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| 3GPP TR 33.866 V0.8.0 (2021-11) |
| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group Services and System Aspects;Study on security aspects of enablers for Network Automation (eNA) for the 5G system (5GS) Phase 2;(Release 17) |
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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 will study the security aspects of enablers for network automation for the 5G system based on the outcome of TR 23.700-91 [1]. More specifically, this study will identify security issues, requirements and corresponding potential security solutions related to the following objectives:

- UE data collection protection to fulfil the NWDAF functionalities including privacy consideration, data authenticity, data integrity, and accessibility aspects requirements.

- Detection of cyber-attacks and anomaly events supported by NWDAF and its related functions, specifically to identify parameters provided by UE and NFs, which can help to detect attacks and abnormal behaviours;

- Protection of data transferring (e.g. privacy consideration) in the inter-NWDAF/NWDAF instances.

NOTE: The user consent for UE data collection is not addressed in the present document, it will be discussed in TR 33.867 [2].

Editor's Note: This study is not complete until the user consent aspects in TR 33.867 that are applicable to eNA are finalized. How TR 33.867 conducts the user consent study (in a general way applicable to eNA or including specific aspects of eNA) will be discussed and addressed in the FS\_UC3S.

# 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 23.700-91: "Study on enablers for network automation for the 5G System (5GS); Phase 2".

[2] 3GPP TS 33.867: "Study on user consent for 3GPP services".

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

[4] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services ".

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

[6] Draft NISTIR 8269: "A Taxonomy and Terminology of Adversarial Machine Learning"; <https://doi.org/10.6028/NIST.IR.8269-draft>

[7] ETSI GR SAI 001: "AI Threat Ontology"..

[8] 3GPP TS 33.501: "Security architecture and procedures for 5G system".

[9] 3GPP TR 28.809: "Study on enhancement of management data analytics".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

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

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

<symbol> <Explanation>

## 3.3 Abbreviations

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

AF Application Function

DoS Denial of Service

DDoS Distributed Denial of Service

eNA enablers for Network Automation

MDAS Management Data Analytics Service

MitM Man in the Middle

ML Machine Learning

NWDAF Network Data Analytics Function

OAM Operation, Administration and Maintenance

4 Overview of eNA

Editor's Note: This clause will contain a brief overview on eNA based on SA2's study (TR 23.700-91), including architectural assumptions, etc.

3GPP TS 23.288 [4] provides the Stage 2 architecture enhancements for 5G System (5GS) to support network data analytics services in 5G Core network, which forms the baseline for the present study on security aspects of enablers for Network Automation (eNA) for the 5G system (5GS).

The Network Data Analytics Function (NWDAF) as specified in 3GPP TS 23.501 [5] interacts with different entities within 5GS for data collection based on subscription to events, retrieval of information from data repositories, retrieval of information about NFs (e.g. from NRF for NF-related information) and on demand provision of analytics to consumers. The NWDAF provides analytics to 5GC NFs and OAM. Analytics information is either statistical information of the past events or predictive information.

3GPP TR 23.700-91 [1] is an architectural study on enhancements for analytics and NWDAF, for which any security impact will be documented in the present document. There is a particular security impact for UE data collection protection, detection of cyber-attacks and anomaly events supported by NWDAF and its related functions, on the protection of data transfer in inter-NWDAF/NWDAF cases.

5 Key issues

Editor's Note: This clause contains all the key issues identified during the study.

5.1 Key issues related to securing the data provided to any type of analytics function

Editor's Note: This clause is for key issues on UE data collection protection to fulfil the NWDAF functionalities including privacy consideration, data authenticity, data integrity, accessibility aspects requirements, according to the first objective of the SID.

5.1.1 Key Issue #1.1:Integrity protection of data transferred between AF and NWDAF

5.1.1.1 Key issue details

The 5GS supports the collection and utilisation of the UE data and delivering it to the NWDAF as an input to generate the analytic information (to be consumed by other NF).

As per KI#8 in TR 23.700-91 [1], there is no direct interface between the UE and the NWDAF. When AF is used for the communication between the NWDAF and UE for data collection, there is a need to study the security aspects for the data provided by the UE to NWDAF via AF and vice versa.

This key issue studies the integrity aspects on data collection and utilization of UE data in order to derive the analytics.

5.1.1.2 Security Threats

If the data shared between AF and NWDAF is not secured, it may lead to the following issue;

Data can be modified and replayed by unauthorized parties.

5.1.1.3 Potential Requirements

Integrity and replay protection shall be supported on the interface between AF and NWDAF for the UE data collection.

5.1.2 Key Issue #1.2: Processing of tampered data

5.1.2.1 Key issue details

5GS is expected to use ML. Two centralized frameworks currently responsible for ML-based analytics, e.g., abnormal behavior analytics, are NWDAF (TS 23.288 [4]) in 5GC and MDAS (TR 28.809 [9]) on OAM. Furthermore, decentralized AI/ML is used in several use cases, such as efficiency optimization in RAN. In addition, a new data collection framework DCCF (clause 6.9, TR 23.700-91 [1]) is proposed for Rel-17.

Network data analytics is including the following steps:

- Request of analytics by consumer

- Collection of data by analytics function

- Processing of collected data by analytics function

- Reply containing analytics output to a consumer by analytics function

While 3GPP provides sound security on the network level, the data used by AI/ML is not being subject to security controls. This key issue seeks solutions to remedy several attacks against a 5GS involving tampered data.

5.1.2.2 Security threats

NOTE: Threats need to be revisited if in line with NIST 8269 [6] and ETSI SAI [7] terminology.

Data used by AI/ML is not being subject to security controls. This allows for a number of attacks against a 5GS with severe impact on performance up to denial of service (DoS) conditions:

 - **Adversarial examples** are generated by slightly perturbating input data. The data is perturbated in a space in which AI/ML algorithms are sensitive to change, leading to severe performance degradation and misclassifications in the inference process. This attack is well-known in human-centric use cases, such as image/audio classification.

- During training, tampered training data can lead to **model skewing**. Skewed models will provide false results in inference.

- Tampered data may also lead to the **information disclosure** of confidential/proprietary AI/ML algorithms by inference.

- In more **simple attacks**, perturbations may not be slight (as those generated by adversarial example methods). In non-human-centric use cases (as most are in 5GS), the perturbations may just be false data to force misinterpretation.

Unprotected analytic functions are subject to:

- Decreased efficiency, e.g. power consumption, load balancing, QoS optimization

- System failure (DoS scenario)

- Inference of confidential ML algorithms employed by 5GS

- Leakage of privacy-related data derived from AI/ML models

5.1.2.3 Potential security requirements

A 5GS analytics function shall be protected from processing unsanitized or tampered data.

NOTE 1: The algoritm used for data sanitization is beyond the scope of 3GPP.

NOTE 2: The threat of data being tampered during transmission is beyond the scope of this key issue.

5.1.3 Key Issue #1.3: Authorization of NF Service Consumers for data access via DCCF

5.1.3.1 Key issue details

A Data Collection Coordination Function (DCCF) is used to coordinate the collection of data from one or more NF(s) based on data collection requests from one or more Consumer NF(s). DCCF and Data Repository Function (DRF) can be standalone NFs, possibly co-located with NWDAF, or can be hosted by NWDAF. Data Collection notification to one or more Consumer NF(s) may be supported via a Messaging Framework. Adaptors supporting 3GPP services allow NFs to interact with the Messaging Framework. Only the interface between 3GPP entities and the adaptors is in 3GPP scope. This includes 3GPP services offered by adaptors to allow NFs to interact with the Messaging Framework.

TR 23.700-91-100 conclusion mentions that "Additional authorization for Consumers to access data from a Data Source via the DCCF and to access data from DRF (directly or via DCCF) needs to be coordinated with SA3". According to SA2 KI#11 conclusions, if a consumer subscribes to analytics notifications to the DCCF, the DCCF can subscribe itself to the data source and notify the data source that notifications are to be sent directly to the consumer. The data source will then send notifications to the consumer via the MF or the DCCF.

This key issue addresses the authorization of data consumer to access the data (via DCCF) from the data source or the DRF, and the authorization aspects of the DCCF being allowed to subscribe the data on behalf of the consumer at the data source or the DRF, i.e. the security aspect on usage subscription/notification mechanisms for a consumer to receive notifications on a different path (as adapted in SA2 conclusions) will be studied.

5.1.3.2 Security threats

DCCF introduces a new path for an NF Service Consumer (NFc) to access the data from data sources or an NF Service Producer (NFp). Due to the introduction of DCCF between consumer and producer, the existing security mechanism will not be sufficient, and the following threats need to be addressed:

An unauthorized data consumer could request service from the DCCF.

NOTE: This threat can be addressed by existing SBA mechanisms. Therefore, no related requirement is added.

Based on a request from a DCCF, the Messaging Framework may provide data from a producer to a requesting data consumer, even though the consumer is not authorized to receive this data.

Based on a request from a DCCF data received from a data producer is stored in the DRF. When the data are later retrieved, the DCCF may provide the stored data to a non-authorized consumer if requested.

A DCCF could subscribe for data from the data source on behalf of the data consumer without the data consumer authorizing DCCF to do so.

The data producer may be unable to correctly verify the identity of the data consumer since the data request is coming from DCCF on behalf of the consumer.

5.1.3.3 Potential security requirements

The data consumer shall be authorized to access the data from the data source.

Authorization of the DCCF shall be supported to access a service of a data source on behalf of a data consumer.

Editor’s Note: Whether the service request including the URI, service name, etc., needs to be verified by the data source is FFS.

5.1.4 Key Issue #1.4: Security protection of data via Messaging Framework

5.1.4.1 Key issue details

In [1], in the conclusions for the Key Issue #11 ‘Increasing efficiency of data collection’, DCCF (Data Collection Coordination Function) is defined for efficient data collection in 5GS. The DCCF is a control-plane function that coordinates data collection and triggers data delivery to Data Consumers.

TR 23.700-91 [1] lists several agreed principles for normative work, some of which are as follows:

- "When a Data Collection Coordination Functionality (DCCF) is deployed, it is used to coordinate collection of data from one or more NF(s) based on data collection requests from one or more Consumer NF(s)."

- "Data Collection notification to one or more Consumer NF(s) may be supported via a Messaging Framework. Adaptors supporting 3GPP services allow NFs to interact with the Messaging Framework.

- "The DCCF coordinates data collection so the same data is not requested multiple times from the same data source."

The Messaging Framework is not expected to be standardized by 3GPP. It contains Messaging Infrastructure that propagates event information and data (e.g.: streaming and notifications) from data sources to data consumers. A Data consumer that uses the Data Management Framework sends requests to the DCCF rather than to a data producer.

In TS 23.288 [2], the Figure 5A.3.2-1 depits the data delivery via a Messaging Framework.

While the Messaging Framework is not standardized by 3GPP, a Messaging Framework Adaptor NF (MFAF) offers 3GPP defined services: 3GPP DCCF Adaptor (3DA) Data Management service and 3GPP Consumer Adaptor (3CA) Data Management service of the Messaging Framework Adaptor Function (MFAF) which are used for interaction between the 3GPP Network and the Messaging Framework.

Since the Messaging Framework is not expected to be standardized by 3GPP, it may not be trusted.

The DCCF and the Messaging Framework decouple the data collection between the data consumer and the data source; however, this may induce a security problem because the data consumer cannot verify that the data from the data source is not modified by the Messaging Framework and the confidentiality of the data cannot be guaranteed by the Messaging Framework.

Formatting and/or Processing instructions are options that may be provided in requests by Data Consumers via the Ndccf\_DataManagement service. When using the MFAF, the DCCF sends the formatting and/or processing instructions to the MFAF via the Nmfaf\_3daData\_Management Service so the MFAF may format and/or process the data before sending notifications to the Data Consumers / notification endpoints. When using Data Delivery via the DCCF, the DCCF performs formatting and/or processing before sending notifications.

