3GPP TSG-WG SA2 Meeting #161 *S2-2402986*

Athens, Feb 26th – Mar 1st, 2024

**Source: Nokia, Nokia Shanghai-Bell**

**Title: Accuracy vs Metrics terminology**

**Document for: Approval**

**Agenda Item: 9.23.2**

**Work Item / Release: eNA\_Ph3 / Rel-18**

*Abstract: This contribution suggest to consistently use “accuracy” terminology in TS 23.288. A related CR is in S2-2402988.*

# Discussion

**Usage of “accuracy in TS 23.288**

The term “accuracy” appears in in TS 23.288 **568** times.

It is used in the following ways:

1. As Input parameter for analytics exposure:  
   Preferred level of Accuracy of the analytics pr analytics subset ("Low", "Medium", "High" or "Highest")
2. As Output parameter for analytics exposure
3. As part of AnLF based analytics accuracy monitoring
4. As part of the analyitics context (both analytics and metric related accuracy)
5. For rating untrusted data sources
6. As part of the MTLF based ML Model Accuracy Monitoring (Using the Nnwdaf\_MLModelProvision service)
7. Within Nnwdaf\_MLModelProvision service for federated learning (unclear how “accuracy threshold” and “accuracy reporting interval” would relate to other metrics
8. Within the procedure for AnLF-assisted MTLF ML Models Accuracy Monitoring
9. Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request for federated learning
10. As part of the Nnwdaf\_MLModelTraining\_Notify for federated learning

**Usage of “metrics” in TS 23.288**

The term “metric”/”metrics” appears in TS 23.288 40 times, out of which **15** occurances relate to the present discussion

It is used in the following ways:

1. Related to input data and data collection  
   (this usge is unrelated to the subsequent discussions and no related changes are proposed)
2. Within Nnwdaf\_MLModelProvision service for federated learning
   1. To qualify input data
   2. As part of the ML Model Monitoring Information (in the request) and as method to compute the reported model accuracy (in the reply)
3. In some places in the Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request for federated learning
4. AS part of the Nnwdaf\_MLModelMonitor\_Subscribe request (one occurrence)

The term “accuracy” is used to describe the reported accuracy. It is defined in Clause 5c (“Analytics/ML Model Accuracy Monitoring Functional Description”) as follows:

*Analytics/ML Model Accuracy Monitoring is to be achieved by comparing the predictions using the current trained ML model and its corresponding ground truth data i.e. the corresponding true observed events.*

*Analytics/ML Model Accuracy information is to represent general performance measurements for analytics and ML Model respectively, which are composed of the number of correct predictions out of all predictions and the corresponding number of samples.*

*NOTE 2: How MTLF/AnLF determines whether the prediction is correct one is up to implementation.*

Clause 5.C relates to accuracy both of Analytics and ML models.

However, while the term “accuracy” is used consistenly for analytics, for ML model the term “metrics” appears instead in some places, and with variations of the meaning:

* It can indicate (e.g. in requests) that accuracy information or reporting is requested (the term” ML Model Accuracy Check Flag” is used elsewhere)
* it can indicate (e.g. in responses or notifications) the observed (accuracy) value
* it can indicate (e.g. in responses or notifications) the (“accuracy”) method (only one in this release) to calculate the observed (accuracy) value

**Observations:**

1. **Related to analytics, the term “accuracy” is used consistently**
2. **Related to models, the usage of terms “accuracy” and metrics is not consitent**

(While the high level description (in particulat Clause 5c) and most procedures only use the term “accuracy”, the usage is not consitent in particular for federated learning)

1. **Overall, the term "accuracy" is predominant by far** (several 100 related occurances vs 15 relevant occurances of “metrics”)
2. **The term “metric” itself appears with several different meanings that are not well explained.**
3. **Different and inconsitent terminology and parameters with unclear meaning can lead to interoperability issues.**

**Is the metric parameter beneficial for future extensions?**

The terminology “metric” is likely a left-over of proposals to support multiple diffrent metrics (With the consumer being allowed to choose the applicable metric in requests) to meassure the correctness of analytivs and models (with “accuracy” based on its current definition beeing one such metric). Those proposals were not agreed.

Proponents of the term “metrics” explained during the SA2#161AH email discussions that they want to maintain the “metrics” parameter to negotiate and indicate the applicable metric method for future compatibility.

The author does not deny that the current defintion of “analytics” has possible room for future improvments:

* How can it be determined if a prediction is accurate?
  + A prediction with a numerical value can deviate to a smaller ot larger extent from the ground truth, and other more suitable parameters to decribe such distributions are known from mathematical statistics
  + A prediction can include multiple parameters, and how can they be weighted against each other?

However, it is not obvious that future metrics extensions can indeed be accomodted with the “metrics” parameter:

For instance, there were proposals to report the accuracy seperately for different output parameters of an analytics ID and to apply different metrics methods for different output parameters depending on their nature (e.g. numerical or boolean value), and/or to provide rules how to combine such different values into a single parameter (e.g based on weights for the accuracy or various output parameters)

Should alternative metrics be introduced in future releases, they can then be added with the help of additional parameters also without the suggested provisions for future compatibility in this release.

**Observations:**

1. **It is uncertain whether the “metrics” parmeter would really be suitable for not yet known future extensions.**

# Proposal**:**

Option 1:

**Remove the term “metrics” from TS 23.288 in Rel-18 and use the term “analytics” consistently.**

Option 2

Consisten usage of terms for models keeping metric for future compatibility:

Usage terminology based on Clause 6.2A.2 with slight updates:

(motivation is to keep overall impacts as small as possible)

*The consumers of the ML model provisioning services (i.e. an NWDAF containing AnLF) may provide*

*- [OPTIONAL] ML Model Monitoring Information:*

*- [OPTIONAL] desired ML Model* ***metric****: e.g. ML Model* ***Accuracy****.*

*NOTE 4: In this release, only “Accuracy” is defined as ML model metric*

*The NWDAF containing MTLF provides to the consumer*

*- [OPTIONAL]ML Model* ***Accuracy*** *Information: indicates the* ***Accuracy*** *of the ML model if ML Model* ***Accuracy*** *threshold is requested, which includes:*

*- the* ***Accuracy*** *value of the ML model.*

*- [OPTIONAL] used ML model* ***metric*** *to calculate Accuracy value (e.g. ML Model* ***Accuracy****).*

# Annex:

# Excerpts from TS 23.288 to show the current Usage of the terms “analytics” and “metrics” with required changes according to option 2

# 5C Analytics/ML Model **Accuracy** Monitoring Functional Description

## 5C.1 General

A NWDAF may have the **Accuracy** checking capability for Analytics and/or ML Models. The NWDAF may provide the **Accuracy** information to consumers when requested or use it for its internal processes.

Input data is collected from Data Producer NF(s) when there is a request for inference/prediction per analytics ID in NWDAF for a specific time period in future. Ground truth data are collected from those Data Producer NF corresponding to the requested analytic ID at the time to which the prediction refers.

The ground truth data is the actual measured data observed at the time which the prediction refers to.

NOTE 1: The ground truth data can be impacted when Analytics Feedback Information shows that an action is triggered by the analytics output in the consumer.

Analytics/ML Model **Accuracy** Monitoring is to be achieved by comparing the predictions using the current trained ML model and its corresponding ground truth data i.e. the corresponding true observed events.

Analytics/ML Model **Accuracy** information is to represent general performance measurements for analytics and ML Model respectively, which are composed of the number of correct predictions out of all predictions and the corresponding number of samples.

NOTE 2: How an MTLF/AnLF determines whether a prediction is correct is up to implementation.

The NWDAF (containing AnLF/MTLF) with **Accuracy** checking capability decides to initiate analytics **Accuracy** monitoring based on:

- A request from an analytics **Accuracy** consumer. The analytics **Accuracy** consumer may be an NWDAF containing AnLF, NWDAF containing MTLF or an analytics consumer NF.

- Analytics Feedback Information which may be provided by an Analytics Consumer NF.

The AnLF with analytics **Accuracy** checking capability as defined in clause 6.2D is able to provide or notify the **Accuracy** information of Analytics IDs to the analytics consumers of such service and when the analytics **Accuracy** does not meet the analytics consumer's requirements, the analytics consumer may stop using analytics for a period of time or obtain new analytics. In addition, updated analytics for the provided Analytics IDs may be provided to analytics consumers as requested, if the updated analytics is able to be generated within the correction time period. The AnLF with analytics **Accuracy** checking capability is as defined in clause 6.2D.1 is able to determine analytics **Accuracy** information based on e.g.:

- Comparing predictions and its corresponding ground truth data, which are collected corresponding to the requested analytic ID at the time which the prediction refers to.

NOTE 3: The ground truth data and the corresponding prediction is to be defined per Analytics ID.

- Comparing changes in internal configuration for the analytics ID generation (e.g. change of data collection parameters, change in data distribution from a Data Source).

- Previous existent records of analytics **Accuracy** information.

- **Accuracy** feedback information provided by an NF consumer.

- Determining analytics **Accuracy** by comparing analytics **Accuracy** using multiple ML models.

The MTLF with ML Model **Accuracy** checking capability as defined in clause 6.2E is able to determine ML Model degradation based on e.g.:

- comparing/evaluating the data: including input data, analytics output and the ground truth data either collected from various data source NFs, DCCF, AnLF, ADRF or configured by OAM;

- or AnLF providing notifications of the analytics **Accuracy** information; or

- AnLF providing analytics feedback information of the analytics generated by the ML model.

