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Modal verbs terminology

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Contents

Foreword

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

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

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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 specifies detailed procedures of Network Data Analytics and the related data collection over the Nnwdaf, Nsmf, Nnsacf, Namf, Nnrf, Nnssf, Nnef, Naf, Ndccf, Nadrf, Nmfaf, Nudm, Nupf, Ngmlc, Npcf, Nscp and Nlmf service-based interfaces and/or from OAM and/or MDAF, and their relationship with the flow level signalling in 5G system.

NOTE: The procedures depicted in this Technical Specification do not cover all traffic cases.

The stage 2 definition and procedures of Network Data Analytics are contained in 3GPP TS 23.288 [2] and 3GPP TS 23.502 [3]. The 5G System Architecture is defined in 3GPP TS 23.501 [4].

Detailed definitions of the involved services are provided in 3GPP TS 29.520 [5], 3GPP TS 29.508 [6], 3GPP TS 29.554 [8], 3GPP TS 29.522 [10], 3GPP TS 29.591 [11], 3GPP TS 29.517 [12], 3GPP TS 29.551 [39], 3GPP TS 29.574 [15], 3GPP TS 29.575 [16], 3GPP TS 29.576 [17], 3GPP TS 29.503 [22], 3GPP TS 29.510 [23], 3GPP TS 29.507 [24], 3GPP TS 29.512 [25], 3GPP TS 29.564 [40], 3GPP TS 29.515 [41], 3GPP TS 29.572 [47], 3GPP TS 29.523 [51], 3GPP TS 29.570 [52], 3GPP TS 29.531 [21], and 3GPP TS 29.244 [45] for NF service-based interfaces, 3GPP TS 28.552 [27], 3GPP TS 28.532 [19], 3GPP TS 28.533 [28], 3GPP TS 28.550 [31] , 3GPP TS 28.554 [30], 3GPP TS 36.331 [34], 3GPP TS 37.320 [29], 3GPP TS 38.331 [33] and 3GPP TS 38.215 [35] for data collection from OAM.

The Technical Realization of the Service Based Architecture and the Principles and Guidelines for Services Definition of the 5G System are specified in 3GPP TS 29.500 [13] and 3GPP TS 29.501 [14].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

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

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[3] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[4] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[5] 3GPP TS 29.520: "5G System; Network Data Analytics Services; Stage 3".

[6] 3GPP TS 29.508: "5G System; Session Management Event Exposure Service; Stage 3".

[7] Void.

[8] 3GPP TS 29.554: "5G System; Background Data Transfer Policy Control Service; Stage 3".

[9] Void.

[10] 3GPP TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".

[11] 3GPP TS 29.591: "5G System; Network Exposure Function Southbound Services; Stage 3".

[12] 3GPP TS 29.517: "5G System; Application Function Event Exposure Service; Stage 3".

[13] 3GPP TS 29.500: "5G System; Technical Realization of Service Based Architecture; Stage 3".

[14] 3GPP TS 29.501: "5G System; Principles and Guidelines for Services Definition; Stage 3".

[15] 3GPP TS 29.574: "5G System; Data Collection Coordination Services; Stage 3".

[16] 3GPP TS 29.575: "5G System; Analytics Data Repository Services; Stage 3".

[17] 3GPP TS 29.576: "5G System; Messaging Framework Adaptor Services; Stage 3".

[18] 3GPP TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".

[19] 3GPP TS 28.532: "Management and orchestration; Generic management services".

[20] 3GPP TS 29.536: "5G System: Network Slice Admission Control Services; Stage 3".

[21] 3GPP TS 29.531: "5G System: Network Slice Selection Services; Stage 3".

[22] 3GPP TS 29.503: "5G System; Unified Data Management Services; Stage 3".

[23] 3GPP TS 29.510: "5G System; Network Function Repository Services; Stage 3".

[24] 3GPP TS 29.507: "5G System; Access and Mobility Policy Control Service; Stage 3".

[25] 3GPP TS 29.512: "5G System; Session Management Policy Control Service; Stage 3".

[26] Void

[27] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[28] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[29] 3GPP TS 37.320: " Radio measurement collection for Minimization of Drive Tests (MDT); Overall description".

[30] 3GPP TS 28.554: " Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[31] 3GPP TS 28.550: "Management and orchestration; Performance assurance".

[32] Void.

[33] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".

[34] 3GPP TS 36.331: "Radio Resource Control (RRC); Protocol specification".

[35] 3GPP TS 38.215: "NR; Physical layer measurements".

[36] 3GPP TS 28.310: "Management and orchestration; Energy efficiency of 5G".

[37] 3GPP TS 28.545: "Management and orchestration; Fault Supervision (FS)".

[38] 3GPP TS 28.104: "Management and orchestration; Management Data Analytics (MDA)".

[39] 3GPP TS 29.551: "5G System; Packet Flow Description Management Service; Stage 3".

[40] 3GPP TS 29.564: "5G System; User Plane Function Services; Stage 3".

[41] 3GPP TS 29.515: "5G System; Gateway Mobile Location Services; Stage 3".

[42] 3GPP TS 28.622: "Generic Network Resource Model (NRM)Integration Reference Point (IRP); Information Service (IS)".

[43] 3GPP TS 32.422: "Subscriber and equipment trace; Trace control and configuration management".

