condition: The MLEntityLoadingProcess MOI is corresponding to the ML entity loading requested by the MnS consumer.
MLEntityLoadingPolicyRef Support Qualifier	Condition: The MLEntityLoadingProcess MOI is corresponding to the ML entity loading initiated by the MnS producer.

7.3a.3.2.3.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.4 Information model definitions for ML inference phase

7.3a.4.1 Class diagram

7.3a.4.1.1 Relationships

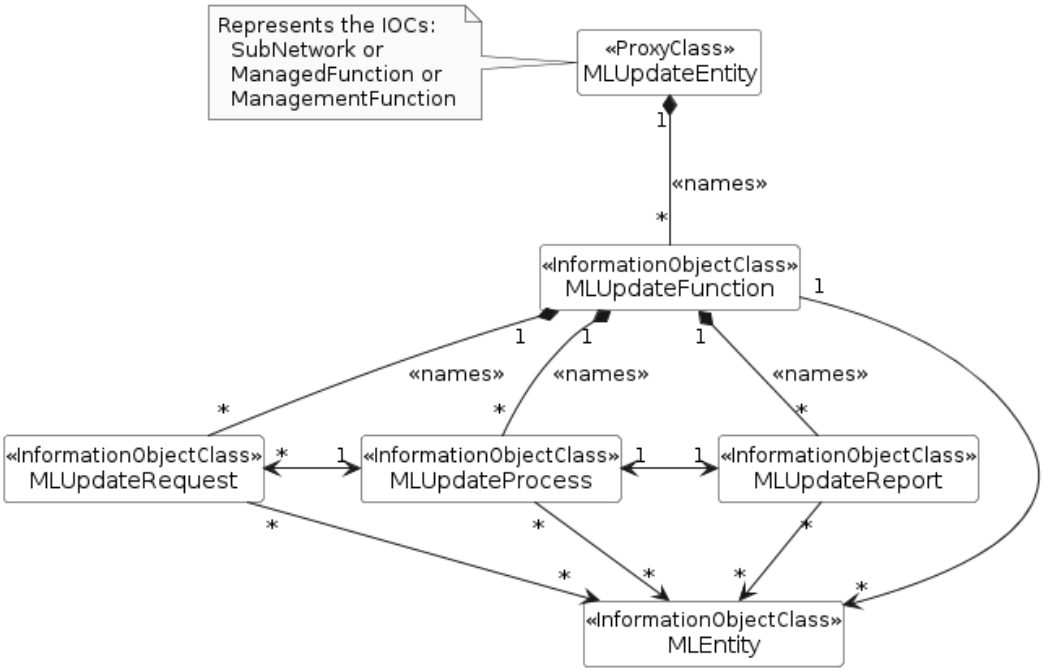
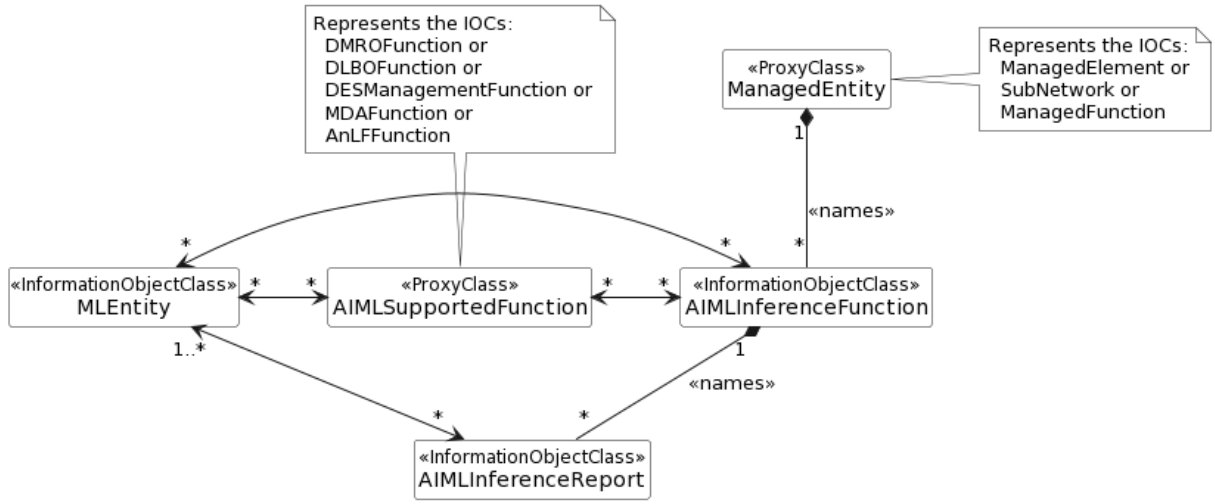


Figure 7.3a.4.1.1-1: NRM fragment for ML update



NOTE: The `ManagedEntity` and `AIMLSupportedFunction` shall not represent the same MOI.

Figure 7.3a.4.1.1-2: NRM fragment for AI/ML inference function

7.3a.4.1.2 Inheritance

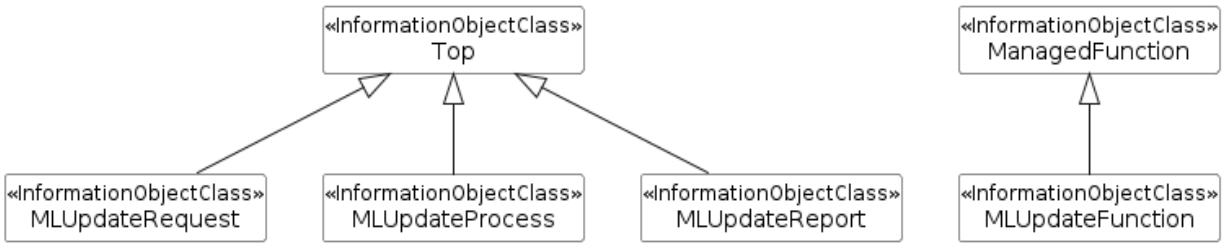


Figure 7.3a.4.1.2-1: Inheritance Hierarchy for ML update related NRMs

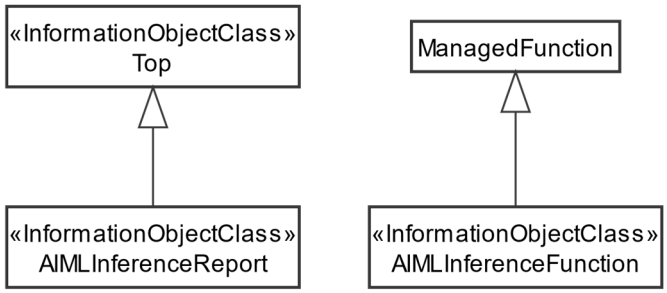


Figure 7.3a.4.1.2-2: Inheritance Hierarchy for AI/ML inference function

7.3a.4.2 Class definitions

7.3a.4.2.1 `MLUpdateFunction`

7.3a.4.2.1.1 Definition

This IOC represents the function responsible for ML update.

The MOI of `MLUpdateFunction` is name-contained in an MOI of either a `subnetwork`, a `managedFunction` or a `managementFunction`.

The MLUpdateFunction is be associated with one or more ML entities.

The MLUpdateFunction contains one or more MLUpdateRequest(s)as well as one or more MLUpdateProcess(s), where an MLUpdateProcess is instantiated corresponding to one received MLUpdateRequest.

7.3a.4.2.1.2 Attributes

The MLUpdateFunction IOC includes attributes inherited from ManagedFunction IOC (defined in TS 28.622 [12]) and the following attributes:

Table 7.3a.4.2.1.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
availMLCapabilityReport	M	T	F	F	F
Attributes related to Role					
mLEntityRef	M	T	F	F	F

7.3a.4.2.1.3 Attribute constraints

None.

7.3a.4.2.1.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.4.2.2 MLUpdateRequest

7.3a.4.2.2.1 Definition

This IOC represents the properties of MLUpdateRequest.

For each request to update the ML capabilities, a consumer creates a new MOI of MLUpdateRequest on the MLUpdateFunction, i.e., MLUpdateRequest is instantiated for each request for updating ML capabilities:

- Each MLUpdateRequest is associated to at least one MLEntity
- Each MLUpdateRequest may have a RequestStatus field that is used to track the status of the specific MLUpdateRequest or the associated MLUpdateProcess. The RequestStatus is updated by MnS producer when there is a change in status of the update progress. The RequestStatus is an enumeration with the values: NOT_STARTED, IN_PROGRESS, CANCELLING, SUSPENDED, FINISHED, and CANCELLED
- Each MLUpdateRequest may contain specific reporting requirements including an mLUpdateReportingPeriod that defines the time duration upon which the MnS consumer expects the ML update is reported. The reporting requirements contained in the MLUpdateRequest are mapped to an existing MLUpdateProcess instance.
- The MLUpdateRequest may specify a performanceGainThreshold which defines the minimum performance gain that shall be achieved with the capability update. This implies that the difference in the performances between the existing capabilities and the new capabilities needs to be at least performanceGainThreshold, otherwise the new capabilities shall not be applied. A threshold of performanceGainThreshold=0% implies that the capabilities should be applied even if there is no noticeable performance gain.

- The MLUpdateRequest may indicates the maximum time that should be taken to complete the update.

7.3a.4.2.2.2 Attributes

The MLUpdateRequest IOC includes attributes inherited from Top IOC (defined in TS 28.622 [30]) and the following attributes:

Table 7.3a.4.2.2.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
performanceGainThreshold	O	T	T	T	F
newCapabilityVersionId	O	T	T	T	F
updateTimeDeadline	O	T	T	T	F
requestStatus	M	T	T	F	T
mLUpdateReportingPeriod	O	T	T	F	T
cancelRequest	O	T	T	F	T
suspendRequest	O	T	T	F	T
Attributes related to Role					
mLUpdateProcessRef	M	T	F	F	F
mLEntityRef	M	T	F	F	F

7.3a.4.2.2.3 Attribute constraints

None.