The NWDAF containing MTLF may reselect a new ML model or retrain the existing ML model and consequently notify the ML model **Accuracy** degradation to the ML Model consumer(s). In addition, the NWDAF containing MTLF may consider the rating of untrusted AF(s) when used as data sources.

### 6.2A.1 ML Model Subscribe/Unsubscribe

The procedure in Figure 6.2A.1-1 is used by an NWDAF service consumer, i.e. an NWDAF containing AnLF to subscribe/unsubscribe at another NWDAF, i.e. an NWDAF containing MTLF, to be notified when ML Model Information on the related Analytics becomes available, using Nnwdaf\_MLModelProvision services as defined in clause 7.5. The ML Model Information is used by an NWDAF containing AnLF to derive analytics. The service is also used by an NWDAF to modify existing ML Model Subscription(s). An NWDAF can be at the same time a consumer of this service provided by other NWDAF(s) and a provider of this service to other NWDAF(s).



Figure 6.2A.1-1: ML Model for analytics subscribe/unsubscribe

 1. The NWDAF service consumer (i.e. an NWDAF containing AnLF) subscribes to, modifies, or cancels subscription for a (set of) trained ML Model(s) associated with a/an (set of) Analytics ID(s) by invoking the Nnwdaf\_MLModelProvision\_Subscribe / Nnwdaf\_MLModelProvision\_Unsubscribe service operation. The parameters that can be provided by the NWDAF service consumer are listed in clause 6.2A.2. The service consumer optionally indicates its support for multiple ML models if available.

When a subscription for a trained ML model associated with an Analytics ID is received, the NWDAF containing MTLF may:

- determine whether existing trained ML Model(s) can be used for the subscription; or

- determine whether triggering further training for the existing trained ML models is needed for the subscription.

If the NWDAF containing MTLF determines that further training is needed, this NWDAF may initiate data collection from NFs, (e.g. AMF/DCCF/ADRF), UE Application (via AF) or OAM as described in clause 6.2, to generate the ML model.

If the service invocation is for a subscription modification or subscription cancelation, the NWDAF service consumer includes an identifier (Subscription Correlation ID) to be modified in the invocation of Nnwdaf\_MLModelProvision\_Subscribe.

2. If the NWDAF service consumer subscribes to a (set of) trained ML model(s) associated to a (set of) Analytics ID(s), the NWDAF containing MTLF notifies the NWDAF service consumer with:

- a set of pair(s) of unique ML Model Identifier and ML Model Information associated with each Analytics ID requested by the service consumer.

NOTE 1: The structure and format of the ML Model identifier and its uniqueness are up to stage 3.

NOTE 2: Parameters defined for Multiple ML models are for Analytics **Accuracy** enhancement.

by invoking Nnwdaf\_MLModelProvision\_Notify service operation. The content of trained ML Model Information that can be provided by the NWDAF containing MTLF is specified in clause 6.2A.2.

The NWDAF containing MTLF also invokes the Nnwdaf\_MLModelProvision\_Notify service operation to notify an available re-trained ML model when the NWDAF containing MTLF determines that the previously provided trained ML Model required re-training at step 1.

When the step 1 is for a subscription modification (i.e. including Subscription Correlation ID), the NWDAF containing MTLF may provide either a new trained ML model different to the previously provided one, or re-trained ML model by invoking Nnwdaf\_MLModelProvision\_Notify service operation.

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When a subscription for a trained ML model associated with an Analytics ID is received, the NWDAF containing MTLF may:

- determine whether existing trained ML Model(s) can be used for the subscription; or

- determine whether triggering further training for the existing trained ML models is needed for the subscription.

If the NWDAF containing MTLF determines that further training is needed, this NWDAF may initiate data collection from NFs, (e.g. AMF/DCCF/ADRF), UE Application (via AF) or OAM as described in clause 6.2, to generate the ML model.

If the service invocation is for a subscription modification or subscription cancelation, the NWDAF service consumer includes an identifier (Subscription Correlation ID) to be modified in the invocation of Nnwdaf\_MLModelProvision\_Subscribe.

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- a set of pair(s) of unique ML Model Identifier and ML Model Information associated with each Analytics ID requested by the service consumer.

NOTE 1: The structure and format of the ML Model identifier and its uniqueness are up to stage 3.

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The NWDAF containing MTLF also invokes the Nnwdaf\_MLModelProvision\_Notify service operation to notify an available re-trained ML model when the NWDAF containing MTLF determines that the previously provided trained ML Model required re-training at step 1.

When the step 1 is for a subscription modification (i.e. including Subscription Correlation ID), the NWDAF containing MTLF may provide either a new trained ML model different to the previously provided one, or re-trained ML model by invoking Nnwdaf\_MLModelProvision\_Notify service operation.

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### 6.2A.2 Contents of ML Model Provisioning

The consumers of the ML model provisioning services (i.e. an NWDAF containing AnLF) as described in clause 7.5 and clause 7.6 may provide the input parameters as listed below:

- Information of the analytics for which the requested ML model is to be used, including:

- A list of Analytics ID(s): identifies the analytics for which the ML model is used.

- [OPTIONAL] NF consumer information: identifies the vendor of NWDAF containing AnLF.

NOTE 1: NF consumer information such as Vendor ID is defined in Stage 3.

- [OPTIONAL] Use case context: indicates the context of use of the analytics to select the most relevant ML model ML model.

NOTE 2: The NWDAF containing MTLF can use the parameter "Use case context" to select the most relevant ML model, when several ML models are available for the requested Analytics ID(s). The values of this parameter are not standardized.

- [OPTIONAL] ML Model Interoperability Information. This is vendor-specific information that conveys, e.g., requested model file format, model execution environment, etc. The encoding, format, and value of ML Model Interoperable Information is not specified since it is vendor specific information, and is agreed between vendors, if necessary for sharing purposes.

- [OPTIONAL] ML Model Filter Information: enables the NWDAF containing MTLF to select which ML model for the analytics is requested, e.g. S-NSSAI, Area of Interest. Parameter types in the ML Model Filter Information are the same as parameter types in the Analytics Filter Information which are defined in procedures.

- [OPTIONAL] Target of ML Model Reporting: indicates the object(s) for which ML model is requested, e.g. specific UEs, a group of UE(s) or any UE (i.e. all UEs).

- [OPTIONAL] Requested representative ratio: a minimum percentage of UEs in the group whose data is a non-empty set and can be used in the model training when the Target of ML Model Reporting is a group of UEs.

- ML Model Reporting Information with the following parameters:

- (Only for Nnwdaf\_MLModelProvision\_Subscribe) ML Model Reporting Information Parameters as per Event Reporting Information Parameter defined in Table 4.15.1-1, TS 23.502 [3].

- [OPTIONAL] ML Model Target Period: indicates time interval [start, end] for which ML model for the Analytics is requested. The time interval is expressed with actual start time and actual end time (e.g. via UTC time).

- [OPTIONAL] Inference Input Data information: contains information about various settings that are expected to be used by AnLF during inferences such as:

- the "Input Data" that are expected be used, each of them optionally accompanied by **metrics** that show the granularity with which this data will be used (i.e., a sampling ratio, the maximum number of input values, and/or a maximum time interval between the samples of this input data).

NOTE 3: This can be a subset of the possible Input Data specified for a certain analytics type.

- the data sources that are expected to be used as a list of NF instance (or NF set) identifiers.

- A Notification Target Address (+ Notification Correlation ID) as defined in clause 4.15.1 of TS 23.502 [3], allowing to correlate notifications received from the NWDAF containing MTLF with this subscription.

- [OPTIONAL] Indication of supporting multiple ML models.

- [OPTIONAL] **Accuracy** level(s) of Interest.

- [OPTIONAL] Number of ML model(s), indicating the maximum number of ML models that the NWDAF containing MTLF could provide to the NWDAF containing AnLF.

NOTE 4: Multiple ML models Filter Information are composed by **Accuracy** level(s) of Interest and Number of ML model(s).

- [OPTIONAL] Time when model is needed: indicates the latest time when the consumer expects to receive the ML model(s).

- [OPTIONAL] ML Model Monitoring Information:

- [OPTIONAL] desired ML Model **metric**: e.g. ML Model **Accuracy**.

NOTE 4: In this release, only “Accuracy” is defined as ML model metric

- [OPTIONAL] ML model monitoring reporting mode: such as **Accuracy** reporting interval or pre-determined status. Depending on the reporting mode, the NWDAF containing MTLF reports the model **Accuracy** to NWDAF containing AnLF either periodically or when the ML model **Accuracy** is crossing an ML Model **Accuracy** threshold, i.e. the **Accuracy** either becomes higher or lower than the ML Model **Accuracy** threshold.

- [OPTIONAL] ML Model **Accuracy** Threshold: indicating the **Accuracy** threshold of the ML Model requested by the consumer (as a kind of pre-determined status). It also can be used as an indication that the MTLF is triggered to execute the **Accuracy** monitoring operations for the ML Model provisioned to AnLF.

- [OPTIONAL] DataSetTag and ADRF ID if available: indicates the inference data (including input data, prediction and the ground truth data at the time which the prediction refers to) stored in ADRF which can be used by MTLF to retrain or reprovision of the ML model.

- [OPTIONAL] ML Model Identifier: indicates the Model that the data corresponding to the DataSetTag is related to (in the case of subscription modification).

