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| Technical Specification |
| 3rd Generation Partnership Project;Technical Specification Group Services and System Aspects;Management and orchestration;Artificial Intelligence/Machine Learning (AI/ML) management (Release 17) |
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# Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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.

# Introduction

This clause is optional. If it exists, it shall be the second unnumbered clause.

# 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 TS 28.104 [2]) and 5G networks (e.g., NWDAF, see TS 23.288 [3]).

This document also describes the functionality and service framework for AI/ML management.

# 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: "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] 3GPP TS 32.423: "Telecommunication management; Subscriber and equipment trace; Trace data definition and management".

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

[10] 3GPP TS 28.406: "Telecommunication management; Quality of Experience (QoE) measurement collection; Information definition and transport".

[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".

# 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].

**AI/ML model:** a 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.

**AI/ML entity:** any entity that is either an AI/ML model or contains an AI/ML model and that can be managed as a single composite entity.

**AI/ML model training:** the capabilities of an AI/ML Training Function to take data, run it through an AI/ML model, derive the associated loss and adjust the parameterization of that AI/ML model based on the computed loss.

**AI/ML training:** the capabilities and associated end-to-end processes to enable an AI/ML Training Function to train its constituent AI/ML model, e.g., to interact with external parties to collect and format the data required for training the AI/ML model.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

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

SBMA Service Based Management Architecture

# 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, 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 4.2-1.

Table 4.2-1: 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 1) | Labelled data (Note 1), and unlabelled data | Unlabelled data | Not pre-defined |
| NOTE 1: 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 continuallearning.

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

The AI/ML-enabled function in the 5GS uses the AI/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 AI/ML model and AI/ML-enabled function (i.e., inference function) need to be managed.

The present document specifies the AI/ML management related capabilities and services, which include the followings:

- AL/ML training.

# 5 AI/ML management functionality and service framework

## 5.1 Functionality and service framework for AI/ML training

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

As illustrated in Figure 5.1-1 the AI/ML training capability is provided via AI/ML training MnS in the context of SBMA to the authorized consumer(s) by AI/ML training MnS producer.



**Figure 5.1-1: Functional overview and service framework for AI/ML model training**

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

- Performance Measurements (PM) as per TS 28.552 [4], TS 32.425 [5] and Key Performance Indicators (KPIs) as per TS 28.554 [6].

- Trace/MDT/RLF/RCEF data, as per TS 32.422 [7] and TS 32.423 [8].

- QoE and service experience data as per TS 28.405 [9] and TS 28.406 [10].

- Analytics data offered by NWDAF as per TS 23.288 [3].

- Alarm information and notifications as per TS 28.532 [11].

- CM information and notifications.

- MDA reports from MDA MnS producers as per TS 28.104 [2].

- Management data from non-3GPP systems.

- Other data that can be used for training.

# 6 AI/ML management use cases and requirements

## 6.1 General

The use cases and requirements for AI/ML management are specified in the following sub-clauses.

## 6.2 AI/ML training

### 6.2.1 Description

In operational environment before the AI/ML Entity (i.e., Inference Function) is deployed to conduct inference, it needs to be trained (e.g., by a separate or an external entity to the Inference function).

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

### 6.2.2 Use cases

#### 6.2.2.1 AI/ML training requested by consumer

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



Figure 6.6.2.1-1: AI/ML training requested by AIMLT MnS consumer

The AI/ML training may be triggered by the request(s) from one or more AIMLT MnS consumer(s). To trigger an AI/ML training, the AIMLT MnS consumer requests the AIMLT MnS producer to train the AI/ML model or AI/ML enabled function. In the AI/ML training request, the consumer should specify the inference type which indicates the function or purpose of the AI/ML Entity, e.g., CoverageProblemAnalysis. The AIMLT MnS producer can perform the training according to the designated inference type. 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 AIMLT MnS producer provides a response to the consumer indicating whether the request was accepted.