5.1.4.2 Threats

An attacker may eavesdrop or manipulate or replay the communication or initiate the MitM attacks on the interface.

If the integrity of the data collected from the data source is not protected, then the Messaging Framework may modify the data, which results in producing wrong analytics.

If the confidentiality of the data collected from the data source is not protected, then the Messaging Framework may access the sensitive data, which may cause privacy leakage.

Replay attacks may lead to the utilization of the same data more than once, and therefore, it may cause wrong analytic results.

5.1.4.3 Potential security requirements

The transfer of the data between the data source and data consumer via the messaging framework shall be confidentiality, integrity, and replay protected.

Confidentiality protection, integrity protection, and replay-protection shall be supported on the new interfaces between 3GPP entities and MFAF.

NOTE: MFAF and its services i.e., Nmfaf\_3caDataManagement Service and Nmfaf\_3daDataManagement Service to interact with the messaging framework are defined in TS 23.288. Further, security and deployment of the messaging framework which is a part of MFAF is up to implementation and out of scope of 3GPP.

5.1.5 Key Issue #1.5: UE data collection protection at NF/NWDAF

5.1.5.1 Key issue details

UEs register to 5GS and request services, e.g. the initial registration request to AMF. For fulfilling the service, but also for analytics purposes, 5GS NFs will collect data about the UE being served, e.g. AMF needs to maintain a mapping between SUPI and 5G-GUTI and for accounting the time window for the service used. UE-related data, processed by one NF, may also need to be transferred to another NF to fulfill a service request or for analytics purposes. UE can also provide privacy-sensitive data such as positioning information, user profiling info, etc to NFs, which may be transferred to NWDAF.

This KI is about NF/NWDAF collecting information about the UEs (e.g., UE mobility events, UE registration failures) from the 5G NFs (e.g., AMF, 5G RAN) and determines the threats and requirements for the protection of data related to UE, which are collected by core NFs.

5.1.5.2 Security threats

If the communication between UE and network is not confidentiality protected, then sensitive information about UEs may be leaked to unauthorized entities.

If the integrity of the data collected from UE is not protected, the analytics may not be accurate.

Replay attacks may lead to the utilization of the same UE data more than once, and therefore, it may cause wrong analytic results.

UE-related data stored in an NF or transferred between different NFs may be altered by a malicious entity. The attacker may provide false or modified information to other NFs or an analytics function such as NWDAF. For instance, the malicious entity can modify the UE information statistics or logs sent to the NWDAF.

In case of the network is not authenticated by the UE, the UE may send UE-related data to an unauthorized entity, which may lead to leakage of sensitive data from the UE.

If an unauthenticated UE is sending data, it may send erroneous data to NF/NWDAF. This can compromise the efficiency, performance, and output of analytics algorithms implemented in the analytics functions. If the NF/NWDAF which is receiving UE data is not properly authenticated and authorized, the sender may transfer the UE-related data to an unauthorized NF or analytics function.

5.1.5.3 Potential security requirements

1. UE and network shall mutually authenticate each other.

2. The communication between UE and the network shall be confidentiality protected.

3. The data collected from UE shall be integrity protected.

4. Data transferred from UE to NFs and from NFs to the analytics function shall be protected against replay attacks.

5. Authorization of NFs and analytics functions to receive, send, or transfer UE-related data shall be assured.

5.2 Key issues related to the detection of cyber-attacks and anomaly events by analytics function

Editor's Note: This clause is for key issues on detection of cyber-attacks and anomaly events supported by NWDAF and its related functions, specifically to define parameters provided by UE to help detect attacks and abnormal behaviours, according to the second objective of the SID.

5.2.1 Key Issue #2.1: Cyber-attacks detection supported by NWDAF

5.2.1.1 Key issue details

NWDAF has been defined to offer automatic network analytics and alarming, with possible capabilities of artificial intelligence and machine learning to help proactively manage the 5G network. 3GPP TR 23.700-91[1] has identified the use case of NWDAF detecting cyber-attacks by monitoring events and data packets in the UE and the network, with the support of machine-learning algorithms. To achieve cyber-attacks detection, the NWDAF can collaborate with UE and any other NFs to collect related data as inputs and providing alerts of anomaly events as outputs to OAM and other NFs which have subscribed to them so that they could take proper actions.

This key issue describes what kind of cyber-attacks can be detected by NWDAF. In order to mitigate the identified cyber-attacks, the data/parameters collected by NWDAF need to be studied.

The specific cyber-attacks for which an analytics function may provide detection support include but are not limited to the following examples:

**(1) MitM attacks on the radio interface:** MitM attacks or fraudulent relay nodes may modify or change messages between the UE and the RAN, resulting in failures of higher layer protocols such as NAS or the primary authentication. The NWDAF may detect MitM attacks.

**(2) DoS attacks:** 5G has high performance requirements for system capacity and data rate, improved capacity and higher data rate may lead to much higher processing capability cost for network entities, which may make some network entities (e.g. RAN, Core Network Entities) to suffer from DDoS attack. The NWDAF may also enable the detection of DDoS attacks, e.g. when observing abnormal amount of transactions dispersed by a UE or group of UEs at a location and/or a slice (refer to table 6.7.5.1-1, TS 23.288) to initiate signaling storm attack.

5.2.1.2 Security threats

Cyber-attack may not be detected by the 5G network, thus further attacks could be conducted.

Anomaly events may not be detected by the 5G network, thus further attacks could be conducted.

5.2.1.3 Potential security requirements

The 5GS system shall support the detection of cyber-attacks by providing related inputs or collecting output analytics using an analytics function such as NWDAF.

Editor's Notes: The requirement may be updated according to SA2's feedback.

5.2.2 Key Issue #2.2: Anomalous NF behaviour detection by NWDAF

5.2.2.1 Key issue details

The 5GC supports different NF deployments that could be in distributed or redundant fashion so that the NF provides the services from several locations and several execution instances. When these NFs are distributed across diverse cloud infrastructure, it is possible that the NFs may behave in an undefined manner. The undefined behaviour of the NF may be caused by internal errors such as configuration mistakes or internal data corruption. This misbehaviour may impact one or more UE services based on the type of NF. Thus, the correlation of which NF is handling which UE data is an important aspect, such that NWDF is enabled to conclude from the reported UE-related data, which NF may have anomalous behaviour.

In all such instances, it is imperative that an analytics function such as NWDAF monitors the behaviour of all the NFs and ensures that the NFs behave as defined. If the NFs behave erroneously, it should be possible to detect the anomaly so that appropriate steps can be taken, e.g. by an operator, to control the potentially damaging behaviour.

Note, it is up to the operator to define the details of what NFs should report if such monitoring and detection by NWDAF is desired. However, there is a need to enable NWDAFs to receive or request reports by NFs which serve the detection of anomalous NF behaviour.

5.2.2.2 Security threats

Different NFs may behave in an undefined manner. Anomalous or malicious NF behaviour could be, for instance, include attempts to access NF/NF service which was not authorized to a NF as NF/NF service consumer, to unusually high consumption of network or compute resources for NF as either NF/NF service consumer or producer, to triggering of DoS attack on NF service producer by continuously sending malicious messages, e.g. ill http request, etc., attempts to exhaust connections of http server.

The above conditions can happen either due to internal data corruption, configuration errors, or cross communication between NFs from different vendors. Based on the NF type, such NFs could cause damage to either one or multiple UEs. For example, in the case of an AMF or SMF dedicated to a network slice, the service for all UEs within the whole network slice could be affected. Even the whole network slice could get out of service.

An erroneous NF may succeed in knocking the whole network out of service by sending wrong messages to other NFs, causing other NFs to get out of service.

The NFs within the 5GC are already authenticated and allowed to communicate with each other based on successful authentication and authorization. If the NF is misconfigured or has internal data corruption, etc, the assumption of trust becomes invalid and causes potential threats.

5.2.2.3 Potential security requirements

It should be possible for the network to detect anomalous NFs using the data collected from UE and NFs.

NOTE: By this requirement, it is only assured that specific data can be collected by and/or reported to an analytics function. Which AI/ML is used is implementation-specific and out of scope in 3GPP.

5.3 Key issues related to data transfer protection

Editor's Note: This clause is for key issues on protection of data transferring (e.g. privacy consideration) in the inter-NWDAF/NWDAF instances, according to the third objective of the SID.

5.3.1 Key Issue #3.1: Privacy preservation for transmitted data between multiple NWDAF instances

5.3.1.1 Key issue details

In the case of Multiple NWDAF Instances, during the transfer of data/metadata/analytics output, it needs to be ensured that the privacy of the user is preserved.

It needs to be ensured that appropriate measures are taken by the sender NWDAF to protect any information which can reveal the privacy of the user, such as positioning information, user profile information, etc., before sending privacy-related data to another NWDAF instance. Privacy-related information that has been allowed by the User for analysis should not be transferred without sufficient protection mechanism.

5.3.1.2 Security threats

Information that can reveal the identity of the user can compromise privacy when transmitted unprotected.

The transfer of personally identifiable information without adequate protection measures constitutes a threat against user privacy and possibly violates regulations on data protection.

Editor's Note: Description of the attacker model is FFS.

NOTE: A user signs the privacy agreement with an operator. When the permission is granted from the user, the operator is authorized to process the data for the purpose agreed by the user. The user is unware of and has no need to know which NWDAF instance the data is transfered to. What matters is whether the data is used for the agreed purpose. Transferring the data from one NWDAF instance to another within the operator’s network has no privacy implications.

5.3.1.3 Potential security requirements

Any information which can reveal the identity of the user, such as positioning information, user profile information, etc, should be securely protected before data is being shared or transferred to other NWDAF Instances.

5.3.2 Key Issue #3.2: Protection of UE data in transit

5.3.2.1 Key issue details

The UE is providing the core network functions with data, which are reported to or requested by analytics functions. The transfer of any data between core network functions needs to be protected.

According to TS 23.288 [y] the NWDAF collects data from various data sources and provides Analytics Output to different NWDAF data consumers. In addition, according to the solutions for KI#2 "Multiple NWDAF Instances" proposed in TR 23.700-91 [x] the analytics data or the analytics output can be transferred from one NWDAF instance to another NWDAF instance.

Data in transit needs to be protected while in transfer between NWDAFs, NF to NWDAFs, and NWDAF to another entity, e.g. DCCF.

This key issue addresses security for data in transit involving an analytics function.

5.3.2.2 Security Threats

If data is transferred between NFs or different NWDAF Instances, a MitM (for instance a malicious SCP) can compromise data by eavesdropping or modification.

A rogue NWDAF Instance can send wrong or modified data to another NWDAF instance.

5.3.2.3 Potential security requirements

Data transferred between core network functions shall be integrity, confidentiality, and replay protected.

5.3.3 Key Issue #3.3: Ensuring restrictive transfer of ML models between authorized NWDAF instances

5.3.3.1 Key issue details

In 3GPP TS 23.288 Clause 5.1 Note 3, it is stated “In this Release of the specification an NWDAF containing AnLF is locally configured with (a set of) NWDAF (MTLF) ID(s) and the analytics ID(s) supported by each NWDAF containing MTLF to retrieve trained ML models. An NWDAF containing AnLF uses NWDAF discovery for NWDAF(MTLF) within the set of configured NWDAF containing MTLF ID(s), if necessary.”

Since machine learning models are trained using proprietary algorithms, and sometimes are also trained using sensitive data, securing them and ensuring restricted usage and secure transfer is paramount. Therefore, this key issue will study how to ensure that trained model sharing is only allowed among authorized NWDAF instances.

5.3.3.2 Security Threats

If ML models are shared with an NF, which is not authorized, proprietary and sensitive implementation-specific information may be leaked.

5.3.3.3 Potential security requirements

Only authorized NWDAF instances should be allowed to consume ML models from other NWDAF instances.

# 6 Solutions

Editor's Note: This clause contains the proposed solutions addressing the identified key issues.