7.3a.4.2.2.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.4.2.3 MLUpdateProcess

7.3a.4.2.3.1 Definition

This IOC represents the ML update process.

For each MLUpdateRequest to update the ML capabilities, the MLUpdateProcess is instantiated for the MLUpdateRequest unless the MLUpdateRequest is associated with an ongoing MLUpdateProcess if the MLUpdateProcess is updating the same MLEntity(s) as stated in the MLUpdateRequest i.e., the MLUpdateProcess is associated with at least one MLUpdateRequest. Relatedly, the MLUpdateProcess is associated with at least one MLEntity.

- Each MLUpdateProcess may have a status attribute (i.e., progressStatus) used to indicate progress status of theupdate process.
- The MLUpdateProcess has the capability of compiling and delivering reports and notifications relating to the ML update request or process.
- Each MLUpdateProcess may have attributes specifying the ML capability update reporting characteristics (e.g. periodically, after completion, etc.).

7.3a.4.2.3.2 Attributes

The MLUpdateProcess IOC includes attributes inherited from Top IOC (defined in TS 28.622 [30]) and the following attributes:

Table 7.3a.4.2.3.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
progressStatus	M	T	T	F	T
Attributes related to Role					
mLEntityRef	M	T	F	F	F
MLUpdateRequestRef	M	T	F	F	F
MLUpdateReportRef	M	T	F	F	F

7.3a.4.2.3.3 Attribute constraints

None.

7.3a.4.2.3.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.4.2.4 MLUpdateReport

7.3a.4.2.4.1 Definition

This IOC represents the properties of ML update report.

- The ML update process may generate one or more MLUpdateReport(s),
- Each MLUpdateReport is associated to one or more MLEntity(s) to indicate ML entities that have been updated.
- The MLUpdateReport may indicate the achieved performance gain for the specific ML capability update, which is the gain in performance of the new capabilities compared with the original capabilities.
- MLUpdateReport provides reports about MLEntity(s) or MLUpdateProcess(s) that themselves are associated with MLEntity(s) for which update is requested and/or executed. Correspondingly, both the MLUpdateRequest(s) and the MLUpdateProcess(s) are conditionally mandatory in that at least one of them must be associated with an instance of MLUpdateReport.

7.3a.4.2.4.2 Attributes

Table 7.3a.4.2.4.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
UpdatedMLCapability	M	T	F	F	F
Attributes related to Role					
mLEntityRef	M	T	F	F	F
mLUpdateProcessRef	M	T	F	F	F

7.3a.4.2.4.3 Attribute constraints

None.

7.3a.4.2.4.4 Notifications

The notifications specified for the IOC using this <<datatype>> for its attribute(s), shall be applicable.

7.3a.4.2.5 AIMLInferenceFunction

7.3a.4.2.5.1 Definition

This IOC represents the common properties of the AI/ML inference function.

The AIMLInferenceFunction MOI may be associated with one or more MOIs that represent the functions/functionalities (Note) provided by the subject AIMLInferenceFunction MOI.

The AIMLInferenceFunction MOI can be only created by the MnS producer but not consumer.

The MOI of AIMLInferenceFunction or the MOI of the IOC inheriting from the AIMLInferenceFunction IOC contains one or more MOI(s) of MLEntity .

NOTE: The IOCs representing the functions/functionalities (Note) that use the AI/ML inference function include MDAFunction, AnLFFunction, DMROFunction, DLBOFunction, and DESManagementFunction.

The AIMLInferenceFunction MOI may be contained by either a SubNetwork MOI, a ManagedElement MOI, or an MOI of ManagedFunction's subclass, and it is allowed for an MnS producer to support multiple AIMLInferenceFunction MOIs contained in different superordinated MOIs among SubNetwork, ManagedElement and the ManagedFunction's subclass.

The generation of inference outputs is based on the configuration of inference, e.g., to start a stated time, or to be executed at all times. The observations of the inference function and information on derived Outputs is registered in the inference report.

7.3a.4.2.5.2 Attributes

Table 7.3a.4.2.5.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
activationStatus	M	T	T	F	T
managedActivationScope	O	T	T	F	T
Attributes related to role					
usedByFunctionRefList	M	T	F	F	T
MLEntityRef	M	T	F	T	T

7.3a.4.2.5.3 Attribute constraints

None.

7.3a.4.2.5.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.3a.4.2.6 AIMLInferenceReport

7.3a.4.2.6.1 Definition

This <<IOC>> represents a report from a AI/ML Inference.

An AIMLInferenceFunction may generate one or more AIMLInferenceReport(s).

Each AIMLInferenceReport provides information about inference outputs from one or more MLEntity.

The AIMLInferenceReport also provides historical inference outputs for a series of time stamps.

7.3a.4.2.6.2 Attributes

The AIMLInferenceReport includes inherited attributes from Top IOC (defined in TS28.622 [12]) and the following attributes:

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceOutputs	M	T	F	F	T
Attributes related to role					
mLEntityRef	M	T	F	F	T

7.3a.4.2.6.3 Attribute constraints

None.

7.3a.4.2.6.4 Notifications

The common notifications defined in clause 7.6 are valid for this IOC, without exceptions or additions.

7.4 Data type definitions

7.4.1 ModelPerformance <<dataType>>

7.4.1.1 Definition

This data type specifies the performance of an ML entity when performing inference. The performance score is provided for each inference output.

7.4.1.2 Attributes

Table 7.4.1.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceOutputName	M	T	T/F (NOTE)	F	T
performanceScore	M	T	T/F (NOTE)	F	T
performanceMetric	M	T	T/F (NOTE)	F	T
decisionConfidenceScore	O	T	F	F	T
NOTE: The isWritable qualifier is “T” if the attribute is used in MLTrainingRequest. The isWritable qualifier is "F" otherwise.					

7.4.1.3 Attribute constraints

None.

7.4.1.4 Notifications

The notifications specified for the IOC using this <<dataType>> for its attribute(s), shall be applicable.

7.4.2 Void

7.4.3 MLContext <<dataType>>

7.4.3.1 Definition

The MLContext represents the status and conditions related to the MLEntity. There are three types of context - the ExpectedRunTimeContext, the TrainingContext and the RunTimeContext, see clause 7.5.1 for details of each type.

7.4.3.2 Attributes

Table 7.4.3.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceEntityRef	CM	T	F	F	F
dataProviderRef	M	T	F	F	F

7.4.3.3 Attribute constraints

Table 7.4.3.3-1

Name	Definition
inferenceEntityRef Support Qualifier	Condition: The MLContext is used for ExpectedRunTimeContext, TrainingContext or RunTimeContext.

7.4.3.4 Notifications

The notifications specified for the IOC using this <<dataType>> for its attribute(s), shall be applicable.

7.4.4 SupportedPerfIndicator <<dataType>>

7.4.4.1 Definition

This data type specifies a Performance indicator of an ML entity. The data type may be used to indicate which performance indicators shall be applicable to either of training, testing or inference.

7.4.4.2 Attributes

Table 7.4.4.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
performanceIndicatorName	M	T	F	F	T
isSupportedForTraining	CM	T	F	F	T
isSupportedForTesting	CM	T	F	F	T

7.4.4.3 Attribute constraints

Table 7.4.4.3-1

Name	Definition
isSupportedForTraining Support Qualifier	Condition: if the performance indicator named performanceIndicatorName is applicable for training, the isSupportedforTraining must be stated
isSupportedForTesting Support Qualifier	Condition: if the performance indicator named performanceIndicatorName is applicable for testing, the isSupportedForTesting must be stated

7.4.4.4 Notifications

The notifications specified for the IOC using this <<dataType>> for its attribute(s), shall be applicable.

7.4.5 AvailMLCapabilityReport <<dataType>>

7.4.5.1 Definition

This dataType represents the the report of available ML capabilities following the update for specific ML capability(es).

- The ML update process may generate one or more AvailMLCapabilityReport(s), which indicate to the consumer that new ML capability(es) is/are available and can be applied.
- Each AvailMLCapabilityReport is associated to one or more MLEntity(s) and may indicate the one or more MLEntity(s) to which it applies.
- The AvailMLCapabilityReport may include CapabilityVersions which indicate that there are multiple candidate sets of available ML capabilities with a different version number for each set.
- The AvailMLCapabilityReport may include the expectedPerformanceGains, which provides information on the expected performance gain if/when the ML capabilities of the respective network function are updated with/to the specific set of newly available ML capabilities.
- associated to one or more MLEntity(s) and may indicate the one or more MLEntity(s) to which it applies.

7.4.5.2 Attributes

The AvailMLCapabilityReport includes the following attributes:

Table 7.4.5.2-1Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
availMLCapabilityReportID	M	T	F	F	F
mLCapabilityVersionId	M	T	F	F	F
expectedPerformanceGains	O	T	F	F	F
Attributes related to Role					
mLEntityRef	M	T	F	F	F

7.4.5.3 Attribute constraints

None.

7.4.5.4 Notifications

The notifications specified for the IOC using this <<datatype>> for its attribute(s), shall be applicable.

7.4.6 AIMLManagementPolicy <<dataType>>

7.4.6.1 Definition

This data type represents the properties of a policy for AI/ML management.

7.4.6.2 Attributes

Table 7.4.6.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
thresholdList	M	T	T	F	T

7.4.6.3 Attribute constraints

None.

7.4.6.4 Notifications

The notifications specified for the IOC using this <<dataType>> for its attribute(s), shall be applicable.

7.4.7 ManagedActivationScope <<choice>>

7.4.7.1 Definition

This <<choice>> defines the scopes for activating or deactivating the ML Inference function. It is a choice between the scopes parameter required for the activation or deactivation.

7.4.7.2 Attributes

Table 7.4.7.2-1

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
CHOICE_1.1 dNList	CM	T	T	F	T
CHOICE_1.2 timeWindow	CM	T	T	F	T
CHOICE_1.3 geoPolygon	CM	T	T	F	T

7.4.7.3 Attribute constraints

Table 7.4.7.3-1

Name	Definition
dNList Support Qualifier CM	Condition: if the sub scope is per list of managed elements (e.g., DN list)
timeWindow Support Qualifier CM	Condition: if the sub scope is per list of time window.
geoPolygon Support Qualifier CM	Condition: if the sub scope is per list of GeoArea.

