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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on enhancement of the management aspects related to Network Data Analytics Functions (NWDAF)  (Release 18) | |
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# Foreword

This Technical Report 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.

# 1 Scope

The present document studies the management enhancement for NWDAF (Network Data Analytics Function).

In the present document, with regarding to the analytic, data management and trained ML model provisioning services provided by the NWDAF, also considering different NWDAF deployment scenarios, some fundamental key issues related the management enhancement for NWDAF are discussed. And the corresponding potential solutions are provided and evaluated.

The present document also provides recommendations for the normative specifications work.

# 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 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[3] 3GPP TS 28.541: "5G Network Resource Model (NRM)"

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

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

[6] 3GPP TS 23.501: "System Architecture for the 5G System (5GS); Stage 2".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 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 TR 21.905 [1].

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

# 4 Key Issues and potential solutions

## 4.1 Key Issue #1: NWDAFFunction IOC enhancement to support Multiple NWDAF Deployment

### 4.1.1 Description

According to [2], in the case where multiple NWDAF instances are deployed, an NWDAF can act as Aggregator NWDAF, while the other NWDAFs may play the role that provides analytics information to this Aggregator NWDAF.

For the Aggregator NWDAF in multiple NWDAF deployment, it has the "analytics aggregation capability", with which the Aggregator NWDAF is able to perform some extra tasks comparing to the normal NWDAF (i.e., the NWDAF without "analytics aggregation capability"), such as:

- divide the area-of-interest and act as the service consumer to interact with the other NWDAF(s) supporting "analytics metadata provisioning capability" to request "Analytics Metadata Information" corresponding to multiple divided area-of-interests.

- aggregate the output analytics for the requested Analytics ID(s).

If the NWDAF with "analytics aggregation capability" is deployed, it is better for the operators to have the NWDAFs with "analytics metadata provisioning capability" deployed as well, so that these NWDAFs can work co-ordinately, and operator may get more performance benefit from this coordination.

Moreover, the NWDAFs with and without "analytics aggregation capability" behave differently. Comparing to the NWDAF without such capability, the NWDAF with "analytics aggregation capability" needs to perform the additional interactions with other NWDAFs and the additional aggregation operation, too. In the multiple NWDAF deployment scenario, the operator needs to monitor the performance related to the additional operations of a NWDAF with "analytics aggregation capability" and take the result as a necessary part of the performance of this NWDAF instance. However, for a NWDAF without "analytics aggregation capability", it is meaningless and even misleading to consider and monitor the performance related to those additional operations.

As a result, when multiple NWDAFs are deployed, the operator may want to distinguish the NWDAF instances based on these differences, so that the management can be performed accordingly.

However, the current NWDAFFunction IOC defined in [3] cannot reflect the differences on the NWDAF capability aspect.

In this Key Issue, the potential solution(s) is provided to enhances the NWDAFFunction IOC to support reflecting the differences on the NWDAF capability aspect in multiple NWDAF deployment.

### 4.1.2 Potential requirements

REQ-NWDAF-NRM-1: the NWDAFFunction IOC should support reflecting the differences on the NWDAF capability aspect in multiple NWDAF deployment.

### 4.1.3 Potential solutions

#### 4.1.3.1 Potential solution #1: the attribute for NWDAF capability

##### 4.1.3.1.1 Introduction

This solution is provided on how to enhance the NWDAFFunction IOC to support reflecting the differences on the NWDAF capability aspect in multiple NWDAF deployment. The proposed attribute indicating the different NWDAF capability is defined in the NWDAFFunction IOC.

The proposed solution can be a potential solution for the NWDAFFunction IOC enhancement to support multiple NWDAF deployment.

##### 4.1.3.1.2 Description

These proposed attributes indicating the "analytics aggregation capability" and "analytics metadata provisioning capability" of NWDAF are defined in NWDAFFunction IOC as follows:

Attribute name: analyticsAggregation;

Documentation: It represents the "analytics aggregation capability" identifier, which indicates whether the NWDAF has the "analytics aggregation capability".

Allowed Values: The allowed value can be "0"and "1", where "1" indicates the NWDAF has the "analytics aggregation capability" and "0" indicates the NWDAF does not support the "analytics aggregation capability".

Attribute name: analyticsMetadataProvisioning;

Documentation: It represents the "analytics metadata provisioning capability" identifier, which indicates whether the NWDAF has the "analytics metadata provisioning capability".

Allowed Values: The allowed value can be "0" and "1", where "1" indicates the NWDAF has the "analytics metadata provisioning capability" and "0" indicates the NWDAF does not support the "analytics metadata provisioning capability".

### 4.1.4 Evaluation

There is one potential solution for the NWDAFFunction IOC enhancement to support Multiple NWDAF Deployment.

In the case where multiple NWDAF instances are deployed, the NWDAFs can be deployed as different NWDAF instances with different capabilities. In the potential solution #1, the attribute analyticsAggregation is defined to indicate whether the NWDAF has the analytics aggregation capability, and the attribute analyticsMetadataProvisioning is defined to indicate whether the NWDAF has the analytics metadata provisioning capability. This solution can be used to distinguish the NWDAF instances based on the NWDAF capability in multiple NWDAF deployment, so that the management can be performed accordingly.

Consequently, this potential solution can satisfy the requirements to enhance the NWDAFFunction IOC to support multiple NWDAF deployment. This solution is a feasible candidate as input to the normative phase on the NWDAFFunction IOC enhancement to support multiple NWDAF deployment.

### 4.1.5 Conclusion for KI#1

The potential solution #1 can provide attributes to distinguish the NWDAF instances based on the NWDAF capability in multiple NWDAF deployment. This solution can satisfy the requirements to enhance the NWDAFFunction IOC to support multiple NWDAF deployment. This solution is a feasible candidate as input to the normative phase on the NWDAFFunction IOC enhancement to support multiple NWDAF deployment.

## 4.2 Key Issue #2: NWDAFFunction IOC enhancement to support the logical decomposition of NWDAF

### 4.2.1 Description

As described in TS 23.288 [2], an NWDAF can be decomposed into Analytics logical function (AnLF) and Model Training logical function (MTLF). And an NWDAF can contain AnLF only, MTLF only, or both.

From the operator's point of view, the logical decomposition provides the operators with the flexibility to deploy three sub-types of NWDAF instances, i.e., NWDAF containing AnLF, NWDAF containing MTLF and NWDAF containing both AnLF and MTLF. NWDAFs containing different logical function supports different sets of service, for example, the "ML model provisioning service" is only provided by the NWDAF containing the MTLF, and the analytic related services are only provided by NWDAF containing AnLF.

The information of the logical decomposition provides necessary indication to the operators on how to monitor and consider the performance of a NWDAF instances. For example, it is necessary to monitor the performance related to the analytics if a NWDAF instance contains AnLF. However, if the operator knows that this NWDAF instance under observation also contains MTLF, the operator needs additionally monitor the performance related to the model training and take both parts of performance together into account.

From the operator's point of view, the NWDAF instances which train ML model only is different from the NWDAF instances which perform inference only. However, the NWDAFFunction IOC defined in [3] cannot reflect this difference. As a result, the performance related to the services or the functionalities of NWDAF instances containing different logical function cannot be provided correctly.

In this key issue, the potential solution(s) is provided to enhance the NWDAFFunction IOC to reflect the logical decomposition of NWDAF.

### 4.2.2 Potential requirements

REQ-NWDAF-NRM-2: the NWDAFFunction IOC should be able to reflect the logical decomposition of NWDAF, i.e., differentiate the NWDAF contains AnLF and/or MTLF.

### 4.2.3 Potential solutions

#### 4.2.3.1 Potential solution #1: the attribute for NWDAF logical decomposition

##### 4.2.3.1.1 Introduction

This solution is provided on how to enhance the NWDAFFunction IOC to support reflecting the logical decomposition of NWDAF. The proposed attribute indicating the different NWDAF logical function is defined in the NWDAFFunction IOC.