## 6.0 Mapping of solutions to key issues

Table 6.0-1: Mapping of solutions to key issues

|  |  |
| --- | --- |
| Solutions | Key Issues |
| 1 Key issues related to securing the data provided to any type of analytics function | 2 Key issues related to detection of cyber-attacks and anomaly events by analytics function | 3 Key issues related to data transfer protection |
|  | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 2.1 | 2.2 | 3.1 | 3.2 | 3.3 |
| #1: UE data collection protection |  |  |  |  | X |  |  |  |  |  |
| #2: Network Analysis Framework for DDoS Attack |  |  |  |  |  | X |  |  |  |  |
| #3: Usage of current SBA mechanisms to protect data in transit |  |  |  |  |  |  |  |  | X |  |
| #4: DCCF determining if NF Service consumer is authorized to invoke a service to a Data Producer NF for data collection |  |  | X |  |  |  |  |  |  |  |
| #5: Providing the security of data via Messaging Framework |  |  |  | X |  |  |  |  |  |  |
| #6: Integrity protection of data transferred between AF and NWDAF | X |  |  |  |  |  |  |  |  |  |
| #7: Detection of anomalous NF behaviour by NWDAF |  |  |  |  |  |  | X |  |  |  |
| #8: Privacy preservation of transmitted data |  |  |  |  |  |  |  | X |  |  |
| #9: Processing of tampered data |  | X |  |  |  |  |  |  |  |  |
| #10:Authorization of NF Service Consumers for data access via DCCF |  |  | X |  |  |  |  |  |  |  |
| #11: Authori-zation of NF Service Consumers to access data from ADRF via DCCF |  |  | X |  |  |  |  |  |  |  |
| #12: Solution on Authorization of Data Consumers for data access via DCCF |  |  | X |  |  |  |  |  |  |  |
| #13: Solution for UE data collection protection at NF/NWDAF |  |  |  |  | X |  |  |  |  |  |
| #14: Solution to ML restrictive transfer |  |  |  |  |  |  |  |  |  | X |
| #15: Solution on Protection of data sent via MFAF using existing SBA mechanisms |  |  |  | X |  |  |  |  |  |  |

## 6.1 Solution #1: UE data collection protection

### 6.1.1 Introduction

This solution addresses KI#1.5 on UE data collection protection at NF/NWDAF

### 6.1.2 Solution details

For enhancing the 5GS to support collection and utilisation of data provided by the UE in NWDAF in order to provide input information to generate analytics information (to be consumed by other NFs) the communication between UE and NF/NWDAF needs to be secured.

In line with 5GS generic security requirements it is therefore proposed that the transfer of data between UE and NF/NWDAF related to UE data collection re-uses existing 5GS security mechanisms.

For UE data collection by NFs and NWDAF, the current NAS and AS security mechanisms for authentication, confidentiality, integrity and replay protection as described in 3GPP TS 33.501 are used.

NOTE: Whether user consent is necessary is subject of the user consent study FS\_UC3S.

For transfer of UE data to NF/NWDAF privacy requirements could apply.

### 6.1.3 Evaluation

This solution reuse the existing 5GS security mechanisms, include the current NAS and AS security mechanisms to solve the security problems between UE and network..

This solution provides authentication, confidentiality, integrity and replay protection as described in 3GPP TS 33.501.

This solution meets the requirement in KI#1.5 without any extra system impact.

## 6.2 Solution #2: Network Analysis Framework for DDoS Attack

### 6.2.1 Introduction

The solution addresses key issue #2.1: Cyber-attacks Detection supported by NWDAF.

### 6.2.2 Solution details

#### 6.2.2.1 Introduction

As depicted in clause 6.7.5 in TS 23.288 [4], the NWDAF could collect the following input data:

- Exceptions information from AF, including: IP address 5-tuple, exception ID, exception level, and exception trend.

- UE mobility information from OAM is UE location carried in MDT data.

- Network data related to UE mobility from AMF, including: UE ID, UE location, Timestamp, TAC, frequent mobility registration update.

- Service data related to UE mobility provided by AF, including: UE ID, Application ID, UE location, Timestamp.

- Service data related to UE communication provided by SMF, AF, UPF, including: UE ID, group ID, S-NSSAI, DNN, Application ID, Expected UE behaviour parameters, communication description per application (e.g. communication start, communication stop, UL data rate, DL data rate, traffic volume), TAC.

The NWDAF could output the following: Exception ID, Exception Level, Exception trend, UE characteristics, SUPI list (1..SUPImax), Ratio, Amount, Additional measurement, Confidence.

Specifically, exception ID can be “Suspicion of DDoS attack” means that the UE may trigger a DDoS attack. In this case, Additional measurement is “Victim's address (target IP address list)”. And the mitigation can be “PCF may request SMF to release the PDU session. SMF may release the PDU session and apply SM back-off timer.”

However, the analysis is just for DDoS attack to external AF.

DDoS attack to internal NF, e.g. RAN, Core Network should also be investigated. In order to make it more clear to capture the DDoS analysis, it is proposed a network analysis framework for DDoS attack.

#### 6.2.2.2 Network Analysis Framework for DDoS attack

The framework is depicted in table 6.2.2.2-1. In column DDoS attack, target network entity and attack method shall be clarified. In column analysis, input, output and mitigation are listed as the same way as TS 23.288 [4]. With the framework, it will be more clear how to capture attack and how to detect the DDoS attack.

Table 6.2.2.2-1 Network Analysis Framework for DDoS attack.

|  |  |
| --- | --- |
| DDoS Attack | Analysis |
| Target | Method | Input | Output | Mitigation |
| AF | DDoS using heavy UP traffic | AF: GPSI, external group ID, Exception information (IP address 5-tuple, exception ID, exception level, and exception trend), Application ID, communication description per application (communication start, communication stop, UL data rate, DL data rate, traffic volume), Expected UE Behaviour parametersSMF: SUPI, internal group ID, Application IDUPF: UE communication description per application (communication start, communication stop, UL data rate, DL data rate, traffic volume)AMF: TAC | DDoS to AF | PCF may request SMF to release the PDU session.SMF may release the PDU session and apply SM back-off timer. |
| RAN | DDoS using heavy RRC signaling | OAM: Global RAN Node ID, time stamp, SUPI, initial RRC message numberAMF: Global RAN Node ID, time stamp, SUPI, initial NAS message number, TAIs, NGAP UE-TNLA binding info, number of requests received, threshold value of requests received per unit time | DDoS to RANVictim RAN Node IDMalicious SUPI | AMF may provide AMF UE N2AP ID and RAN UE N2AP ID to RAN of malicious SUPI.RAN may treat the malicious UEs based on local policy, e.g. release its resource. |
| AMF | DDoS using heavy NAS signaling | OAM: Global RAN Node ID, time stamp, SUPI, initial RRC message numberAMF: AMF instance ID, Global RAN Node ID, time stamp, SUPI, initial NAS message number, initial SM message number | DDoS to AMFVictim AMF instance IDMalicious SUPI | AMF may treat the malicious UEs based on local policy, e.g. release its resource. |

#### 6.2.2.3 The Rational of Each Input Data

When the UEs initiate a DDoS attack to the AF using heavy UP traffic, exception information can provide training data for identifying abnormal UP traffic, communication description per application and Expected UE Behaviour parameters can provide training data for identifying normal UP traffic, TAC identifies the same type of the UE.

When the UEs initiates a DDoS attack to the RAN using heavy RRC signaling, number of initial RRC messages and number of initial NAS messages to RAN or AMF can provide training data for identifying normal RRC signaling. Further information about the TAI assist in understanding the geographical area from where the attack might be originating, and the NGAG UE-TNLA binding information assist in identifying the UEs from which the attack is being generated.

When the UEs initiates a DDoS attack to the AMF using heavy NAS signaling, number of initial RRC messages and number of initial NAS messages to AMF can provide training data for identifying normal NAS signalling, number of initial SM message can identify the abnormal SM signaling caused by UP faults.

### 6.2.3 Evaluation

TBA

## 6.3 Solution #3: Usage of current SBA mechanisms to protect data in transit

### 6.3.1 Introduction

This solution addresses KI#3.2 on protection of data in transfer.

### 6.3.2 Solution details

Any data transferred between core network functions is protected by SBA mechanisms as described in clause 13.3 and clause 13.4 of 3GPP TS 33.501 [8] for authentication and authorization of NF Service Consumer and NF Service Producer.

According to 3GPP TS 33.501 [8], clause 13.3.0, all network functions shall support mutually authenticated TLS and HTTPS. TLS shall be used for transport protection within a PLMN unless network security is provided by other means. Thus, communication between NFs is integrity, confidentiality and replay protected.

By using an access token issued by NRF, NFs are authorized for requesting analytics from an analytics function or providing analytics data to the analytics function.

### 6.3.3 Evaluation

 This solution addresses the requirement of key issue #3.2.

This solution reuses the existing 5GS security mechanisms, including the current SBA security mechanisms to solve the security problems of data transition between NFs.

This solution provides mutual authentication, confidentiality, integrity and replay protection between NFs as described in 3GPP TS 33.501 [8].

## 6.4 Solution #4: DCCF determining if NF Service consumer is authorized to invoke a service to a Data Producer NF for data collection

### 6.4.1 Introduction

This solution addresses KI#1.3, especially the threat that based on a request from a DCCF, the Messaging Framework may provide data from a NF Service Producer to a requesting NF Service Consumer, even though the NF Service Consumer is not authorized to receive this data.

### 6.4.2 Solution details

Currently before an NF Service Consumer invokes a service of an NF Service producer, the NF Service Consumer needs to request authorization from the NRF. The NRF determines if the NF Service Consumer is authorized to use the service of the Service Producer and provides an authorization token. The NF Service Consumer uses the authorization token in the service request to the NF Service Producer and the NF Service Producer executes the service by validating the authorization token.

The above procedure will be used when the NF Service Consumer requires the service of the DCCF for data collection. In such a case the NF Service Consumer will provide an access\_token provided by the NRF in the service request to the DCCF.

NOTE: It is assumed that the NF Service Consumer relies on the DCCF to determine the Data Producer NFs for data collection.

When the DCCF receives the request for data collection, the DCCF identifies the Data Producer NF that can provide the requested data and request authorization from the NRF to invoke the services supported by the identified Data Producers in order to retrieve the data. The issue is that in the authorization request to the NRF, the NRF will not have information on the identity of the NF Service Consumer that requested the data. It is proposed to solve the issue by allowing the DCCF to include in the authorization request to the NRF the authorization token provided by the NF Service Consumer in the service request to the DCCF. In addition, to allow the NRF to verify the identity of the service consumer it is also proposed to NF Service Consumer includes a CCA token which will be used by the NRF to verify the identity of the NF Service Consumer.

Editor's Note: The solution shall be re-visited after SA3 FS\_eSBA\_SEC SID concludes

Editor’s Note: Procedure and messages need to be aligned with SA2

Editor's Note: Authorization aspects for MFAF are FFS, i.e. if MFAF need also be authorized to receive data.

The solution is shown in detail in the following section.

#### 6.4.2.1 Detailed Procedure



Figure 6.4.2-1: Service consumer authorization for DCCF selected Service Producers

1. An NF service consumer (e.g. NWDAF) discovers a DCCF to retrieve data. The NF Service consumer requests authorization from an NRF by invoking an Nnrf\_AccessToken\_Get request including the information to identify the target NF (DCCF) and the source NF.

2. The NRF authorizes the request and generates an access token as described in 3GPP TS 33.501

3. The access token (access\_token\_nwdaf) is provided to the NF service consumer.

4. The NF Service Consumer initiates an NF service request to the DCCF which includes the access\_token\_nwdaf. The NF Service Consumer also generates a Client Credentials Assertion (CCA) token (CCA\_NWDAF) as described in 3GPP TS 33.501 and includes it in the request message in order to authenticate itself towards the NRF when the request is sent via the DCCF. From NF service consumer perspective, the NF service producer is the DCCF and end point is NRF, both included in the CCA.