If the request is accepted, the AIMLT MnS producer decides when to start the AI/ML training with consideration of the request(s) from the consumer(s). Once the training is decided, the producer shall perform the followings,

- 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 AI/ML Entity, the AIMLT MnS producer may examine the consumer’s provided training data and decide to select none, some or all of them. In addition, the AIMLT MnS producer may select some other training data that are available.

- trains the AI/ML Entity using the selected training data, and

- provides the training results (including the location of the trained AI/ML Entity, etc.) to the AIMLT MnS consumer(s).

#### 6.2.2.2 AI/ML training initiated by producer

The AI/ML training may be initiated by the AIMLT MnS producer, for instance as a result of performance evaluation of the AI/ML model, based on feedback received from the consumer, or when new training data describing the new network status/events become available.

When the AIMLT MnS producer decides to start the AI/ML training, the producer shall perform the followings,

- selects the training data,

- trains the AI/ML Entity using the selected training data, and

- provides the training results (including the location of the trained AI/ML Entity, etc) to the AIMLT MnS consumer(s) who have subscribed to receive the AI/ML training results.

#### 6.2.2.3 Selecting AI/ML models and AI/ML-enabled Functions

For a given machine learning-based use case, different entities that apply the respective ML model or AI/ML enabled function may have different inference requirements and capabilities. For example, one consumer with specific responsibity and wish to have an AI/ML enabled function 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 wish to have a model fitting that environment. The different consumers need to know the available versions of AI/ML enabled functions and to select the appropriate AI/ML enabled function for their respective conditions.

Besides there is no guarantee that the available AI/ML enabled functions have been trained according to the characteristics that the consumers expect. As such the consumers need to know the conditions for which the models or AI/ML enabled functions have been trained to then enable the consumers to select the models that are best fitted to their conditions.

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 when 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 level of complexity and performance which would then allow different relevant models to be delivered to different network functions depending on operating conditions and performance requirements. The network functions 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.

#### 6.2.2.4 Managing AI/ML Training Processes

This machine learning capability relates to means for managing and controlling AI/ML training processes.

To achieve the desired outcomes of any machine learning relevant use-case, the AI/ML Model applied for such analytics and decision making, needs to be trained with the appropriate network data. The training may be undertaken in managed function or in a management function.

In either case, the network (or the OAM system thereof) not only needs to have the required training capabilities but needs to also have the means to manage the training of the AI/ML models and or AI/ML-enabled functions. 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 any such training process.