The proposed solution can be a potential solution for the NWDAFFunction IOC enhancement to support logical decomposition of NWDAF.

##### 4.2.3.1.2 Description

These proposed attributes indicating the "Analytics logical function (AnLF)" and "Model Training logical function (MTLF)" of NWDAF are defined in NWDAFFunction IOC as follows:

Attribute name: nWDAFAnLFId;

Documentation: It represents the "Analytics logical function (AnLF)" identifier, which indicates whether the NWDAF has "Analytics logical function (AnLF)" supporting the analytics services.

Allowed Values: The allowed value can be "0" and "1", where "1" indicates the NWDAF has AnLF and "0" indicates the NWDAF does not support AnLF.

Attribute name: nWDAFMTLFId;

Documentation: It represents the "Model Training logical function (MTLF)" identifier, which indicates whether the NWDAF has "Model Training logical function (MTLF)" supporting the ML model related services.

Allowed Values: The allowed value can be "0" and "1", where "1" indicates the NWDAF has MTLF and "0" indicates the NWDAF does not support MTLF.

### 4.2.4 Evaluation

There is one potential solution for the NWDAFFunction IOC enhancement to support the logical decomposition of NWDAF.

The NWDAF can be decomposed into Analytics Logical Function (AnLF) and Model Training Logical Function (MTLF), and an NWDAF can contain AnLF only, MTLF only, or both. In the potential solution #1, the attribute nWDAFAnLFId is defined to indicate whether the NWDAF has AnLF supporting the analytics services, and the attribute nWDAFMTLFId is defined to indicate whether the NWDAF has MTLF supporting the ML model related services. This solution can be used to distinguish the NWDAF instances based on the logical decomposition, so that the management can be performed accordingly.

Consequently, this potential solution can satisfy the requirements to enhance the NWDAFFunction IOC to support the logical decomposition of NWDAF. This solution is a feasible candidate as input to the normative phase on the NWDAFFunction IOC enhancement to support the logical decomposition of NWDAF.

### 4.2.5 Conclusion for KI#2

The potential solution #1 can provide attributes to distinguish the NWDAF instances based on the logical decomposition. This solution can satisfy the requirements to enhance the NWDAFFunction IOC to support the logical decomposition of NWDAF. This solution is a feasible candidate as input to the normative phase on the NWDAFFunction IOC enhancement to support the logical decomposition of NWDAF.

## 4.3 Key Issue #3: Performance Measurement of the NWDAF on the Interaction Aspect

### 4.3.1 Description

The NWDAF was firstly introduced in Rel-15 and it follows the SBA concept. The interaction between the producer and consumer of the services provided by NWDAF are defined in TS 23.288 [2].

As the requirement on network automation kept increasing, the NWDAF is expected to provide a variety of services to the other NFs and play a very important role in the future. Moreover, in the scenario where multiple NWDAFs are deployed, the NWDAF is also able to act as an Aggregator NWDAF to interact with one to multiple other NWDAFs.

From the perspective of management, it is necessary for the operator to monitor the performance of NWDAF based on the interaction between the producer and consumer of the services provided by the NWDAF. The performance measurements of NWDAF on the interaction aspect can be used to estimate how busy the NWDAF is on specific services. The interaction may include the requests, subscriptions, responses and notifications received and/or generated by NWDAF.

However, in the management domain, the performance measurement of NWDAF on this aspect is missing.

In this key issue, the potential solution(s) is provided on the metrics and KPIs for performance measurement of the NWDAF based on the interaction between the producer and consumer of the analytics services provided by the NWDAF.

### 4.3.2 Potential requirements

**REQ-NWDAF-SERV-COUNT-1：**the 3GPP management system should have a capability to provide the statistic information of the analytic services provided by NWDAF, if applicable , about how frequently a specific analytic is requested and the service successful rate.

**REQ-NWDAF-SERV-COUNT-2：**the 3GPP management system should have a capability to provide the statistic information of the ML model provisioning services provided by NWDAF, if applicable, about how frequently a ML model which specified for an analytic is requested and the service successful rate.

**REQ-NWDAF-SERV-AGG-COUNTER-1:** the 3GPP management system should have a capability to provide the statistic information of the analytic services requested by the Aggregator NWDAF for aggregating the analytics information from the other NWDAFs. The provided statistic information should be about how frequently a specific analytic is requested and the service successful rate

**REQ-NWDAF- SERV-KPI-1:** the 3GPP management system may have a capability to provide the NWDAF service usage based on the measurement of the interaction between the producer and consumer of the services provided by the NWDAF.

### 4.3.3 Potential solutions

#### 4.3.3.1 Potential solution #1: number of subscriptions and/or requests

##### 4.3.3.1.1 Introduction

This solution is proposed on how to provide the performance measurements of the NWDAF based on the subscriptions and/or requests received by NWDAF. The proposed performance measurements are defined as the number of subscriptions and/or requests received by NWDAF.

The proposed solution can be a potential solution for the performance measurement of the NWDAF supporting analytics services, such as NWDAF containing Analytics Logical Function (AnLF), based on the interaction aspect.

##### 4.3.3.1.2 Description

This proposed performance measurements of the NWDAF are defined as the number of subscriptions and/or requests received by NWDAF.

Moreover, since different type of analytics, network slices and 5G VN group may consume different resource (e.g., virtual CPU resource, virtual memory resource or virtual disk resource) of NWDAF, it is necessary to define the performance measurements of NWDAF based on the granularity of analytics, slice or 5G VN group.

Therefore, this proposed performance measurements are also defined as the number of subscriptions and/or requests received by NWDAF based on the analytics ID, S-NSSAI or 5G VN group ID. The analytics ID identifies the requested analytics and the S-NSSAI identifies the network slice. The 5G VN group ID use External Group ID and Internal Group ID to identify the 5G VN group. The analytics ID, S-NSSAI and Internal or External Group ID can be obtained from the NWDAF service consumer (see TS 23.288 [2]).

The number of subscriptions received by NWDAF can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant counter.

The number of requests received by NWDAF can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant counter.

The number of subscriptions received by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant subcounter per analytics ID.

The number of subscriptions received by NWDAF based on the S-NSSAI can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant subcounter per S-NSSAI.

The number of subscriptions received by NWDAF based on the 5G VN group can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant subcounter per Internal or External Group ID.

The number of requests received by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant subcounter per analytics ID.

The number of requests received by NWDAF based on the S-NSSAI can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant subcounter per S-NSSAI.

The number of requests received by NWDAF based on the 5G VN group can be measured as follows:

- When the NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant subcounter per Internal or External Group ID.

#### 4.3.3.2 Potential solution #2: number of notifications and/or responses

##### 4.3.3.2.1 Introduction

This solution is proposed on how to provide the performance measurements of the NWDAF based on the notifications and/or responses generated by NWDAF. The proposed performance measurements are defined as the number of notifications and/or responses generated by NWDAF.

The proposed solution can be a potential solution for the performance measurement of the NWDAF supporting analytics services, such as NWDAF containing Analytics Logical Function (AnLF), based on the interaction aspect.

##### 4.3.3.2.2 Description

This proposed performance measurements of the NWDAF are defined as the number of notifications and/or responses generated by NWDAF.

Moreover, since different type of analytics, network slices and 5G VN group may consume different resource (e.g., virtual CPU resource, virtual memory resource or virtual disk resource) of NWDAF, it is necessary to define the performance measurements of NWDAF based on the granularity of analytics, slice or 5G VN group.

Therefore, this proposed performance measurements are also defined as the number of notifications and/or responses generated by NWDAF based on the analytics ID(s), S-NSSAI or 5G VN group ID. The analytics ID identifies the requested analytics and the S-NSSAI identifies the network slice. The 5G VN group ID use External Group ID and Internal Group ID to identify the 5G VN group. The analytics ID(s), S-NSSAI and Internal or External Group ID can be obtained from the NWDAF service consumer (see TS 23.288 [2]).