[44] 3GPP TS 28.537: "Management and orchestration; Management capabilities".

[45] 3GPP TS 29.244: "Interface between the Control Plane and the User Plane Nodes".

[46] 3GPP TS 28.558: "User Equipment (UE) level measurements for 5G system".

[47] 3GPP TS 29.572: "5G System; Location Management Services; Stage 3".

[48] 3GPP TS 28.404: "Quality of Experience (QoE) measurement collection; Concepts, use cases and requirements".

[49] 3GPP TS 28.405:"Quality of Experience (QoE) measurement collection; Control and configuration".

[50] 3GPP TS 28.406:"Quality of Experience (QoE) measurement collection; Information definition and transport".

[51] 3GPP TS 29.523: "5G System; Policy Control Event Exposure Service; Stage 3".

[52] 3GPP TS 29.570: "5G System; Service Communication Proxy Services; Stage 3".

[53] 3GPP TS 29.530: "5G System; Application Function Artificial Intelligence/Machine Learning (AI/ML) Services; Stage 3".

[54] Void.

3 Definitions of terms, symbols and abbreviations

3.1 Terms

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

3.2 Symbols

None.

3.3 Abbreviations

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

ADRF	Analytics Data Repository Function
AF	Application Function
AMF	Access and Mobility Management Function
AnLF	Analytics Logical Function
CEF	Charging Enablement Function
DCAF	Data Collection Application Function
DCCF	Data Collection Coordination Function
FL	Federated Learning
GMLC	Gateway Mobile Location Centre
HFL	Horizontal Federated Learning
LMF	Location Management Function
MDAF	Management Data Analytics Function
MDT	Minimization of Drive Tests
MFAF	Messaging Framework Adaptor Function
ML	Machine Learning
MTLF	Model Training Logical Function
NEF	Network Exposure Function
NRF	Network Repository Function
NSACF	Network Slice Admission Control Function
NSSF	Network Slice Selection Function

NWDAF	Network Data Analytics Function
OAM	Operation, Administration, and Maintenance
PCF	Policy Control Function
PFDF	Packet Flow Description Function
RE-NWDAF	Roaming Exchange NWDAF
SCP	Service Communication Proxy
SMF	Session Management Function
UDM	Unified Data Management
UPF	User Plane Function
VFL	Vertical Federated Learning

4 Reference Architecture for Data Analytics

4.1 General

For the enablement of network data analytics services, the NWDAF interacts with different entities for different purposes:

- Data Collection:

  a) collecting Data from OAM, MDAF and/or 5GC NFs (e.g. AMF);

  b) collecting Data from untrusted AF via NEF; and/or

  c) collecting Analytics and/or Data from 5GC NFs via DCCF or via DCCF together with ADRF and/or MFAF or via NWDAF hosting DCCF i.e. an NWDAF that implements DCCF functionality internally and supports the Nnwdaf_DataManagement API for collecting data, the Nnwdaf_EventSubscription API for collecting analytics;

- Analytics Exposure:

  a) Exposing Analytics to 5GC NFs;

  b) Exposing Analytics to untrusted AF via NEF; and/or

  c) Exposing Analytics to 5GC NFs via DCCF or via DCCF together with ADRF and/or MFAF or via NWDAF hosting DCCF and/or ADRF i.e. an NWDAF that implements DCCF and/or ADRF functionality internally and supports the Nnwdaf_EventSubscription API;

- Storing and Retrieving data in ADRF.

The entities mentioned above interact also with each other as described in the procedures of clause 5.

4.2 Data Collection

As depicted in Figure 4.2-1, the 5G System architecture allows NWDAF to collect data from any 5GC NF (e.g. AMF, SMF), OAM and/or MDAF directly or via DCCF, DCCF together with ADRF and/or MFAF, or via NWDAF in non-roaming case. The roaming architecture for data collection is defined in clause 4.5.