### 6.2.3 Requirements for AI/ML training

|  |  |  |
| --- | --- | --- |
| **Requirement label** | **Description** | **Related use case(s)** |
| **REQ-AIML\_TRAIN-FUN-01** | The AIMLT MnS producer shall have a capability allowing the consumer to request AI/ML training. | AI/ML training requested by consumer (clause 6.2.2.1) |
| **REQ- AIML\_TRAIN-FUN-02** | The AIMLT MnS producer shall have a capability allowing the consumer to specify the data sources containing the candidate training data for AI/ML training. | AI/ML training requested by consumer (clause 6.2.2.1) |
| **REQ- AIML\_TRAIN-FUN-03** | The AIMLT MnS producer shall have a capability allowing the consumer to specify the inference type of the AI/ML Entity to be trained. | AI/ML training requested by consumer (clause 6.2.2.1) |
| **REQ- AIML\_TRAIN-FUN-04** | The AIMLT MnS producer shall have a capability to provide the training result (including the location of the trained AI/ML Entity) to the consumer. | AI/ML training requested by consumer (clause 6.2.2.1), and AI/ML training initiated by producer (clause 6.2.2.2) |
| **REQ-AIML\_SELECT-01** | 3GPP management system shall have the capability for authorized consumer to discover the characteristics of available models including the contexts under which each of the models was trained.  | Selecting AI/ML models and AI/ML-enabled Functions (clause 6.2.2.3) |
| **REQ-AIML\_SELECT-02** | 3GPP management system shall have the capability to enable an authorized consumer to select an AI/ML model. | Selecting AI/ML models and AI/ML-enabled Functions (clause 6.2.2.3) |
| **REQ-AIML\_SELECT-03** | 3GPP management system shall have the capability to enable an authorized consumer to request for a model to be trained to satisfy the consumer's expectations.  | Selecting AI/ML models and AI/ML-enabled Functions (clause 6.2.2.3) |
| **REQ-AIML\_SELECT-04** | 3GPP management system shall have the capability to enable an authorized consumer to request for information and be informed about the available alternative models of differing complexity and performance.  | Selecting AI/ML models and AI/ML-enabled Functions (clause 6.2.2.3) |
| **REQ-AIML\_SELECT- -05** | 3GPP management system shall have the capability to enable an authorized consumer to request one of the known or available alternative models of differing complexity and performance to be used for inference. | Selecting AI/ML models and AI/ML-enabled Functions (clause 6.2.2.3) |
| **REQ-AIML\_SELECT-06** | The 3GPP management system shall have a capability to provide a selected AI/ML enabled function to the consumer. | Selecting AI/ML models and AI/ML-enabled Functions (clause 6.2.2.3) |
| **REQ-AIML\_TRAIN- MGT\_01** | 3GPP management system shall have the capability to enable an authorized consumer to manage and configure one or more requests for the training of specific AI/ML models or AI/ML enabled functions, e.g., to modify the characteristics of the request or to delete a request.  | Managing AI/ML Training Processes (clause 6.2.2.4) |
| **REQ-AIML\_TRAIN- MGT\_02** | 3GPP management system shall have the capability to enable an authorized consumer to manage and configure one or more training processes, e.g., to start, suspend or restart the training; or to adjust the training conditions and/or characteristics. | Managing AI/ML Training Processes (clause 6.2.2.4) |
| **REQ-AIML\_TRAIN- MGT\_03** | 3GPP management system shall have the capability to enable an authorized consumer (e.g., the function/entity different from the function that generated a request for AI/ML enabled function training) to request for a report on the outcomes of a specific training instance.  | Managing AI/ML Training Processes (clause 6.2.2.4) |
| **REQ-AIML\_TRAIN- MGT\_04** | 3GPP management system shall have the capability to enable an authorized consumer to define the reporting characteristics related to a specific training request or training instance. | Managing AI/ML Training Processes (clause 6.2.2.4) |
| **REQ-AIML\_TRAIN- MGT\_05** | 3GPP management system shall have the capability to enable the AI/ML Training function to report to any authorized consumer about specific ML Training process and/or report about the outcomes of any such ML Training process. | Managing AI/ML Training Processes (clause 6.2.2.4) |

# 7 Information model definitions for AI/ML management

## 7.1 Imported and associated information entities

### 7.1.1 Imported information entities and local labels

|  |  |
| --- | --- |
| Label reference | Local label  |
| TS 28.622 [12], IOC, Top | Top |
| TS 28.622 [12], IOC, SubNetwork | SubNetwork |
| TS 28.622 [12], IOC, ManagedElement | ManagedElement |
| TS 28.622 [12], IOC, ManagedFunction | ManagedFunction |

### 7.1.2 Associated information entities and local labels

|  |  |
| --- | --- |
| Label reference | Local label  |
|  |  |
|  |  |

## 7.2 Class diagram

### 7.2.1 Relationships

This clause depicts the set of classes (e.g., IOCs) that encapsulates the information relevant to AI/ML model training. For the UML semantics, see 3GPP TS 32.156 [13].



**Figure 7.2.1-1: NRM fragment for AI/ML model training**

### 7.2.2 Inheritance



**Figure 7.2.2-1: Inheritance Hierarchy for AI/ML model training related NRMs**

## 7.3 Class definitions

### 7.3.1 AIMLTrainingFunction

#### 7.3.1.1 Definition

The IOC AIMLTrainingFunction represents the entity that undertakes AI/ML training and is also the container of the AIMLTrainingRequest IOC(s).