The NWDAF containing MTLF provides to the consumer of the ML model provisioning service operations as described in clause 7.5 and 7.6, the output information as listed below:

- (Only for Nnwdaf\_MLModelProvision\_Notify) The Notification Correlation Information.

- For each Analytics ID requested by the service consumer, a set of pair (s) of unique ML Model identifier and the following information.

- ML Model Information, which includes:

- the ML model file address (e.g. URL or FQDN); or

- ADRF (Set) ID.

When ADRF (Set) ID is provisioned, a Storage Transaction ID may also be provisioned.

- [OPTIONAL] ML model degradation indicator: indicates whether the provided ML model is degraded.

- [OPTIONAL] Validity period: indicates time period when the provided ML Model Information applies.

- [OPTIONAL] Spatial validity: indicates Area where the provided ML Model Information applies.

NOTE 5: Spatial validity and Validity period are determined by MTLF internal logic and it is a subset of AoI if provided in ML Model Filter Information and of ML Model Target Period, respectively.

- [OPTIONAL] ML model representative ratio: indicating the percentage of UEs in the group whose data is used in the ML model training when the Target of ML Model Reporting is a group of UEs.

- [OPTIONAL] Training Input Data Information: contains information about various settings that have been used by MTLF during training, such as:

- the "Input Data" that have been used, each of them optionally accompanied by **metrics** that show the data characteristics and granularity with which this data has been used (i.e. a sampling ratio, the maximum number of input values and/or a maximum time interval between the samples of this input data, data range including maximum and minimum values, mean and standard deviation and data distribution when applicable) and the time, i.e. timestamp and duration, when this data was obtained.

- the data sources related to the "Input Data" that were used for ML model training, which have been identified by a list of NF instance (or NF set) identifiers.

NOTE 6: This can be a subset of the possible Input Data specified for a certain analytics type.

NOTE 7: Data source information enables ML Model selection when different models are available for an Analytics ID, or it enables a consumer to avoid selecting a ML model that used data from a specific data source at a particular time or used data characterized by specific data characteristics.

- [OPTIONAL]ML Model **Accuracy** Information: indicates the **Accuracy** of the ML model if ML Model **Accuracy** threshold is requested, which includes:

- the **Accuracy** value of the ML model.

- [OPTIONAL] used ML model **metric** to calculate Accuracy value (e.g. ML Model **Accuracy**).

#### 6.2C.2.2 General procedure for Federated Learning among Multiple NWDAF Instances



Figure 6.2C.2.2-1: General procedure for Federated Learning among Multiple NWDAF

0. The consumer (NWDAF containing AnLF or NWDAF containing MTLF) sends a subscription request to FL server NWDAF to retrieve an ML model, using Nnwdaf\_MLModelProvision service as defined in clause 7.5 including Analytics ID, desired ML model **metric** (e.g., ML model **Accuracy**), **Accuracy** reporting interval, pre-determined status (ML model **Accuracy** threshold or Time when the ML model is needed).

NOTE 1: The ML model **Accuracy** threshold can be used to indicate the target ML Model **Accuracy** of the training process and the FL server NWDAF may stop the training process when the ML model **Accuracy** threshold is achieved during the training process.

If the consumer (i.e. the NWDAF containing AnLF or NWDAF containing MTLF) provides the Time when the ML model is needed, the FL Server NWDAF can take this information into account to decide the maximum response time for its FL Client NWDAF(s).

1. FL Server NWDAF selects NWDAF(s) containing MTLF (FL Client NWDAF(s)) as described in clause 6.2C.2.1.

2. FL Server NWDAF sends a Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request to the selected NWDAF containing MTLF (FL Client NWDAF(s)), which participates in the Federated learning to perform the local model training and determine the interim local ML model information based on the input parameter in the request from FL Server NWDAF. The request includes the desired ML model **metric** and initial ML model and also includes the maximum response time, the FL Client NWDAF has to report the interim local ML model information to the FL Server NWDAF before the maximum response time elapses.

3. [Optional] Each FL Client NWDAF collects its local data by using the current mechanism in clause 6.2 if the Client NWDAF has not local data available already.

4. During Federated Learning training procedure, each FL Client NWDAF further trains the ML model provided by the FL Server NWDAF based on its own data and reports the interim local ML model information to the FL Server NWDAF in Nnwdaf\_MLModelTraining\_Notify or Nnwdaf\_MLModelTrainingInfo\_Request response. The Nnwdaf\_MLModelTraining\_Notify or Nnwdaf\_MLModelTrainingInfo\_Request response may also include the Status report of FL training that includes local ML model accuracy value (and optional the used **metric)** computed by the FL Client NWDAF and Training Input Data Information (e.g. areas covered by the data set, sampling ratio, maximum/minimum of value of each dimension of data, etc.) in the FL Client NWDAF. The Nnwdaf\_MLModelTraining\_Notify or Nnwdaf\_MLModelTrainingInfo\_Response also includes the global ML Model **Accuracy** value (and optionally the used metric) when the ML Model **Accuracy** Check Flag was included in the Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request (as described in step 7), the global ML Model **Accuracy** value is calculated by the FL Client NWDAF using the local training data as the testing dataset.

NOTE 2: The parameters in characteristics of local training dataset are up to the implementation.

The local ML model, which is sent from the FL Client NWDAF(s) to the FL Server NWDAF during the FL training process, is the information needed by the FL Server NWDAF to build the aggregated model.

If the FL Client NWDAF is not able to complete the training of the interim local ML model within the maximum response time provided by the FL Server NWDAF, the FL Client NWDAF shall send the Delay Event Notification that include the delay event indication, an optional cause code (e.g. local ML model training failure, more time necessary for local ML model training) and the expected time to complete the training if available to the FL Server NWDAF before the maximum response time elapses.

4a. [Optional]If FL Server NWDAF receives notification/response that the FL Client NWDAF is not able to complete the training within the maximum response time, the FL Server NWDAF may send to the FL Client NWDAF a new maximum response time in Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request, before which the FL Client NWDAF has to report the interim local ML model information to the FL Server NWDAF. Otherwise, the FL Server NWDAF may indicate FL Client NWDAF to skip reporting for this iteration. FL Server NWDAF includes the current iteration round ID in the message to indicate that the request is to modify the training parameters of the current iteration round.

Alternatively, the FL Server NWDAF may inform the FL Client NWDAF to cease the ML model training by sending termination request and to report back the current local ML model updates.

5. The FL Server NWDAF aggregates all the local ML model information retrieved at step 4, to update the global ML model. The FL Server NWDAF may also compute the global ML model accuracy value, e.g. based on the local ML model accuracy values or by applying the global model on the validation dataset (if available). The FL Server NWDAF may update the global ML model each time a FL Client NWDAF provides updated local ML model information, or the FL Server NWDAF may decide to wait for local ML model information from all FL Client NWDAFs before updating the global ML model.

If the FL Server NWDAF provides the maximum response time for the FL Client NWDAF(s) to provide the interim local ML model information in step 2, or the new maximum response time in step 4a, the FL Server NWDAF decides either to wait for the FL Client NWDAF(s) which have not yet provided their interim local ML model within the new maximum response time or to aggregate only the retrieved local ML model information instances to update global ML model. The FL Server NWDAF makes this decision, considering the notification/response from the FL Client NWDAF or, if the notification is not received, based on local configuration.

6a. [Optional] Based on the consumer request in step 0, the FL Server NWDAF sends a Nnwdaf\_MLModelProvision\_Notify message to update the ML model accuracy value to the consumer periodically (e.g. a certain number of training rounds or every 10 min) or dynamically when some pre-determined status is achieved (e.g. the ML Model **Accuracy** threshold is achieved or training time expires).

6b. [Optional] The consumer decides whether the current model can fulfil the requirement, e.g. global ML model accuracy value is satisfactory for the consumer and determines to stop or continue the training process. The consumer re-invokes Nnwdaf\_MLModelProvision\_Subscribe service operation as used in step 0 to continue the training process or invokes Nnwdaf\_MLModelProvision\_Unsubscribe service operation to stop the training process.

6c. [Optional] Based on the subscription request sent from the consumer in step 6b, the FL Server NWDAF updates or terminates the current FL training process.

If the FL Server NWDAF received a request in step 6b to stop the Federated Training process, steps 7 and 8 are skipped.

7. If the FL procedure continues, FL Server NWDAF may determine FL Client NWDAF as described in clause 6.2C.2.3 and sends Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request that includes the aggregated ML model information to selected FL Client NWDAF(s) for next round of Federated Training. The request may also include the ML Model **Accuracy** Check Flag, that indicates the FL Client NWDAF(s) to use the local training data as the testing dataset to calculate the Model **Accuracy** value of the global ML model provided by the FL Server NWDAF.

8. Each FL Client NWDAF updates its own ML model based on the aggregated ML model information distributed by the FL Server NWDAF at step 7.

NOTE 3: The steps 3-8 should be repeated until the training termination condition (e.g. maximum number of iterations, or the result of loss function is lower than a threshold) is reached.

When the Federated Training procedure is complete, the FL Server NWDAF requests the FL client NWDAF(s) to terminate the FL procedure by invoking Nnwdaf\_MLModelTraining\_Unsubscribe service with a cause code that the FL process has finished and optionally with the final aggregated ML model information. Then the FL client NWDAF(s) terminate the local model training and if the final aggregated ML model information is received from the FL server NWDAF, the FL client NWDAF(s) can store it for further use.

9. After the training process is complete, the FL Server NWDAF may send Nnwdaf\_MLModelProvision\_Notify that includes the globally optimal ML model information to the consumer.