7.4.7.4 Notifications

The notifications specified for the IOC using this <<dataType>> for its attribute(s), shall be applicable.

7.4.8. MLCapabilityInfo <<dataType>>

7.4.8.1. Definition

This dataType represents information about what the ML entity can make inference for. The inferenceOutputName is used as the identifier for the ML capability.

7.4.8.2 Attributes

The MLCapabilityInfo <<dataType>> includes the following attributes:

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceType	M	T	F	F	T
capabilityName	O	T	F	F	T
mLCapabilityParameters	O	T	F	F	T

7.4.8.3 Attribute constraints

None.

7.4.8.4 Notifications

The notifications specified for the IOC using this <<dataType>> for its attribute(s), shall be applicable.

7.4.9 InferenceOutput <<dataType>>

7.4.9.1 Definition

This dataType represents the properties of the content of an inference output.

The inference output contains a time stamp which indicates the time at which the inference output is generated.

7.4.9.2 Attributes

The InferenceOutput includes the following attributes:

Attribute name	Support Qualifier	isReadable	isWritable	isInvariant	isNotifyable
inferenceOutputId	M	T	F	F	T
inferenceType	M	T	F	F	T
inferenceOutputTime	M	T	F	F	T
inferencePerformance	O	T	F	F	T
outputResult	M	T	F	F	T

NOTE: The relation between the Output and Outputs of other instances like MDA is not addressed in the present document

7.4.9.3 Attribute constraints

None.

7.4.9.4 Notifications

The notifications specified for the IOC using this <<datatype>> for its attribute(s), shall be applicable.

7.5 Attribute definitions

7.5.1 Attribute properties

Table 7.5.1-1

Attribute Name	Documentation and Allowed Values	Properties
mLEntityId	It identifies the ML entity. It is unique in each MnS producer. allowedValues: N/A.	type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
candidateTrainingDataSource	It provides the address(es) of the candidate training data source provided by MnS consumer. The detailed training data format is vendor specific. allowedValues: N/A.	type: String multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
inferenceType	It indicates the type of inference that the ML model supports. allowedValues: the values of the MDA type (see 3GPP TS 28.104 [2]), Analytics ID(s) of NWDAF (see 3GPP TS 23.288 [3]), types of inference for RAN, and vendor's specific extensions.	type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
areConsumerTrainingDataUsed	It indicates whether the consumer provided training data have been used for the ML model training. allowedValues: ALL, PARTIALLY, NONE.	type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
usedConsumerTrainingData	It provides the address(es) where lists of the consumer-provided training data are located, which have been used for the ML model training. allowedValues: N/A.	type: String multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
trainingRequestRef	It is the DN(s) of the related MLTrainingRequest MOI(s). allowedValues: DN.	type: DN multiplicity: * isOrdered: False isUnique: True defaultValue: None

Attribute Name	Documentation and Allowed Values	Properties
		isNullable: False
trainingProcessRef	It is the DN(s) of the related MLTrainingProcess MOI(s) that produced the MLTrainingReport. allowedValues: DN.	type: DN multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
trainingReportRef	It is the DN of the MLTrainingReport MOI that represents the reports of the ML training. allowedValues: DN.	type: DN multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
lastTrainingRef	It is the DN of the MLTrainingReport MOI that represents the reports for the last training of the ML model. allowedValues: DN.	type: DN multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: True
modelConfidenceIndication	It indicates the average confidence value (in unit of percentage) that the ML model would perform for inference on the data with the same distribution as training data. Essentially, this is a measure of degree of the convergence of the trained ML model. allowedValues: { 0..100 }.	type: integer multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
trainingRequestSource	It describes the entity that requested to instantiate the MLTrainingRequest MOI. This attribute can be of type String or DN.	type: <<CHOICE>> multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
MLTrainingRequest.requestStatus	It describes the status of a particular ML training request. allowedValues: NOT_STARTED, IN_PROGRESS, CANCELLING, SUSPENDED, FINISHED, and CANCELLED.	type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
mLTrainingProcessId	It identifies the training process. It is unique in each instantiated process in the MnS producer. allowedValues: N/A.	type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
priority	It indicates the priority of the training process. The priority may be used by the ML training to schedule the training processes. Lower value indicates a higher priority. allowedValues: { 0..65535 }.	type: integer multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: 0 isNullable: False
terminationConditions	It indicates the conditions to be considered by the MLtraining MnS producer to terminate a specific training process. allowedValues: MODEL UPDATED_IN_INFERENCE_FUNCTION, INFERENCE FUNCTION_TERMINATED, INFERENCE FUNCTION_UPGRADED, INFERENCE_CONTEXT_CHANGED.	type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
progressStatus	It indicates the status of the process. allowedValues: N/A.	type: ProcessMonitor multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None

Attribute Name	Documentation and Allowed Values	Properties
		isNullable: False
mLEntityVersion	It indicates the version number of the ML entity. allowedValues: N/A.	type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
performanceRequirements	It indicates the expected performance for a trained ML entity when performing on the training data. allowedValues: N/A.	type: ModelPerformance multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
modelPerformanceTraining	It indicates the performance score of the ML entity when performing on the training data. allowedValues: N/A.	type: ModelPerformance multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
mLTrainingProcess.progressStatus.progressStateInfo	It provides the following specialization for the "progressStateInfo" attribute of the "ProcessMonitor" data type for the "MLTrainingProcess.progressStatus". When the ML training is in progress, and the " mLTrainingProcess.progressStatus.status " is equal to "RUNNING", it provides the more detailed progress information. allowedValues for " mLTrainingProcess.progressStatus.status " = "RUNNING": - “COLLECTING_DATA” - “PREPARING_TRAINING_DATA” - “TRAINING” + DN of the MLEntity being trained The allowed values for " mLTrainingProcess.progressStatus.status " = "CANCELLING" are vendor specific. The allowed values for " mLTrainingProcess.progressStatus.status " = "NOT_STARTED" are vendor specific.	Type: String multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
inferenceOutputName	It indicates the name of an inference output of an ML entity. allowedValues: the name of the MDA output IEs (see 3GPP TS 28.104 [2]), name of analytics output IEs of NWDAF (see TS 23.288 [3]), RAN inference output IE name(s), and vendor's specific extensions.	Type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
performanceMetric	It indicates the performance metric used to evaluate the performance of an ML entity, e.g. "accuracy", "precision", "F1 score", etc. allowedValues: N/A.	Type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
performanceScore	It indicates the performance score (in unit of percentage) of an ML entity when performing inference on a specific data set (Note). The performance metrics may be different for different kinds of ML models depending on the nature of the model. For instance, for numeric prediction, the metric may be accuracy; for classification, the metric may be a combination of precision and recall, like the "F1 score". allowedValues: { 0..100 }.	Type: Real multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
MLTrainingRequest.cancelRequest	It indicates whether the ML training MnS consumer cancels the ML training request. Setting this attribute to "TRUE" cancels the ML training request. The request can be resumed by setting this attribute to "FALSE" when it is suspended. Cancellation is possible when the requestStatus is the "NOT_STARTED", " IN_PROGRESS", and "SUSPENDED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
MLTrainingRequest.suspendRequest	It indicates whether the ML training MnS consumer suspends the /ML training request. Setting this attribute to "TRUE" suspends the ML training process. Suspension is possible when the requestStatus is not the "FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
MLTrainingProcess.cancelProcess	It indicates whether the ML training MnS consumer cancels the ML training process. Setting this attribute to "TRUE" cancels the ML training request. Cancellation is possible when the " mLTrainingProcess.progressStatus.status" is not the "FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
MLTrainingProcess.suspendProcess	It indicates whether the ML training MnS consumer suspends the ML training process. Setting this attribute to "TRUE" suspends the ML training process. The process can be resumed by setting this attribute to “FALSE” when it is suspended. Suspension is possible when the " mLTrainingProcess.progressStatus.status" is not the "FINISHED", "CANCELLING" or "CANCELLED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
inferenceEntityRef	It describes the target entities that will use the ML entity for inference.	Type: DN multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
dataProviderRef	It describes the entities that have provided or should provide data needed by the ML entity e.g. for training or inference	Type: DN multiplicity: * isOrdered: False isUnique: True