The entity represented by AIMLTrainingFunction MOI supports training of one or more AIMLEntity(s).

The AIMLTrainingFunction contains one or more AIMLTrainingRequest MOIs.

#### 7.3.1.2 Attributes

The AIMLTrainingFunction IOC includes attributes inherited fromTOP IOC (defined in TS 28.622) and the following attributes:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable | isWritable | isInvariant | isNotifyable |
| aIMLEntityList | M | T | F | F | F |

#### 7.3.1.3 Attribute constraints

None.

#### 7.3.1.4 Notifications

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

### 7.3.2 AIMLTrainingRequest

#### 7.3.2.1 Definition

The IOC AIMLTrainingRequest represents the AI/ML model training request that is created by the AI/ML training MnS consumer.

The AIMLTrainingRequest MOI is contained under one AIMLTrainingFunction MOI. Each AIMLTrainingRequest is associated to at least one AIMLEntity.

The AIMLTrainingRequest may have a source to identify where it is coming from, and 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 AIMLTrainingRequest may indicate the expectedRunTimeContext that describes the specific conditions for which the AIMLEntity (either AIML Model or AIML-enabled function) should be trained for.

In case the request is accepted, the AI/ML training MnS producer decides when to start the AI/ML training. Once the MnS producer decides to start the training based on the request, the AI/ML training MnS producer instantiates one or more AI/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 training data, with consideration of the consumer provided candidate training data if any. The AI/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 AI/ML training MnS producer may select some other training data that are available,

- trains the AIMLEntity using the selected and prepared training data.

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

- The attribute values are "NOT\_STARTED", "TRAINING\_IN\_PROGRESS", "SUSPENDED", "FINISHED", and "CANCELLED".

- When value turns to "TrainingInProcess", the AI/ML training MnS producer instantiates one or more AIMLTrainingProcess MOI(s) representing the training process(es) being performed per the request and notifies the 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.

#### 7.3.2.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable  | isWritable | isInvariant | isNotifyable |
| aIMLEntityId | M | T | T | F | T |
| candidateTraingDataSource | O | T | T | F | T |
| trainingRequestSource | M | T | T | F | T |
| requestStatus | M | T | T | F | T |
| expectedRuntimeContext | O | T | T | F | T |
| peformanceRequirements | M | T | T | F | T |
| cancelRequest | O | T | T | F | T |
| suspendRequest | O | T | T | F | T |
| **Attribute related to role** |  |  |  |  |  |
|  |  |  |  |  |  |

#### 7.3.2.3 Attribute constraints

|  |  |
| --- | --- |
| Name | Definition |
|  |  |
|  |  |

#### 7.3.2.4 Notifications

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

### 7.3.3 AIMLTrainingReporting

#### 7.3.3.1 Definition

The IOC AIMLTrainingReporting represents the container of the AIMLTrainingReport IOC(s).

#### 7.3.3.2 Attributes

No additional attributes other than the ones inherited from the parent class.

#### 7.3.3.3 Attribute constraints

None.

#### 7.3.3.4 Notifications

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

### 7.3.4 AIMLTrainingReport

#### 7.3.4.1 Definition

The IOC AIMLTrainingReport represents the AI/ML model training report that is provided by the training MnS producer.

The AIMLTrainingReport MOI is contained under one AIMLTrainingFunction MOI.

#### 7.3.4.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable  | isWritable | isInvariant | isNotifyable |
| aIMLEntityId | M | T | F | F | T |
| areConsumerTrainingDataUsed | M | T | F | F | T |
| usedConsumerTrainingData | CM | T | F | F | T |
| confidenceIndication | O | T | F | F | T |
| modelPeformanceTraining | 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 |

#### 7.3.4.3 Attribute constraints

|  |  |
| --- | --- |
| Name | Definition |
| usedConsumerTrainingData Support Qualifier | Condition: The value of areConsumerTrainingDataUsed attribute is ALL or PARTIALLY.  |
| trainingRequestRef Support Qualifier | Condition: The AIMLTrainingReport MOI represents the report for the AI/ML model training that was requested by the MnS consumer (via AIMLTrainingRequest MOI).  |
| lastTrainingRef Support Qualifier | Condition: The AIMLTrainingReport MOI represents the report for the AI/ML model training that was not initial training (i.e., the model has been trained before). |

#### 7.3.4.4 Notifications

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

### 7.3.5 AIMLTrainingProcess

#### 7.3.5.1 Definition

The IOC AIMLTrainingProcess represents the AI/ML training process.