#### 6.2C.2.3 Procedures for Maintaining Federated Learning Processes

This clause specifies how to maintain a Federation Learning process in FL execution phase, including FL Server NWDAF triggers reselection, addition, or removal of FL Client NWDAF(s), discovers new FL Client NWDAF(s) via NRF and FL Client NWDAF(s) joins or leaves Federated Learning process dynamically.

In Federated Learning execution phase, FL Server NWDAF monitors the status changes of FL Client NWDAF(s) and may reselects FL Client NWDAF(s) based on the updated status, availability and/or capability, etc.

NOTE 1: FL Server NWDAF checks if there is a need to carry on the FL execution phase and then reselects FL members for the next iteration if needed.



Figure 6.2C.2.3-1: Procedure of FL Server NWDAF reselects FL Client NWDAF(s), FL Client NWDAF(s) Join or Leave Federated Learning Process Dynamically in Federated Learning execution phase

The procedure for FL Server NWDAF reselecting FL Client NWDAF(s), FL Client NWDAF(s) joining or leaving Federated Learning process dynamically is as follows:

1a. FL Server NWDAF may get the updated status of current FL Client NWDAF(s) via NRF by using Nnrf\_NFManagement service (as in clause 5.2.7.2 of TS 23.502 [3]) in the Federated Learning execution phase.

FL Server NWDAF may subscribe to NRF for notifications of status changes of the current NWDAF(s) (FL Client NWDAFs 1…N) by invoking an Nnrf\_NFManagement\_NFStatusSubscribe service operation. NRF notifies the FL Server NWDAF the status changes of the current FL Client NWDAF(s) by invoking Nnrf\_NFManagement\_NFStatusNotify service operation(s).

The status of a current FL Client NWDAF could be availability changes, capability changes (e.g. it will not support FL anymore, etc.).

1b. The current FL Client NWDAF(s) may inform FL Server NWDAF that it is leaving the Federated Learning process by invoking Nnwdaf\_MLModelTraining\_Notify service operation with Termination Request and cause code (reason for leaving, e.g. high NF load, time availability changes).

1c. FL Server NWDAF may get the information of the new FL Client NWDAF(s) dynamically via NRF by subscribing to the event that a new FL Client NWDAF registers (Nnrf\_NFManagement\_NFStatusSubscribe service as in clause 5.2.7.2 of TS 23.502 [3]).

1d. NWDAF may subscribe for NF load analytics of the FL Client NWDAF(s).

1e. FL Client NWDAF(s) may send Status report of FL training and Global ML Model **Accuracy** Information by invoking Nnwdaf\_MLModelTraining\_Notify service.

2. FL Server NWDAF checks FL Client NWDAF(s) status based on the received information and may determine whether reselection of FL Client NWDAF(s) for the next round(s) of Federated Learning is needed based on the received information from step 1.

NOTE 2: Several examples of the factors that the FL Server NWDAF can consider to reselect the FL Client NWDAF(s) are updated status of FL Client NWDAF reported by NRF is different than the criteria were initially used for selecting the client; characteristics of local training dataset is different than global validation dataset owned by FL Server NWDAF and/or the **Accuracy** value of the global model calculated using the local training dataset is much different from that calculated by other FL Client NWDAFs; the **Accuracy** value of the global model calculated using the local training dataset is lower than the **Accuracy** value calculated using the global validation dataset owned by FL Server NWDAF; the **Accuracy** value of the global model calculated using the local training dataset is lower than ML Model **Accuracy** information received in Nnwdaf\_MLModelMonitor\_Notify when FL Server NWDAF using AnLF-assisted MTLF ML Models **Accuracy** Monitoring; the load of the FL Client NWDAF (from the NF load Analytics or from the FL Client NWDAF directly) is high; the FL Server NWDAF receives leave request from the FL Client NWDAF; the FL Client NWDAF did not report the status of FL Training within the maximum response time.

3. [If re-selection is needed as judged in step 2] If step 1c is not performed, FL Server NWDAF may discover new candidate FL Client NWDAF(s) via NRF by using Nnrf\_NFDiscovery services as in clause 5.2.7.3 of TS 23.502 [3]. FL Server NWDAF reselects FL Client NWDAF(s) from the current FL Client NWDAF(s) and the new candidate FL Client NWDAF(s) (found in steps 1c or 3). For the new candidate FL Client NWDAF(s), the interaction between FL Server NWDAF and FL Client NWDAF(s) is same as the selection procedure described in clause 6.2C.2.1. The adding / deleting FL Client NWDAF(s) may happen at the end of each iteration.

4. FL Server NWDAF sends termination request by invoking Nnwdaf\_MLModelTraining\_Unsubscribe service operation or Nnwdaf\_MLModelTrainingInfo\_Request service operation with Correlation Termination Flag to the FL Client NWDAF(s), optionally indicating the reason, e.g. FL Client NWDAF is unselected by the FL Server NWDAF for the FL process, or the FL process is suspended, etc. And FL server may also send the updated global ML model information to the unselected FL client NWDAF. FL Client NWDAF(s) terminates operations for the Federated Learning process if receive termination request from the FL Server NWDAF and may perform further action to be qualified in participation of FL training in the next cycles.

NOTE 3: In the case of high load, the FL Client NWDAF can e.g. decline new service request. In the case of low **Accuracy**, the FL Client NWDAF can gather new local training data.

## 6.2E MTLF-based ML Model **Accuracy** Monitoring

### 6.2E.1 General

MTLF-based ML Model **Accuracy** Monitoring procedure is where an NWDAF containing MTLF determines ML Model degradation based on newly collected test data and retrain or reprovisioning the existing ML Model.

### 6.2E.2 Procedure for MTLF-based ML Model **Accuracy** Monitoring

Figure 6.2E.2-1 illustrates the procedure for monitoring the **Accuracy** of the provisioned ML model using newly collected data. NWDAF containing AnLF may provide inference data to NWDAF containing MTLF for model **Accuracy** monitoring and the NWDAF containing MTLF determines retraining or re-provisioning of the ML model.



Figure 6.2E.2-1: Procedure for MTLF-based ML Model Accuracy Monitoring

1. An analytics consumer initiates a subscription for analytics exposure services towards an NWDAF containing AnLF.

2. The NWDAF containing AnLF requests an ML model from the appropriate NWDAF containing MTLF, using the Nnwdaf\_MLModelProvision\_Subscribe service operation. The NWDAF containing AnLF may include an ML Model **Accuracy** threshold which is used as an indicator to execute the **Accuracy** monitoring operations as defined in clause 6.2A.2. NWDAF containing AnLF may include a DataSetTag (see clause 6.2B.1) and/or ADRF ID, which is used to store and fetch the inference data (including input data, prediction and the ground truth data at the time which the prediction refers to) from ADRF which are relevant for the **Accuracy** monitoring and re-training/re-provisioning of ML model.

If the NWDAF containing AnLF receives ML model(s), the NWDAF containing AnLF sends set of tuples (unique ML model identifier and the DataSetTag and/or ADRF ID) to the NWDAF containing MTLF by invoking Nnwdaf\_MLModelProvision\_Subscribe service operation for subscription modification.

3. The NWDAF containing MTLF provides trained ML model(s) to the NWDAF containing AnLF. The NWDAF containing MTLF may include an **Accuracy** information which is used to indicate the **Accuracy** of ML model during the training.

When the step 1 is for a subscription modification (i.e. including Subscription Correlation ID) and contains the set of tuples (unique ML model identifier and the DataSetTag and/or ADRF ID), the NWDAF containing MTLF determines the relationship between the ML model and the DataSetTag.

4. The NWDAF containing AnLF registers the use of the ML model with the NWDAF containing MTLF to indicate its capability of sending Analytics feedback information and/or ML model **Accuracy** information from the analytics consumers for the ML model.

5. Due to the registration in the previous step, the NWDAF containing MTLF may subscribe to the NWDAF containing AnLF to get Analytics feedback information and/or ML model **Accuracy** information from the analytics consumers for the provisioned ML model by invoking Nnwdaf\_MLModelMonitor\_Subscribe service operation, if the service operation is supported by the NWDAF containing AnLF.

6. The Analytics consumer may send Analytics feedback information in an Nnwdaf\_AnalyticsSubscription\_Subscribe message as described in clause 6.1.1.

7. The NWDAF containing AnLF may send the Analytics feedback information and/or ML model **Accuracy** information received from the analytics consumer for the provisioned ML model by invoking Nnwdaf\_MLModelMonitor\_Notify service operation as requested in step 5. When the NWDAF containing MTLF receives Analytics feedback information and/or ML model **Accuracy** information, the NWDAF containing MTLF may trigger step from 8 to 13 to enhance the ML model **Accuracy**.

8a-8f. The NWDAF containing MTLF, based on the request(s) from one or more NWDAF containing AnLF or its local policy, determines whether to perform ML model **Accuracy** monitoring and re-training/re-provisioning of ML model by collecting new data from various data sources:

- The NWDAF containing MTLF may collect new data for ML Model **Accuracy** monitoring, re-training and re-provisioning from the data source NFs and DCCF by invoking Nnf\_EventExposure\_Subscribe and Ndccf\_DataManagement\_Susbscribe service operation, respectively.