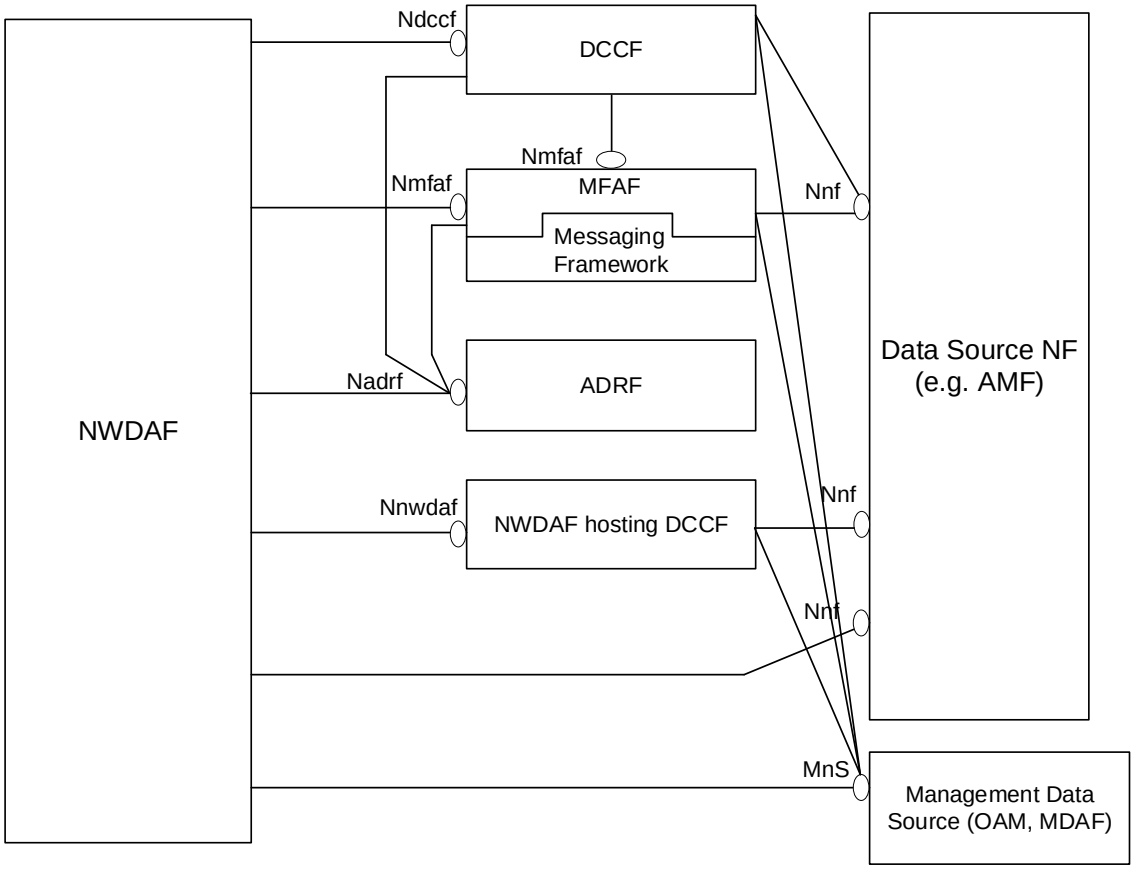

Figure 4.2-1: Data Collection Architecture

When DCCF, ADRF, MFAF or NWDAF hosting DCCF are present in the network, whether the NWDAF directly contacts the Data Source NF or goes via the DCCF, or NWDAF hosting DCCF is based on configuration of the NWDAF.

The Data Source NF may be AMF, SMF, UDM, UPF, GMLC, AF/DCAF, NSSF, NSACF, LMF, PCF, SCP, NRF, and/or NEF/NEF(PFDF) with the related data collection procedures described in clause 5.5. If the Data Source is OAM, the NWDAF may collect relevant management data from the services in the OAM as configured by the PLMN operator with NG RAN or 5GC performance measurements as defined in TS 28.552 [27] and 5G End to end KPIs as defined in TS 28.554 [30]. The NWDAF may use the OAM services e.g. generic performance assurance and fault supervision management services as defined in TS 28.532 [19], PM (Performance Management) services as defined in TS 28.550 [31] and/or FS (Fault Supervision) services as defined in TS 28.545 [37]. The procedure for data collection from OAM is defined in clause 6.2.3.2 of TS 23.288 [2]. The NWDAF may collect the analysis results from MDAF, e.g. service experience and energy saving state analysis and/or end-to-end latency analysis in TS 28.104 [38]. The procedure for analytics collection from MDAF is defined in clause 6.2.14.2 of TS 23.288 [2]. Before NWDAF requests analytics from the MDA Management Function, the NWDAF firstly discovers the MDAF via the MnS discovery service producer as defined in clause 5 of TS 28.537 [42].

For the specific analytics event, the applicable Data Source NF(s) and the related data collection procedures and scope are described in the corresponding analytics event subclause within clause 5.7.

4.3 Analytics Exposure

As depicted in Figure 4.3-1, the 5G System architecture allows NWDAF to expose data to any 5GC NF (e.g. AMF) directly or via DCCF/MFAF in non-roaming case. For roaming case, the roaming architecture as described in clause 4.5 is added between HPLMN and VPLMN.