The number of notifications generated by NWDAF can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsSubscription\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant counter.

The number of responses generated by NWDAF can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsInfo\_Request Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant counter.

The number of notifications generated by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsSubscription\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant subcounter per analytics ID.

The number of notifications generated by NWDAF based on the S-NSSAI can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsSubscription\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant subcounter per S-NSSAI.

The number of notifications generated by NWDAF based on the 5G VN group can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsSubscription\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant subcounter per Internal or External Group ID.

The number of responses generated by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsInfo\_Request Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant subcounter per analytics ID.

The number of responses generated by NWDAF based on the S-NSSAI can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsInfo\_Request Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant subcounter per S-NSSAI.

The number of responses generated by NWDAF based on the 5G VN group can be measured as follows:

- When the NWDAF generates the Nnwdaf\_AnalyticsInfo\_Request Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant subcounter per Internal or External Group ID.

#### 4.3.3.3 Potential solution #3: number of subscriptions/requests generated by Aggregator NWDAF

##### 4.3.3.3.1 Introduction

In the cases where a NWDAF service consumer requests Analytics ID(s) that requires multiple NWDAFs to collectively serve the request, the Aggregator NWDAF (i.e. the NWDAF with analytics aggregation capability) may be deployed to support requesting the analytics information from other NWDAFs and aggregating this analytics information.

This solution is proposed on how to provide the performance measurements of the NWDAF based on the subscriptions and/or requests sent by Aggregator NWDAF. The proposed performance measurements are defined as the number of subscriptions and/or requests sent by Aggregator NWDAF.

The proposed solution can be a potential solution for the performance measurement of the NWDAF based on the interaction aspect.

##### 4.3.3.3.2 Description

These proposed performance measurements of the NWDAF are defined as the number of subscriptions/requests sent by Aggregator NWDAF. Moreover, since different type of analytics may consume different resource (e.g., virtual CPU resource, virtual memory resource or virtual disk resource) of NWDAF, it is necessary to define the performance measurements of NWDAF based on the granularity of analytics. Therefore, this proposed performance measurements are also defined as the number of subscriptions/requests generated by Aggregator NWDAF based on the analytics ID(s). The analytics ID identifies the requested analytics, which can be obtained from the NWDAF service consumer (see TS 23.288 [2]).

The number of subscriptions sent by the Aggregator NWDAF to the other NWDAFs to subscribe analytics information for analytics aggregation can be measured as follows:

- When the Aggregator NWDAF sends the Nnwdaf\_AnalyticsSubscription\_Subscribe service operations (See TS 23.288 [2]) to the other NWDAFs to subscribe analytics information for analytics aggregation, each subscription is added to the relevant counter.

The number of subscriptions sent by the Aggregator NWDAF to the other NWDAFs to subscribe analytics information for analytics aggregation, based on the analytics ID(s), can be measured as follows:

- When the Aggregator NWDAF sends the Nnwdaf\_AnalyticsSubscription\_Subscribe service operations (See TS 23.288 [2]) to the other NWDAFs to subscribe analytics information for analytics aggregation, each subscription is added to the relevant subcounter per analytics ID.

The number of requests sent by the Aggregator NWDAF to the other NWDAFs to request analytics information for analytics aggregation can be measured as follows:

- When the Aggregator NWDAF sends the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) to the other NWDAFs to request analytics information for analytics aggregation, each request is added to the relevant counter.

The number of requests sent by the Aggregator NWDAF to the other NWDAFs to request analytics information for analytics aggregation, based on the analytics ID(s), can be measured as follows:

- When the Aggregator NWDAF sends the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) to the other NWDAFs to request analytics information for analytics aggregation, each request is added to the relevant subcounter per analytics ID.

#### 4.3.3.4 Potential solution #4: number of notifications/responses received by Aggregator NWDAF

##### 4.3.3.4.1 Introduction

In the cases where a NWDAF service consumer requests Analytics ID(s) that requires multiple NWDAFs to collectively serve the request, the Aggregator NWDAF (i.e. the NWDAF with analytics aggregation capability) may be deployed to support requesting the analytics information from other NWDAFs and aggregating this analytics information.

This solution is proposed on how to provide the performance measurements of the NWDAF based on the notifications and/or responses received by Aggregator NWDAF. The proposed performance measurements are defined as the number of notifications and/or responses received by Aggregator NWDAF.

The proposed solution can be a potential solution for the performance measurement of the NWDAF based on the interaction aspect.

##### 4.3.3.4.2 Description

These proposed performance measurements of the NWDAF are defined as the number of notifications/responses received by Aggregator NWDAF. Moreover, since different type of analytics may consume different resource (e.g., virtual CPU resource, virtual memory resource or virtual disk resource) of NWDAF, it is necessary to define the performance measurements of NWDAF based on the granularity of analytics. Therefore, this proposed performance measurements are also defined as the number of notifications/responses received by Aggregator NWDAF based on the analytics ID(s). The analytics ID identifies the requested analytics, which can be obtained from the NWDAF service consumer (see TS 23.288 [2]).

The number of notifications received by the Aggregator NWDAF from the other NWDAFs to get analytics information for analytics aggregation can be measured as follows:

- When the Aggregator NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Notify service operation (See TS 23.288 [2]) from the other NWDAFs to get analytics information for analytics aggregation, each notification is added to the relevant counter.

The number of notifications received by the Aggregator NWDAF from the other NWDAFs to get analytics information for analytics aggregation, based on the analytics ID(s), can be measured as follows:

- When the Aggregator NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Notify service operation (See TS 23.288 [2]) from the other NWDAFs to get analytics information for analytics aggregation, each notification is added to the relevant subcounter per analytics ID.

The number of responses received by the Aggregator NWDAF from the other NWDAFs to get analytics information for analytics aggregation can be measured as follows:

- When the Aggregator NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request Response service operation (See TS 23.288 [2]) from the other NWDAFs to get analytics information for analytics aggregation, each response is added to the relevant counter.

The number of responses received by the Aggregator NWDAF from the other NWDAFs to get analytics information for analytics aggregation, based on the analytics ID(s), can be measured as follows:

- When the Aggregator NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request Response service operation (See TS 23.288 [2]) from the other NWDAFs to get analytics information for analytics aggregation, each response is added to the relevant subcounter per analytics ID.

#### 4.3.3.5 Potential solution #5: correctness of service usage

##### 4.3.3.5.1 Introduction

This solution is proposed on how to provide the performance measurements of the NWDAF **service usage**. The proposed key performance indicator is defined as a Boolean that expresses whether the NWDAF is observing the "**Expected service usage**" or "**Abnormal service usage**". "Expected service usage" represents the case where the distribution of requests is similar distribution of requests observed during normal operations, otherwise "Abnormal service usage" represents the case where there mare major variations in the number of requests.

##### 4.3.3.5.2 Description

The solution proposes to use as input the requests received by an NWDAF service producer, and to produces an analysis of the expected incoming requests distribution. For this the MnS producer is given an indication of a period of normal operations, e.g., one where the operator monitors the incoming requests to confirm that they are normal and expected requests. Based on those requests, the MnS producer computes this "expected distribution of incoming requests" parameterised by different characteristics like time, location, requesting function, etc.

Then at any point during operations, the MnS producer computes a "distribution of the arriving service requests" which is computed the same way as the "expected distribution of incoming requests" but from requests received at that time (i.e., when the operator does not monitor the requests). The MnS producer may take as input the expected behaviour of the service producers' incoming requests as the specific "expected distribution of incoming requests " e.g. for a specific requesting function and provides a comparison between these expected distribution of incoming requests " and the distribution of the arriving service requests.