- When ADRF ID and/or DataSetTag is given by step 2, the NWDAF containing MTLF may retrieve historical data from the ADRF indicated by the NWDAF containing AnLF at step 2. by invoking Nadrf\_DataManagementRetrievalRequest or Nadrf\_DataManagementRetrieval\_Subscribe service operation. Otherwise, the NWDAF containing MTLF may retrieves the historical data from the DCCF or the NWDAF containing AnLF by invoking Ndccf\_DataManagement\_Subscribe or Nnwdaf\_DataManagement\_Subscribe service operation, respectively.

- If the NWDAF containing AnLF does not include a DataSetTag with ADRF ID at step 2, the NWDAF containing MLTF may request ADRF to subscribe for the collection of the analytics and data that correspond to the analytics generated by the ML model provisioned in step 3, using the procedures defined in clause 6.2B.3.

- The NWDAF containing MTLF may subscribe to UDM to get notification on change in the subscription data for Target of ML Model Reporting by invoking Nudm\_SDM\_Subscribe service operation and the UDM subscribes to the UDR to get notifications of the modification on UE subscription data by invoking Nudr\_DM\_Subscribe service operation.

- The NWDAF containing MTLF may consider the data quality into the **Accuracy** monitoring by collecting fault prediction analytics data from MDAS to determine the status of Data Source NFs, using MDA Request.

If the NWDAF containing MTLF has already collected new test data and performed ML model **Accuracy** monitoring and retraining which is triggered by other NWDAF containing AnLF(s) (for ML model **Accuracy** monitoring and retraining), the NWDAF containing MTLF, based on its internal logic, determines whether to use the data for the subscription or not.

9a-9f. The NWDAF containing MTLF receives the requested data from various sources as requested in steps 8a-8f.

10. Based on the collected analytics and data from steps 9a-9f, the NWDAF containing MTLF computes the **Accuracy** using the methods described in clause 5C.1. The NWDAF containing MTLF may discard data from data sources if it detects the data quality of that source is not good. The NWDAF containing MTLF may generate prediction with the collected input data to calculate the **Accuracy** if only input data and ground truth data are available.

NOTE: How the NWDAF containing MTLF determines whether the data from the data source is of good quality or needs to be discarded is up to the NWDAF implementation and configuration.

11. An **Accuracy** report is sent to the NWDAF containing AnLF, e.g. when the reporting threshold is met by invoking Nnwdaf\_MLModelProvision\_Notify service operation.

12. Based on the computed **Accuracy**, the NWDAF containing MTLF may decide to re-train/re-provision the ML model.

13. When the newly generated or re-trained ML model is ready, the NWDAF containing MTLF sends new or re-trained ML model to the NWDAF containing AnLF by invoking Nnwdaf\_MLModelProvision\_Notify service operation. The NWDAF containing MTLF may send the **Accuracy** report of the new or re-trained ML model to the NWDAF containing AnLF.

### 6.2E.3 Procedure for AnLF-assisted MTLF ML Models **Accuracy** Monitoring

#### 6.2E.3.1 General

The procedures described in this clause enable the following functionality:

- An NWDAF containing AnLF may register with an NWDAF containing MTLF when it starts using an ML model and monitoring the **Accuracy** of analytics generated by that ML Model for a given Analytics ID. It is assumed that the NWDAF containing AnLF obtained the ML model in a previous interaction with the NWDAF containing MTLF, e.g. using the Nnwdaf\_MLModelInfo\_Request or Nnwdaf\_MLModelProvision services. This registration enables the NWDAF containing MTLF to become aware of NWDAF containing AnLF that are using a given ML model for certain Analytics ID and that the NWDAF containing AnLF supports the capability of monitoring the **Accuracy** of the corresponding analytics.

- An NWDAF containing MTLF may subscribe to an NWDAF containing AnLF where an existing Nnwdaf\_MLModelMonitor service is established for receiving notifications of the **Accuracy** of analytics generated by a given ML model for a certain Analytics ID. NWDAF containing AnLF can generate the **Accuracy** information in many ways: e.g. comparing predictions of ML model and its corresponding ground truth data, comparing changes in internal configuration for the analytics ID generation, previous existent records of analytics **Accuracy** information etc.

#### 6.2E.3.2 Procedures for registering the monitoring of the analytics **Accuracy** of an ML Model

When an NWDAF containing AnLF starts making use of an ML model and it has the ability either to monitor the analytics **Accuracy** of the ML model, or to deliver Analytics feedback information for the analytics generated by the ML model, it registers with the NWDAF containing MTLF, that is responsible for training/updating this ML model.

When the NWDAF containing AnLF is no longer using the ML model or monitoring the **Accuracy** of the analytics generated by that ML model for the Analytics ID, it de-registers it with the responsible NWDAF containing MTLF.

Figure 6.2E.3.2-1 illustrates the procedure by which an NWDAF containing AnLF registers with an NWDAF containing MTLF that it is starting to make use and monitor the analytics **Accuracy** of an ML model. A new Nnwdaf\_MLModelMonitor\_Register service operation is used for that purpose.



Figure 6.2E.3.2-1: Procedure for ML Model monitoring registration

An NWDAF containing AnLF may start monitoring the **Accuracy** of an ML model based on local policy or request from its service consumer.

1-2. The NWDAF containing AnLF sends an Nnwdaf\_MLModelMonitor\_Register request to an NWDAF containing MTLF (NWDAF containing AnLF NF ID, unique identifier of the ML model, optionally: subscription endpoint of the Nnwdaf\_MLModelMonitor\_Subscribe service operation at the NWDAF containing AnLF). The NWDAF containing MTLF is now aware of the NF ID of the NWDAF containing AnLF that is monitoring the **Accuracy** of that ML model.

If the NWDAF containing AnLF is a target NWDAF in analytics transfer procedure (as defined in clause 6.1B), based on the ML Model **Accuracy** information received from source NWDAF containing AnLF, the NWDAF containing AnLF also includes in the Nnwdaf\_MLModelMonitor\_Register service request the ML Model **Accuracy** transfer indication, which includes the original Subscription Correlation ID for the ML model **Accuracy** information provided by the source NWDAF containing AnLF and the source NF ID of the NWDAF containing AnLF.

NOTE 1: These parameters support the NWDAF containing MTLF to map the registration of a new NWDAF containing AnLF with an existing subscription for consumption of ML model **Accuracy** information from a previous NWDAF containing AnLF (i.e. source NWDAF containing AnLF which as described in steps 3-4 may provide a termination indication), enabling NWDAF containing MTLF to reassociate the data from the previous subscription to the new the subscription for ML Model **Accuracy** provisioning at the new NWDAF containing AnLF.

3-4. When the NWDAF containing AnLF is no longer using the ML model, it sends an Nnwdaf\_MLModelMontior\_Deregister service operation.

If NWDAF containing AnLF is registered with a NWDAF containing MTLF, is a source NWDAF containing AnLF in an analytics transfer procedure (as defined in clause 6.1B) and is no longer using the ML model, the NWDAF containing AnLF sends Nnwdaf\_MLModelMontior\_Deregister service operation request including the ML Model **Accuracy** provisioning termination information, which includes: a termination indication, the termination cause set to analytics transfer and optionally the NWDAF containing AnLF NF ID of the target NWDAF.

NOTE 2: The ML Model **Accuracy** termination information is used by the NWDAF containing MTLF to determine whether the termination request is from the source NWDAF containing AnLF. If so, the NWDAF containing MTLF will not delete any data immediately upon receiving of a de-registration request. Then the NWDAF containing MTLF is able to associate the data from the source NWDAF containing AnLF to the target NWDAF containing AnLF.

#### 6.2E.3.3 Procedures for monitoring the analytics **Accuracy** of an ML model

An NWDAF containing MTLF, due to the registration of monitoring of the analytics **Accuracy** of an ML model received from NWDAF containing AnLF and local policies, subscribes to the NWDAF containing AnLF for receiving notifications of either the **Accuracy** of the ML Model, or Analytics feedback information of the ML model. The NWDAF containing MTLF may get the Subscription endpoint address of the NWDAF containing AnLF from the information received in a previous registration or through a service discovery procedure at the NRF.

Figure 6.2E.3.3-1 illustrates the procedure either for monitoring the analytics **Accuracy** of an ML model or for delivery of Analytics feedback information of an ML model. Nnwdaf\_MLModelMonitor\_Subscribe and Nnwdaf\_MLModelMonitor\_Notify service operations are used for the purposes. A service consumer, i.e. an NWDAF containing MTLF, subscribes at a service producer, i.e. an NWDAF containing AnLF, to be notified when either the analytics **Accuracy** of the previously provisioned ML model is not sufficient, or Analytics feedback information is retrieved from analytics consumer NF.



Figure 6.2E.3.3-1: Procedure for monitoring the analytics Accuracy of an ML model

0. Upon the reception of an Nnwdaf\_MLModelMonitor\_Register request and based on local policy, the NWDAF containing MTLF determines to subscribe to the analytics **Accuracy** monitoring for the ML model as defined in clause 5C.1.

1. The NWDAF containing MTLF sends an Nnwdaf\_MLModelMonitor\_Subscribe request (Analytics ID(s), unique identifier(s) of the ML model(s) to be monitored, desired **Accuracy** **metrics** to be monitored, optionally Reporting Threshold(s) or Reporting Period) to an NWDAF containing AnLF subscription endpoint.