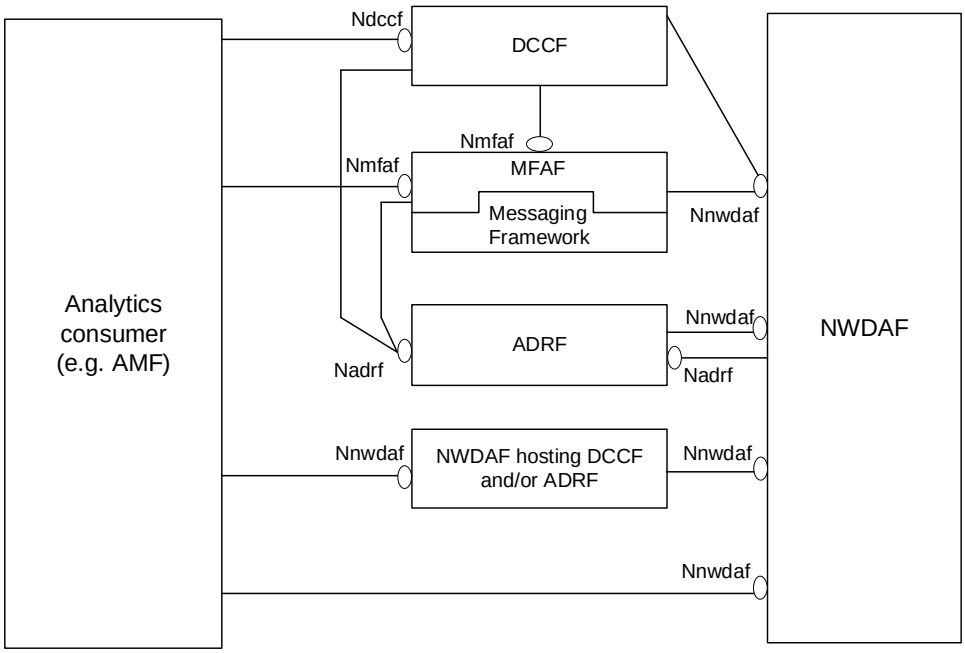

Figure 4.3-1: Analytics Exposing Architecture

When DCCF, ADRF, MFAF or NWDAF are present in the network, whether the Analytics consumer directly contacts the NWDAF or goes via the DCCF or via the NWDAF hosting DCCF and/or ADRF is based on configuration of the Analytics consumer.

The Analytics consumer may be AMF, SMF, NSSF, PCF, LMF, AF, NEF, OAM and/or CEF when directly contacts NWDAF with the related analytics exposure procedures described in clause 5.2.2 and clause 5.2.3. The Analytics consumers may be AMF, SMF, NSSF, PCF, LMF, AF and/or NEF when contacts via the DCCF with the related analytics exposure procedures described in clause 5.2.4 and clause 5.2.5.

For the specific analytics event, the applicable Analytics consumer(s) and the related analytics exposure procedures and scope are descibed in the corresponding analytics event subcluase within clause 5.7.

4.4 Data Storage and Retrieval

As depicted in Figure 4.4-1, the 5G System architecture allows the consumer to store and retrieve the collected data in the ADRF directly or via DCCF/MFAF.

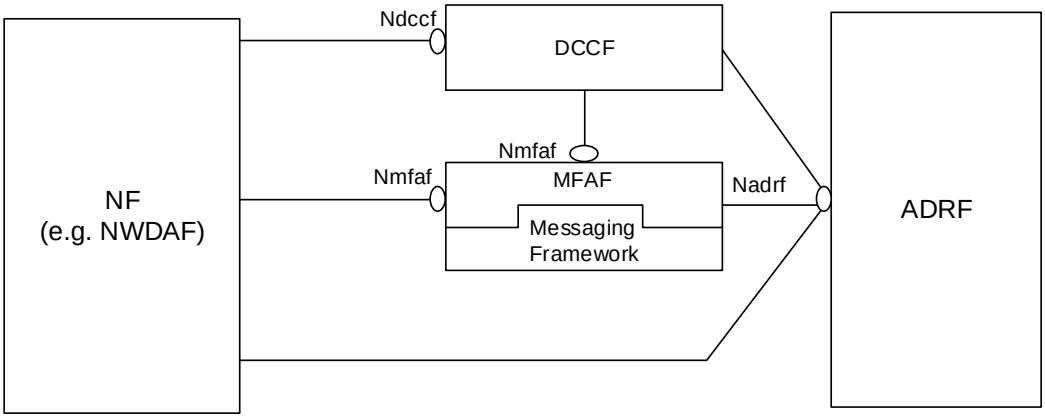

Figure 4.4-1: Data Storage and Retrieval Architecture

4.5 Roaming architecture for data collection and analytics exposure

Based on operator's policy and local regulations (e.g. privacy), data or analytics may be exchanged between PLMNs (i.e. HPLMN and VPLMN) via RE-NWDAF (i.e. an NWDAF with roaming exchange capability in each PLMN used as exchange point to exchange data and/or analytics with other PLMNs) using the architecture shown in Figure 4.5-1.

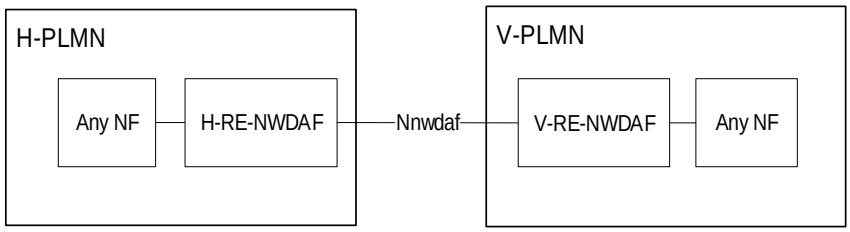

Figure 4.5-1: Roaming Architecture to exchange Data or Analytics between V-PLMN and H-PLMN

In roaming scenario, the H-RE-NWDAF is the enforcement point to check user consent. The H-RE-NWDAF retrieves the roaming-related user consent for a user from the UDM.

5 Signalling Flows for the Network Data Analytics Framework

5.1 General

This clause describes the Network Data Analytics related Signalling Flows, including the procedures for analytics exposure, analytics aggregation from multiple NWDAFs, analytics context and analytics subscription transferring between different NWDAFs, ML model provisioning, ML model training, data collection, specified Network Data Analytics generation, Analytics Data Repository, Analytics accuracy monitoring, ML model accuracy monitoring, Federated Learning, DCCF change and the NWDAF discovery and selection. The specific NF service operations which are used in these procedures are also provided in the procedure descriptions.