5. The DCCF verifies that the access\_token\_nwdaf is valid and executes the service.

6. The DCCF determines that the requested service is provided by a different NF Service Producer(s). Since the service is provided by different NF(s) the DCCF verifies that the NF Service Consumer can access (indirectly) the services provided by the identified NF Service Producer(s).

7. The DCCF requests authorization from the NRF by invoking an Nnrf\_AccessToken\_Get request including the information to identify the target NF (NF Service Producer), the source NF (DCCF) and additional authorization information by including the the CCA\_nwdaf provided by the NF Service Consumer.

 For indirect communications, the DCCF may also include its own CCA, if there is SCP in between DCCF and NRF.

8. The NRF determines whether the DCCF and the NF Service Consumer (based on the CCA\_nwdaf) are allowed to access the service provided by the identified NF Service Producers. Since the CCA\_nwdaf includes the NF instance ID, the NF type of the expected audience and the signature based on the private key, the NRF can determine that this NF instance was authorized to access the DCCF before. Further based on the NF type in the CCA and the requested NF Service Producers from the DCCF in the access token request, the NRF can determine whether the selected NF Service Producers match that NF type and can be authorizes for the NF instance ID from the NF Service Consumer.

9. The NRF generates and provides an access token to the DCCF as described in TS 33.501.

10. The DCCF uses the access token to initiate an NF service to the identified NF Service Producer to retrieve the data. The DCCF includes the CCA\_nwdaf in the request. If the DCCF determines that the service consumer is not allowed to use the service of the data producer then the DCCF does not instruct the MF to collect data from the data producer.

11. The NF Service Producer(s) verify the access token and the CCA\_nwdaf and execute the service.

12. The NF Service Producer(s) provide requested data in the response to step 10.

13. The DCCF forwards the provided data to the NF Service Consumer in the response to step 4.

### 6.4.3 Evaluation

 The proposed solution fullfills the following security requirements:

The data consumer shall be authorized to access the data from the data source.

Authorization of the DCCF shall be supported to access a service of a data source on behalf of a data consumer.

Service consumer authorization is based on the CCA\_nwdaf.

## 6.5 Solution #5: Providing the Security protection of data via Messaging Framework

### 6.5.1 Introduction

This solution addresses KI#1.4 on the security of data via Messaging Framework.

The DCCF is a control-plane function that coordinates data collection and triggers data delivery to Data Consumers.

The Figure 6.2.6.3.4-1 in TS 23.288 [4] depicts how a data consumer (e.g. NWDAF) obtain data and be notified of events using the DCCF and a Messaging Framework. The 3GPP DCCF Adaptor (3da) Data Management service and 3GPP Consumer Adaptor (3ca) Data Management service of the Messaging Framework Adaptor Function (MFAF) are used to interact with the 3GPP Network and the Messaging Framework.

### 6.5.2 Solution details

This solution proposes to use existing SBA mechanism for confidentiality protection, integrity protection, and replay-protection on the new interfaces between 3GPP entities and the MFAF.

This solution also proposes a procedure for the confidentiality, integrity, and replay protection of the transferred data against the Messaging Framework in case that the collected data is not requested to be formatted/processed.

For the same type of data collection, the DCCF can manage an encryption key and an integrity key. The DCCF provides the keys to the data consumer and the data producer. The data producer will use the keys to encrypt the data and generating the MIC (Message Integrity Code), while the data consumer will use the key to decrypt the data and check the MIC. In such way, the data will not be revealed to the Messaging Framework and any modification of the data can be detected. In case a new Data Consumer subscribes to the same type of data where a notification procedure is already ongoing, then a key refresh procedure is carried out. In the following the term subscription ID is used, where the subscription ID includes information to identify the Data required (e.g. a set of Event ID(s) from Data Producer NF), information to identify the UE (single UE, group of UE(s) or any UE), optionally information to identify the data producer, and filtering information such as location area or time of day where data is required from.

Our solution is exemplified using the steps of the solution shown in Figure 6.5.2-1 based on the procedure shown in Figure 6.2.6.3.4-1 in TS 23.288 [2]. Our solution steps are marked as bold, as additional steps to this example procedure.

Figure 6.5.2-1: Protection of data sent via the messaging framework

 1. The data consumer-1 subscribes to data via the DCCF by invoking the Ndccf\_DataManagement\_Subscribe (Service\_Operation, Data Specification, NF (or NF-Set) ID, ADRF Information, Data Consumer Notification Target Address (+ Notification Correlation ID)) service operation as specified in clause 8.2.2 in [4]. The data consumer may specify one or more notification endpoints and the NF or NF set to collect data from.

Service\_Operation is the service operation to be used by the DCCF to request data (e.g. Namf\_EventExposure\_Subscribe or OAM Subscribe). Data Specification provides Service\_Operation-specific required parameters (e.g. event IDs, UE-ID(s), target of event reporting) and optional input parameters used to retrieve the data. The data consumer may optionally include the Data Source NF Instance (or NF Set) ID and ADRF information indicating whether the data are to be stored in an ADRF and, optionally, an ADRF ID.

2. If the NF instance or NF Set ID is not provided by the data consumer, the DCCF determines the NF instances that can provide data as described in clause 5A.2 and clause 6.2.2.2 in [4]. If the consumer requested storage of data in an ADRF, but the ADRF ID is not provided by the data consumer, or the collected data is to be stored in an ADRF according to configuration on the DCCF, the DCCF selects an ADRF to store the collected data.

3. The DCCF determines the Data Source (e.g. AMF-1) that can provide the data and checks that the requested data is not already being collected.

**If the requested data is not being collected yet, then the DCCF generates a data encryption** **key KE and a data integrity key KI. The DCCF will keep a mapping between the subscription (Identified by a Subscription ID) and the pair of keys.**

4. The DCCF sends an Nmfaf\_3daDataManagement\_ Configure (Data Consumer Information, MFAF Notification Information) to configure the MFAF to map notifications received from the Data Source to outgoing notifications sent to endpoints.

Data Consumer Information contains for each notification endpoint, the data consumer Notification Target Address (+ Data Consumer Notification Correlation ID to be used by the MFAF when sending notifications in step 8.

**4a. The DCCF sends the subscription response to the Data Consumer-1. In the response, the DCCF provides key KE and key KI as well as a Subscription ID.**

5. The DCCF subscribes to data from the NF using the Nnf\_EventExposureSubscribe (Data Specification, MFAF Notification Target Address (+ MFAF Notification Correlation ID)) service operation as specified in clause 5A.2 and clause 6.2.2.2 in [4], using the MFAF Notification Target Address (+ MFAF Notification Correlation ID) received in step 4. The DCCF adds the data consumer to the list of data consumers that are subscribed for these data.

**The request also includes key KE and a data integrity key KI**.

6. The Data Source acknowledges the request with a Subscription ID.

7. When new output data are available, the Data Source uses Nnf\_EventExposure\_Notify to send the data to the MFAF. The Notification includes the MFAF Notification Correlation ID.

**The data source associates the data with a Sequence Number. The data source encrypts the data using KE and protects the integrity of the data by including a MIC (Message Integrity Code). The data source computes the MIC as HASH KI (data || Sequence Number).**

8. The MFAF uses Nmfaf\_3caDataManagement\_Notify to send the data to all notification endpoints indicated in step 4. Notifications are sent to the Notification Target Address(es) using the Data Consumer Notification Correlation ID(s) received in step 4. The MFAF may store the information in ADRF if requested by consumer or if required by DCCF configuration.

**The message also includes the Sequence number received in step 7.**

**When Data Consumer-1 receives the data, it will check the data integrity and decrypt the data.**

9. Data Consumer-2 (e.g.: NWDAF-2) sends a request for the same Data via the DCCF by invoking the Ndccf\_DataManagement\_Subscribe. The message may indicate whether the requested data should be sent to Data Consumer-2, and/or to other Consumers such as Data Repository. The Notification Correlation ID of Consumer-2 is included for notifications sent to Data Consumer-2.

10. The DCCF determines that the requested data is already being collected from a Data Source (e.g.: AMF-1).

**10a. (If key refresh is needed) The DCCF initiates a key refresh procedure for the data as described in Figure 6.5.2.2-1.**

**10b-12. Same procedure as in step 4a-7 for Data Consumer-2.**

**13-14. Same procedure as in step8 for Data Consumer-1 and Data Consumer-2.**

**When the DCCF provides the key KE and key KI, it also maintains a timer for renewing the keys. When DCCF decides to renew the keys, it will send to the data consumer a message with the new keys associated with the Subscription ID mentioned in step 4a. When the DCCF sends the new keys to the data consumer, it put the Subscription ID mentioned in step 6 in the message.**

#### 6.5.2.1 DCCF initiated key refresh procedure

Since the keys KE andKI are shared between several data consumers and data source, it is recommended to frequently change the keys either with a limited lifetime or sequence number wrap around in data source. The data consumer is trusted in this solution, when to perform the key refresh procedure depends on different events, e.g., when the key lifetime expires, or sequence number wrap around in data source.

 Figure 6.5.2.2-1: DCCF initiated key refresh

1. The DCCF receives a new subscription request from Data Consumer-2 to an existing event notification for a specific subscription ID or the keyrefresh timer for a specific subscription ID expires/reaches the value of the key lifetime. The DCCF generates fresh keys KE and KI .

2. The DCCF identifies based on the subscription ID the subscribed Data Consumer and the Data Source. The DCCF deletes the old key pairs and binds the new key pair to the involved NFs of the subscription ID.

3. The DCCF sends a Key Refresh Request to all Data Consumers and the Data Source including the subscription ID and the new keys KE and KI.

In case the DCCF would like to store data in the Data Repository Function (DRF), then the DCCF adds the DRF as a data consumer for a specific subscription ID. The DRF then can decrypt the encrypted data and store it unencrypted in the DRF (tamperproof) memory. Once a data consumer would like to read historic data of a specific subscription ID from the DRF, then it creates a corresponding subscription ID and the DCCF will add the DRF as a data source. With those scenarios, the DRF will always be able to store the data of producers and to provide them to consumers, because the DRF will always have the corresponding keys KE and KI to encrypt/decrypt the data.

### 6.5.3 Evaluation

This solution addresses key issue#1.4 (Security protection of data via Messaging Framework) and fulfils the requirements in case that the collected data is not requested to be formatted/processed.

The solution proposes to use existing SBA mechanism for the protection of the new interfaces.

According to the solution, DCCF provides keys to data consumers and data producer to establish security for data transfer.

Impacts to DCCF:

- Groups the data consumers for the same type of data collection

- Manages the encryption and integrity keys, which are the same for all data consumers of this group of data collection and data producer to establish security for data transfer.

Impacts to data producer:

- Produced data is encrypted with the keys from the DCCF and protected with a MIC (Message Integrity Code)

Impacts to data consumer:

- Received data is decrypted with the keys from the DCCF and validated by checking the MIC.

Editor's Note: Further evaluation is FFS.

## 6.6 Solution #6: Integrity protection of data transferred between AF and NWDAF

### 6.6.1 Introduction

This solution addresses KI#1.1 on integrity protection of data transferred between AF and NWDAF.

### 6.6.2 Solution details

To enhance the 5GS to support collection and utilisation of UE related data for providing the inputs to generate analytics information (to be consumed by other NFs), the communication between UE and AF/NWDAF needs to be secured.

The NWDAF interacts with the 5GC NFs and the AF using Service-based Interfaces. When the AF is located in the operator’s network, the NWDAF uses Service-Based Interface to communicate with the AF directly. When the AF is located outside the operator’s network, the NEF is used to exchange the messages between the AF and the NWDAF as defined in Rel-16. The security aspects of NEF is specified in chapter 12 of 3GPP TS 33.501[8].

The existing 5G security mechanism can be re-used for the transfer of UE data over the SBA interface between AF and NWDAF. For the UE data collection by AF and NWDAF, the current NAS and SBA based security mechanisms for authentication, confidentiality, integrity and replay protection as described in 3GPP TS 33.501 are used.