One AIMLTrainingProcess MOI may be instantiated for each AIMLTrainingRequest MOI or a set of AIMLTrainingRequest MOIs.

For each AIMLEntity under training, a AIMLTrainingProcess is instantiated, i.e., an AIMLTrainingProcess is associated with exactly one AIMLEntity.The AIMLTrainingProcess may be associated with one or more AIMLTrainingRequest MOI.

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

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

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

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

The "ProgressStatus" attribute represents the status of the AI/ML model training and includes information the AI?ML training MnS consumer can use to monitor the progress and results. The data type of this attribute is "ProcessMonitor" (see TS 28.622 [12]). The following specialisations are provided for this data type for the AI/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 MnS producer provides the training report, by creating an AIMLTrainingReport MOI, to the MnS consumer.

7.3.5.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable  | isWritable | isInvariant | isNotifyable |
| aIMLTrainingProcessId | M | T | T | F | T |
| 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 |

Editor’s note: the relation of progressStateInfo and ProgressStatus is FFS.

Editor's Note: The nature of the terminationConditions is FFS

#### 7.3.5.3 Attribute constraints

|  |  |
| --- | --- |
| Name | Definition |
| trainingRequestRef Support Qualifier | Condition: The AIMLTrainingReport MOI represents the report for the AI/ML model training that was requested by the training MnS consumer (via AIMLTrainingRequest MOI).  |

#### 7.3.5.4 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 score of an AI/ML entity when performing inference. The performance score is provided for each inference output.

#### 7.4.1.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable  | isWritable | isInvariant | isNotifyable |
| inferenceOutputName | M | T | F | F | T |
| performanceScore | M | T | F | F | T |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

#### 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 AIMLEntity <<dataType>>

#### 7.4.2.1 Definition

This data type represents the properties of an AI/ML entity which could be either an AI/ML model or AI/ML-enabled function containing the AI/ML model. AIML training may be requested for either an AI/ML model or AI/ML-enabled function. The algorithm of AI/ML model or AI/ML-enabled function is not to be standardized.

For each AIMLEntity under training, one or more AIMLTrainingProcess are instantiated.

The AIMLEntity may contain 3 types of contexts - TrainingContext which is the context under which the AIMLEntity has been trained, the ExpectedRunTimeContext which is the context where an AIMLEntity is expected to be applied or/and the RunTimeContext which is the context where the model is being applied.

#### 7.4.2.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable  | isWritable | isInvariant | isNotifyable |
| aIMLEntityId | M | T | F | F | T |
| inferenceType | M | T | F | F | T |
| aIMLEntityVersion | M | T | F | F | T |
| expectedRunTimeContext | O | T | T | F | T |
| trainingContext | CM | T | F | F | T |
| runTimeContext | O | T | F | F | T |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

#### 7.4.3.3 Attribute constraints

None.

|  |  |
| --- | --- |
| Name | Definition |
| trainingContext Support Qualifier | Condition: The TrainingContext represents the status and conditions related to training and should be added when training is completed  |

#### 7.4.3.4 Notifications

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

### 7.4.3 AIMLContext <<dataType>>

#### 7.4.3.1 Definition

The AIMLContext represents the status and conditions related to the AIMLEntity. Specially it may be one of three types of context - the ExpectedRunTimeContext, the TrainingContext, and the RunTimeContext.