The outcome is an indication whether the service is used as expected or is being used abnormally.

Note: the service usage performance indication can be computed for any of the services of the NWDAF.

#### 4.3.3.6 Potential solution #6: number of subscriptions and/or requests received by NWDAF supporting ML model provision services

##### 4.3.3.6.1 Introduction

In order to measure the performance of the NWDAF related to the Model Training Logical Function (MTLF) on the interaction aspect, this solution is proposed to provide the performance measurements based on the subscriptions and/or requests received by NWDAF. The proposed performance measurements are provided as the number of subscriptions and/or requests received by NWDAF.

The proposed solution can be a potential solution for the performance measurement of the NWDAF supporting ML model provision services, such as NWDAF containing Model Training Logical Function (MTLF), based on the interaction aspect.

##### 4.3.3.6.2 Description

These performance measurements of the NWDAF related to the MTLF on the interaction aspect are provided as the number of subscriptions and/or requests received by NWDAF supporting model provision services. Moreover, the ML model is associated with the analytics ID. Therefore, these proposed performance measurements are also provided as the number of subscriptions and/or requests received by NWDAF based on the analytics ID. The analytics ID identifies the analytics for which the ML model is used and can be obtained from the NWDAF service consumer (see TS 23.288 [2]).

The number of subscriptions received by NWDAF can be measured as follows:

- When the NWDAF receives the Nnwdaf\_MLModelProvision\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant counter.

The number of requests received by NWDAF can be measured as follows:

- When the NWDAF receives the Nnwdaf\_MLModelInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant counter.

The number of subscriptions received by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF receives the Nnwdaf\_MLModelProvision\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant subcounter per analytics ID.

The number of requests received by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF receives the Nnwdaf\_MLModelInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant subcounter per analytics ID.

#### 4.3.3.7 Potential solution #7: number of notifications and/or responses generated by NWDAF supporting ML model provision services

##### 4.3.3.7.1 Introduction

In order to measure the performance of the NWDAF related to the Model Training Logical Function (MTLF) on the interaction aspect, this solution is proposed to provide the performance measurements based on the notifications and/or responses generated by NWDAF. The proposed performance measurements are provided as the number of notifications and/or responses generated by NWDAF.

The proposed solution can be a potential solution for the performance measurement of the NWDAF supporting ML model provision services, such as NWDAF containing Model Training Logical Function (MTLF), based on the interaction aspect.

##### 4.3.3.7.2 Description

These performance measurements of the NWDAF related to the MTLF on the interaction aspect are provided as the number of notifications and/or responses generated by NWDAF supporting ML model provision services. Moreover, the ML model is associated with the analytics. Therefore, this proposed performance measurements are also provided as the number of notifications and/or responses generated by NWDAF based on the analytics ID(s). The analytics ID identifies the analytics for which the ML model is used and can be obtained from the NWDAF service consumer (see TS 23.288 [2]).

The number of notifications generated by NWDAF can be measured as follows:

- When the NWDAF generates the Nnwdaf\_MLModelProvision\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant counter.

The number of responses generated by NWDAF can be measured as follows:

- When the NWDAF generates the Nnwdaf\_MLModelInfo\_Request Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant counter.

The number of notifications generated by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF generates the Nnwdaf\_MLModelProvision\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant subcounter per analytics ID.

The number of responses generated by NWDAF based on the analytics ID(s) can be measured as follows:

- When the NWDAF generates the Nnwdaf\_MLModelInfo\_Request Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant subcounter per analytics ID.

### 4.3.4 Evaluation

In order to measure how busy the NWDAF is on specific services, there are multiple potential solutions proposed for the performance measurement of the NWDAF on the interaction aspect.

In the potential solution #1, the performance measurements of NWDAF on the interaction aspect are provided as the number of subscriptions and/or requests received by NWDAF. In the potential solution #2, the performance measurements of NWDAF on the interaction aspect are provided as the number of notifications and/or responses generated by NWDAF.

In the potential solution #3, the performance measurements of Aggregator NWDAF on the interaction aspect are provided as the number of subscriptions and/or requests invoked by the Aggregator NWDAF to subscribe and/or request the analytics information for analytics aggregation. In the potential solution #4, the performance measurements of Aggregator NWDAF on the interaction aspect are provided as the number of notifications and/or responses received by Aggregator NWDAF to get analytics information for analytics aggregation.

The potential solution #1 and #2 can support the performance measurement of the NWDAF on the interaction aspect for performing the normal task (i.e., the analytics services). The potential solution #3 and #4 can support the performance measurement of the Aggregator NWDAF on the interaction aspect for performing the extra tasks (i.e., subscribe/request the analytics information from the other NWDAFs and aggregate the analytics output) compared to the normal task. These proposed performance measurements on the interaction aspect can indicate how busy the NWDAF is on analytics related services.

The potential solution #5 introduces the idea that a MnS producer will provide statistic information such as "distribution of the arriving service requests" and "expected distribution of incoming requests" and based on which, whether the NWDAF is observing the "Expected service usage" or "Abnormal service usage" can be provided as performance measurements of the NWDAF service usage.

However, the potential solution #5 is not complete, since it is not clear which NFs/MFs will be the MnS producer used to provide the results corresponding the "expected distribution of incoming requests" and/or "distribution of the arriving service requests" and how.

In the potential solution #6, the performance measurements of NWDAF related to MTLF on the interaction aspect are provided as the number of subscriptions and/or requests received by NWDAF supporting model provisioning services. In the potential solution #7, the performance measurements of NWDAF related to MTLF on the interaction aspect are provided as the number of notifications and/or responses generated by NWDAF supporting model provisioning services.

The potential solution #6 and #7 can support the performance measurements of the NWDAF on the interaction aspect for performing the model provisioning related services. These proposed measurements on the interaction aspect are basic statistic information which can be used to indicate how busy the NWDAF is on model provisioning related services. Moreover, with these basic measurements, we can derive the other performance of NWDAF such as successful rate of model provisioning related services, etc.

Consequently, the potential solutions #1, #2, #3, #4, #6 and #7 can provide the performance measurement of the NWDAF on the interaction aspect. These potential solutions are feasible candidates as input to the normative phase on the performance measurement of the NWDAF performing the normal task and extra task.

### 4.3.5 Conclusion for KI#3

The potential solutions #1, #2, #3, #4, #6 and #7 can provide the performance measurement of the NWDAF on the interaction aspect. These potential solutions are feasible candidates as input to the normative phase on the performance measurement of the NWDAF performing the normal task and extra task.

## 4.4 Key Issue #4: Performance Measurement for NWDAF Data Collection

### 4.4.1 Description

The Data Collection feature permits NWDAF to retrieve data from various data sources (e.g., NF such as AMF, SMF, PCF, UDM and AF; OAM), as a basis of the computation of network analytics [2].

The retrieval of data has impacts on the performance of both the data source and NWDAF. For the data source, all the data required by NWDAF needs to be generated or prepared accordingly before they are retrieved by NWDAF. And for the NWDAF, it needs to distinguish every piece of data received from different data sources and of data received from the same data source but for different network analytic purposes.

The operator may notice that the data collection is the major task of one NWDAF instance, therefore, less computation resource can be allocated to that NWDAF instance, and more storage and network resources may be allocated if necessary. Or on the extreme cases, a new NWDAF instance needs to be provided or we may find out that deploying a DCCF is the optimum solution. For making a decision, the measurement data is needed, such as how many data is collected by a NWDAF instance or by all NWDAF instances related to some areas of interests, so that the operator could have the understanding and estimation of the working load and working status of the NWDAF instance.

Moreover, it is also beneficial to have the granular measurement of data collection, such as measuring the data collected from different type of data sources. This measurement may provide information about if it is possible to optimize the deployment of NWDAF. For example, the NWDAF instance may be geographically deployed closer to its major data source to reduce the latency and save network resources.