### 6.6.3 Evaluation

This solution reuse the current mechanisms to protect the communication between AF and NWDAF.

AF may located in or outside the operator’s network,both of the situation use the current mechanisms in this solution.

This solution meets the requirement in KI#1.1 without any extra system impact.

## 6.7 Solution#7: Detection of anomalous NF behaviour by NWDAF

### 6.7.1 Introduction

This solution addresses key issue #2.2.

The 5GC supports various NF deployments in order to ensure that the NF can provide services from multiple locations. These cloud platforms may be owned and operated by the PLMN operator himself or they may be run on commercial public cloud platforms. When NFs are distributed across multiple cloud infrastructures, it is possible that the NFs behave in an anomalous manner. Such anomalous behaviour can arise either due to configuration errors or internal data corruption, or due to an attack.

To allow an operator to manage its NF cloud deployment efficiently, additional security relevant log data from the NFs can be provided to the NWDAF, which can then be used to analyse and detect the root cause for an anomaly.

### 6.7.2 Solution details

#### 6.7.2.1 General

The OAM or some operator defined AF may subscribe/request to the NWDAF to notify/respond when it detects an abnormal behaviour for a particular NF instance (for example excessive resource usage or consistent failure to provide its service). There can be various causes of abnormal behaviour such as an erroneous operation at a NF, an error at the side of the cloud provider where the NF is deployed, or an impending attack at a particular NF by a malicious entity in the system.

In order to analyse the root cause of the anomaly with certain degree of confidence, more information or related data can help. Thus, NWDAF requests inputs from different entities in the system (such as OAM, NRF and NFs) for detailed analysis. Security related data for analytics can also be collected by NWDAF from the NFs (or via OAM). The final output analytics is then sent to the OAM or the AF for adequate measures.

In order to facilitate the security related log data collection from NFs two different methods are proposed

NOTE: Defining the protocols used for log collection is not in the scope of this document

#### 6.7.2.2 Collection of security related log data of NFs via NFs EventExposure APIs

The procedure depicted in Figure 6.7.2.2-1 allows a consumer to request analytics from NWDAF for anomalous NF behaviour and its root cause.



Figure 6.7.2.2-1: NF anomalous behaviour analytics provided by NWDAF using security logs obtained from NFs EventExposure APIs

1. The OAM or operator's AF sends a request/subscription to the NWDAF for NF anomalous behaviour analytics using either the *Nnwdaf\_AnalyticsInfo\_Request* or *Nnwdaf\_AnalyticsSubscription\_Subscribe* service operation.

2. If the request is authorized, and in order to provide the requested analytics, the NWDAF may subscribe to OAM services to retrieve resource usage and NF resources configuration of all targeted NF instances, following the procedure specified in clause 6.2.3.2 in TS 23.288 [1].

3a. The NWDAF subscribes to NRF to receive notification on changes, e.g., on the load and status of NF instances registered in NRF, using *Nnrf\_NFManagement\_NFStatusSubscribe* service operation for all targeted NF instances. NF instances are identified by their NF id.

3b. NRF notifies NWDAF of changes on the load and status of the requested NF instances by using *Nnrf\_NFManagement\_NFStatusNotify* service operation.

4a. The NWDAF subscribes or requests the additional security specific log info (as specified in the table 6.7.2.3-1) for a particular NF by invoking the *Nnf\_EventExposure\_Subscribe* service operation.

4b. The NF then notifies the NWDAF (e.g. with the complete log report) by invoking *Nnf\_EventExposure\_Notify* service operation.

5. The NWDAF derives the relevant analytics using the inputs provided by the OAM, NRF, and the NF (as specified in the table 6.7.2.3-2)

6. The NWDAF provides requested NF anomalous information along with the corresponding root cause (for instance a malicious NF trying to attack other NF for denial of service, or an erroneous NF unable to provide service to other NFs) using either the *Nnwdaf\_AnalyticsInfo\_Request* response or *Nnwdaf\_AnalyticsSubscription\_Subscribe* response, depending on the service used in step 1.

#### 6.7.2.3 Collection of security related log data of NFs via OAM

The procedure depicted in Figure 6.7.2.3-1 allows a consumer to request analytics from NWDAF for anomalous NF behaviour and its root cause using the security specific NF logs obtained from OAM



Figure 6.7.2.3-1: NF anomalous behaviour analytics provided by NWDAF using security logs obtained from OAM

1. The OAM or operator's AF sends a request/subscription to the NWDAF for NF anomalous behaviour analytics using either the *Nnwdaf\_AnalyticsInfo\_Request* or *Nnwdaf\_AnalyticsSubscription\_Subscribe* service operation.

2. If the request is authorized, and in order to provide the requested analytics, the NWDAF may subscribe to OAM services to retrieve resource usage and NF resources configuration of all targeted NF instances, following the procedure specified in clause 6.2.3.2 in TS 23.288 [1]. The NWDAF further sends the request to the OAM to provide the security specific log into (as specified in the table 6.7.2.3-1).

3. OAM then collects all the requested information along with the security logs from the NFs and provide it to NWDAF.

4a. The NWDAF subscribes to NRF to receive notification on changes, e.g., on the load and status of NF instances registered in NRF, using *Nnrf\_NFManagement\_NFStatusSubscribe* service operation for all targeted NF instances. NF instances are identified by their NF id.

4b. NRF notifies NWDAF of changes on the load and status of the requested NF instances by using *Nnrf\_NFManagement\_NFStatusNotify* service operation.

5. The NWDAF derives the relevant analytics using the inputs provided by the OAM and NRF (as specified in the table 6.7.2.3-2)

6. The NWDAF provides requested NF anomalous information along with the corresponding root cause (for instance a malicious NF trying to attack other NF for denial of service, or an erroneous NF unable to provide service to other NFs) using either the *Nnwdaf\_AnalyticsInfo\_Request* response or *Nnwdaf\_AnalyticsSubscription\_Subscribe* response, depending on the service used in step 1.

Table 6.7.2.3-1 Security specific parameters provided by NFs (NF/NRF) to assist in detection

|  |  |
| --- | --- |
| Information | Description |
| Timestamp | A time stamp associated with the service request which was sent by the NF Service Consumer to a NF Service Producer. |
| NF Service Consumer / SCP Identifier | The consumer instance or the SCP which sends the service request along with the access token to the NF Service Producer. |
| NF Service Producer Identifier | The producer instance which receives the requests and which verifies the access token received along with the requests |
| Authorization status of NF Service Consumer  | Indicated if a given NF Service Consumer is authorized to receive an access token or not, as provided by NRF. |
| Access Token Authenticity | Information such as, if access token provided is for the service request it is sent, and if it is generated for the NF Service Consumer which is requesting the service. |
| Access Token Validity | Verification result, i.e. whether the access token is valid or invalid. |
| Number of requests to access a service | Number of simultaneous requests received at the NF Service Producer for a particular time window. |
| Requested Service Name | Name of the service for which the requests had been received. |
| Service Response Confirmation | Confirmation whether the NF Service Producer was able to fulfil the service requests or not. |

Table 6.7.2.3-2 Inputs provided to NWDAF in assisting the detection of anomalous NF

|  |  |  |
| --- | --- | --- |
| Information | Source | Description |
| Security Log Data | OAM/NF | Additional security relevant log info as described in table 6.7.2-1. |
| NF Load  | NRF | The load of specific NF instance(s) recorded in their NF profile as defined per TS 29.510 [2]. |
| NF resource usage | OAM | The usage of assigned virtual resources for specific NF instance(s) (e.g., mean usage of virtual CPU, memory, disk) as defined in TS 28.552 [3] clause 5.7. |

Table 6.7.2.3-3 and Table 6.7.2.3-4 specifies the output analytics from NWDAF

Table 6.7.2.3-3: Anomalous NF behaviour statistics

|  |  |
| --- | --- |
| **Information** | **Description** |
| Exceptions (1..max) | List of observed exceptions |
| > Exception ID | The risk detected by NWDAF |
| > Exception category | Indication if the anomalous behaviour is an attack or geniune error  |
| > Exception level | Scalar value indicating the severity of the abnormal behaviour |
| > List of target NF(s)  | One or more NFs which are affected due to the anomoulous NF in the system |
| > List of anomolous NF(s)  | One or more NFs which are the probable cause of the anomalous activity in the system (either because they are malicious or due to internal errors) |

Table 6.7.2.3-4: Anomalous NF behaviour predictions

|  |  |
| --- | --- |
| **Information** | **Description** |
| Exceptions (1..max) | List of predicted exceptions |
| > Exception ID | The risk detected by NWDAF |
| > Exception category | Indication if the anomalous behaviour is an attack or geniune error  |
| > Exception level | Scalar value indicating the severity of the abnormal behaviour |
| > List of target NF(s)  | One or more NFs which are affected due to the anomoulous NF in the system |
| > List of anomolous NF(s)  | One or more NFs which are the probable cause of the anomalous activity in the system (either because they are malicious or due to internal errors) |
| > Confidence  | Confidence of this prediction |

Based on the input, an analytics function can monitor and find abnormalities in NF load or NF resource usage, which can result in an alert. Specific security log data can help to understand if this is normal behaviour or could be resulting from a NF that is behaving anomalous.

Thus, when NFs send service requests to other NFs, input data such as the number of service requests sent, the percentage of successful service requests, the percentage of successful access token verification and the serving NF load and resource usage can be used to provide training data for normal service requests reception and load.

Input data such as NF Service Consumer / SCP identifier, the NF Service Producer Identifier and the Requested Service Name can be used to identity the anomalous/erroneous NF in the system.

NOTE: The derivation of output from input depends on the algorithms used or the policy present. How to derive the output from input is up to implementation logic, which is out of scope of 3GPP.

### 6.7.3 Evaluation

The solution proposes NWDAF to collect NF related data such as resource utilization, load information and additional security specific log data to facilitate analysis and detection in anomolous behavior.

The solution proposes to provide input data which will be useful in addressing the security requirements present in the KI 2.2

## 6.8 Solution#8: Privacy preservation of transmitted data

Editor's Note: The solution needs to be revised to cut off the relation with user consent.

### 6.8.1 Introduction

This solution addresses key issue #3.1.

During the transfer of data/metadata/analytics-output from one NWDAF to another NWDAF, it should be ensured that any information that can reveal the identity of the user or compromise in another way the privacy of the user is protected.

Therefore, appropriate measures should be taken by the sender NWDAF to protect any information that can hamper privacy and maybe reveal the identity of the user. Some of the examples are positioning information, user profile information, etc. These information should be processed/filtered by a NWDAF before sending the data to another NWDAF.

Thus, the privacy-sensitive information has to be protected (in accordance with the regulatory requirements and the operator's policies) before being transferred to any other NWDAF.

### 6.8.2 Solution details

To protect the sensitive and private information of the user, a privacy framework is introducedBy this, different privacy rules can be applied by different operators/vendors based upon specific policies and requirements, e.g. by local policy.

The privacy rules can be stored in the home network in

- UDM/UDR if privacy is configured per subscriber, or

- NRF if privacy is generic for all the subscribers of one or several NFs.

User privacy policies and rules can be retrieved from UDM. NRF can also push this information to NFs.

Service requests related to User data need to be indicated, e.g. by an IE 'DataPurposeID'. The NF Service Consumer (i.e. requester NWDAF1 NF) needs to send this 'DataPurposeID' along with the request to the NF Service Producer (e.g. NWDAF2). Based on this IE, the NWDAF2 will process privacy related data accordingly to the specific policy or requirement valid in this operator network, before sending a service response to the requester NWDAF1.



Figure 6.8.2-1: Generic Procedure to preserve user privacy based upon the predefined policies

Step 0: If an operator configures the privacy rules in the NRF (generic for all subscribers), then the NRF can push the policy/rules to NF in the response of registration/heartbeat. A heartbeat message is sent by NFs every some seconds (i.e. 10-20 seconds). Therefore whenever the privacy rule is changed in the NRF, the NRF can push updated rules to the NFs.