#### 7.4.3.2 Attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Support Qualifier | isReadable  | isWritable | isInvariant | isNotifyable |
| managedEntityRef | M | T | F | F | F |
| dataProviderRef | M | T | F | F | F |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

Editor’s note: Whether other attributes are needed for the context is FFS.

#### 7.4.3.3 Attribute constraints

None.

#### 7.4.1.4 Notifications

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

## 7.5 Attribute definitions

### 7.5.1 Attribute properties

| Attribute Name | Documentation and Allowed Values | Properties |
| --- | --- | --- |
| aIMLEntityId | It identifies the AI/ML entity.It is unique in each MnS producer.allowedValues: N/A. | type: Stringmultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: True |
| candidateTraingDataSource | 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: Stringmultiplicity: \*isOrdered: FalseisUnique: TruedefaultValue: None isNullable: True |
| inferenceType | It indicates the type of inference that the AI/ML model supports. allowedValues: the values of the MDA type (see TS 28.104 [2]), Analytics ID(s) of NWDAF (see TS 23.288 [3]), types of inference for RAN-intelligence, and vendor’s specific extensions. | type: Stringmultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: True |
| areConsumerTrainingDataUsed | It indicates whether the consumer provided training data have been used for the AI/ML model training.allowedValues: ALL, PARTIALLY, NONE. | type: Enummultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: True |
| usedConsumerTrainingData | It provides the address(es) where lists of the consumer-provided training data are located, which have been used for the AI/ML model training.allowedValues: N/A. | type: Stringmultiplicity: \*isOrdered: FalseisUnique: TruedefaultValue: None isNullable: True |
| trainingRequestRef | It is the DN(s) of the related AIMLTrainingRequest MOI(s).allowedValues: DN. | type: DN (see TS 32.156 [13])multiplicity: \*isOrdered: FalseisUnique: TruedefaultValue: None isNullable: True |
| lastTrainingRef | It is the DN of the AIMLTrainingReport MOI that represents the reports for the last training of the AI/ML model.allowedValues: DN. | type: DN (see TS 32.156 [13])multiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: True |
| confidenceIndication | It indicates the confidence (in unit of percentage) that the AI/ML model would perform for inference on the data with the same distribution as training data.allowedValues: { 0..100 }. | type: integermultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| aIMLEntityList | It describes the list of aIMLEntity. | type: AIMLEntitymultiplicity: \*isOrdered: FalseisUnique: N/TruedefaultValue: None isNullable: False |
| trainingRequestSource | It descriobes the entity that requested to instantiatethe AIMLTrainingRequest MOI. | type: integermultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| requestStatus | It describes the status of a particular AI/ML training request. T.allowedValues: NOT\_STARTED, TRAINING\_IN\_PROGRESS, CANCELLING, SUSPENDED, FINISHED, and CANCELLED. | type: Enummultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| aIMLTrainingProcessId | It identifies the training process.It is unique in each instantiated process in the MnS producer.allowedValues: N/A. | type: Stringmultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: True |
| priority | It indicates the priority of the training process.The priority may be used by the AI/ML training to schedule the training processes.allowedValues: { 0..100 }. | type: ENUMmultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| terminationConditions | It indicates the conditions to be considered by the AIMLTraining to terminate a specific training process.Editor's Note: The specific nature of the termination conditions is FFSallowedValues: FFS. | type: FFSmultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| progressStatus | It indicates the status of the AI/ML training process.allowedValues: N/A. | type: ProcessMonitor (see TS 28.622 [12])multiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| aIMLEntityVersion | It indicates the version number of the AI/ML entity.allowedValues: N/A. | type: Stringmultiplicity: 1isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| performanceRequirements | It indicates the expected performance for a trained AI/ML entity when performing on the training data.allowedValues: N/A. | type: ModelPeformancemultiplicity: \*isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: True |