Attribute Name	Documentation and Allowed Values	Properties
		defaultValue: None isNullable: False
areNewTrainingDataUsed	It indicates whether the other new training data have been used for the ML model training. allowedValues: TRUE, FALSE.	type: Boolean multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
trainingDataQualityScore	It indicates numerical value that represents the dependability/quality of a given observation and measurement type. The lowest value indicates the lowest level of dependability of the data, i.e. that the data is not usable at all. allowedValues: { 0..100 }.	Type: Real multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
decisionConfidenceScore	It is the numerical value that represents the dependability/quality of a given decision generated by the AI/ML inference function. The lowest value indicates the lowest level of dependability of the decisions, i.e. that the data is not usable at all. allowedValues: { 0..100 }.	Type: Real multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
expectedRuntimeContext	This describes the context where an MLEntity is expected to be applied. allowedValues: N/A	Type: MLContext multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
trainingContext	This specify the context under which the MLEntity has been trained. allowedValues: N/A	Type: MLContext multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
runTimeContext	This specifies the context where the MLmodel or entity is being applied. allowedValues: N/A	Type: MLContext multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
mLEntityToTrainRef	It identifies the DN of the MLEntity requested to be trained. allowedValues: DN	Type: DN multiplicity: 0..1 isOrdered: False isUnique: True defaultValue: None isNullable: False
mLEnityGeneratedRef	It identifies the DN of the MLEntity generated by the ML training. allowedValues: DN	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: False
mLEntityRepositoryRef	It identifies the DN of the MLEntityRepository.	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: False
mLRepositoryId	It indicates the unique ID of the ML repository.	type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
modelPerformanceValidation	It indicates the performance score of the ML entity when performing on the validation data. allowedValues: N/A	type: ModelPerformance multiplicity: * isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
dataRatioTrainingAndValidation	It indicates the ratio (in terms of quantity of data samples) of the training data and validation data used during the training and validation process. It is represented by the percentage of the validation data samples in the total training data set (including both training data samples and validation data samples). The value is an integer reflecting the rounded number of percent * 100. allowedValues: { 0 .. 100 }.	type: Integer multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
mLEntityIdList	It identifies a list of ML entities. allowedValues: N/A.	type: String multiplicity: * isOrdered: N/A isUnique: True defaultValue: None isNullable: False
MLTestingRequest.requestStatus	It describes the status of a particular ML testing request. allowedValues: NOT_STARTED, IN_PROGRESS, CANCELLING, SUSPENDED, FINISHED, and CANCELLED.	type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
MLTestingRequest.cancelRequest	It indicates whether the ML testing MnS consumer cancels the ML testing request. Setting this attribute to "TRUE" cancels the ML testing request. Cancellation is possible when the requestStatus is the "NOT_STARTED", " IN_PROGRESS", and "SUSPENDED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
MLTestingRequest.suspendRequest	It indicates whether the ML testing MnS consumer suspends the ML testing request. Setting this attribute to "TRUE" suspends the ML testing request. The request can be resumed by setting this attribute to “FALSE” when it is suspended. Suspension is possible when the requestStatus is not the "FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
mLEntityToTestRef	It identifies the DN of the MLEntity requested to be tested. allowedValues: DN	Type: DN multiplicity: 0..1 isOrdered: False isUnique: True defaultValue: None isNullable: True
modelPerformanceTesting	It indicates the performance score of the ML entity when performing on the testing data. allowedValues: N/A.	type: ModelPerformance multiplicity: * isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
mLTestingResult	It provides the address where the testing result (including the inference result for each testing data example) is provided. The detailed testing result format is vendor specific. allowedValues: N/A.	type: String multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
testingRequestRef	It identifies the DN of the MLTestingRequest MOI. allowedValues: DN	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
supportedPerformanceIndicators	This parameter lists specific PerformanceIndicator(s) of an ML entity. allowedValues: N/A.	type: SupportedPerfIndicator multiplicity: 1..* isOrdered: False isUnique: True defaultValue: None isNullable: False
performanceIndicatorName	It indicates the identifier of the specific performance indicator. allowedValues: N/A	type: string multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
isSupportedForTraining	It indicates whether the specific performance indicator is supported a performance metric of ML training for the ML entity Default value is set to "FALSE". allowedValues: TRUE, FALSE.	type: Boolean multiplicity: 1 isOrdered: False isUnique: True defaultValue: FALSE isNullable: False
isSupportedForTesting	It indicates whether the specific performance indicator is supported a performance metric of ML testing for the ML entity. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	type: Boolean multiplicity: 1 isOrdered: False isUnique: True defaultValue: FALSE isNullable: False
mLUpdateProcessRef	It is the DN of the mLUpdateProcess MOI that represents the process of updating an ML entity. allowedValues: DN.	Type: multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
mLUpdateRequestRef	It is the DN of the MLUpdateRequest MOI that represents an ML update request. allowedValues: DN.	Type: multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
mLUpdateReportRef	It is the DN of the MLUpdateReport MOI that represents an ML update report. allowedValues: DN.	Type: multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
mLUpdateReportingPeriod	It specifies the time duration upon which the MnS consumer expects the ML update is reported.	Type: TimeWindow multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: False
availMLCapabilityReport	It represents the available ML capabilities. allowedValues: N/A.	Type: AvailMLCapabilityReport multiplicity: 1 isOrdered: N/A

Attribute Name	Documentation and Allowed Values	Properties
		isUnique: N/A defaultValue: None isNullable: False
UpdatedMLCapability	It represents the updated ML capabilities. allowedValues: N/A.	Type: AvailMLCapabilityReport multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
newCapabilityVersionId	It indicates the specific version of AI/ML capabilities to be applied for the update. It is typically the one indicated by the MLCapabilityVersionID in a newCapabilityVersion	type: String multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
mlCapabilityVersionId	It indicates the version of ML capabilities that is available for the update.	type: String multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
performanceGainThreshold	It defines the minimum performance gain as a percentage that shall be achieved with the capability update, i.e., the difference in the performances between the existing capabilities and the new capabilities should be at least performanceGainThreshold otherwise the new capabilities should not be applied. Allowed value: float between 0.0 and 100.0	type: ModelPerformance multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
expectedPerformanceGains	It indicates the expected performance gain if/when the AI/ML capabilities of the respective network function are updated with/to the specific set of newly available AI/ML capabilities.	Type: ModelPerformance multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
updateTimeDeadline	It indicates the maximum as stated in the MLUpdate request that should be taken to complete the update	Type: TimeWindow multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: False
mLEntityRef	It indicates the list of references to MLEntity instances that can be updated.	Type: DN multiplicity: 1 .. * isOrdered: False isUnique: True defaultValue: None isNullable: False
MLUpdateRequest.requestStatus	It describes the status of a particular ML update request. allowedValues: NOT_STARTED, IN_PROGRESS, CANCELLING, SUSPENDED, FINISHED, and CANCELLED.	Type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
MLUpdateRequest.cancelRequest	It indicates whether the MnS consumer cancels the ML update request. Setting this attribute to "TRUE" cancels the ML update request. Cancellation is possible when the requestStatus is the "NOT_STARTED", " IN_PROGRESS", and "SUSPENDED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
MLUpdateRequest.suspendRequest	It indicates whether the MnS consumer suspends the ML update request. Setting this attribute to "TRUE" suspends the ML update request. The request can be resumed by setting this attribute to “FALSE” when it is suspended. Suspension is possible when the requestStatus is not the "FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
memberMLEntityRefList	It identifies the list of member ML entities within a level of an ML entity coordination group. allowedValues: DN list	Type: DN multiplicity: 2..* isOrdered: True isUnique: True defaultValue: None isNullable: False
mLEntityCoordinationGroupToTrainRef	It identifies the DN of the MlEntityCoordinationGroup requested to be trained. allowedValues: DN	Type: DN multiplicity: 0..1 isOrdered: False isUnique: True defaultValue: None isNullable: False
mLEnityCoordinationGroupGeneratedRef	It identifies the DN of the MlEntityCoordinationGroup generated by the ML training. allowedValues: DN	Type: DN multiplicity: 0..1 isOrdered: False isUnique: True defaultValue: None isNullable: False
mLEntityCoordinationGroupToTestRef	It identifies the DN of the MlEntityCoordinationGroup requested to be tested. allowedValues: DN	Type: DN multiplicity: 0..1 isOrdered: False isUnique: True defaultValue: None isNullable: False
retrainingEventsMonitorRef	It indicates the DN of the ThresholdMonitor MOI that indicates the performance measurements and its corresponding thresholds to be used by MnS producer to initiate the re-training of the MLEntity.	Type: DN multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
sourceTrainedMLEntityRef	It identifies the DN of the source trained MLEntity whose copy has been loaded from the ML entity repository to the inference function. allowedValues: DN	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
MLEntityLoadingRequest.requestStatus	It describes the status of a particular ML entity loading request. allowedValues: NOT_STARTED, IN_PROGRESS, CANCELLING, SUSPENDED, FINISHED, and CANCELLED.	type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
MLEntityLoadingRequest.cancelRequest	It indicates whether the MnS consumer cancels the ML entity loading request. Setting this attribute to "TRUE" cancels the ML entity loading. Cancellation is possible when the requestStatus is the "NOT_STARTED", " IN_PROGRESS", and "SUSPENDED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
MLEntityLoadingRequest.suspendRequest	It indicates whether the MnS consumer suspends the ML entity loading request. Setting this attribute to "TRUE" suspends the ML entity loading request. The request can be resumed by setting this attribute to “FALSE” when it is suspended. Suspension is possible when the requestStatus is not the "FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
mLEntityToLoadRef	It identifies the DN of a trained MLEntity requested to be loaded to the target inference function(s).	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
policyForLoading	It provides the policy for controlling ML entity loading triggered by the MnS producer. This policy contains two thresholds in the thresholdList attribute. The first threshold is related to the ML entity to be loaded, and the second threshold is related to the existing ML entity being used for inference.	Type: AIMLManagementPolicy multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
thresholdList	It provides the list of threshold.	Type: ThresholdInfo multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: True
MLEntityLoadingProcess.progressStatus.progressStateInfo	It provides the following specialization for the "progressStateInfo" attribute of the "ProcessMonitor" data type for the "MLEntityLoadingProcess.progressStatus". When the ML loading is in progress, and the " MLEntityLoadingProcess.progressStatus.status " is equal to "RUNNING", it provides the more detailed progress information. allowedValues for " MLEntityLoadingProcess.progressStatus.status " = "RUNNING": The allowed values for " MLEntityLoadingProcess.progressStatus.status " = "CANCELLING" are vendor specific. The allowed values for " MLEntityLoadingProcess.progressStatus.status " = "NOT_STARTED" are vendor specific.	Type: String multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
MLEntityLoadingProcess.cancelProcess	It indicates whether the MnS consumer cancels the ML entity loading process. Setting this attribute to "TRUE" cancels the process. Cancellation is possible when the "MLEntityLoadingProcess.progressStatus.status" is not the "FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
MLEntityLoadingProcess.suspendProcess	It indicates whether the MnS consumer suspends the ML entity loading process. Setting this attribute to "TRUE" suspends the process. The process can be resumed by setting this attribute to "FALSE" when it is suspended. Suspension is possible when the "MLEntityLoadingProcess.progressStatus.status" is not the "FINISHED", "CANCELLING" or "CANCELLED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE.	Type: Boolean multiplicity: 0..1 isOrdered: N/A isUnique: N/A defaultValue: FALSE isNullable: False
MLEntityLoadingRequestRef	It identifies the DN of the associated MLEntityLoadingRequest. allowedValues: DN.	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
MLEntityLoadingPolicyRef	It identifies the DN of the associated MLEntityLoadingPolicyRef. allowedValues: DN.	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
LoadedMLEntityRef	It identifies the DN of the MLEntity that has been loaded to the inference function. allowedValues: DN	Type: DN multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: True
activationStatus	It describes the activation status. allowedValues: ACTIVATED, DEACTIVATED.	Type: Enum multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False
managedActivationScope	It provides a list of sub scopes for which ML inference is activated as triggered by a policy on the MnS producer. For example, the sub scopes may be a list of cells or of geographical areas. The list is an ordered list indicating the inference is activated for the first sub scope and gradually extended to the next sub scope if the policy evaluates to true. allowedValues: N/A	Type: ManagedActivationScope multiplicity: 1 isOrdered: False isUnique: True defaultValue: None isNullable: False
ManagedActivationScope.dNList	It indicates the list of DN, the list is an ordered list indicating the inference is activated for the first sub scope and gradually extended to the next sub scope. allowedValues: N/A	Type: DN multiplicity: * isOrdered: True isUnique: True defaultValue: None isNullable: False
ManagedActivationScope.timeWindow	It indicates the list of time window; the list is an ordered list indicating the inference is activated for the first sub scope and gradually extended to the next sub scope. allowedValues: N/A	Type: TimeWindow multiplicity: * isOrdered: True isUnique: True defaultValue: None isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
ManagedActivationScope.geoPolygon	It indicates the list of GeoArea, the list is an ordered list indicating the inference is activated for the first sub scope and gradually extended to the next sub scope. allowedValues: N/A	Type: GeoArea multiplicity: * isOrdered: True isUnique: True defaultValue: None isNullable: False
usedByFunctionRefList	It provides the DNs of the functions supported by the AIMLInferenceFunction. allowedValues: N/A	Type: DN multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
inferenceOutputId	It identifies an inference output within an AIMLinferenceReport.	type: String multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
inferenceOutputs	It indicates the Outputs that have been derived by the AIMLInferenceFunction instance from a specific ML entity. Each ML entity, inferenceOutputs may be a set of values. allowedValues: N/A.	type: InferenceOutput multiplicity:f 1..* isOrdered: False isUnique: True defaultValue: None isNullable: False
inferencePerformance	It indicates the performance score of the ML entity during Inference. allowedValues: N/A.	type: ModelPerformance multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
inferenceOutputTime	It indicates the time at which the inference output is generated. allowedValues: N/A	Type: DateTime multiplicity: * isOrdered: True isUnique: True defaultValue: None isNullable: False
outputResult	It indicates the result of an inference.	type: AttributeValuePair multiplicity: * isOrdered: FALSE isUnique: TRUE defaultValue: Null isNullable: False
AIMLInferenceEmulationReportRefs	It indicates the DNs of set of reports generated on AIMLInferenceEmulationFunction. The AIMLInferenceEmulationReport has the same structure as the AIMLInferenceReport. allowedValues: N/A.	type: DN of AIMLInferenceReport multiplicity: 1..* isOrdered: False isUnique: True defaultValue: None isNullable: False
mLCapabilitiesInfoList	It indicates information about what an ML entity can generate inference for. allowedValues: N/A.	type: MLCapabilityInfo multiplicity: 1..* isOrdered: False isUnique: True defaultValue: None isNullable: False
capabilityName	It indicates the name of a capability for which an ML entity can generate inference. allowedValues: N/A.	type: String multiplicity: 1 isOrdered: N/A isUnique: N/A defaultValue: None isNullable: False