In the other case, the monitoring of data collection will help improve the other services provided by NWDAF. For example, for model training, the training data are expected to be collected periodically. However, in practical, not all of the data are collected successfully, some of them can be missing which is probably caused the malfunctioning of the data source or network transmission issue. The more the data is missing the worse the degradation of the quality of the training data will be. And it will bring negative effect to the model training, such as a slow converging rate. Similar situation may also happen to input data of analytic services and analytic results.

By monitoring the periodical notification which is used for data collection expected and actually received by the NWDAF, it is possible to estimate the quality of the data collected in a period which will indicate whether the data collected in this period is able to reflect the network correctly and sufficiently and whether some additional data cleansing or data augmentation are needed before the they are used for model training or analytics.

In this key issue, the potential solutions are provided to define the new performance measurement reflecting the data collection performed by NWDAF to fulfil the following potential requirements:

**REQ-NWDAF\_COUNT-1** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to monitoring the data collection actions initiated by the NWDAF and the corresponding result, respectively. And the monitoring shall be able to distinguish the data collection from different type of data sources.

**REQ-NWDAF\_COUNT-2** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to monitoring the periodical notification which is used for data collection expected and received by the NWDAF, respectively.

### 4.4.2 Potential requirements

**REQ-NWDAF-DC-SERV-COUNT-1:** the 3GPP management system should have the capability to allow an authorized consumer to configure the NWDAF to provide statistic information of the data collection actions initiated by the NWDAF and the corresponding result, respectively. The provided statistic information should be about how frequently the NWDAF collects data and should be able to distinct different data sources.

**REQ-NWDAF-DC-SERV-COUNT-2:** the 3GPP management system should have a capability to allow an authorized consumer to configure the NWDAF to provide statistic information of the periodical data collection requested by the NWDAF.

### 4.4.3 Potential solutions

#### 4.4.3.1 Potential solution #1: number of subscriptions for NWDAF Data Collection

##### 4.4.3.1.1 Introduction

Data collection may be performed via NWDAF by using at least one of the following services from OAM, and NFs (including AFs directly or via NEF) to collect data. The services includes (see TS 23.288 [2]):

- the Generic management services, the Performance Management services or the Fault Supervision services, offered by OAM in order to collect OAM global NF data.

- the Exposure services offered by NFs in order to retrieve data and other non-OAM pre-computed metrics available in the NFs.

- Other NF services in order to collect NF data (e.g. NRF)

The number of subscriptions generated by NWDAF for the services can be a potential performance metric for NWDAF Data Collection. If the NWDAF sends subscriptions with different Analytics IDs to the same data sources for data collection, then more storage resources may be recommended to be allocate to the NWDAF to store these data and prevent data sources from having to handle multiple subscriptions containing the same information.

##### 4.4.3.1.2 Description

This proposed performance measurements of the NWDAF are defined as the number of subscriptions generated by NWDAF. Since the Data Source and the services used are different, the number of subscriptions is defined based on the Data Source.

The number of subscriptions generated by NWDAF from NFs for Data Collection can be measured as follows:

- When the NWDAF generates the Nnf\_EventExposure\_Subscribe service operation to NF (See TS 23.288 [2]), each generated subscription is added to the relevant subcounter per data source.

The number of subscriptions generated by NWDAF from AF via NEF for Data Collection can be measured as follows:

- When the NWDAF generates the Nnef\_EventExposure\_Subscribe service operation to NEF (See TS 23.288 [2]), each generated subscription is added to the relevant subcounter per data source.

#### 4.4.3.2 Potential solution #2: number of notifications for NWDAF Data Collection

##### 4.4.3.2.1 Introduction

The number of notifications received by NWDAF for these services can be a potential performance metric for NWDAF Data Collection, which can reflect the amount of data and how often data is received. If the NWDAF receives notifications with the same or different Analytics ID(s) from the same data sources for data collection, then more storage resources may be recommended to be allocated to the NWDAF to store these data and to prevent data sources from having to send multiple notifications.

##### 4.4.3.2.2 Description

This proposed performance measurements of the NWDAF are defined as the number of notifications received by NWDAF. Since the Data Source and the services used are different, the number of notifications is defined based on the Data Source.

The number of notifications received by NWDAF from NFs for Data Collection can be measured as follows:

- When the NWDAF receives the Nnf\_EventExposure\_Notify service operation from NF (See TS 23.288 [2]), each received notifications is added to the relevant subcounter per data source.

The number of notifications received by NWDAF from AF via NEF for Data Collection can be measured as follows:

- When the NWDAF receives the Nnef\_EventExposure\_Notify service operation from NEF (See TS 23.288 [2]), each received notifications is added to the relevant subcounter per data source.

### 4.4.4 Evaluation

There are two potential solutions for the performance measurement for NWDAF data collection. In the potential solution #1, the performance measurement for NWDAF data collection is provided as the number of subscriptions generated by NWDAF. In the potential solution #2, the performance measurement for NWDAF data collection is provided as the number of notifications received by NWDAF.

These measurements can reflect how often the NWDAF collect data. Moreover, these measurements can be also used to infer the quality of the data collected in a period which can indicate whether the data requested is missing or collected successfully, so that the additional data cleansing or data augmentation action can be performed accordingly before these data are used for model training or analytics. However, there is still an Editor’s note which describes that the potential solutions can not reflect the amount of data collected by NWDAF. So how to measure the amount of data is FFS.

Consequently, the potential solutions #1 and #2 can provide the performance measurement of NWDAF on the data collection aspect. These two potential solutions can reflect how often the NWDAF collect data and can be used to infer the performance of NWDAF on data collection (e.g., the quality of the data collected). These two potential solutions can satisfy requirements proposed before. These potential solutions are feasible candidates as input to the normative phase on the performance measurement for NWDAF data collection. How to accurately quantify the amount of data collected by NWDAF is FFS.

### 4.4.5 Conclusion for KI#4

The potential solutions #1 and #2 can provide the performance measurement of NWDAF on the data collection aspect. These two potential solutions can reflect how often the NWDAF collect data and can be used to infer the performance of NWDAF on data collection (e.g., the quality of the data collected). These potential solutions are feasible candidates as input to the normative phase on the performance measurement for NWDAF data collection. How to accurately quantify the amount of data collected by NWDAF is FFS.

## 4.5 Key Issue #5: Performance Measurement on Data Collection Exposed by NWDAF

### 4.5.1 Description

Data collection play an important role for the NWDAF providing analytic services and model training services.

In the Rel-17, the enhanced data collection feature is introduced, with which the data collection may be performed via Nnwdaf DataManagement services provided by NWDAF.

The Nnwdaf\_DataManagement services enable the consumer to subscribe/unsubscribe, be notified about data exposed by NWDAF, or fetch the subscribed data. The consumer of the Nnwdaf\_DataManagement services can be the other NWDAF instances.

The operator may be interested in the how often the Nnwdaf\_DataManagement services are requested or how many data are provided via Nnwdaf\_DataManagement services.

On one hand, the service provider NWDAF will prepare the data before they are provided to consumer, and since the preparation includes both collection and processing of the data from the other data sources and historical data having been collected by NWDAF, this measurement will indicate how busy the NWDAF is on data collection related services which can be taken as a reflection of the overhead variation of NWDAF. This measurement will also lead to adjusting the network resource allocated to the service provider NWDAF instance to support data exchange with other consumers. And on some other cases, this measurement may indicate that deploying a dedicated DCCF is necessary.

On the other hand, as the enhanced data collection feature is introduced for Rel-17 NWDAF to increases data collection efficiency, this measurement will be a complimentary for the performance measurement of the NWDAFs which does not support DataManagement services. This measurement will also provide information on how many data collection is performed with the more effective manner, which can contribute the potential reduction of the CAPEX.

In this key issue, the potential solutions are provided on the performance measurement about the Nnwdaf\_DataManagement services provided by NWDAF.