When the NWDAF containing MTLF determines during the registration process described in clause 6.2E.3.2 that a subscription request for ML model **Accuracy** monitoring to an NWDAF containing AnLF is related to a previous subscription for ML model **Accuracy** information to a different NWDAF containing AnLF (due to changes in the provider of the ML **Accuracy** monitoring for a given ML model, as an effect of analytics transfer among NWDAFs containing AnLF), the NWDAF containing MTLF may use as base for the new subscription request at the new NWDAF containing AnLF the parameters associated with the original subscription identification for the ML model **Accuracy** information that was received in the registration request of the new NWDAF containing AnLF, as described in steps 1-2 of clause 6.2E.3.2.

2. The NWDAF containing AnLF sends a response to the NWDAF containing MTLF.

3. The analytics consumer NF may send Analytics feedback information to the NWDAF containing AnLF as described in clause 6.1.1.

4. When step 1 is triggered, the NWDAF containing AnLF may start monitoring the analytics **Accuracy** of the ML model(s), if it not started yet.

NOTE 1: The NWDAF containing AnLF can monitor the analytics **Accuracy** in many ways: e.g. comparing predictions of ML model and its corresponding ground truth data, comparing changes in internal configuration for the analytics ID generation, previous existent records of analytics **Accuracy** information etc.

5. The NWDAF containing AnLF determines whether the analytics **Accuracy** of the ML model is insufficient, i.e. deviation of the output analytics using the trained ML model from ground truth data (which are collected from Data Producer NF corresponding to analytic ID requested at the time which the prediction refers to) is greater than the Reporting Threshold(s) (which are locally configured or received in the Subscribe request), or the Reporting Period indicated in the Subscribe request is reached.

6. Either the Analytics feedback information is retrieved at step 3 or the NWDAF containing AnLF detects the analytics **Accuracy** of ML model is insufficient at step 5, the NWDAF containing AnLF sends an Nnwdaf\_MLModelMonitor\_Notify request to the notification endpoint (e.g. the NWDAF containing MTLF). The Notify request includes either Analytics feedback information, or the monitored ML model **Accuracy** information of the ML model (e.g. a Deviation value which indicates the deviation of the predictions generated using the ML model(s) from the ground truth data and the network data when the deviation occurs (which can be used by the NWDAF containing MTLF for possible ML model retraining) and the number of inferences that were performed during the time interval between Nnwdaf\_MLModelMonitor\_Register request and the Notify request or between the time of last Notification message and the time of the current Notification message and optionally an indication that the analytics **Accuracy** of the ML model does not meet the requirement of **Accuracy** for the ML model.

7. The NWDAF containing MTLF sends a response.

8. The NWDAF containing MTLF determines whether the ML model is degraded or not based on the notification at step 6. If the notification contains Analytics feedback information, the NWDAF containing MTLF may determine ML model degradation based on the procedures as described in clause 6.2E.2. Otherwise when the NWDAF containing MTLF has received the multiple analytics **Accuracy** information, from one or more NWDAFs containing AnLF, it may consider that the ML model is degraded/to be updated (i.e. enough number analytics **Accuracy** information received from one or more NWDAFs containing AnLF, indicating insufficient analytics **Accuracy**).

NOTE 2: The actual mechanism for the NWDAF containing MTLF for determining the degradation of the ML model degradation is an internal procedure of the NWDAF containing MTLF, e.g. the NWDAF containing MTLF calculate a global **Accuracy** based on the analytics **Accuracy** information and the number of inferences received from multiple NWDAFs containing AnLF.

9. When an ML model is considered degraded / to be updated at step 8, the NWDAF containing MTLF re-trains the existing ML model or selects a new ML model. If the network data was not included in the Nnwdaf\_MLModelMonitor\_Notify request of step 5, the NWDAF containing MTLF may request data from the NWDAF containing AnLF, ADRF and/or other 5GS entities as specified in clause 6.2 and use the collected data for ML model retraining. The NWDAF containing MTLF notifies the NWDAF(s) containing AnLF with the updated trained ML Model Information by invoking Nnwdaf\_MLModelProvision\_Notify service operation, as described in clause 6.2A.

## 6.2F Procedure for ML Model Training

### 6.2F.1 ML Model Training Subscribe/Unsubscribe

The procedure in Figure 6.2F.1-1 is used by an NWDAF service consumer, i.e. an NWDAF containing MTLF to subscribe to another NWDAF, i.e. an NWDAF containing MTLF, for a trained ML model based on the ML model file or ML Model information as described in clause 6.2F.2 provided by the NWDAF service consumer. The service may be used by an NWDAF containing MTLF to enable e.g. Federated Learning or to update ML model. The service is also used by an NWDAF service consumer to request an NWDAF containing MTLF to prepare training ML model or modify existing ML Model training subscription.



Figure 6.2F.1-1: Procedure for ML Model Training subscribe/unsubscribe

1. The NWDAF service consumer may subscribe or unsubscribe for training an ML model by invoking the Nnwdaf\_MLModelTraining\_Subscribe/ Nnwdaf\_MLModelTraining\_Unsubscribe service operation. The parameters that can be provided by the NWDAF service consumer are listed in clause 6.2F.2.

In order to enable Federated Learning, NWDAF Service consumer act as FL Server NWDAF can subscribe to multiple NWDAFs containing MTLF act as FL Client NWDAFs, which are selected by the FL Server NWDAF.

The FL server NWDAF may use the request to check if an NWDAF can meet the ML model training requirement (e.g. ML Model Interoperability information, Analytics ID, Serving Area and/or availability of data and time). In such case, the FL server NWDAF includes an ML Preparation Flag. When the ML Preparation Flag presents in the request, the service provider NWDAF only checks if it can meet the ML model training requirement (e.g. ML Model Interoperability information, Analytics ID, Serving Area and/or availability of data and time) and / or can successfully download the model if the model information is provided.

The FL server NWDAF may use the request to get the Model **Accuracy** information of the global ML Model calculated by the FL Client NWDAFs. In such cases, the service consumer NWDAF includes a Model **Accuracy** Check Flag. When the Model **Accuracy** Check Flag is present in the request, the service provider NWDAF uses the local training data as the testing dataset to calculate the Model **Accuracy** information of the ML model provided by the service consumer NWDAF.

When NWDAF service consumer determine to further update the ML model, NWDAF service consumer modifies the subscription by invoking Nnwdaf\_MLModelTraining\_Subscribe service operation including Subscription Correlation ID with ML Model Information (as defined in clause 6.2A.2).

2. The NWDAF containing MTLF trains ML model provided at step 1 by collecting new data or re-use the data that it owns. If the ML model file is not provided in step 1, the NWDAF containing MTLF shall first get the ML model using the information indicated at step 1.

3. When the NWDAF containing MTLF completes ML model training, the NWDAF containing MTLF notifies the NWDAF service consumer with ML Model Information (as defined in clause 6.2A.2) of updated ML Model) by invoking the Nnwdaf\_MLModelTraining\_Notify service operation. The parameters that can be provided by the NWDAF containing MTLF as service provider is specified in clause 6.2F.2.

If the NWDAF containing MTLF determines to terminate the ML model training, i.e. NWDAF containing MTLF will not provide further notifications related to this request, then the NWDAF containing MTLF may notify the NWDAF Service consumer a Terminate Request indication with cause code (e.g. NWDAF overload, not available for the FL process anymore, etc.) by invoking the Nnwdaf\_MLModelTraining\_Notify service operation.

In order to enable Federated Learning, NWDAF containing MTLF acting as FL Client NWDAF can notify NWDAF Service consumer acting as FL Server NWDAF the local ML model information and status report of FL training including **Accuracy** information of local model and Training Input Data Information (e.g. areas covered by the data set, sampling ratio, maximum/minimum of value of each dimension, etc.).

If the Model **Accuracy** Check Flag is present in the Nnwdaf\_MLModelTraining\_Subscribe, the service provider NWDAF acting as FL Client NWDAF may notify the NWDAF Service consumer acting as FL Server NWDAF the Model **Accuracy** information of the global ML Model.

### 6.2F.2 Contents of ML Model Training

The consumers of the ML model training services (i.e. an NWDAF containing MTLF) may provide the input parameters in Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request service operations as listed below:

- Analytics ID: identifies the analytics for which the ML model is requested to be trained.

- ML Model Interoperability Information as defined in clause 6.2A.2.

- (Only for Nnwdaf\_MLModelTraining\_Subscribe) A Notification Target Address (+ Notification Correlation ID) as defined in TS 23.502 [3] clause 4.15.1, allowing to correlate notifications received from the NWDAF containing MTLF with the subscription.

- [OPTIONAL] ML Model Information (as defined in clause 6.2A.2).

- [OPTIONAL] ML Model file.

NOTE 1: It is up to NWDAF implementation to determine whether to include ML Model file in input parameters considering ML Model file size, etc.

- [OPTIONAL] ML Model ID: identifies the provided ML model.

- [OPTIONAL] ML Preparation Flag: identifies whether the request is for preparing Federated Learning or executing Federated Learning.

- [OPTIONAL] ML Model **Accuracy** Check Flag: identifies that the request is for using the local training data as the testing dataset to calculate the Model **Accuracy** information of the global ML model provided by the NWDAF service consumer acting as the FL Server NWDAF.

- [OPTIONAL] ML Correlation ID: identifies the Federated Learning procedure for training the ML model. This parameter is included when the service is used for Federated Learning.

- [OPTIONAL] Available data requirement. This is for informing the requirement on available data for the ML model training. e.g. FL Server NWDAF sends the requirement in preparation request to a FL Client NWDAF for selecting the FL Client NWDAF which can meet the available data requirement. The following available data requirements can be included:

- Event ID list to be collected for local model training.