Attribute Name	Documentation and Allowed Values	Properties
mLCapabilityParameters	It indicates a set of optional parameters that apply for an inferenceType and capabilityName. allowedValues: N/A	Type: AttributeValuePair multiplicity: * isOrdered: False isUnique: True defaultValue: None isNullable: False
NOTE: When the performanceScore is to indicate the performance score for ML training, the data set is the training data set. When the performanceScore is to indicate the performance score for ML validation, the data set is the validation data set. When the performanceScore is to indicate the performance score for ML testing, the data set is the testing data set.		

7.5.2 Constraints

None.

7.6 Common notifications

7.6.1 Configuration notifications

This clause presents a list of notifications, defined in 3GPP TS 28.532 [11], that an MnS consumer may receive. The notification header attribute objectClass/objectInstance shall capture the DN of an instance of a class defined in the present document.

Table 7.6.1-1

Name	Qualifier	Notes
notifyMOICreation	O	--
notifyMOIDeletion	O	--
notifyMOIAttributeValueChanges	O	--
notifyEvent	O	--

8 Service components

8.1 Service components for ML model training MnS

The components for ML model training MnS are listed in table 8.1-1.

Table 8.1-1: Components for ML model training MnS

Management service component type A	Management service component type B	Management service component type C
The operations and notifications for generic provisioning management service (see clause 11.1.1 of 3GPP TS 28.532 [11]).	MLTrainingFunction IOC; MLTrainingRequest IOC; MLTrainingReport IOC; MLTrainingProcess IOC.	N/A

9 Solution Set (SS)

The present document defines the following NRM Solution Set definitions for ML management:

- YAML based Solution Set (Annex B).

Annex A (informative): PlantUML source code for NRM class diagrams

A.1 General

This annex contains the PlantUML source code for the NRM diagrams defined in clause 7.2a of the present document.

A.2 PlantUML code for Figure 7.3a.1.1.1-1: NRM fragment for ML model training

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250
skinparam nodesep 60

class ManagedEntity <<ProxyClass>>
class MLEntity <<InformationObjectClass>>
class MLEntityCoordinationGroup <<InformationObjectClass>>
class MLTrainingFunction <<InformationObjectClass>>
class MLTrainingRequest <<InformationObjectClass>>
class MLTrainingReport <<InformationObjectClass>>
class MLTrainingProcess <<InformationObjectClass>>
class MLEntityRepository <<InformationObjectClass>>
class ThresholdMonitor <<InformationObjectClass>>

ManagedEntity "1" *-- "*" MLTrainingFunction: <<names>>
MLTrainingFunction "1" *-- "*" MLTrainingProcess: <<names>>
MLTrainingFunction "1" *-- "*" MLTrainingRequest: <<names>>
MLTrainingFunction "1" *-- "*" MLTrainingReport: <<names>>
'SubNetwork "1" *-- "*" MLEntityRepository: <<names>>
MLEntityRepository "1" *-- "*" MLEntity : <<names>>
MLTrainingFunction "1" *-- "*" ThresholdMonitor : <<names>>

MLTrainingFunction "*" -l-> "*" MLEntityRepository
MLTrainingProcess "1" <-r-> "1" MLTrainingReport
MLTrainingReport "1" --> "1" MLTrainingReport
MLTrainingProcess "*" -l-> "*" MLTrainingRequest
MLTrainingRequest "*" --> "0..1" MLEntity
MLTrainingRequest "*" --> "0..1" MLEntityCoordinationGroup
MLTrainingReport "*" --> "1" MLEntity
MLTrainingReport "*" --> "1" MLEntityCoordinationGroup
MLEntityCoordinationGroup "*" --> "2..*" MLEntity
MLEntity"*" -u-> "1" ThresholdMonitor


(MLTrainingReport, MLEntity) ... (MLTrainingReport, MLEntityCoordinationGroup) : {xor}
(MLTrainingRequest, MLEntity) ... (MLTrainingRequest, MLEntityCoordinationGroup) : {xor}


note left of ManagedEntity
  This represents the following IOCs:
    SubNetwork or
    ManagedFunction or
    ManagedElement
  end note

@enduml
```

A.3 PlantUML code for Figure 7.3a.1.1.2-1: Inheritance Hierarchy for ML model training related NRMs

```
@startuml

skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>
class ManagedFunction <<InformationObjectClass>>
class MLTrainingFunction <<InformationObjectClass>>
class MLTrainingRequest <<InformationObjectClass>>
class MLTrainingProcess <<InformationObjectClass>>
class MLTrainingReport <<InformationObjectClass>>

ManagedFunction <|-- MLTrainingFunction
Top <|-- MLTrainingRequest
Top <|-- MLTrainingProcess
Top <|-- MLTrainingReport

@enduml
```

A.4 PlantUML code for Figure 7.2a.1.2-1: Inheritance Hierarchy for common information models for AI/ML management

```
@startuml

skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>
class MLEntityRepository <<InformationObjectClass>>
class MLEntity <<InformationObjectClass>>
class MLEntityCoordinationGroup <<InformationObjectClass>>

Top <|-- MLEntityRepository
Top <|-- MLEntity
Top <|-- MLEntityCoordinationGroup

@enduml
```

A.5 PlantUML code for Figure 7.2a.1.1-1: Relationships for common information models for AI/ML management

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250
skinparam nodesep 60

class MLEntityRepository <<InformationObjectClass>>
class MLEntity <<InformationObjectClass>>
class MLEntityCoordinationGroup <<InformationObjectClass>>
class SubNetwork <<InformationObjectClass>>


MLEntityRepository "1" *-- "*" MLEntity: <<names>>
MLEntityRepository "1" *-- "*" MLEntityCoordinationGroup: <<names>>
SubNetwork"1" *-- "*" MLEntityRepository : <<names>>

MLEntityCoordinationGroup "*" -r-> "2..*" MLEntity

@enduml
```

A.6 PlantUML code for Figure 7.3a.1.1.1-2: NRM fragment for ML entity testing

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250
```

```
class MLTestingEntity <<ProxyClass>>
class TestingFunction <<ProxyClass>>
class MLEntity <<InformationObjectClass>>
class MLEntityCoordinationGroup <<InformationObjectClass>>
class MLTestingFunction <<InformationObjectClass>>
class MLTestingRequest <<InformationObjectClass>>
class MLTestingReport <<InformationObjectClass>>

MLTestingEntity "1" *-- "*" MLTestingFunction: <<names>>

TestingFunction "1" *-- "*" MLTestingRequest : <<names>>
TestingFunction "1" *-- "*" MLTestingReport : <<names>>