5.2 Analytics Exposure Procedures

5.2.1 General

The analytics exposure procedures allow the NF service consumers (i.e. NFs, OAM and AFs) to obtain the analytics information from the NWDAF.

5.2.2 Network data analytics Subscribe/Unsubscribe/Notify

5.2.2.1 Analytics Subscribe/Unsubscribe/Notify initiated by 5GC NFs, OAM or AFs

This procedure is used in non-roaming case by the NF service consumers (i.e. NFs, OAM and AFs) to subscribe to/unsubscribe from analytics information directly from the NWDAF, it is also used by the NWDAF to notify the observed analytics event(s) to the NF service consumer if subscribed before.

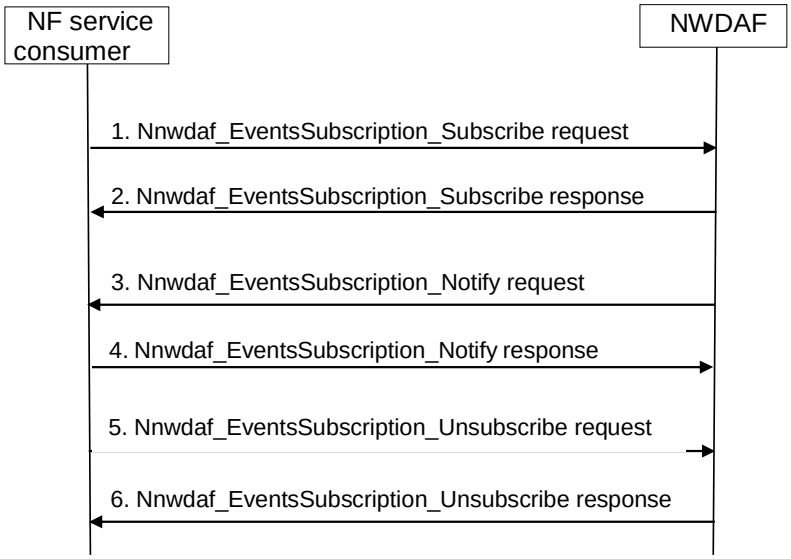

Figure 5.2.2.1-1: Analytics Subscribe/Unsubscribe/Notify initiated by 5GC NFs, OAM or AFs

1. In order to subscribe to notification(s) of analytics information from the NWDAF, the NF service consumer invokes Nnwdaf_EventsSubscription_Subscribe service operation by sending an HTTP POST request targeting the resource "NWDAF Events Subscriptions". The request includes the subscribed events and may include event filter information.

   In order to update the existing subscription, the NF service consumer invokes Nnwdaf_EventsSubscription_Subscribe service operation by sending an HTTP PUT request with Resource URI of the resource "Individual NWDAF Event Subscription".

2. The NWDAF responds to the Nnwdaf_EventsSubscription_Subscribe service operation. Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF responds to the NF service consumer with "201 Created", and the URI of the created subscription is included in the Location header field.

   Upon receipt of the HTTP PUT request, if the subscription is accepted to be updated, the NWDAF responds to the NF service consumer with "200 OK" or "204 No Content"

3. If the NWDAF observes the subscribed event(s), the NWDAF invokes Nnwdaf_EventsSubscription_Notify service operation to report the event(s) by sending an HTTP POST request with {notificationURI} as Notification URI.

4. The NF service consumer sends an HTTP "204 No Content" response to the NWDAF.

5. In order to unsubscribe to the notification(s) of analytics information from the NWDAF, the NF service consumer invokes Nnwdaf_EventsSubscription_Unsubscribe service operation by sending an HTTP DELETE request targeting the resource "Individual NWDAF Event Subscription", to the NWDAF to unsubscribe from analytics information.

6. The NWDAF responds to the Nnwdaf_EventsSubscription_Unsubscribe service operation. If the unsubscription is accepted, the NWDAF responds with "204 No Content".

NOTE: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.2.2.2 Analytics Subscribe/Unsubscribe/Notify initiated by AFs via the NEF

This procedure is used by the AF to subscribe to/unsubscribe from analytics information from the NWDAF via the NEF, it is also used by the NWDAF to notify the analytics event(s) to the AF via the NEF, if subscribed before.