| performanceTraining | It indicates the performance score of the AI/ML entity when performing on the training data.allowedValues: N/A. | type: ModelPeformancemultiplicity: \*isOrdered: N/AisUnique: N/AdefaultValue: None isNullable: False |
| AIMLTrainingProcess.progressStatus.progressStateInfo | It provides the following specialisation for the "progressStateInfo" attribute of the "ProcessMonitor" data type for the "AIMLTrainingProcess".When the AI/ML training is in progress, and the "status" is equal to " RUNNING" it provides the more detailed progress information.allowedValues for "status" = "RUNNING": - COLLECTING\_DATA - PREPARING\_TRAINING\_DATA - TRAININGThe allowed values for "status" = "CANCELLED" are vendor specific. | Type: Stringmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: NoneisNullable: False |
| inferenceOutputName | It indicates the name of an inference output of an AI/ML entity.allowedValues: the name of the MDA output IEs (see TS 28.104 [2]), name of analytics output IEs of NWDAF (see TS 23.288 [3]), RAN-intelligence inference output IE name(s), and vendor’s specific extensions. | Type: Stringmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: NoneisNullable: False |
| performanceScore | It indicates the performance score (in unit of percentage) of an AI/ML entity when performing inference on a specific data set (Note).The performance metrics may be different for different kinds of AI/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: Realmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: NoneisNullable: False |
| cancelRequest | It indicates whether the training MnS consumer cancels the AI/ML training request.Setting this attribute to "TRUE" cancels the AI/ML training request. Cancellation is possible when the requestStatus is the "NOT\_STARTED", " TRAINING\_IN\_PROGRESS", and "SUSPENDED" state. Setting the attribute to "FALSE" has no observable result.Default value is set to "FALSE". allowedValues: TRUE, FALSE. | Type: ENUMmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: FALSEisNullable: False |
| suspendRequest | It indicates whether the training MnS consumer suspends the AI/ML training request.Setting this attribute to "TRUE" suspends the AI/ML training request. Suspension is possible when the requestStatus is the not “FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE. | Type: ENUMmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: FALSEisNullable: False |
| cancelProcess | It indicates whether the training MnS consumer cancels the AI/ML training process.Setting this attribute to "TRUE" cancels the AI/ML training request. Cancellation is possible when the progressStateInfo is the not “FINISHED" state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE. | Type: ENUMmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: FALSEisNullable: False |
| suspendProcess | It indicates whether the training MnS consumer suspends the AI/ML training process.Setting this attribute to "TRUE" suspends the AI/ML training request. Suspension is possible when the progressStateInfo is the not “FINISHED", “CANCELLING” or “CANCELLED” state. Setting the attribute to "FALSE" has no observable result. Default value is set to "FALSE". allowedValues: TRUE, FALSE. | Type: ENUMmultiplicity: 0..1isOrdered: N/AisUnique: N/AdefaultValue: FALSEisNullable: False |
| managedEntityRef | It describes the entities that the MLApp is responsible for managing or optmimizing | Type: DN (see TS 32.156 [13])multiplicity: \*isOrdered: FalseisUnique: TruedefaultValue: None isNullable: True |
| dataProviderRef | It describes the entities that have provided or should provide data needed by the MLApp, say for training or inference | Type: DN (see TS 32.156 [13])multiplicity: \*isOrdered: FalseisUnique: TruedefaultValue: None isNullable: True |
| NOTE: when the performanceScore is to indicate the performance score for AI/ML training, the data set is the training data set. |