- Dataset statistical properties as defined in clause 6.1.3.

- Time window of the data samples.

- Minimum number of data samples.

- [OPTIONAL] Availability time requirement. This is for informing the requirement on availability time for the ML model training, e.g. FL Server NWDAF sends the requirement in preparation request to FL Client NWDAF for selecting the FL Client NWDAF which is available in the required time for training ML model.

- [OPTIONAL] Training Filter Information: enables to select which data for the ML model training is requested, e.g. S-NSSAI, Area of Interest. Parameter types in the Training Filter Information are the same as or subset of parameter types in the ML Model Filter Information which are defined in procedure 6.2A.1.

- [OPTIONAL] Target of Training Reporting: indicates the object(s) for which data for ML model training is requested, i.e. a group of UEs or any UE (i.e. all UEs).

- [OPTIONAL] Use case context: indicates the context of use of ML model.

- [OPTIONAL] Training Reporting Information with the following parameters:

- Maximum response time: indicates maximum time for waiting notifications (i.e. model training results).

- [OPTIONAL] Iteration round ID: indicates the iteration round number of current ML model training.

- [OPTIONAL] Expiry time.

The NWDAF containing MTLF provides to the consumer of the ML model training service operations as described in clause 7.10, the output information in notification as listed below:

- The Notification Correlation Information.

- [OPTIONAL] ML Model Information (as defined in clause 6.2A.2).

- [OPTIONAL] ML Model ID: identifies the provisioned ML model.

- [OPTIONAL] Model **Accuracy information**: The model **Accuracy** value of the global ML model and optionally the used metric, which is calculate by the FL Client NWDAF using the local training data as the testing dataset.

[OPTIONAL] Status report of FL training: **Accuracy** information of local model and Training Input Data Information (e.g. areas covered by the data set, sampling ratio, maximum/minimum of value of each dimension , etc.), which are generated by the FL Client NWDAF during FL procedure.

NOTE 2: The parameters in Training Input Data Information are up to the implementation.

- [OPTIONAL] ML Correlation ID. This parameter may be included when the service is used for Federated Learning.

- [OPTIONAL] Iteration round ID: indicates the iteration round number of ML model training indicated by the FL Server NWDAF.

- [OPTIONAL] Delay Event Notification with the following parameters:

- delay event indication: this parameter indicates that FL Client NWDAF is not able to complete the training of the interim local ML model within the maximum response time provided by the FL Server NWDAF.

- [OPTIONAL] cause code (e.g. local ML model training failure, more time necessary for local ML model training, etc.).

- [OPTIONAL] Expected time to complete the training: Indicates to the FL Server NWDAF that expected remaining training time and may be provided with Delay Event Notification.

### 6.2F.3 ML Model Training Information Request

The procedure in Figure 6.2F.3-1 is used by an NWDAF service consumer, i.e., an NWDAF containing MTLF to request another NWDAF, i.e., an NWDAF containing MTLF, for the information about ML model training based on the ML model file or ML Model information as described in clause 6.2F.2 provided by the NWDAF service consumer. The service may be used by an NWDAF containing MTLF to enable e.g. Federated Learning.



Figure 6.2F.3-1: Procedure for ML Model Training Information Request

1. The NWDAF service consumer may request the NWDAF containing MTLF to get the information about the ML model training based on the ML model file or ML Model information as described in clause 6.2F.2 provided by the service consumer by invoking the Nnwdaf\_MLModelTrainingInfo\_Request service operation. The parameters that can be provided by the NWDAF service consumer are listed in clause 6.2F.2.

In order to enable Federated Learning, NWDAF Service consumer acting as FL Server NWDAF requests to get ML Model Training Information from an NWDAF containing MTLF acting as FL Client NWDAF, which is selected by the FL Server NWDAF. The details are specified in clause 6.2C.

The NWDAF service consumer may use the request to check if an NWDAF can meet the ML model training requirements (e.g. ML Model Interoperability information, Analytics ID, Service Area/DNAI and/or availability of data and time). In such cases, the NWDAF service consumer includes an ML Preparation Flag.

The NWDAF service consumer may use the request to get the Model **Accuracy** of the ML Model provided by the service consumer using local training data in the NWDAF containing MTLF as the testing dataset. In such cases, the service consumer NWDAF includes a Model **Accuracy** Check Flag.

2. When the ML Preparation Flag is present in the request, the NWDAF containing MTLF only checks whether it can meet the ML model training requirement and/or can successfully download the model if the model information is provided. Based on the check result, the NWDAF containing MTLF gets a successful return code or failure cause code (e.g. NWDAF does not meet the ML training requirements) as the information about the ML model training.

When the Model **Accuracy** Check Flag is present in the request, the NWDAF containing MTLF uses the local training data as the testing dataset to calculate the Model **Accuracy** information of the ML model provided by the service consumer. The NWDAF containing MTLF includes the Model **Accuracy information** into the information about the ML model training.

When the NWDAF containing MTLF is ongoing ML model training based on the ML model file or ML Model information as described in clause 6.2F.2 provided by the NWDAF service consumer, the NWDAF containing MTLF gets a failure cause code (e.g. ML training is not complete) as the information about the ML model training.

When the NWDAF containing MTLF completes ML model training based on the ML model file or ML Model information as described in clause 6.2F.2 provided by the NWDAF service consumer, the NWDAF containing MTLF gets a successful return code and the ML Model Information of the trained ML model as the information about the ML model training.

3. The NWDAF containing MTLF replies to the NWDAF service consumer with the information about the ML model training by invoking the Nnwdaf\_MLModelTrainingInfo\_Request response service operation.

### 7.5.2 Nnwdaf\_MLModelProvision\_Subscribe service operation

**Service operation name:** Nnwdaf\_MLModelProvision\_Subscribe.

**Description:** Subscribes to NWDAF ML model provision with specific parameters.

**Inputs, Required:** (set of) Analytics ID(s) defined in Table 7.1-2, Notification Target Address (+ Notification Correlation ID).

**Inputs, Optional:** Subscription Correlation ID (in the case of modification of the ML model subscription), ML Model Filter Information to indicate the conditions for which ML model for the analytics is requested and Target of ML Model Reporting to indicate the object(s) for which ML model is requested (e.g. specific UEs, a group of UE(s) or any UE (i.e. all UEs)), NF consumer information, Requested representative ratio, ML Model Reporting Information (including e.g. ML Model Target Period), Expiry time, Use case context, Inference Input Data information, indication of support for multiple ML models, multiple ML models Filter Information to indicate the conditions for which multiple ML models are requested, ML Model Interoperability Information, Time when model is needed, ML Model Monitoring Information (including e.g. desired ML Model **metric**, ML model monitoring reporting mode, ML Model **Accuracy** Threshold, DataSetTag and ADRF ID, ML Model Identifier).

### 7.5.4 Nnwdaf\_MLModelProvision\_Notify service operation

**Service operation name:** Nnwdaf\_MLModelProvision\_Notify.

**Description:** NWDAF notifies the ML model information to the consumer instance which has subscribed to the specific NWDAF service.

**Inputs, Required:** Notification Correlation Information, Set of:

- the tuple (Analytics ID, one or more tuples of unique ML Model identifier and ML Model Information as defined in clause 6.2A.2).

**Inputs, Optional:** ML Model **Accuracy** Information.

**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** None.

## 7.9 Nnwdaf\_MLModelMonitor Service

### 7.9.1 General

**Service Description:** This service enables the consumer to subscribe/unsubscribe for ML model **Accuracy** (i.e. Analytics **Accuracy** for an ML model as described in clause 6.2E.3.3) information monitored. The service can additionally provide Analytics feedback information for the analytics generated by an NWDAF (i.e. NWDAF containing AnLF). The service also enables the NWDAF containing AnLF registers the use and monitoring capability for an ML model into the model provider NWDAF, i.e. NWDAF containing MTLF.

### 7.9.2 Nnwdaf\_MLModelMonitor\_Subscribe service operation

**Service operation name:** Nnwdaf\_MLModelMonitor\_Subscribe

**Description:** Subscribes to NWDAF for the monitored ML model **Accuracy** (i.e. Analytics **Accuracy** for an ML model as described in clause 6.2E.3.3) information and Analytics feedback information for the analytics generated by the NWDAF with specific parameters.

**Inputs, Required:** (set of) Unique ML Model identifier(s), Notification Target Address (+ Notification Correlation ID).

**Inputs, Optional:** Subscription Correlation ID (in the case of modification of the ML model monitor subscription), desired **Accuracy** **metrics** to indicate the **metrics** to calculate the **Accuracy** information, reporting period to indicate the reporting periodicity in which the monitored ML Model **Accuracy** information shall be reported, **Accuracy** reporting threshold to indicate the reporting condition above which the **Accuracy** information shall be reported.

**Outputs Required:** When the subscription is accepted: Subscription Correlation ID (required for management of this subscription), Expiry time (required if the subscription can be expired based on the operator's policy).

**Outputs, Optional:** None.

### 7.9.3 Nnwdaf\_MLModelMonitor\_Unsubscribe service operation

**Service operation name:** Nnwdaf\_MLModelMonitor\_Unsubscribe

**Description:** The NF consumer unsubscribes to the NWDAF for the monitored ML model **Accuracy** (i.e. Analytics **Accuracy** for an ML model as described in clause 6.2E.3.3) information and Analytics feedback information for the analytics generated by the NWDAF.