MLTestingRequest "*" --> "0..1" MLEntity
MLTestingRequest "*" --> "0..1" MLEntityCoordinationGroup
MLTestingReport "*" -l-> "1" MLTestingRequest

(MLTestingRequest, MLEntity) ... (MLTestingRequest, MLEntityCoordinationGroup) : {xor}


note left of MLTestingEntity
  Represents the following IOCs:
    Subnetwork or
    ManagedFunction or
    ManagedElement
  end note

note left of TestingFunction
  Represents the following IOCs:
    MLTestingFunction or
    MLTrainingFunction
  end note

@enduml
```

A.7 PlantUML code for Figure 7.3a.1.1.2-2: Inheritance Hierarchy for ML entity testing related NRMs

```
@startuml

skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>
class ManagedFunction <<InformationObjectClass>>
class MLTestingFunction <<InformationObjectClass>>
class MLTestingRequest <<InformationObjectClass>>
class MLTestingReport <<InformationObjectClass>>

ManagedFunction <|-- MLTestingFunction
Top <|-- MLTestingRequest
Top <|-- MLTestingReport

@enduml
```

A.8 PlantUML code for Figure 7.3a.4.1.1-1: NRM fragment for ML update

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250
```

```
skinparam nodesep 60

class MLUpdateEntity <<ProxyClass>>
class MLUpdateFunction <<InformationObjectClass>>
class MLUpdateRequest <<InformationObjectClass>>
class MLUpdateProcess <<InformationObjectClass>>
class MLUpdateReport <<InformationObjectClass>>
class MLEntity <<InformationObjectClass>>

MLUpdateEntity "1" *-- "*" MLUpdateFunction:<<names>>
MLUpdateFunction "1" *-- "*" MLUpdateRequest:<<names>>
MLUpdateFunction "1" *-- "*" MLUpdateProcess:<<names>>
MLUpdateFunction "1" *-- "*" MLUpdateReport:<<names>>

MLUpdateFunction "1" --> "*" "MLEntity"
MLUpdateRequest "*" <-r-> "1" "MLUpdateProcess"
MLUpdateProcess "1" <-r-> "1" "MLUpdateReport"
MLUpdateProcess "*" --> "*" "MLEntity"
MLUpdateReport "*" --> "*" "MLEntity"
MLUpdateRequest "*" --> "*" "MLEntity"


note left of MLUpdateEntity
 Represents the IOCs:
   SubNetwork or
   ManagedFunction or
   ManagementFunction
 end note

@enduml
```

A.9 PlantUML code for Figure 7.3a.4.1.2-1: Inheritance Hierarchy for ML update related NRMs

```
@startuml

skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>
class ManagedFunction <<InformationObjectClass>>
class MLUpdateFunction <<InformationObjectClass>>
class MLUpdateRequest <<InformationObjectClass>>
class MLUpdateProcess <<InformationObjectClass>>
class MLUpdateReport <<InformationObjectClass>>

ManagedFunction <|-- MLUpdateFunction
Top <|-- MLUpdateRequest
Top <|-- MLUpdateProcess
Top <|-- MLUpdateReport

@enduml
```

A.10 PlantUML code for Figure 7.3a.3.1.1-1: NRM fragment for ML entity loading

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class AiMlInferenceFunction <<InformationObjectClass>>
```

```
class MLEntity <<InformationObjectClass>>
class MLEntityLoadingRequest <<InformationObjectClass>>
class MLEntityLoadingPolicy <<InformationObjectClass>>
class MLEntityLoadingProcess <<InformationObjectClass>>

AiMlInferenceFunction "1" *-- "*" MLEntityLoadingRequest : <<names>>
AiMlInferenceFunction "1" *-- "*" MLEntityLoadingPolicy : <<names>>
AiMlInferenceFunction "1" *-- "*" MLEntityLoadingProcess : <<names>>


MLEntityLoadingRequest  "1" <-r- "*" MLEntityLoadingProcess
MLEntityLoadingProcess  "*" -r-> "1" MLEntityLoadingPolicy

MLEntityLoadingRequest "1" --> "1" MLEntity
MLEntityLoadingProcess "1" --> "1" MLEntity

AiMlInferenceFunction "1" *-- "*" MLEntity : <<names>>

(MLEntityLoadingProcess, MLEntityLoadingRequest) ... (MLEntityLoadingProcess, MLEntityLoadingPolicy)
: {xor}


@enduml
```

A.11 PlantUML code for Figure 7.3a.3.1.2-1: Inheritance Hierarchy for ML entity loading related NRMs

```
@startuml

skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>

class MLEntityLoadingRequest <<InformationObjectClass>>
class MLEntityLoadingPolicy <<InformationObjectClass>>
class MLEntityLoadingProcess <<InformationObjectClass>>

Top <|-- MLEntityLoadingRequest
Top <|-- MLEntityLoadingPolicy
Top <|-- MLEntityLoadingProcess

@enduml
```

A.12 PlantUML code for Figure 7.3a.4.1.1-2: NRM fragment for AI/ML inference function

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250
skinparam nodesep 60

class AIMLInferenceFunction <<InformationObjectClass>>
class AIMLInferenceReport <<InformationObjectClass>>
class MLEntity <<InformationObjectClass>>
class ManagedEntity <<ProxyClass>>
class AIMLSupportedFunction <<ProxyClass>>

ManagedEntity  "1" *-- "*" AIMLInferenceFunction : <<names>>
AIMLInferenceFunction  "*" <-l-> "*" AIMLSupportedFunction
MLEntity  "*" <-r-> "*" AIMLSupportedFunction
```

```
MLEntity  "*" <-r-> "*" AIMLInferenceFunction
AIMLInferenceFunction  "1" *-- "*" AIMLInferenceReport: <<names>>
MLEntity "1..*" <--> "*" AIMLInferenceReport


note right of ManagedEntity #white
 Represents the IOCs:
   ManagedElement or
   SubNetwork or
   ManagedFunction
 end note

note top of AIMLSupportedFunction #white
 Represents the IOCs:
   DMROFunction or
   DLBOFunction or
   DESManagementFunction or
   MDAFunction or
   AnLFFunction
 end note

@enduml
```

A.13 PlantUML code for Figure 7.3a.4.1.2-2: Inheritance Hierarchy for AI/ML inference function

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>
class AIMLInferenceFunction << InformationObjectClass >>
class AIMLInferenceReport <<InformationObjectClass>>

ManagedFunction <|-- AIMLInferenceFunction
Top <|-- AIMLInferenceReport

@enduml
```

A.14 PlantUML code for Figure 7.3a.2.1.1-1: NRM fragment for AI/ML inference emulation Control

```
@startuml
scale max 350 height
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class ManagedEntity <<ProxyClass>>
class AIMLInferenceEmulationFunction <<InformationObjectClass>>
class AIMLInferenceEmulationReport << InformationObjectClass >>

ManagedEntity "1" *-- "*" AIMLInferenceEmulationFunction: <<names>>
AIMLInferenceEmulationFunction "1" *-- "*" AIMLInferenceEmulationReport : <<names>>

note left of ManagedEntity
  Represents the following IOCs:
    SubNetwork or
    ManagedFunction or
    Managed Element
  end note
```

```
@enduml
```

A.15 PlantUML code for Figure 7.3a.2.1.2-1: AI/ML inference emulation Inheritance Relations

```
@startuml
skinparam ClassStereotypeFontStyle normal
skinparam ClassBackgroundColor White
skinparam shadowing false
skinparam monochrome true
hide members
hide circle
'skinparam maxMessageSize 250

class Top <<InformationObjectClass>>
class ManagedFunction <<InformationObjectClass>>
class AIMLInferenceEmulationFunction << InformationObjectClass >>
class AIMLInferenceEmulationReport << InformationObjectClass >>

ManagedFunction <|-- AIMLInferenceEmulationFunction
Top <|-- AIMLInferenceEmulationReport

@enduml
```

Annex B (normative): OpenAPI definition of the AI/ML NRM

B.1 General

This annex contains the OpenAPI definition of the AI/ML NRM in YAML format.

The information models of the AI/ML NRM are defined in clause 7.

Mapping rules to produce the OpenAPI definition based on the information model are defined in 3GPP TS 32.160 [14].

B.2 Solution Set (SS) definitions

B.2.1 OpenAPI document "TS28105_AiMlNrm.yaml"

```
<CODE BEGINS>
openapi: 3.0.1
info:
  title: AI/ML NRM
  version: 18.3.0
  description: >-
    OAS 3.0.1 specification of the AI/ML NRM
    © 2024, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).
    All rights reserved.
externalDocs:
  description: 3GPP TS 28.105; AI/ML Management
  url: http://www.3gpp.org/ftp/Specs/archive/28_series/28.105/
paths: {}
components:
  schemas:

#-------- Definition of types---------------------------------------------------

    MLContext:
      type: object
      properties:
        inferenceEntityRef:
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
        dataProviderRef:
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

    RequestStatus:
      type: string
      enum:
        - NOT_STARTED
        - IN_PROGRESS
        - SUSPENDED
        - FINISHED
        - CANCELLED
        - CANCELLING

    ModelPerformance:
      type: object
      properties:
        inferenceOutputName:
          type: string
        performanceMetric:
          type: string
        performanceScore:
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/Float'
        decisionConfidenceScore:
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/Float'

    ProcessMonitor:
      description: >-
        This data type is the "ProcessMonitor" data type defined in â œgenericNrm.yamlâ
        with specialisations for usage in TS 28.105.
```

```
      type: object
      properties:
        status:
          type: string
        progressPercentage:
          type: integer
          minimum: 0
          maximum: 100
        progressStateInfo:
          type: string
        resultStateInfo:
          type: string

    AIMLManagementPolicy:
      description: >-
            This data type represents the properties of a policy for AI/ML management.
      type: object
      properties:
        thresholdList:
          type: array
          items:
            $ref: 'TS28623_ThresholdMonitorNrm.yaml#/components/schemas/ThresholdInfo'