### 7.5.2 Constraints

|  |  |  |
| --- | --- | --- |
| Name | Affected attribute(s) | Definition |
|  |  |  |

## 7.6 Common notifications

### 7.6.1 Configuration notifications

This clause presents a list of notifications, defined in 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.

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

# 8 Service components

## 8.1 Service components for AI/ML model training MnS

The components for AI/ML model training MnS are listed in table 8.1-1:

Table 8.1-1: Components for AI/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 TS 28.532[11]). | ; AIMLTrainingRequest IOC;;AIMLTrainingReport IOC. | None |

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 7.2 of the present document.

# A.2 PlantUML code for Figure 7.2.1-1: NRM fragment for AI/ML model training

@startuml

skinparam ClassStereotypeFontStyle normal

skinparam ClassBackgroundColor White

skinparam shadowing false

skinparam monochrome true

hide members

hide circle

'skinparam maxMessageSize 250

class ManagedEntity <<ProxyClass>>

class AIMLEntity <<dataType>>

class AIMLTrainingFunction <<InformationObjectClass>>

class AIMLTrainingReporting <<InformationObjectClass>>

class AIMLTrainingRequest <<InformationObjectClass>>

class AIMLTrainingReport <<InformationObjectClass>>

class AIMLTrainingProcess <<InformationObjectClass>>

ManagedEntity "1" \*-- "\*" AIMLTrainingFunction: <<names>>

AIMLTrainingFunction "1" -d-> "\*" AIMLEntity

AIMLTrainingFunction "1" \*-- "\*" AIMLTrainingProcess: <<names>>

AIMLTrainingFunction "1" \*-r- "\*" AIMLTrainingReporting: <<names>>

AIMLTrainingFunction "1" \*-- "\*" AIMLTrainingRequest: <<names>>

AIMLTrainingReporting "1" \*-- "\*" AIMLTrainingReport: <<names>>

AIMLTrainingProcess "1" <-r-> "1" AIMLTrainingReport

AIMLTrainingReport "1" --> "1" AIMLTrainingReport

AIMLTrainingRequest "\*" -l-> "1" AIMLEntity

AIMLTrainingRequest "\*" -r-> "\*" AIMLTrainingProcess

note left of ManagedEntity

 Represents the following IOCs:

 Subnetwork or

 ManagedFunction or

 ManagementFunction

 end note

@enduml

# A.3 PlantUML code for Figure 7.2.2-1: Inheritance Hierarchy for AI/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 AIMLTrainingFunction <<InformationObjectClass>>

class AIMLTrainingRequest <<InformationObjectClass>>

class AIMLTrainingProcess <<InformationObjectClass>>

class AIMLTrainingReporting <<InformationObjectClass>>

class AIMLTrainingReport <<InformationObjectClass>>

Top <|-- AIMLTrainingFunction

Top <|-- AIMLTrainingRequest

Top <|-- AIMLTrainingProcess

Top <|-- AIMLTrainingReporting

Top <|-- AIMLTrainingReport

@enduml

Annex X (informative):
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-01 | SA5#141e | n/a | - | - | - | Initial skeleton | 0.0.0 |
| 2022-01 | SA5#141e | S5-221616 | - | - | - | Add scope | 0.1.0 |
| 2022-01 | SA5#141e | S5-221617 | - | - | - | Add overview | 0.1.0 |
| 2022-01 | SA5#141e | S5-221618 | - | - | - | Add service framework for AI-ML model training | 0.1.0 |
| 2022-01 | SA5#141e | S5-221335 | - | - | - | Move in ML model training part from TS 28.104 | 0.1.0 |
| 2022-01 | SA5#141e | S5-221614 | - | - | - | Add the requirements for ML model training for MDA | 0.1.0 |
| 2022-02 | SA5#141e | S5-221620 | - | - | - | Add NRMs for AI-ML model training | 0.1.0 |
| 2022-03 | SA#95e | SP-220128 |  |  |  | Presented for information | 1.0.0 |
| 2022-04 | SA5#142e | S5-222688 | - | - | - | Add requirements for AI/ML selection | 1.1.0 |
| 2022-04 | SA5#142e | S5-222689 | - | - | - | Add requirements for control of AI/ML Training | 1.1.0 |
| 2022-04 | SA5#142e | S5-222690 | - | - | - | Add NRM fragments for AI/ML Training | 1.1.0 |
| 2022-04 | SA5#142e | S5-222691 | - | - | - | Support for Training of ML-based functions | 1.1.0 |
| 2022-04 | SA5#142e | S5-222696 | - | - | - | Add AI-ML background | 1.1.0 |
|  |  |  |  |  |  |  |  |