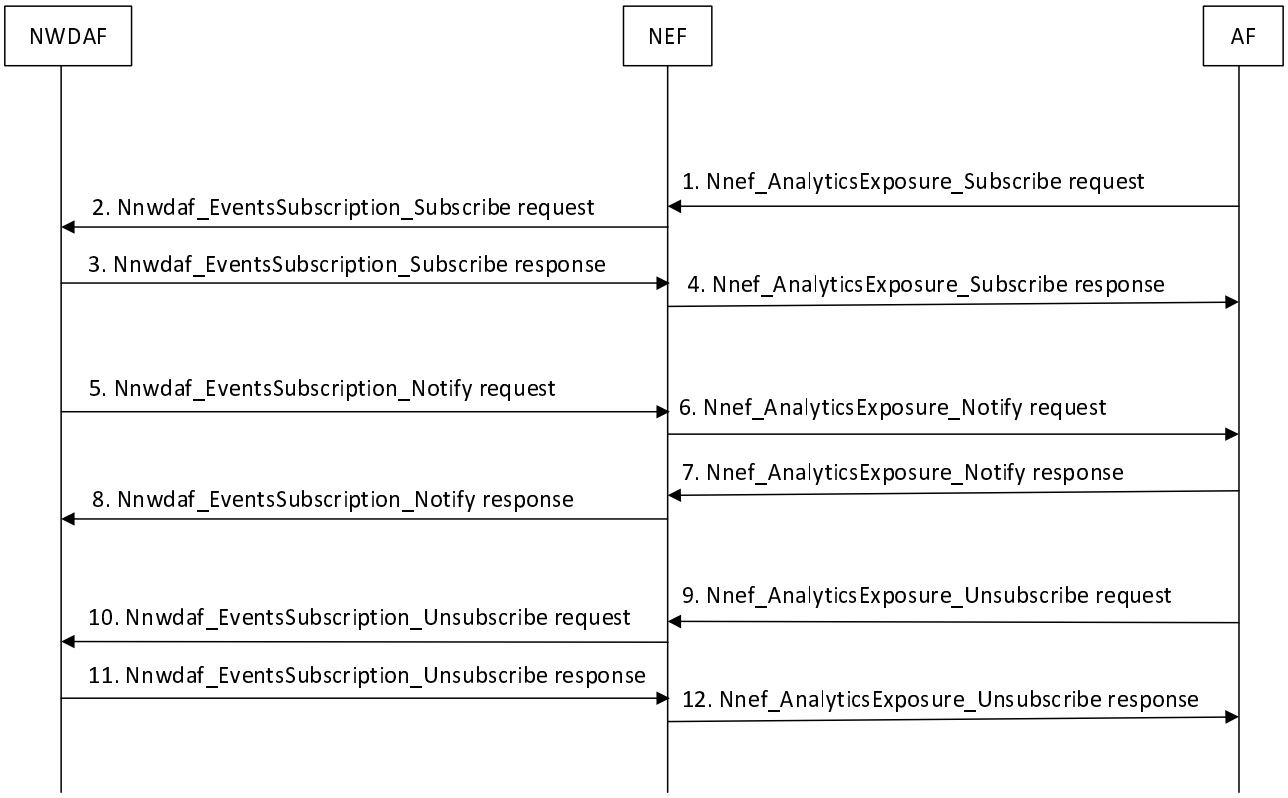

Figure 5.2.2.2-1: Analytics Subscribe/Unsubscribe/Notify initiated by AFs via the NEF

1. In order to subscribe to notification(s) of analytics exposure via the NEF, the AF invokes the Nnef_AnalyticsExposure_Subscribe request by sending an HTTP POST request message targeting the resource "Analytics Exposure Subscriptions" as defined in clause 4.4.14.1 of 3GPP TS 29.522 [10].

   In order to update an existing analytics exposure subscription, the AF shall send an HTTP PUT request message to the NEF to the resource "Individual Analytics Exposure Subscription" requesting to change the subscription.

2. Upon receipt of the HTTP request from the AF, if the AF is authorized with the requested analytics event(s) and the requested parameters comply with the inbound restriction in the analytics exposure mapping, the NEF shall invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in step 1 in clause 5.2.2.1.

3. The NWDAF responds to the Nnwdaf_EventsSubscription_Subscribe service operation as described in step 2 in clause 5.2.2.1.

4. Upon receipt of the HTTP request response from the NWDAF, the NEF shall invoke the Nnef_AnalyticsExposure_Subscribe response message by mapping and forwarding the response to the AF.

5. If the NWDAF observes the subscribed event(s), the NWDAF invokes Nnwdaf_EventsSubscription_Notify service operation as described in step 3 in clause 5.2.2.1 to the NEF.

6. If the NEF receives an analytics information notification from the NWDAF indicating that the subscribed analytics event has been detected, the NEF shall invoke the Nnef_AnalyticsExposure_Notify request by sending HTTP POST request message provide a notification to the AF request including the AnalyticsEventNotification data structure at least with the detected analytics event identified by the notification URI together with the notification correlation identifier received during creation of the Individual Analytics Exposure Subscription.

7. Upon receipt of the analytics event notification, the AF shall respond the NEF with a "204 No Content" status code to confirm the received notification in Nnef_AnalyticsExposure_Notify response message.

8. The NEF shall forward the HTTP "204 No Content" response to the NWDAF.

9. In order to delete an existing analytics exposure subscription, the AF shall invoke the Nnef_AnalyticsExposure_Unsubscribe request by sending an HTTP DELETE request message to the NEF to the resource "Individual Analytics Exposure Subscription".

10. If the NEF receives an HTTP DELETE request from the AF, the NEF shall invoke the Nnwdaf_EventsSubscription_Unsubscribe service operation as described in step 5 in clause 5.2.2.1.

11. The NWDAF responds to the Nnwdaf_EventsSubscription_Unsubscribe service operation as described in step 6 in clause 5.2.2.1.

12. The NEF shall forward the HTTP "204 No Content" response to the AF.

NOTE: Details of AnalyticsExposure API refer to clause 4.4.14 and clause 5.6 of 3GPP TS 29.522 [10].