### 4.5.2 Potential requirements

**REQ-NWDAF-DM-SERV-COUNT-1：**the 3GPP management system should have a capability to provide the statistic information of the Nnwdaf\_DataManagement services provided by NWDAF about how frequently the services are requested and about the service successful rate.

### 4.5.3 Potential solutions

#### 4.5.3.1 Potential solution #1: number of Nnwdaf\_DataManagement service subscriptions and/or requests

##### 4.5.3.1.1 Introduction

This solution is proposed on how to provide the performance measurement about the Nnwdaf\_DataManagement service provided by NWDAF. In this solution, the proposed performance measurements are defined as the number of Nnwdaf\_DataManagement service subscriptions and/or requests received by NWDAF.

The proposed solution can be a potential solution for the performance measurement about the Nnwdaf\_DataManagement services provided by NWDAF.

##### 4.5.3.1.2 Description

The proposed performance measurements about the Nnwdaf\_DataManagement service are defined as the number of Nnwdaf\_DataManagement service subscriptions and/or requests received by NWDAF.

The number of Nnwdaf\_DataManagement service subscriptions received by NWDAF can be measured as follows:

- When the NWDAF receives the Nnwdaf\_DataManagement\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted subscription is added to the relevant counter.

- When the NWDAF receives the Nnwdaf\_DataManagement\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, each rejected subscription is added to the relevant counter.

The number of Nnwdaf\_DataManagement service requests received by NWDAF can be measured as follows:

- When the NWDAF receives the Nnwdaf\_DataManagement\_Fetch service operation (See TS 23.288 [2]) from the NWDAF service consumer, each accepted request is added to the relevant counter.

- When the NWDAF receives the Nnwdaf\_DataManagement\_Fetch service operation (See TS 23.288 [2]) from the NWDAF service consumer, each rejected request is added to the relevant counter.

#### 4.5.3.2 Potential solution #2: number of Nnwdaf\_DataManagement service notifications and/or responses

##### 4.5.3.2.1 Introduction

This solution is proposed on how to provide the performance measurement about the Nnwdaf\_DataManagement service provided by NWDAF. In this solution, the proposed performance measurements are defined as the number of Nnwdaf\_DataManagement service notifications and/or responses generated by NWDAF.

The proposed solution can be a potential solution for the performance measurement about the Nnwdaf\_DataManagement services provided by NWDAF.

##### 4.5.3.2.2 Description

The proposed performance measurements of the NWDAF are defined as the number of Nnwdaf\_DataManagement service notifications and/or responses generated by NWDAF.

The number of Nnwdaf\_DataManagement service notifications generated by NWDAF can be measured as follows:

- When the NWDAF generates the Nnwdaf\_DataManagement\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated notification is added to the relevant counter.

- When the NWDAF generates the Nnwdaf\_DataManagement\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated error notification is added to the relevant counter.

The number of Nnwdaf\_DataManagement service responses generated by NWDAF can be measured as follows:

- When the NWDAF generates the Nnwdaf\_DataManagement\_Fetch Response service operation to NWDAF service consumer (See TS 23.288 [2]), each generated response is added to the relevant counter.

- When the NWDAF generates the Nnwdaf\_DataManagement\_Notify service operation to NWDAF service consumer (See TS 23.288 [2]), each generated error response is added to the relevant counter.

### 4.5.4 Evaluation

In order to measure how busy the NWDAF is on data collection related services, there are multiple potential solutions for the performance measurement on data collection exposed by NWDAF. The data collection may be performed via Nnwdaf DataManagement services provided by NWDAF.

In the potential solution #1, the performance measurements on data collection exposed by NWDAF are provided as the number of Nnwdaf\_DataManagement service subscriptions and/or requests received by NWDAF. In the potential solution #2, the performance measurements on data collection exposed by NWDAF are provided as the number of Nnwdaf\_DataManagement service notifications and/or responses generated by NWDAF.

These two proposed performance measurements can indicate how often the Nnwdaf\_DataManagement services are requested and how busy the NWDAF is on data collection related services.

Consequently, these two potential solutions are feasible candidates as input to the normative phase on the performance measurement on data collection exposed by NWDAF.

### 4.5.5 Conclusion for KI#5

The potential solution #1 and #2 can provide the performance measurements on data collection exposed by NWDAF which can satisfy the requirements. These two potential solutions are feasible candidates as input to the normative phase on the performance measurement on data collection exposed by NWDAF.

## 4.6 Key Issue #6: Performance measurement of the NWDAF related to the analytics result generation

### 4.6.1 Description

The analytic result provided by the NWDAF may be time sensitive. For those analytics, the consumers of analytics services may indicate to the NWDAF the latest time that they expect to receive the analytics result provided by the NWDAF, e.g., "in 10 minutes". And at the same time, this time should not be set to a value less than the Supported Analytics Delay of the selected NWDAF, if applicable. Otherwise, after NWDAF receives the service requests/subscriptions, the NWDAF does not have enough time to perform the actions related to the analysing.

Not only the service consumers have additional requirements on the time used by NWDAF to generate the analytic result, but the operators may also want to have a close look at how much time is consumed by a NWDAF instance to generate the analytics result. For example, an increasing average time consumed by a NWDAF instance to provide a specific type of analytic, e.g., a specific Analytics ID or a group of Analytics IDs, may indicate efficiency problems which may be caused by inefficient data collection, insufficient resource allocation or even worse: something wrong within the NWDAF instance. With this information, the operators are able to understand the working status of the NWDAF instance under monitoring and make correct decisions on whether they need to provide the management actions to solve the problem or to optimize the situation.

The time consumed by the NWDAF to provide the analytic services reflects the performance of the NWDAF. Monitoring this information is a specific and unique requirement which is particularly important for NWDAF.

In this key issue, the potential solution(s) is provided on the performance measurements of the NWDAF related to the time consumed by the NWDAF to provide the analytics services.

### 4.6.2 Potential requirements

**REQ-NWDAF\_DELAY-1:** the 3GPP management systemshall have a capability to measure the time consumed by the NWDAF to perform the analytics subscription service.

**REQ-NWDAF\_DELAY-2:** the 3GPP management systemshall have a capability to measure the time consumed by the NWDAF to perform the analytics request service.

### 4.6.3 Potential solutions

#### 4.6.3.1 Potential solution #1: time consumption of NWDAF generating analytics result

##### 4.6.3.1.1 Introduction

This solution is proposed on how to provide the performance measurement of the NWDAF based on the time consumed by the NWDAF to provide the analytics services. In this solution, the proposed performance measurements are defined as the time consumption of NWDAF generating analytics result.

The proposed solution can be a potential solution for the performance measurement of the NWDAF related to the analytics result generation.

##### 4.6.3.1.2 Description

These proposed performance measurements of the NWDAF are defined as the time consumption of the NWDAF generating analytics result.

The time consumption of the NWDAF generating analytics result can be measured as follows:

- The time when the NWDAF receives the Nnwdaf\_AnalyticsSubscription\_Subscribe service operation (See TS 23.288 [2]) from the NWDAF service consumer, minus the time when the NWDAF invokes the Nnwdaf\_AnalyticsSubscription\_Notify service operation (See TS 23.288 [2]) to notify the NWDAF service consumer,

- or the time when the NWDAF receives the Nnwdaf\_AnalyticsInfo\_Request service operation (See TS 23.288 [2]) from the NWDAF service consumer, minus the time when the NWDAF sends the corresponding response to the NWDAF service consumer.

### 4.6.4 Evaluation

The performance measurements of NWDAF include many aspects, such as time performance of NWDAF (i.e., time consumed by the NWDAF to perform services). In order to measure how much time is consumed by a NWDAF to generate the analytics result, there is one potential solution for the performance measurement of the NWDAF on the time aspect for the analytics result generation.