    SupportedPerfIndicator:
      type: object
      properties:
        performanceIndicatorName:
          type: string
        isSupportedForTraining:
          type: boolean
        isSupportedForTesting:
          type: boolean

    ManagedActivationScope:
      oneOf:
        - type: object
          properties:
            dNList:
              type: array
              items:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
        - type: object
          properties:
            timeWindow:
              type: array
              items:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/TimeWindow'
        - type: object
          properties:
            geoPolygon:
              type: array
              items:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/GeoArea'

    MLCapabilityInfo:
      type: object
      properties:
        inferenceType:
          type: string
        capabilityName:
          type: string
        mLCapabilityParameters:
          description: A map (list of key-value pairs) for an inferenceType and capabilityName
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/AttributeNameValuePairSet'

    AvailMLCapabilityReport:
      type: object
      properties:
        mLCapabilityVersionId:
          type: array
          items:
            type: string
        expectedPerformanceGains:
          type: array
          items:
            $ref: '#/components/schemas/ModelPerformance'
        mLEntityRef:
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
```

```
    InferenceOutput:
      type: object
      properties:
        inferenceOutputId:
          type: array
          items:
            type: string
        inferenceType:
          type: string
        inferenceOutputTime:
          type: array
          items:
            $ref: 'TS28623_ComDefs.yaml#/components/schemas/DateTime'
          # FIXME, isOrder/isUnique both as True
        inferencePerformance:
          $ref: '#/components/schemas/ModelPerformance'
        outputResult:
          description: A map (list of key-value pairs) for Inference result name and it's value
          $ref: 'TS28623_ComDefs.yaml#/components/schemas/AttributeNameValuePairSet'

#-------- Definition of types for name-containments ------
    SubNetwork-ncO-AiMlNrm:
      type: object
      properties:
        MLTrainingFunction:
          $ref: '#/components/schemas/MLTrainingFunction-Multiple'
        MLTestingFunction:
          $ref: '#/components/schemas/MLTestingFunction-Multiple'
        MLEntityRepository:
          $ref: '#/components/schemas/MLEntityRepository-Multiple'
        MLUpdateFunction:
          $ref: '#/components/schemas/MLUpdateFunction-Multiple'
        AIMLInferenceFunction:
          $ref: '#/components/schemas/AIMLInferenceFunction-Multiple'

    ManagedElement-ncO-AiMlNrm:
      type: object
      properties:
        MLTrainingFunction:
          $ref: '#/components/schemas/MLTrainingFunction-Multiple'
        MLTestingFunction:
          $ref: '#/components/schemas/MLTestingFunction-Multiple'
        MLEntityRepository:
          $ref: '#/components/schemas/MLEntityRepository-Multiple'
        MLUpdateFunction:
          $ref: '#/components/schemas/MLUpdateFunction-Multiple'
        AIMLInferenceFunction:
          $ref: '#/components/schemas/AIMLInferenceFunction-Multiple'

#-------- Definition of concrete IOCs ----------------------------------------

    MLTrainingFunction-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-Attr'
                - type: object
                  properties:
                    mLEntityRepositoryRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-ncO'
        - type: object
          properties:
            MLTrainingRequest:
              $ref: '#/components/schemas/MLTrainingRequest-Multiple'
            MLTrainingProcess:
              $ref: '#/components/schemas/MLTrainingProcess-Multiple'
            MLTrainingReport:
              $ref: '#/components/schemas/MLTrainingReport-Multiple'
            ThresholdMonitors:
              $ref: 'TS28623_ThresholdMonitorNrm.yaml#/components/schemas/ThresholdMonitor-Multiple'

    MLTrainingRequest-Single:
      allOf:
```

```
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            allOf:
              - type: object
                properties:
                  inferenceType:
                    type: string
                  candidateTrainingDataSource:
                    type: array
                    items:
                      type: string
                  trainingDataQualityScore:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Float'
                  trainingRequestSource:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                  requestStatus:
                    $ref: '#/components/schemas/RequestStatus'
                  expectedRuntimeContext:
                    $ref: '#/components/schemas/MLContext'
                  performanceRequirements:
                    type: array
                    items:
                      $ref: '#/components/schemas/ModelPerformance'
                  cancelRequest:
                    type: boolean
                  suspendRequest:
                    type: boolean
                  mLEntityToTrainRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                  mLEntityCoordinationGroupToTrainRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

    MLTrainingProcess-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - type: object
                  properties:
                    priority:
                      type: integer
                    terminationConditions:
                      type: string
                      enum:
                        - UPDATED_IN_INFERENCE_FUNCTION
                        - INFERENCE FUNCTION_TERMINATED
                        - INFERENCE FUNCTION_UPGRADED
                        - INFERENCE_CONTEXT_CHANGED
                    progressStatus:
                      $ref: '#/components/schemas/ProcessMonitor'
                    cancelProcess:
                      type: boolean
                    suspendProcess:
                      type: boolean
                    trainingRequestRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
                    trainingReportRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                    mLEntityRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

    MLTrainingReport-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - type: object
                  properties:
                    areConsumerTrainingDataUsed:
                      type: string
                      enum:
                        - ALL
```

```
                    - PARTIALLY
                    - NONE
                usedConsumerTrainingData:
                  type: array
                  items:
                    type: string
                modelconfidenceIndication:
                  type: integer
                modelPerformanceTraining:
                  type: array
                  items:
                    $ref: '#/components/schemas/ModelPerformance'
                modelPerformanceValidation:
                  type: array
                  items:
                    $ref: '#/components/schemas/ModelPerformance'
                dataRatioTrainingAndValidation:
                  type: integer
                areNewTrainingDataUsed:
                  type: boolean
                trainingRequestRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
                trainingProcessRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                lastTrainingRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                mLEnityGeneratedRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                mLEntityCoordinationGroupGeneratedRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                mLEntityRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

    MLTestingFunction-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-Attr'
                - type: object
                  properties:
                    mLEntityRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-ncO'
        - type: object
          properties:
            MLTestingRequest:
              $ref: '#/components/schemas/MLTestingRequest-Multiple'
            MLTestingReport:
              $ref: '#/components/schemas/MLTestingReport-Multiple'

    MLTestingRequest-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - type: object
                  properties:
                    requestStatus:
                      $ref: '#/components/schemas/RequestStatus'
                    cancelRequest:
                      type: boolean
                    suspendRequest:
                      type: boolean
                    mLEntityToTestRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                    mLEntityCoordinationGroupToTestRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

    MLTestingReport-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
```

```
        attributes:
          allOf:
            - type: object
              properties:
                modelPerformanceTesting:
                  type: array
                  items:
                    $ref: '#/components/schemas/ModelPerformance'
                mLTestingResult:
                  type: string
                testingRequestRef:
                  $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

  MLEntityLoadingRequest-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            allOf:
              - type: object
                properties:
                  requestStatus:
                    $ref: '#/components/schemas/RequestStatus'
                  cancelRequest:
                    type: boolean
                  suspendRequest:
                    type: boolean
                  mLEntityToLoadRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

  MLEntityLoadingPolicy-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            allOf:
              - type: object
                properties:
                  inferenceType:
                    type: string
                  policyForLoading:
                    $ref: '#/components/schemas/AIMLManagementPolicy'
                  mLEntityRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

  MLEntityLoadingProcess-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            allOf:
              - type: object
                properties:
                  progressStatus:
                    $ref: '#/components/schemas/ProcessMonitor'
                  cancelProcess:
                    type: boolean
                  suspendProcess:
                    type: boolean
                  resumeProcess:
                    type: boolean
                  MLEntityLoadingRequestRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                  MLEntityLoadingPolicyRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
                  LoadedMLEntityRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

  MLEntity-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            type: object
```

```
          properties:
            mLEntityId:
              type: string
            inferenceType:
              type: string
            mLEntityVersion:
              type: string
            expectedRunTimeContext:
              $ref: '#/components/schemas/MLContext'
            trainingContext:
              $ref: '#/components/schemas/MLContext'
            runTimeContext:
              $ref: '#/components/schemas/MLContext'
            supportedPerformanceIndicators:
              $ref: '#/components/schemas/SupportedPerfIndicator'
            mLCapabilitiesInfoList:
              type: array
              items:
                $ref: '#/components/schemas/MLCapabilityInfo'
            retrainingEventsMonitorRef:
              $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
            sourceTrainedMLEntityRef:
              $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

  MLEntityRepository-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            type: object
            properties:
              mLEntityRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
      - type: object
        properties:
          MLEntity:
            $ref: '#/components/schemas/MLEntity-Multiple'
          MLEntityCoordinationGroup:
            $ref: '#/components/schemas/MLEntityCoordinationGroup-Multiple'

  MLEntityCoordinationGroup-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            type: object
            properties:
              memberMLEntityRefList:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

  ## 7.3a.4.1 IOC
  MLUpdateFunction-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
           attributes:
            allOf:
              - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-Attr'
              - type: object
                properties:
                  availMLCapabilityReport:
                    $ref: '#/components/schemas/AvailMLCapabilityReport'
                  mLEntityRef:
                    $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-ncO'
      - type: object
        properties:
          MLUpdateRequest:
            $ref: '#/components/schemas/MLUpdateRequest-Multiple'
          MLUpdateProcess:
            $ref: '#/components/schemas/MLUpdateProcess-Multiple'
          MLUpdateReport:
            $ref: '#/components/schemas/MLUpdateReport-Multiple'

  MLUpdateRequest-Single:
```

```
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            type: object
            properties:
              performanceGainThreshold:
                type: array
                items:
                  $ref: '#/components/schemas/ModelPerformance'
              newCapabilityVersionId:
                type: array
                items:
                  type: string
              updateTimeDeadline:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/TimeWindow'
              requestStatus:
                $ref: '#/components/schemas/RequestStatus'
              mLUpdateReportingPeriod:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/TimeWindow'
              cancelRequest:
                type: boolean
              suspendRequest:
                type: boolean
              mLUpdateProcessRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'
              mLEntityRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