5.2.3 Network data analytics information request

5.2.3.1 Analytics information request initiated by 5GC NFs, OAM or AFs

This procedure is used in non-roaming case by the NF service consumers (i.e. 5GC NFs, OAM and AFs) to retrieve analytics information directly from the NWDAF. The analytics architecture for analytics exposure is defined in clause 4.5.

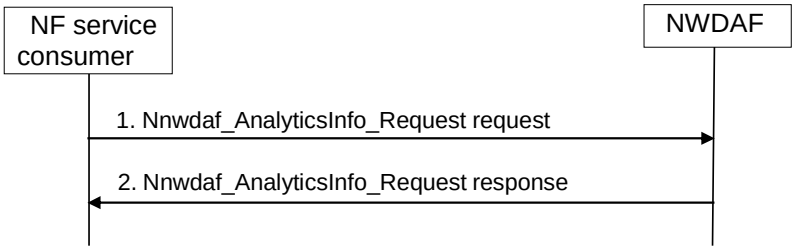

Figure 5.2.3.1-1: Network data analytics info request procedure

1. The NF Service Consumer invokes Nnwdaf_AnalyticsInfo_Request service operation by sending an HTTP GET request targeting the resource "NWDAF Analytics", to the NWDAF to request the analytics information. The request includes analytics identifier and related event filter information.

2. The NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation. If the request is accepted, the response includes the requested analytics information with "200 OK".

NOTE: For details of Nnwdaf_AnalyticsInfo_Request service operation refer to 3GPP TS 29.520 [5].

5.2.3.2 Analytics information request initiated by AFs via the NEF

This procedure is used by the AFs to retrieve analytics information from the NWDAF via the NEF.

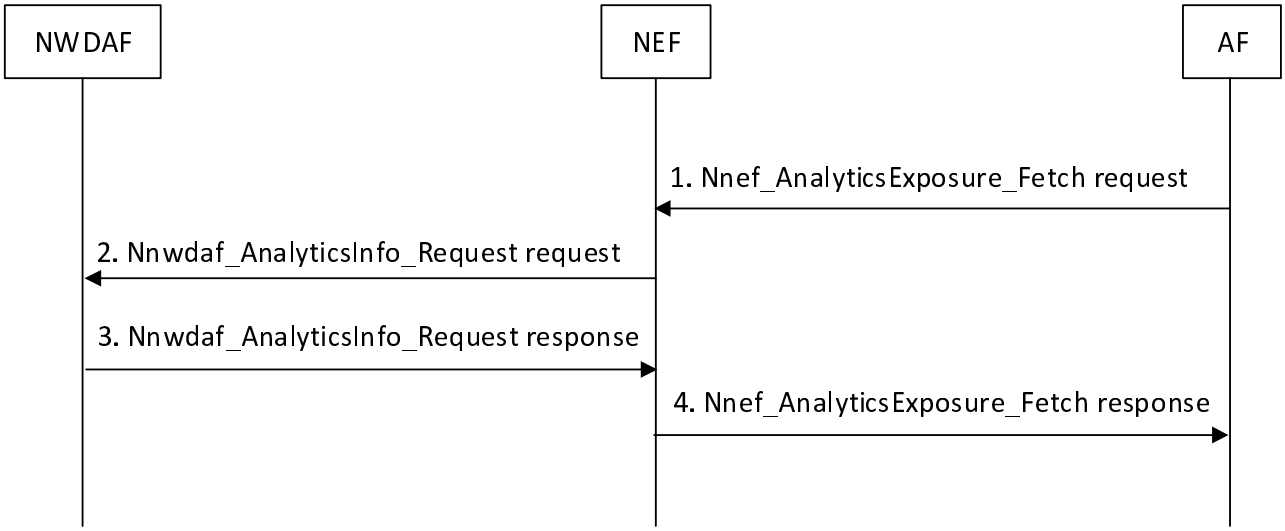

Figure 5.2.3.2-1: Analytics Request initiated by AFs via the NEF

1. In order to fetch analytics information, the AF invokes the Nnef_AnalyticsExposure_Fetch request by sending an HTTP POST request message to the NEF to the customized operation URI "{apiRoot}/3gpp-analyticsexposure/v1/fetch" as defined in clause 4.4.14.2 of 3GPP TS 29.522 [10].
2. Upon receipt of the HTTP request from the AF, if the AF is authorized with the requested analytics event and the requested parameters comply with the inbound restriction in the analytics exposure mapping, the NEF shall invoke the Nnwdaf_AnalyticsInfo_Request service operation as described in step 1 in clause 5.2.3.1.
3. The NWDAF responds with the analytics information as described in step 2 in clause 5.2.3.1 to the NEF.
4. The NEF responds with the analytics information to the AF.

NOTE: Details of AnalyticsExposure API refer to clause 4.4.14 and clause 5.6 of 3GPP TS 29.522 [10].

5.2.4 Analytics Exposure via DCCF

This procedure is used by NF service consumer(s) based on local configuration, to subscribe/unsubscribe to NWDAF analytics event(s) via the DCCF, and upon the delivery option "Delivery via DCCF" configured on the DCCF, also used by DCCF to notify the NF service consumer(s) of the analytics information via the DCCF if subscribed before.