In the potential solution #1, the performance measurements of the NWDAF on the time aspect are provided as the time consumption of NWDAF generating analytics result. This performance measurement can indicate the time consumed by the NWDAF to perform the analytics subscription and or request service.

Consequently, this potential solution can satisfy the REQ1 and REQ2 to provide the performance measurement of the NWDAF on the time aspect for the analytics result generation. This potential solution is a feasible candidate as input to the normative phase on the performance measurement of the NWDAF on the time aspect for the analytics result generation.

### 4.6.5 Conclusion for KI#6

This potential solution #1 can satisfy the REQ1 and REQ2 to provide the performance measurement of the NWDAF on the time aspect for the analytics result generation. This potential solution is a feasible candidate as input to the normative phase on the performance measurement of the NWDAF on the time aspect for the analytics result generation.

## 4.7 Key Issue #7: Performance Management of the NWDAF Analytics-related Timing

### 4.7.1 Description

One area for NWDAF performance management is to study NWDAF’s performance in case of errors due to timer expiration. The optional time "Time when analytics information is needed" could be specified during the analytics subscription/request by the consumer. It indicates to the NWDAF the latest time at which the analytics consumer expects to receive the requested analytics data. Meanwhile, the NWDAF has a delay per Analytics ID, called "Supported Analytics Delay", that is specified in the NWDAF profile and indicates the amount of time per per Analytics ID that is expected to lapse between the instant that the NWDAF receives a request for analytics and the time point at which the NWDAF delivers the corresponding analytics report.

Ideally, the time "Time when analytics information is needed" should not be set to a value lower than "Supported Analytics Delay". Otherwise, if the time "Time when analytics information is needed" is reached but the analytics information is not ready, the UNSATISFIED\_REQUESTED\_ANALYTICS\_TIME error message might be returned, while if the time "Time when analytics information is needed" is set to a value lower than "Supported Analytics Delay", it is expected that the NWDAF might not be able to treat the Analytics ID on time.

On the other hand, the specifications indicate that NWDAF should trigger ML model training, but the time required for that operation (which can be significantly long under certain circumstances) is not considered in the "Supported Analytics Delay" attribute. In addition, the performance management of NWDAF related to errors generated by expiration of "Time when analytics information is needed" is missing. Thus, there is the need of introducing performance measurement and KPI for performance management of the NWDAF based on this aspect.

The 3GPP management system should introduces the enablers to manage NWDAF performance based on expiration of "Time when analytics information is needed" specified by analytics consumer in the analytics subscription/request. In particular, the 3GPP management system should introduce a mechanism to keep track of analytics production failures due to infringement of timing attributes specified in the analytics subscription/request.

### 4.7.2 Potential requirements

**REQ-NWDAF\_TIMER-1:** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to track the number of events/scenarios for which all the times are appropriately configured, which is the case when the " Time when Analytics is delivered to the consumer" is lower than "Supported Analytics Delay" and the "Supported Analytics Delay" is lower than the "Time when Analytics information is needed".

**REQ-NWDAF\_TIMER-2:** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to track the number of events/scenarios for which the analytics is delivered after the supported delay but before the deadline, which is the case when the "Supported Analytics Delay" is lower than " Time when Analytics is delivered to the consumer" and "time within which Analytics is delivered to the consumer" is lower than "Time when Analytics information is needed".

**REQ-NWDAF\_TIMER-3**: the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to track the number of events/scenarios for which analytics computation is too late. which is the case when "Supported Analytics Delay" is lower than " Time when Analytics is delivered to the consumer".

**REQ-NWDAF\_TIMER-4:** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to track the number of events/scenarios for which the consumer request is misconfigured, which is the case when the " Time when Analytics is delivered to the consumer", is lower than "Time when Analytics information is needed" but "Time when Analytics information is needed" is itself lower than the "Supported Analytics Delay

**REQ-NWDAF\_TIMER-5:** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to track the number of events/scenarios for which the analytics is delivered before the supported delay but not by the deadline, analytics deadline is misconfigured configured, which is the case when the " Time when Analytics is delivered to the consumer" is lower than "Supported Analytics Delay" but not lower than "Time when Analytics information is needed".

**REQ-NWDAF\_TIMER-6:** the 3GPP management system shall have a capability to allow an authorized consumer to configure the NWDAF to track the number of events/scenarios for which the analytics is delivered after both the supported delay and the deadline, but the deadline is misconfigured, which is the case when the " Time when Analytics is delivered to the consumer" is lower "Time when Analytics information is needed" and lower than "Supported Analytics Delay" but , "Supported Analytics Delay" is greater than the "Time when Analytics information is needed".

### 4.7.3 Potential solutions

#### 4.7.3.1 Potential solution #1: the number of events/scenarios for which all the times are appropriately configured

##### 4.7.3.1.1 Introduction

This potential solution is proposed on how to provide the performance management of the NWDAF analytics-related timing in the case where all the time are appropriately configured, which is the case when the "Time when Analytics is delivered to the consumer" is lower than "Supported Analytics Delay" and the "Supported Analytics Delay" is lower than the "Time when Analytics is needed".

In this solution, the number of events/scenarios for which all the times are appropriately configured are defined. This proposed solution is used to satisfy the REQ-NWDAF\_TIMER\_1 and can be a potential solution for the performance management of the NWDAF analytics-related timing.

##### 4.7.3.1.2 Description

This proposed solution defined the number of events/scenarios for which all the times are appropriately configured.

The number of events/scenarios for which all the times are appropriately configured can be measured as follows:

- Calculate the difference between the "Time when Analytics is delivered to the consumer" and the "Supported Analytics Delay", and calculate the difference between the "Supported Analytics Delay" and the "Time when Analytics is needed". If both results are less than 0, the related events will be added to the relevant counter.

#### 4.7.3.2 Potential solution #2: the number of events/scenarios for which the analytics is delivered after the supported delay but before the deadline

##### 4.7.3.2.1 Introduction

This potential solution is proposed on how to provide the performance management of the NWDAF analytics-related timing in the case where the analytics is delivered after the supported delay but before the deadline, which is the case when the "Supported Analytics Delay" is lower than "Time when analytics is delivered to the consumer" and "Time when analytics is delivered to the consumer" is lower than "Time when Analytics is needed".

In this solution, the number of events/scenarios for which the analytics is delivered after the supported delay but before the deadline are defined. This proposed solution is used to satisfy the REQ-NWDAF\_TIMER\_2 and can be a potential solution for the performance management of the NWDAF analytics-related timing.

##### 4.7.3.2.2 Description

This proposed performance measurements of the NWDAF are defined as the number of events/scenarios for which the analytics is delivered after the supported delay but before the deadline.

The number of events/scenarios for which the analytics is delivered after the supported delay but before the deadline can be measured as follows:

- Calculate the difference between the "Supported Analytics Delay" and the "Time when analytics is delivered to the consumer", and calculate the difference between the "Time when analytics is delivered to the consumer" and "Time when analytics is needed". If both results are less than 0, the related events will be added to the relevant counter.

#### 4.7.3.3 Potential solution #3: the number of events/scenarios for which analytics computation is too late

##### 4.7.3.3.1 Introduction

This potential solution is proposed on how to provide the performance management of the NWDAF analytics-related timing in the case where analytics computation is too late, which is the case when the "Supported Analytics Delay" is lower than "Time when Analytics is delivered to the consumer".

In this solution, the number of events/scenarios for which analytics computation is too late are defined. This proposed solution is used to satisfy the REQ-NWDAF\_TIMER\_3 and can be a potential solution for the performance management of the NWDAF analytics-related timing.

##### 4.7.3.3.2 Description

This proposed performance measurements of the NWDAF are defined as the number of events/scenarios for which analytics computation is too late.