Editor's Note: Definition on policies/rules to be added. Clarification needed how to specify them in our TR/TS.

Step 1: NWDAF1 sends a user data request to NWDAF 2 (Sending NWDAF Instance) with an additional IE DataPurposeID indicating the purpose.

NOTE: DataPurposeID specifies the purpose of the user data request corresponding to an analytics ID. For instance, the DataPurposeID can be 'Advertisement' corresponding to the user data request of analytics ID 'location'.

Step 2: NWDAF2 sends a request to retrieve the user privacy policies for a specific subscriber from the UDM/UDR. Or it can use the locally configured policies based upon the operator's or geographical requirements.

Step 3: UDM/UDR sends the privacy policies configured for the subscriber either by the operator or by the user or based upon the privacy local policy for a specific geographical region.

Editor's Note: Clarification needed on what is privacy local policy of a specific geographical region.

Step 4: NWDAF2, after receiving the policies, applies them to the requested user data for the DataPurposeID. For instance, because of the privacy policy it can either reject the request completely or it sends the data without or with anonymization. The latter preserves the sensitive information of the user. Policies received in Step 0 are also applied along with policy received in Step 3.

Editor's Note: Clarification needed on "DataPurposeID" in relation with privacy.

Step 5: NWDAF2 sends the processed data to NWDAF1 as a response to the initial request.

### 6.8.3 Evaluation

TBD

## 6.9 Solution#9: Processing of tampered data

### 6.9.1 Introduction

This solution addresses key issue #1.2.

NOTE: The solution proposed will not be in normative scope of SA3 in the present release.

Consumer NFs request analytics from the analytics function. The analytics function then requests the requested data from the data providers. These can be any NF but can also be third party data resources).

While 3GPP provides sound security on network function level, the data used by AI/ML is not being subject to these security controls so far. The attack potential makes it necessary that a 5G analytics functions must be protected from processing unsanitized/tampered data received from different resources (data providers).

Thus, to protect 5GS analystic functions from attacks on data level (i.e. manipulated data to influence analytics result), a proctection mechanisms is required. This mechanism needs to be suited to procted different types of analytics functions and input data.

### 6.9.1 Solution details

To protect 5G analytics function from attacks on data level, an additional function (NF for Adversarial ML protection) is added to the analytics process which will provide protection on data level. The analytics function therefore sends, based on the request for analytics in step 1, the data request via the NF for Adversarial ML protection (step 2), which forwards it to the data provider (step 3).

The NF for Adv. ML protection is able to sanitize input data to filter potentially malicious modifications. For this, a set of sanitation algorithms are included in the function and an identifier is provided to indicate which sanitation policy to use. The sanitation policy includes the type of data that is expected and the type of sanitation that is required. The policies are pre-configured by the operator.

Before the analytics function re-collects and processes the information from the data provider, the NF for Adversarial ML protection pre-processes the analytics data receiced in a reply from the data provider in step 4, i.e. it provides sanitation to the collected data before forwarding it back to the analytics function in step 5. The analytics function then processes the sanitized data. After the analytics function has processed the data, it sends the result to the consumer that requested the analytics.

The sanitization policies for instance may include the following parameters:

• A sanitation policy identifier (SP ID) to differentiate and reference each sanitation policy.

• A request type (e.g. “Analytics ID” for NWDAF). The request type defines the structure of the data that is expected to be received by the consumer or the data which data provider sends to the consumer and also the usage of the data during analytics.

• (Optional) A flag that indicates whether the sanitized data is used for learning or inference. The reason to differenciate between learning and interference is that some sanitation algorithms, e.g. adversarial learning, may not be suitable for inference. However, depending on the actual policies configured, this flag may not be relevant.

NOTE: The actual sanitization policies and their implementation are operator's specific and out of scope of 3GPP

The detailed procedure is depicted in Figure 6.9.1-1:

Consumer

function

1. Request analytics

Analytics

function

Data Sanitization NF

Data

 provider

2. Request data

3. Forward request

function

6. Reply analytics

5. Forward sanitized data

4. Reply data

**Figure 6.9.1-1 Data sanitization to prevent adversarial attacks on the analytics function**

Pre-configuration: The sanitation polices are configured to the adversarial machine learning protection/sanitation NF. These policies are typically operator specific.

Step 1. Data consumer requests analytics service from any analytics function, e.g. NWDAF.

Step 2. The analytics function determines which NF (or data provider) is responsible for providing the required data for the analytics and sends a data request to the NF responsible for data sanitization or Adversarial ML protection.

Step 3. The Data Sanitzation NF forwards the data request to the data provider and subscribe to the respective data.

Step 4. The data provider then sends the data to the Data Sanization NF. This data may contain perturbations aimed at attacking the analytics function.

Step 5. The sanitization NF receives the data, identifies the sanitization policy, and then processes the data according the policy defined. The NF then sends this data to the analytics finction.

Step 6. The analytics function sends the subscribed analytics to the NF Service Consumer using the sanitized data.

### 6.9.3 Evaluation

The proposed solution satisfies the stated security requirements of key issue #1.2.

If a new NF is introduced, the new interfaces with it would extend the attack surface.

## 6.10 Solution #10: Authorization of NF Service Consumers for data access via DCCF

### 6.10.1 Introduction

This solution addresses KI# 1.3, specially the following threats:

- Based on a request from a DCCF, the Messaging Framework may provide data from a producer to a requesting data consumer, even though the consumer is not authorized to receive this data.A DCCF could subscribe for data from the data source on behalf of data consumer without the data consumer authorizing DCCF to do so.

- A DCCF could subscribe for data from the data source on behalf of data consumer without the data consumer authorizing DCCF to do so.

- The data producer may be unable to correctly verify the identity of the data consumer since the data request is coming from DCCF on behalf of the consumer.

### 6.10.2 Solution details

NF Service consumer (for instance NWDAF) accesses the services of DCCF using the existing SBI mechanisms.

Similarly, DCCF accesses the services of MFAF (if the notification is sent via MFAF) using the existing SBI mechanisms.

The service request to access the DCCF by NF Service Consumer also contains the Client Credentials Assertion (CCA) token (CCA\_NWDAF) as described in 3GPP TS 33.501. DCCF now further requests the NRF to provide an access token to access services on behalf of the NF Service Consumer. The access token request to access a service from a service producer (i.e. data producer) by DCCF or MFAF, also contains the NF Service consumer information, therefore, enabling NRF to authorize both DCCF, NF Service Consumer and MFAF (if notification is sent via MFAF). The NRF also adds the NF service consumer information to the claims of the access token sent to DCCF to request data from the data producer.

The NRF is also able to verify if the NF Service Consumer has authorized DCCF to access services on its behalf by verifying the CCA\_NWDAF and whether its audience claims match the DCCF.

The service producer (i.e. the data producer) when receiving the service request by DCCF is therefore able to verify the actual NF service consumer, since it is part of the access token claims sent along with the request by the DCCF, and the service producer is able to verify if the NF service consumer has authorized DCCF to access services on its behalf or not. Finally, NF Service Producer is also able to verify if MFAF (if the notification is sent via MFAF) is authorized to receive the notification data. Only after this successful verification, the NF Service Producer sends the notification to the NF Service Consumer via DCCF or MFAF.

#### 6.10.2.1 Authorization of NF Service Consumer (i.e. Data consumer) when notification sent via DCCF

The detailed procedure for NF Service Consumer to receive data from Service Producers via DCCF is depicted in Figure 6.10.2-1:



Figure 6.10.2-1: Service Consumer Authorization to receive data from Service Producers via DCCF

1. An NF service consumer (e.g. NWDAF) discovers a DCCF to retrieve data. The NF Service consumer requests authorization from an NRF by invoking Nnrf\_AccessToken\_Get request including the information to identify the target NF (DCCF) and the source NF (NWDAF).

2. The NRF verifies the information provided by the NF Service Consumer and generates an access token as described in 3GPP TS 33.501.

3. The access token (access\_token\_nwdaf) is provided to the NF service consumer.

4. The NF Service Consumer initiates an NF service request to the DCCF which includes the access\_token\_nwdaf. The NF Service Consumer also generates a Client Credentials Assertion (CCA) token (CCA\_NWDAF) as described in 3GPP TS 33.501 and includes it in the request message in order to authenticate itself towards the NF Service Producers.

5. The DCCF verifies that the access\_token\_nwdaf is valid and executes the service.

6. The DCCF determines the NF Service Producer(s) from where the data is to be collected.

NOTE: If the NF Service Consumer sends the info of NF Service Producer (i.e. NF Service Producer type and Instance ID) along with the service request in Step 4, then DCCF does not determine the NF Service Producer, but requests an access token from the NRF using the NF Producer details sent by the NF Service Consumer (as described in Step 7.)

7. The DCCF requests authorization from the NRF by invoking an Nnrf\_AccessToken\_Get request including the information to identify the target NF (NF Service Producer), the source NF (DCCF, NF Service Consumer i.e., NWDAF) and the CCA\_NWDAF provided by the NF Service Consumer.

8. The NRF determines whether the DCCF and the NF Service Consumer (e.g. NWDAF) are allowed to access the service provided by the identified NF Service Producers. The NRF also verifies if the NF Service Consumer has authorized the DCCF to request an access token on its behalf by verifying the audience included in its CCA.

9. The NRF after successful verification generates and provides an access token to the DCCF as described in 3GPP TS 33.501, with additional access token claims, such that the subject of the access token claims maps to DCCF and NF Service Consumer (e.g. NWDAF).

10. The DCCF uses the access token to initiate an NF service to the identified NF Service Producer to subscribe to the data. The request also consists of CCA\_NWDAF, so that the NF Service Producer(s) can authenticate the NF Service Consumer (e.g. NWDAF) and can also implicitly ensure that the NF service consumer has authorized DCCF to access services on its behalf.

11. The NF Service Producer(s) authenticate the NF Service Consumer and verify the access token as specified in TS 33.501. NF Service Producer(s) execute the service after successful verification.

12. The NF Service Producer(s) provide requested data to the DCCF.

13. The DCCF forwards the received data to the data consumer(s).

NOTE: In the case a new data consumer comes at a later stage to request the data which is already being collected by DCCF, steps 1-10 apply. When the request is received by the NF Service Producer (i.e. the data producer), it authenticates the NF Service Consmer and verifies the access token provided along with the service request, and sends to DCCF the access token verification response. DCCF based upon the response received, either updates the subscription info to include the new data consumer as well and sends the data to both the consumers, or in the case of access token verification failure, the DCCF rejects the request received by the data consumer.

#### 6.10.2.2 Authorization of NF Service Consumer (i.e. Data consumer) when notification sent via MFAF

The detailed procedure for NF Service Consumer to receive data from Service Producers via MFAF is depicted in Figure 6.10.2-2:



**Figure 6.10.2-2 : Service Consumer Authorization to receive data from Service Producers via MFAF**

1. An NF service consumer (e.g. NWDAF) discovers a DCCF to retrieve data. The NF Service consumer requests authorization from an NRF by invoking Nnrf\_AccessToken\_Get request including the information to identify the target NF (DCCF) and the source NF (NWDAF).

2. The NRF verifies the information provided by the NF Service Consumer and generates an access token as described in 3GPP TS 33.501.

3. The access token (access\_token\_nwdaf) is provided to the NF service consumer.

4. The NF Service Consumer initiates an NF service request to the DCCF which includes the access\_token\_nwdaf. The NF Service Consumer also generates a Client Credentials Assertion (CCA) token (CCA\_NWDAF) as described in 3GPP TS 33.501 and includes it in the request message in order to authenticate itself towards the NF Service Producers.

5. The DCCF verifies that the access\_token\_nwdaf is valid and executes the service.

6. If the NF Service consumer does not send the NF Service Producer info in Step 4., the DCCF determines the NF Service Producer(s) from where the data is to be collected.