**Inputs, Required:** Subscription Correlation ID.

**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** None.

### 7.9.4 Nnwdaf\_MLModelMonitor\_Notify service operation

**Service operation name:** Nnwdaf\_MLModelMonitor\_Notify.

**Description:** NWDAF notifies the monitored ML model **Accuracy** (i.e. Analytics **Accuracy** for an ML model as described in clause 6.2E.3.3) information and Analytics feedback information for the analytics generated by the NWDAF to the consumer instance which has subscribed to the specific NWDAF service.

**Inputs, Required:** Notification Correlation Information, at least one of the following:

- the monitored ML model **Accuracy** information which includes:

- Unique ML model identifier;

- Monitoring interval: time interval during which the ML model **Accuracy** monitoring was conducted;

- Monitored Analytics **Accuracy** value of the ML Model and a deviation value which indicates the deviation of the predictions generated using the ML model(s) from the ground truth data;

- Number of inferences that were performed during the monitoring interval;

- used **Accuracy** **metrics** as requested in Subscribe service operation.

- Analytics feedback information: indicates that the consumer NF of the analytics generated by the provisioned ML model has taken an action(s) influenced by the analytics and includes the following parameter(s):

- Corresponding Analytics ID(s) which has been used for taking an action(s);

- Corresponding ML Model identifier(s) which has been used for generating Analytics;

- Indication whether the action will affect on ground truth data (if available);

- Time stamp(s) when the action(s) are taken.

**Inputs, Optional:**

- Input data used for inferencing indicated by DataSetTag with ADRF ID when the prediction generated from the ML Model is not correct (which can be used by the NWDAF containing MTLF for possible ML model retraining);

NOTE: How MTLF/AnLF determines whether the prediction is correct one is up to implementation.

- An indication that the analytics **Accuracy** of the ML model does not meet the requirement of **Accuracy** for the ML model.

**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** None.

### 7.9.5 Nnwdaf\_MLModelMonitor\_Register

**Service operation name:** Nnwdaf\_MLModelMonitor\_Register

**Description:** The consumer registers the use and monitoring capability for an ML model at an NWDAF containing MTLF.

**Inputs, Required:** Consumer NF ID, Unique ML Model identifier.

**Inputs, Optional:** Endpoint address of the Nnwdaf\_MLModelMonitor\_Subscribe service operation. ML Model **Accuracy** transfer indication as defined in clause 6.2E.3.2

**Outputs, Required:** ML model monitoring registration ID.

**Outputs, Optional:** None.

### 7.9.6 Nnwdaf\_MLModelMonitor\_Deregister

**Service operation name:** Nnwdaf\_MLModelMonitor\_Deregister

**Description:** The consumer deregisters, from an NWDAF containing MTLF, a previous MLModelMonitor registration, e.g. when the consumer is no longer using or monitoring the **Accuracy** of the analytics generated using the ML model.

**Inputs, Required:** ML model monitoring registration ID.

**Inputs, Optional:** A termination indication, a termination cause, the NWDAF containing AnLF NF ID of the target NWDAF (in the case that the termination cause is due to analytics transfer).

**Outputs, Required:** None.

**Outputs, Optional:** None.

## 7.10 Nnwdaf\_MLModelTraining Service

### 7.10.1 General

**Service Description:** This service enables the consumer to subscribe/unsubscribe/notify/modify for ML model training.

NOTE: In this release of the specification, the service provider and consumer are limited to NWDAF containing MTLF.

When used for Federated Learning, this service enables FL server NWDAF to enable Federated Learning while providing global ML model information to FL Client NWDAF and getting local ML model information and status report of FL training as defined in clause 6.2C.2.3 from the FL Client NWDAF.

This service may also be used by the consumer (i.e. FL Server NWDAF) to check if the service provider (i.e. FL Client NWDAF) can meet the ML model training requirement as described in clause 6.2F.1.

This service may also be used by the consumer (i.e. FL Server NWDAF) to request the service provider (i.e. FL Client NWDAF) to calculate and provide Model **Accuracy** of the global ML Model as described in clause 6.2F.1.

### 7.10.2 Nnwdaf\_MLModelTraining\_Subscribe service operation

**Service operation name:** Nnwdaf\_MLModelTraining\_Subscribe

**Description:** Subscribes to NWDAF ML model training with specific parameters.

**Inputs, Required:**

- Analytics ID as defined in Table 7.1-2;

- ML Model Interoperability information;

- Notification Target Address (+ Notification Correlation ID).

**Inputs, Optional:**

- ML Model ID: identifies the provided ML model.

- ML Model Information (as defined in clause 6.2A.2);

- ML model file;

- Subscription Correlation ID (in the case of modification of the ML Model Training subscription);

- ML Training Information, i.e. data availability requirement, time availability requirement.

- ML Preparation Flag;

- ML Model **Accuracy** Check Flag;

- ML Correlation ID;

- Training Filter Information;

- Target of Training Reporting;

- Training Reporting Information as defined in clause 6.2F.2;

- Use case context;

- Iteration round ID;

- Expiry time.

**Outputs Required:** When the request is accepted: Subscription Correlation ID (required for management of this subscription). When the request is not accepted, an error response with cause code (e.g. NWDAF does not meet the ML training requirements, ML training is not complete, NWDAF overload, not available for the FL process anymore, etc.).

NOTE: The detail reasons in the cause code are up to Stage 3.

**Outputs, Optional:** ML Correlation ID (e.g. confirm of the subscription for this FL process).

### 7.10.3 Nnwdaf\_MLModelTraining\_Unsubscribe service operation

**Service operation name:** Nnwdaf\_MLModelTraining\_Unsubscribe

**Description:** Terminate NWDAF ML model training.

**Inputs, Required:** Subscription Correlation ID.

**Inputs, Optional:** None.

**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** Cause code (e.g. FL Client NWDAF is unselected by the FL Server NWDAF for the FL process, or the FL process is suspended or finished, etc.). Final aggregated ML model information (if FL has finished) or updated aggregated ML model information (if FL is suspended).

### 7.10.4 Nnwdaf\_MLModelTraining\_Notify service operation

**Service operation name:** Nnwdaf\_MLModelTraining\_Notify

**Description:** NWDAF notifies the consumer instance of the trained ML model that has subscribed to the specific NWDAF service. The NWDAF can also use this service to indicate to consumer it will terminate the ML model training.

**Inputs, Required:**

- Notification Correlation Information: this parameter indicates the Notification Correlation ID that has been assigned by the consumer during ML model training.

**Inputs, Optional:**

- Set of the tuple (Analytics ID, ML model Information as defined in clause 6.2F.2;

- ML Correlation ID, when for Federated Learning;

- Corresponding Use case context;

- Termination Request: this parameter indicates that NWDAF requests to terminate the ML model training, i.e. NWDAF will not provide further notifications related to this request, with cause code (e.g. NWDAF overload, not available for the FL process anymore, etc.);

- ML Model ID: this parameter identifies the provisioned ML model;

- Global ML Model **Accuracy information**: The model **Accuracy** of the global ML model, which is calculate by the FL Client NWDAF using the local training data as the testing dataset;

- Status report of FL training: local ML Model **accuracy information** and Training Input Data Information (e.g. areas covered by the data set, sampling ratio, maximum/minimum of value of each dimension, etc.), which are generated by the FL Client NWDAF during FL procedure;

- Delay Event Notification: as defined in clause 6.2F.2;

- Iteration round ID.

NOTE: The detail reasons in the cause code are up to stage 3.

**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** None.

### 7.11.2 Nnwdaf\_MLModelTrainingInfo\_Request service operation

**Service operation name:** Nnwdaf\_MLModelTrainingInfo\_Request

**Description:** Request information about NWDAF ML model training with specific parameters.

**Inputs, Required:**

- Analytics ID as defined in Table 7.1-2.

- ML Model Interoperability information.

**Inputs, Optional:**

- ML Model ID: identifies the provided ML model.

- ML Model Information (as defined in clause 6.2A.2).

- ML Model file.

- ML Training Information (i.e. data availability requirement, time availability requirement).

- Training Reporting Information as defined in clause 6.2F.2.

- ML Preparation Flag.

- ML Model **Accuracy** Check Flag.

- ML Correlation ID.

- Termination Request, when terminating the Federated Learning identified by the ML Correlation ID and optionally indicating the reason, e.g. FL Client NWDAF is unselected by the FL Server NWDAF for the FL process, or the FL process is suspended, etc.

- Training Filter Information.

- Target of Training Reporting.

- Use case context.

**Outputs Required:** When the request is accepted: Operation execution result indication. When the request is not accepted, an error response with cause code (e.g. NWDAF does not meet the ML training requirements, ML training is not complete, NWDAF overload, not available for the FL process anymore, etc.).

NOTE: The detail reasons in the cause code are up to stage 3.

**Outputs, Optional:**

- ML Model ID.

- Set of the tuple (Analytics ID, ML model Information (as defined in clause 6.2A.2)).

- ML Correlation ID, when for Federated Learning.

- Corresponding Use case context.

- Global ML Model **Accuracy information**: The model **Accuracy** of the global ML model, which is calculate by the FL Client NWDAF using the local training data as the testing dataset.

- Status report of FL training: local ML model **accuracy information** and Training Input Data Information (e.g. areas covered by the data set, sampling ratio, maximum/minimum of value of each dimension of data, etc.), which are generated by the FL Client NWDAF during FL procedure.

- Delay Event Notification as defined in clause 6.2F.2;