  MLUpdateProcess-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            type: object
            properties:
              progressStatus:
                $ref: '#/components/schemas/ProcessMonitor'
              mLEntityRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
              mLUpdateRequestRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
              mLUpdateReportRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

  MLUpdateReport-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            type: object
            properties:
              updatedMLCapability:
                $ref: '#/components/schemas/AvailMLCapabilityReport'
              mLEntityRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
              mLUpdateProcessRef:
                $ref: 'TS28623_ComDefs.yaml#/components/schemas/Dn'

  AIMLInferenceFunction-Single:
    allOf:
      - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
      - type: object
        properties:
          attributes:
            allOf:
              - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-Attr'
              - type: object
                properties:
                  activationStatus:
                    type: string
                    enum:
                      - ACTIVATED
                      - DEACTIVATED
                  managedActivationScope:
```

```
                      $ref: '#/components/schemas/ManagedActivationScope'
                    usedByFunctionRefList:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
                    mLEntityRef:   # FIXME S5-240805,S5-240917 both define here
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-ncO'
        - type: object
          properties:
            AIMLInferenceReport:
              $ref: '#/components/schemas/AIMLInferenceReport-Multiple'

    AIMLInferenceReport-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - type: object
                  properties:
                    inferenceOutputs:  #stage 2: attribute table name as: aimlInferenceOutputs
FIXME
                      type: array
                      items:
                        $ref: '#/components/schemas/InferenceOutput'
                      minItems: 1
                    mLEntityRef:
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'

    AIMLInferenceEmulationFunction-Single:
      allOf:
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/Top'
        - type: object
          properties:
            attributes:
              allOf:
                - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-Attr'
                - type: object
                  properties:
                    AIMLInferenceEmulationReportRefs: # FIXME stage 2 of IOC
AIMLInferenceEmulationReport missing
                      $ref: 'TS28623_ComDefs.yaml#/components/schemas/DnList'
        - $ref: 'TS28623_GenericNrm.yaml#/components/schemas/ManagedFunction-ncO'

#-------- Definition of JSON arrays for name-contained IOCs ----------------------

    MLTrainingFunction-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTrainingFunction-Single'
    MLTrainingRequest-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTrainingRequest-Single'
    MLTrainingProcess-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTrainingProcess-Single'
    MLTrainingReport-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTrainingReport-Single'
    MLEntity-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLEntity-Single'
    MLEntityRepository-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLEntityRepository-Single'
    MLEntityCoordinationGroup-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLEntityCoordinationGroup-Single'
    MLTestingFunction-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTestingFunction-Single'
```

```
    MLTestingRequest-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTestingRequest-Single'
    MLTestingReport-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLTestingRequest-Single'
    MLEntityLoadingRequest-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLEntityLoadingRequest-Single'
    MLEntityLoadingProcess-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLEntityLoadingProcess-Single'
    MLEntityLoadingPolicy-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLEntityLoadingPolicy-Single'
    MLUpdateFunction-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLUpdateFunction-Single'
    MLUpdateRequest-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLUpdateRequest-Single'
    MLUpdateProcess-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLUpdateProcess-Single'
    MLUpdateReport-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/MLUpdateReport-Single'
    AIMLInferenceFunction-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/AIMLInferenceFunction-Single'
    AIMLInferenceReport-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/AIMLInferenceReport-Single'
    AIMLInferenceEmulationFunction-Multiple:
      type: array
      items:
        $ref: '#/components/schemas/AIMLInferenceEmulationFunction-Single'
#-------- Definitions in TS 28.104 for TS 28.532 ----------------------------------

    resources-AiMlNrm:
      oneOf:
        - $ref: '#/components/schemas/MLTrainingFunction-Single'
        - $ref: '#/components/schemas/MLTrainingRequest-Single'
        - $ref: '#/components/schemas/MLTrainingProcess-Single'
        - $ref: '#/components/schemas/MLTrainingReport-Single'
        - $ref: '#/components/schemas/MLEntity-Single'
        - $ref: '#/components/schemas/MLEntityRepository-Single'
        - $ref: '#/components/schemas/MLEntityCoordinationGroup-Single'
        - $ref: '#/components/schemas/MLTestingFunction-Single'
        - $ref: '#/components/schemas/MLTestingRequest-Single'
        - $ref: '#/components/schemas/MLTestingReport-Single'
        - $ref: '#/components/schemas/MLEntityLoadingRequest-Single'
        - $ref: '#/components/schemas/MLEntityLoadingProcess-Single'
        - $ref: '#/components/schemas/MLEntityLoadingPolicy-Single'

        - $ref: '#/components/schemas/MLUpdateFunction-Single'
        - $ref: '#/components/schemas/MLUpdateRequest-Single'
        - $ref: '#/components/schemas/MLUpdateProcess-Single'
        - $ref: '#/components/schemas/MLUpdateReport-Single'
        - $ref: '#/components/schemas/AIMLInferenceFunction-Single'
        - $ref: '#/components/schemas/AIMLInferenceReport-Single'
        - $ref: '#/components/schemas/AIMLInferenceEmulationFunction-Single'
<CODE ENDS>
```

Annex C (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2022-06	SA#96					Upgrade to change control version	17.0.0
2022-09	SA#97e	SP-220851	0003	-	F	Corrections to the terms and definition description and corresponding updates	17.1.0
2022-09	SA#97e	SP-220850	0004	1	F	fix incorrect yaml file name in TS28.105	17.1.0
2022-09	SA#97e	SP-220851	0005	1	F	Clarifications and corrections of Use cases	17.1.0
2022-09	SA#97e	SP-220851	0006	1	F	Clarifications and corrections into the Class definitions and Attribute properties	17.1.0
2022-09	SA#97e	SP-220851	0007	1	F	Correction and clarifications of the Requirements	17.1.0
2022-09	SA#97e					Alignment with content with FORGE	17.1.1
2022-12	SA#98e	SP-221166	0008	2	F	Adding missing attributes	17.2.0
2022-12	SA#98e	SP-221166	0009	-	F	Correction of stage 3 openAPI	17.2.0
2023-03	SA#99	SP-230193	0011	-	F	Adding the missing definition of attributes Stage 2 and Stage 3	17.3.0
2023-03	SA#99	SP-230193	0013	1	F	Correcting the attribute properties	17.3.0
2023-03	SA#99	SP-230193	0014	1	F	Correction of the Handling errors in data and ML decisions	17.3.0
2023-03	SA#99	SP-230193	0015	1	F	Correction of terminologies	17.3.0
2023-03	SA#99	SP-230193	0017	1	F	Correct AI/ML related terms	17.3.0
2023-03	SA#99	SP-230193	0018	1	F	Correct formatting and spelling errors	17.3.0
2023-03	SA#99	SP-230193	0019	1	F	Correct attribute definitions	17.3.0
2023-06	SA#100	SP-230655	0022	1	F	Correcting the attribute properties	17.4.0
2023-06	SA#100	SP-230649	0024	1	F	Grammatical Corrections	17.4.0
2023-06	SA#100	SP-230655	0030	-	F	Removal of SW loading from training phase	17.4.0
2023-06	SA#100	SP-230655	0031	1	F	Correction of the figure for ML training function	17.4.0
2023-06	SA#100	SP-230668	0023	1	C	Not implemented due to violation of drafting rules. It will be modified and included in a future CR (MCC).	18.0.0
2023-09	SA#101	SP-230948	0023	3	C	Modelling ML Entity	18.1.0
2023-09	SA#101	SP-230948	0035		A	Clarify ML models as proprietary	18.1.0
2023-09	SA#101	SP-230948	0039	1	A	Restore the wrongly voided clause “5 Service and functional framework”	18.1.0
2023-12	SA#102	SP-231459	0041	1	F	Rel-18 CR TS 28.105 Adding the missing relation between ML entity and ML process – Partially implemented (1st change could not be implemented due to a clash with CR 066)	18.2.0
2023-12	SA#102	SP-231467	0043	1	A	Correction on ModelPerformance	18.2.0
2023-12	SA#102	SP-231490	0045	-	A	Rel-18 CR TS 28.105 Corrections of ML training related use cases description	18.2.0
2023-12	SA#102	SP-231490	0047	-	A	Rel 18 CR TS 28.105 Remove unused decision entity term	18.2.0
2023-12	SA#102	SP-231490	0049	-	A	Rel 18 CR TS 28.105 Clarify the description of confidenceIndication attribute	18.2.0
2023-12	SA#102	SP-231467	0061	-	A	Rel 18 CR TS 28.105 Remove unused attribute mLEntityList	18.2.0
2023-12	SA#102	SP-231467	0063	1	A	CR TS 28.105 Rel-18 Correction of IOC name	18.2.0
2023-12	SA#102	SP-231467	0065	1	A	TS 28.105 Rel-18 Correction of attribute properties	18.2.0
2023-12	SA#102	SP-231459	0066	1	F	TS 28.105 Rel-18 Correction of MLTrainingFunction constraints – Partially implemented (1st change could not be implemented due to a clash with CR 041)	18.2.0
2023-12	SA#102	SP-231467	0068	1	A	Rel 18 CR TS 28.105 Resolve issues related to the usage of confidenceIndication attribute	18.2.0
2023-12	SA#102	SP-231490	0069	-	A	Rel 18 CR TS 28.105 Fix incorrect figure label	18.2.0
2023-12						Alignment with the Forge	18.2.0
2024-03	SA#103	SP-240186	0073	-	F	TS28.105 Rel18 correction to Schema definition Issues for SubNetwork and ManagedElement of OpenAPI SS	18.3.0
2024-03	SA#103	SP-240155	0075	-	A	Rel-18 Correct trainingRequestSource attribute type	18.3.0
2024-03	SA#103	SP-240155	0076	1	B	Enhancements for AI-ML management	18.3.0
2024-03	SA#103	SP-240162	0080	1	A	Rel 18 CR TS 28.105 Add additional reference related to NWDAF	18.3.0
2024-03	SA#103	SP-240162	0082	1	A	Rel 18 CR TS 28.105 Add missing abbreviations	18.3.0

History

Document history		
V18.3.0	May 2024	Publication