7. If the data collection and coordination is happening via MFAF, the DCCF requests authorization from the NRF by invoking an Nnrf\_AccessToken\_Get request including the information to identify the target NF (NF Service Producer), the source NF (DCCF, NF Service Consumer i.e. NWDAF ) and the CCA\_nwdaf provided by the NF Service Consumer.

8. The NRF determines whether the DCCF and the NF Service Consumer (e.g. NWDAF) are allowed to access the service provided by the identified NF Service Producers. The NRF also verifies if the NF Service Consumer has authorized the DCCF to request an access token on its behalf by verifying the audience included in its CCA.

9. The NRF after successful verification generates and provides an access token to the DCCF as described in 3GPP TS 33.501, with additional access token claims, such that the subject of the access token claims maps to DCCF, NF Service Consumer (e.g. NWDAF).

10, 11. DCCF then requests NRF to obtain an access token to consume the services of MFAF in order to send configuration request to MFAF. The NRF after verifying provides an access token (access\_token\_dccf) as a response.

12. DCCF then sends a configuration request as specified in TS 23.288 clause 6.2.6.3.4 to MFAF (along with access\_token\_dccf). The MFAF then verifies the access\_token\_dccf and in case of successful verification, services the request.

NOTE: MFAF, when receiving the request from DCCF to configure the notification address, needs to verify the that NF Service Consumer in fact initiates the data request and the received configuration.

13. The DCCF uses the access\_token\_nwdaf to initiate an NF service to the identified NF Service Producer to subscribe to the data. The request also consists of CCA\_nwdaf, so that the NF Service Producer can authentication the NF Service Consumer (i.e. NWDAF) and also implicitly ensure that NF service consumer has authorized DCCF to access services on its behalf.

14. The NF Service Producer(s) authenticate the NF Service Consumer and verify the access token as specified in TS 33.501. NF Service Producer(s) execute the service after successful verification.

15. The NF Service Producer(s) provide requested data to MFAF as notification.

16. The MFAF then forwards the provided data to the NF Service Consumer as a notification.

NOTE: In case a new data consumer comes at a later stage to request the data, which is already being collected by DCCF or MFAF, steps 1-9 apply. When the request is received by the NF Service Producer (i.e. the data producer), it authenticates the NF Service Consmer and verifies the access token provided along with the service request and sends to DCCF the access token verification response. DCCF based upon the response received, either updates the subscription info at the MFAF to include the new data consumer as well and instructs MFAF to send the data to both the consumers, or in the case of access token verification failure, the DCCF rejects the request received by the data consumer.

### 6.10.3 Evaluation

The solution proposes authorization mechanisms in order to authorize a data consumer to request a service of data producer, and to authorize DCCF and MFAF to request service on behalf of the data consumer.

The solution reuses existing mechanisms of CCA and OAuth 2.0 as defined in TS 33.501, with the enhancements in the access token request sent by the NF Service Consumer and the claims generated by the NRF, and provides protection against the following threats :-

1. Based on a request from a DCCF, the Messaging Framework may provide data from a producer to a requesting data consumer, even though the consumer is not authorized to receive this data.

2. A DCCF could subscribe for data from the data source on behalf of the data consumer without the data consumer authorizing DCCF to do so.

3. The data producer may be unable to correctly verify the identity of the data consumer since the data request is coming from DCCF on behalf of the consumer.

The solution fulfills the following requirements of the KI 1.3

1. The data consumer shall be authorized to access the data from the data source.

2. Authorization of the DCCF shall be supported to access a service of a data source on behalf of a data consumer.

## 6.11 Solution #11: Authorization of NF Service Consumers to access data from ADRF via DCCF

### 6.11.1 Introduction

This solution addresses KI #1.3, specially the following threats:

- Based on a request from a DCCF, data received from a data producer is stored in the DRF. When the data are later retrieved, the DCCF may provide the stored data to a non-authorized consumer if requested.

### 6.11.2 Solution details

NF Service consumer (e.g. NWDAF) accesses the services of DCCF using the existing SBI mechanisms. NF Service Producer (or Data producer) when sending the data to the NF Service Consumer, may also send the data to ADRF for storage and archiving if requested/subscribed to by ADRF (e.g. based on a requested by the NF Service Consumer or the DCCF). Alternatively, the Messaging Framework may be configured by DCCF to forward a copy of the data to ADRF.

The NF Service Producer (Data Producer), when sending the data to the ADRF also appends its own NF type and its own NF Instance ID as metadata to the data which is sent for archiving. If NF Service Producer does not add this metadata, then DCCF may add this information before sending it to the ADRF.

The access token get request sent from DCCF to NRF to request the desired data on behalf of the NF Service Consumer contains the following information: NF Instance IDs of the NF Service Consumer (e.g. NWDAF) and the DCCF, NF Type (or NF Instance ID) of the NF Service Producers (i.e. ADRF and the Data Producer).

NRF after verifying the request, authorizes the NF Service Consumer to request the data and adds in the access token claims the NF Type (or the NF Instance ID) of the NF Service Producers (i.e. the ADRF and the Data Producer).

The ADRF when receiving the request from DCCF (based on a request from the NF Service Consumer) verifies the access token generated by ensuring that the NF Type (or NF Instance ID) matches that of ADRF, and the NF Type (or NF Instance ID) of the Data Producer matches the metadata information that was earlier appended by the Data Producer (or DCCF or MFAF) when archiving the data. Only after a successful verification, ADRF sends the data to the NF Service Consumer via DCCF (or MFAF).

The detailed procedures are depicted in Figure 6.11.2-1 (without MFAF) and Figure 6.Y.2-2 (with MFAF).

**Procedure 1: Service Consumer Authorization to receive data from ADRF via DCCF (without MFAF)**

Figure 6.11.2-1: Service Consumer Authorization to receive data from ADRF via DCCF(without MFAF)

Step 0. ADRF subscribes/requests data from data producer (directly or via DCCF).

Step 1. NF Service Producer (data producer) sends the data to ADRF (directly or via DCCF) and may add metadata information containing Source NF Type as its own NF Type and Source NF Instance ID as its own Instance ID.

Step 2. If, in step 1, the data is sent via DCCF and the data producer did not add its metadata, then DCCF when forwarding the data to ADRF, adds the metadata related to the data producer (i.e. NF type and NF Instance ID) prior to sending the data to ADRF for storage.

NOTE: Steps 1-2 ensure that the NF Service Producer information from which the data was collected is present in the ADRF. If the information is already present, Steps 1-2 are not needed, and the procedure defined in Clause 6.2.6.3.3 in TS 23.288 is followed.

Step 3. NF Service consumer (data consumer) sends request to DCCF to get historical data (as specified in clause 6.2.6.3.3, TS 23.288 [) with optionally also providing the NF Type (or NF Instance ID) of the target NF Service Producer (or data producer). The request also contains the access token to request services from DCCF and CCA of NF Service Consumer.

Step 4. DCCF, after verifying that the NF Service Consumer is authorized to access the services of DCCF, sends to NRF an access token request to collect historical data from data producer(s) including the information to identify the target NFs (NF Service Producer (i.e ADRF) and data producer), the source NF (DCCF, NF Service Consumer) and the CCA provided by the NF Service Consumer

NOTE: Both ADRF and data producer info is needed in the access token request as target NFs, since DCCF is consuming ADRF services, and the data producer audience claim is required for the ADRF to verify if the data consumer and DCCF are authorized to receive the data belonging to a data producer,

Step 5. The NRF determines whether the DCCF and the NF Service Consumer are allowed to access the services provided by the identified NF Service Producers(s). The NRF also verifies if the NF Service Consumer has authorized the DCCF to request an access token on its behalf by verifying the audience included in its CCA. NRF, after verification, provides an access token containing ADRF NF Type (or NF Instance ID) and data producer NF Type (or NF Instance ID(s)) in the audience claims of the access token and the NF Service Consumer (i.e. the data consumer) and the DCCF in the subject claim of the access token.

Step 6. DCCF forwards the historical data request to ADRF along with with the access token received.

Step 7. ADRF now authenticates the NF Service Consumer via the CCA provided and performs two verifications. First, it verifies the access token as mentioned in the TS 33.501 [X], ADRF then also verifies if the metadata info of the requested data (e.g. Source NF type (or NF Instance ID)) matches the claims info of the access token.

Step 8. ADRF sends the data to NF consumer via DCCF in case of successful verification.

 **Procedure 2: Service Consumer Authorization to receive data from ADRF via DCCF (with MFAF)**



**Figure 6.Y.2-2: Service Consumer Authorization to receive data from ADRF via DCCF (with MFAF)**

Step 0. ADRF subscribes/requests data from Data Producer (directly or via DCCF). If DCCF is involved, DCCF configures MFAF to forward the data to the ADRF and to add metadata information containing Source NF Type as the NF Type of the Data Producer and source NF Instance ID as NF Instance ID of the data producer (if the data producer does not append this metadata information).

Step 1. NF Service Producer (data producer) sends the data to ADRF (directly or via DCCF) and may add metadata information containing Source NF Type as its own NF Type and Source NF Instance ID as its own Instance ID.

Step 2. If the data producer did not add its metadata, then MFAF when forwarding the data to ADRF, adds the metadata related to the data producer (i.e. NF type and NF Instance ID) (as instructed by the DCCF in step 0) prior to sending the data to ADRF for storage.

NOTE: Steps 1-2 ensure that the NF Service Producer information from which the data was collected is present in the ADRF. If the information is already present, Steps 1-2 are not needed, and the procedure defined in Clause 6.2.6.3.3 in TS 23.288 is followed.

Step 3. NF Service consumer (data consumer) sends request to DCCF to get historical data (as specified in clause 6.2.6.3.3, TS 23.288) with optionally also providing the NF Type (or NF Instance ID) of the target NF Service Producer (or data producer). The request also contains the access token to request services from DCCF and CCA of NF Service Consumer.

Step 4. DCCF, after verifying that the NF Service Consumer is authorized to access the services of DCCF, sends to NRF an access token request to collect historical data from data producer(s) including the information to identify the target NFs (NF Service Producer (i.e ADRF) and data producer), the source NF (DCCF, NF Service Consumer) and the CCA provided by the NF Service Consumer

Step 5. NRF, after verification, provides an access token containing ADRF NF Type (or NF Instance ID) and data producer NF Type (or NF Instance ID(s)) in the audience claims of the access token.

Step 6a/6b. DCCF forwards the historical data request to ADRF along with with the access token received. DCCF also configures the MFAF to forward the data to the data consumer

NOTE: For communication between DCCF and MFAF, authorization token for enabling DCCF to access services of MFAF will also be included

Step 7. ADRF now performs two verifications. First, it checks if an audience claim is matching its own NF type (or NF Instance ID). Second, ADRF verifies if the Source NF type (or NF Instance ID) present in the metadata of the requested data matches an audience claim anof the access token.

Step 8. ADRF sends the data to NF consumer via MFAF in case of successful verification.

### 6.11.3 Evaluation

The solution proposes authorization mechanisms in order to authorize a data consumer to request a service of data producer via DCCF, and to authorize DCCF and MFAF to request services on behalf of the data consumer. Further, the solution proposes mechanisms to enable ADRF to verify is a NF Service Consumer is authorized to access and receive the data which is already collected from the NF Service Producer and stored in the ADRF.

The solution uses existing mechanisms of CCA and OAuth 2.0 as defined in TS 33.501, with the enhancements in the access token request sent by the NF Service Consumer and the claims generated by the NRF, and provides protection against the following threats :-

1. Based on a request from a DCCF, the Messaging Framework may provide data from a producer to a requesting data consumer, even though the consumer is not authorized to receive this data.

2. Based on a request from a DCCF data received from a data producer is stored in the ADRF. When the data are later retrieved, the DCCF may provide the stored data to a non-authorized consumer if requested.

3. A DCCF could subscribe for data from the data source on behalf of the data consumer without the data consumer authorizing DCCF to do so.