The number of events/scenarios for which analytics computation is too late can be measured as follows:

- Calculate the difference between the "Supported Analytics Delay" and the "Time when Analytics is delivered to the consumer". If the result is less than 0, the related events will be added to the relevant counter.

#### 4.7.3.4 Potential solution #4

Let denote with the "Supported Analytics Delay", with TA the "Time when Analytics information is needed" and with TD the "Time when Analytics is delivered to the consumer". Then the following measurements and or counters for NWDAF timing performance may be introduced in one of the specifications TS 28.552, TS 28.554, TS 23.501, TS 23.288:

- **NbrAnalSuccNWDAFTimeAn (TD≤DS≤TA):** This measurement provides the number of analytics produced in time when "Time when analytics information is needed" timer is correctly sets higher than "Supported Analytics Delay".

- **NbrAnalWarnSuccNWDAFTimeAn (DS<TD≤TA ):** This measurement provides the number of analytics produced before "Time when analytics information is needed" timer expiration but with a longer time than "Supported Analytics Delay".



- **NbrAnalFailNWDAFTimeAn( TA expiration ):** This measurement provides the number of analytics failures due to "Time when analytics information is needed" timer expiration.

- **NbrAnalSuccNWDAFSuppAnDelay (number of success when TD≤TA< DS ):** This measurement provides the number of analytics successes when "Time when analytics information is needed" timer has been set to a value lower than "Supported Analytics Delay".



- **NbrAnalFailNWDAFSuppAnDelay (number of failure when TA≤DS):** This measurement provides the number of analytics failures due to "Time when analytics information is needed" timer expiration when the timer has been set to a value lower than "Supported Analytics Delay". In this case, the NWDAF produced the analytics with a time lower than "Supported Analytics Delay".



- **NbrAnalFailNWDAFProactTimeAn (number of failure when TA≤DS and NWDAF rejected the request):** This measurement provides the number of analytics failures due to proactively reject of analytics request/subscription in case NWDAF predicts that an analytics request/subscription cannot be satisfied within "Time when analytics information is needed" time with high probability.



### 4.7.4 Evaluation

In order to keep track of NWDAF services failures due to infringement of timing attributes, there are four potential solutions proposed for the performance management on the NWDAF analytics-related timing.

In potential solution #1, the number of events for which all the times are appropriately configured is provided. In potential solution #2, the number of events for which the analytics is delivered after the supported delay but before the deadline is provided. In the potential solution #3, the number of events for which analytics computation is too late is provided. The potential solution #4 is based on timer which provides the number of analytics or analytics failures in different specific cases. All the potential solutions can monitor the NWDAF services failures and satisfy the requirements provided in clause 4.7.2.

Consequently, the potential solution #1, #2, #3, #4 can satisfy the requirements to provide the performance measurement on the NWDAF analytics-related timing. These solutions are feasible candidates as input to the normative phase on the performance management of the NWDAF analytics-related timing.

### 4.7.5 Conclusion for KI#7

The potential solution #1, #2, #3, #4 can satisfy the requirements to provide the performance measurement on the NWDAF analytics-related timing. These solutions are feasible candidates as input to the normative phase on the performance management of the NWDAF analytics-related timing.

# 5 Conclusions and recommendations

The technical report identified and documented a wide range of key issues for enhancement of the management aspects related to NWDAF, derived the corresponding potential requirements on 3GPP management system, proposed potential solutions to address the related key issues and evaluated the potential solutions (see clause 4).

For enhancement of the management aspects related to NWDAF in normative work in 3GPP Rel-18, it is recommended:

To specify:

> 3GPP management enhancement related to the NWDAF for conditionally managing NWDAF to the specific deployment scenarios, based on the key issues studied, evaluated and concluded in TR 28.864, which includes the following issues:

>> For the NWDAF applying for all deployment scenarios,

- Specifying enhancement to support monitoring the data collection performance of NWDAF;

>> For the deployment scenario supporting multiple NWDAFs and coordination between multiple NWDAFs:

- Specifying enhancement to 3GPP NRMs to support management of NWDAF deployed with different capabilities including the “analytics aggregation capability” and “analytics metadata provisioning capability”;

- Specifying enhancement to support monitoring the performance of NWDAF which support the “analytics aggregation capability”.

>> For the deployment scenario including NWDAF with logical decomposition:

- Specifying enhancement to 3GPP NRMs to support management of NWDAF deployed with different logical functions including the MTLF (Model Training Logical Function) and AnLF (Analytics Logical Function);

- Specifying enhancement to support monitoring the performance of NWDAF which contain AnLF;

- Specifying enhancement to support monitoring the performance of NWDAF which contain MTLF;

Note: The NWDAF containing AnLF and/or MTLF is the NWDAF supporting logical decomposition.

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-04 | SA5#142e | S5-222052  S5-222621  S5-222622  S5-222623  S5-222624 |  |  |  | Initial Skeleton  clause titles for TR28864  new KI on NRM enhancement to support Multiple NWDAF Deployment  Add new key issue for the NRM enhancement of NWDAF to support the logical decomposition of NWDAF  Add new key issue for the performance management of the NWDAF on the interaction aspect | 0.1.0 |
| 2022-05 | SA5#143e | S5-223578  S5-223587 |  |  |  | Add potential solution for KI#3  Add New KIs about performance measurement of NWDAF on data collection aspect. | 0.2.0 |
| 2022-07 | SA5#144e | S5-224373  S5-224374  S5-224375  S5-224377  S5-224265 |  |  |  | Update KI#1 and KI#2  Add potential solution#1 for KI#1  Add potential solution#1 for KI#2  Add potential solution#1 for KI#5  Update potential solution#2 for KI#3 | 0.3.0 |
| 2022-08 | SA5#145e | S5-225488  S5-225707  S5-225708  S5-225709  S5-225710  S5-225711  S5-225712 |  |  |  | Update KI#3, potential solution#1 and #2 for KI#3  Update use case and add potential requirements for KI#4  Add new key issue for the performance measurement of the NWDAF related to the analytics result generation and new potential solution.  Add the potential requirements and potential solution for KI#3  Add potential solutions for KI#4  Add new key issue on NWDAF Analytics-related Timing  Add potential solution on service usage of NWDAF for KI#3 | 0.4.0 |
| 2022-11 | SA5#146 | S5-226832  S5-226833  S5-226835  S5-226836  S5-226837  S5-226838  S5-226453  S5-226834 |  |  |  | Add the evaluation for KI#1  Add the evaluation for KI#2  Add the evaluation for KI#3  Add the potential solution for KI#3  Add the evaluation for KI#5  Add the evaluation for KI#6  Add the potential solutions for KI#7 NWDAF Analytics-related Timing  Potential Solution for KI#7 NWDAF Analytics-related Timing | 0.5.0 |
| 2023-03 | SA5#147 | S5-232559  S5-232560  S5-232561  S5-232562  S5-232563  S5-233004  S5-232999  S5-233000  S5-233001  S5-233002 |  |  |  | Add conclusions for KI#1 and KI#2  Update the evaluation and add the conclusion for KI#3  Add the evaluation and conclusion for KI#4  Add conclusions for KI#5 and KI#6  Add the evaluation and conclusion for KI#7  Add conclusions and recommendations for TR 28.864  Update the Scope section  Add requirements for KI#1 and KI#2  Update requirements for KI#3 and KI#4  Provide description of the requirements having been discussed in KI#5 | 0.6.0 |
| 2023-03 | SA#99 | SP-230189 |  |  |  | Presented for information | 1.0.0 |
| 2023-04 | SA5#148e | S5-233581  S5-233582 |  |  |  | Update Evaluation and Conclusion for KI#3  Discussion paper on summarization of TR 28.864 and work plan for MANWDAF | 1.1.0 |
| 2023-06 | SA#100 | SP-230637 |  |  |  | Presented for approval | 2.0.0 |
| 2023-06 | SA#100 |  |  |  |  | Upgrade to change control version | 18.0.0 |