The solution fulfills the following requirements of the KI 1.3

1. The data consumer shall be authorized to access the data from the data source.

2. Authorization of the DCCF shall be supported to access a service of a data source on behalf of a data consumer.

## 6.12 Solution #12: Solution on Authorization of Data Consumers for data access via DCCF

### 6.12.1 Introduction

This solution addresses KI#1.3 on Authorization of data consumers for data access via DCCF.

Based on a request from a DCCF, data producer sends data to a requesting data consumer, even though the data consumer is not authorized to receive this data. This solution addresses the unauthorized data consumer issue in the case that DCCF is used to coordinate the data collection.

### 6.12.2 Solution details

The data consumer requests authorization from the NRF to invoke services of a DCCF and a data producer. After data consumer requests a token for the DCCF service request, the consumer requests another token for data collection request.

The NRF determines if the data consumer is authorized to use the service of the DCCF and the NRF sends a token for DDCF service. The NRF then determines if the data consumer is authorized to collect the requested data from the data producer, and then the NRF provides another access token to the data consumer. The data consumer uses these tokens for the service requests to the DCFF and data producer. The DCCF executes the service by verifying the token for DCCF service. Then the DCCF sends the data request by the token for data collection to the data producer. The data producer executes the service by verifying the token and sends the data to the data consumer via DCCF.

It is assumed that data consumer knows the data producer in advance.

The solution is shown in detail below:



Figure 6.12.2-. Authorization of data consumer for services of DCCF and data producer

1. The data consumer requests a token from the NRF for the DCCF service.

2. The NRF checks if the data consumer is allowed to access DCCF. If the check was successful, NRF generates the token. The access token that the consumer receives from the NRF contains the information that the consumer is authorized to invoke DCCF services.

3. The NRF sends the token for the DCCF service to the data consumer.

4. The data consumer requests a token from the NRF for the data collection requests from the target data producer if possible. In the token request, the data consumer includes, besides the existing token request parameters, the following additional parameters: the data that the data consumer wants to collect, information about the data producer that is available to the data consumer, e.g., name of the data producer service or data producer NF instance ID if available to the data consumer.

5. The NRF checks if the data consumer is allowed to consume the data. If the check was successful, NRF generates the token. The access token that the consumer receives from the NRF contains the information that which data the consumer is allowed to retrieve. Besides the existing parameters, the token contains the following additional information: the data that the data consumer wants to collect, both the data producer NF ID (if there exists) and the name of the data producer service.

6. The NRF sends the token for data collection to the data consumer.

7. The consumer sends the received token for the DCCF service to the DCCF. This request also includes the access token for data collection.

8. The DCCF verifies the token and checks the authorization result. If the consumer is allowed to get services from the DCCF and collect data, then the DCCF coordinates the data collection request.

8a. DCCF requests an access token for itself from the NRF to get the service from data producer. NRF provides an access token for the service of data producer to the DCCF.

9. The DCCF sends the request to the data producer to retrieve the service. This request includes the access token received by DCCF in step 8a and the access token for data collection, ensuring the data consumer is authorized to consume this data.

10. The data producer verifies the access token, checks the tokens from the data consumer and execute the service.

11. The data producer provides requested data to the DCCF.

12. The DCCF forwards the provided data to the data consumer.

NOTE: In the case that a second Data Consumer comes a later stage for the same type of data, steps 1-12 are applied.

### 6.12.3 Evaluation

TBD

## 6.13 Solution #13: Solution for UE data collection protection at NF/NWDAF

### 6.13.1 Introduction

This solution solves the key issue #1.5, UE data collection at NF/NWDAF.

There are 5 security requirements in key issue #1.5, namely,

- R1: UE and network shall mutually authenticate each other.

- R2: The communication between UE and network shall be confidentiality protected.

- R3: The data collected from UE shall be integrity protected.

- R4: Data transferred from UE to NFs and from NFs to the analytics function shall be protected against replay attacks.

- R5: Authorization of NFs and analytics functions to receive, send, or transfer UE related data shall be guaranteed.

This solution re-uses existing security mechanism to solve all these security requirements.

### 6.13.2 Solution details

Existing security mechanism to solve each of the above security requirement is explained below.

- R1: UE and network shall mutually authenticate each other.

Existing primary authentication in TS 33.501[8] is used to authenticate UE and network.

- R2: The communication between UE and network shall be confidentiality protected.

Existing AS and NAS security mechanism in TS 33.501 [8] is used to provide the required confidentiality.

- R3: The data collected from UE shall be integrity protected.

Existing AS and NAS security mechanism in TS 33.501 [8] is used to provide the required integrity.

- R4: Data transferred from UE to NFs and from NFs to the analytics function shall be protected against replay attacks.

Existing AS and NAS security mechanism in TS 33.501 [8] is used to provide the required protection against replay attacks between the communication from UE and NFs in the network.

For the communication between two NFs in the network, replay attack prevention is provided by security in transport layer (e.g. via TLS) and application layer (via HTTPS).

- R5: Authorization of NFs and analytics functions to receive, send, or transfer UE related data shall be guaranteed.

Current authorization for SBA is re-used to provide the authorization of NFs and NWDAF to request data.

NOTE: The security of data transfer involving messaging framework and DCCF is studied in other key issues.

### 6.13.3 System impact

 There is no system impact.

### 6.13.4 Evaluation

The solution fulfils the requirement of key issue #1.5.

This solution reuses the existing 5GS security mechanisms, including the primary authentication mechanism, NAS and AS security mechanism, SBA security mechanism to solve the security problems of UE data collection.

This solution provides mutual authentication, confidentiality, integrity and replay protection between UE and network and provides authorization and replay protection between NFs as described in 3GPP TS 33.501 [8].

## 6.14 Solution #14: Solution to ML restrictive transfer

### 6.14.1 Introduction

This contribution proposes a solution to key issue #3.3, Ensuring restrictive transfer of ML models between authorized NWDAF instances.

This solution leverages existing SBA authorization to fulfil the requirement, i.e. “only authorized NWDAF instances should be allowed to consume ML models from other NWDAF instances.”

### 6.14.2 Solution details

The solution is predcicated on that NDWAFs instances that are allowed to share the ML models are placed in the same set. The existing SBA authorization mechanism is then re-used.

**Access Token Request**

When a service consumer NWDAF requests a token from NRF to access the service from an expected service provider NWDAF for ML provisioning or subscription, the NRF includes in the access token the NF Set ID of the expected service provider NWDAF, as specified in clause 13.4.1.1 of TS 33.501[8].

**Service Request**

When the service consumer NWDAF request to access the service for ML provisioning or subscription from the service provider NWDAF, the service consumer sends, among others, the access token obtained from NRF which includes the NF Set ID of the expected service provider NWDAF.

The service provider NWDAF then checks that the NF Set ID in the access token matches its own NF Set ID, as specified in clause 13.4.1.1 of TS 33.501 [8]. If the check fails, then the service consumer NWDAF is denied of the requested service.

### 6.14.3 System impact

There is no system impact.

### 6.14.4 Evaluation

This solution requires that NWDAF instances that are allowed to share ML models are placed in the same NF set.

The solution fulfils the security requirement of the key issue #3.3.

## 6.15 Solution #15: Protection of data sent via MFAF using existing SBA mechanisms

### 6.15.1 Introduction

This solution addresses KI 1.4 on security and protection of data via Messaging Framework

### 6.15.2 Solution details

In TS 23.288 Clause 5A.3.2, Messaging Framework Adaptor NF (MFAF) has been defined which offers 3GPP defined services that allow the 5GS to interact with the Messaging Framework. Furthermore, MFAF receives the data from Data source and sends the data to the Data Consumer via 3GPP defined services.

According to 3GPP TS 33.501 clause 13.3.0 all network functions shall support mutually authenticated TLS and HTTPS. TLS shall be used for transport protection within a PLMN, and thus ensuring communication between NFs is integrity, confidentiality and replay protected. Since the services defined to access the MFAF and to send data to MFAF and receive data from MFAF are 3GPP defined services, they shall adhere to the authorization mechanisms defined for SBA.

Therefore, the existing TLS and HTTPS protection and the authorization mechanisms defined for SBA are applicable for protection of data sent via MFAF.

### 6.15.3 Evaluation

The solution proposes the security of data via Messaging Framework and MFAF by resuing the existing security mechanism defined for SBA in TS 33.501 Clause 13.

# 7 Conclusions

7.1.1 Conclusions on Key Issue #1.1

Solution #6 is recommended as baseline for integrity protection of data transferred between AF and NWDAF.

7.1.2 Conclusions on Key Issue #1.2

 There will be no normative work need to do in this release since there is no valid solution for key issue #1.2 in release 17 by now.

7.1.3 Conclusions on Key Issue #1.3

Solution #10 is recommended as baseline for the normative work for KI 1.3

Editorial Note: ‘Whether an additional solution is necessary for the case that the data consumer knows the data producer instance in advance is FFS’

7.1.4 Conclusions on Key Issue #1.4

This contribution proposes to use Solution #15 (Protection of data sent via MFAF using existing SBA mechanisms) as the normative basis for key issue #1.4 (security protection of data via Messaging Framework. The Solution #15 proposes to re-use existing SBA security mechanism and it satisfies the security requirements of key issue #1.4.

7.1.5 Conclusions on Key Issue #1.5

It’s recommended to use solution #1 and #13 as baseline of KI#1.5.

There is no extra normative work to do for KI#1.5.

7.2.1 Conclusions on Key Issue #2.1

There is no normative work needed for key issue #2.1.

7.2.2 Conclusions on Key Issue #2.2

Since standardizing NF abnormal behaviour and the exact inputs requires more time to study, therefore no normative work is considered for KI #2.2 for this release.

7.3.1 Conclusions on Key Issue #3.1

There is no normative work needed for key issue #3.1.

7.3.2 Conclusions on Key Issue #3.2

Solution #3 is recommended as baseline for the protection of UE data in transit.

7.3.3 Conclusions on Key Issue #3.3

There is no normative work needed for key issue #3.3.

Annex A (informative):
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2020-10 | SA3#100bis-e | S3-202767 |  |  |  | S3-202674, S3-202766，S3-202425 | 0.1.0 |
| 2020-11 | SA3#101-e | S3-203463 |  |  |  | S3-203450, S3-203353, S3-203367, S3-203359, S3-203449, S3-203277, S3-203370, S3-203363, S3-203473 | 0.2.0 |
| 2021-01 | SA3#102-e | S3-210681 |  |  |  | S3-210569, S3-210570, S3-210581, S3-210115, S3-210571, S3-210446, S3-210109, S3-210110, S3-210572, S3-210229, S3-210573, S3-210574,S3-210679 | 0.3.0 |
| 2021-03 | SA3#102bis-e | S3-211322 |  |  |  | S3-211038, S3-211040, S3-211241, S3-211209, S3-211234, S3-211207, S3- 211201, S3-211303, S3-211239, S3- 211237, S3-211238 | 0.4.0 |
| 2021-05 | SA3#103-e | S3-212214 |  |  |  | S3-211466, S3-212160, S3-212161, S3-212162, S3-212221, S3-212238, S3-211839, S3-211840, S3-211841, S3-211659, S3-211699, S3-212202, S3-212163, S3-211692, S3-212237 | 0.5.0 |
| 2021-08 | SA3#104-e | S3-213094 |  |  |  | S3-213152, S3-212995, S3-213064, S3-213154, S3-213039, S3-213041, S3-213044, S3-212978, S3-213052, S3-213051, S3-213153, S3-212631, S3-212993, S3-213124, S3-213050, S3-212814, S3-213047, S3-212989, S3-213113, S3-212632, S3-212658, S3-212660, S3-213125, S3-212659 | 0.6.0 |
| 2021--10 | SA3#104-e ad-hoc | S3-213706 |  |  |  | S3-213495, S3-213615, S3-213616, S3-213617, S3-213713, S3-213714 | 0.7.0 |
| 2021-11 | SA3#105-e | S3-214410 |  |  |  | S3-214095, S3-214266, S3-214267, S3-214268 | 0.8.0 |