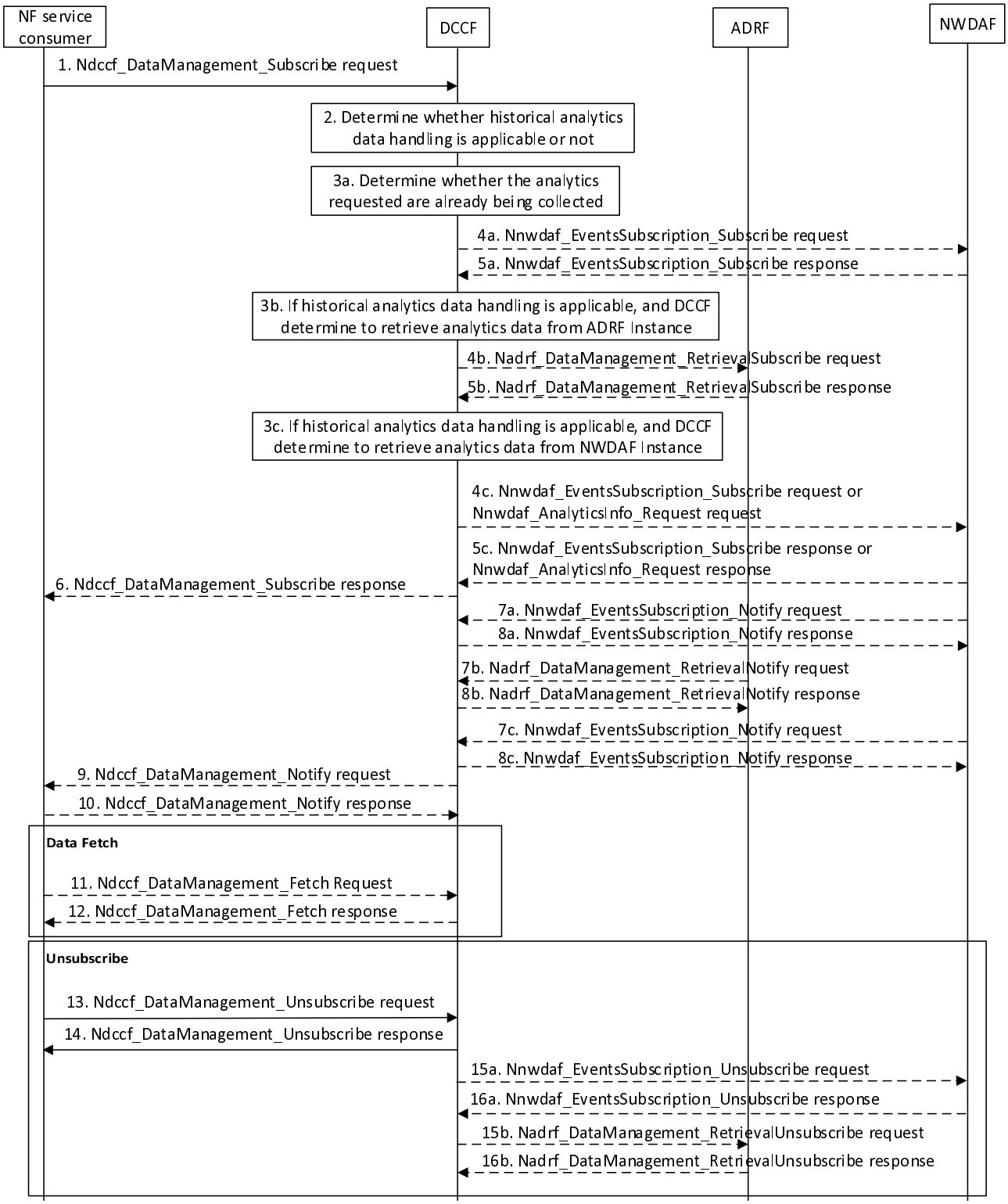

Figure 5.2.4-1: Analytics Exposure via DCCF

1. In order to subscribe to notification(s) of analytics exposure via the DCCF based on local configuration, the NF service consumer invokes the Ndccf_DataManagement_Subscribe service operation by sending an HTTP POST request message targeting the resource "DCCF Analytics Subscriptions", the HTTP POST message shall include the NdccfAnalyticsSubscription data structure as request body with parameters as defined in clause 5.1.6.2.2 of 3GPP TS 29.574 [15].

2. The DCCF keeps track of the analytics actively being collected for the Analytics Subscription it is coordinating. The NWDAF or ADRF may register the analytics data profile (may include the analytics data related service

operation, Analytics Specification, NWDAF ID or ADRF ID) with the DCCF. The DCCF may then determine whether certain historical analytics data may be available in the NWDAF or ADRF based on the analytics data profile and the request time window.

If the historical analytics data handling is not applicable or not supported, the DCCF shall proceed step 3a, skip step 3b, step 4b, step 5b, step 3c, step 4c and step 5c.

If the historical analytics data is available in an ADRF, the DCCF shall proceed step 3a and step 3b, skip step 3c, step 4c and step 5c.

If the historical analytics data is available in an NWDAF, the DCCF shall proceed step 3a and step 3c, skip step 3b, step 4b and step 5b.

3a. The DCCF shall determine whether the analytics requested are already being collected.

If the requested analytics are already being collected by an NF service consumer, the DCCF adds the new NF service consumer to the list of NF service consumers that are subscribed for these analytics.

If the DCCF cannot handle the subscription request, shall take the error handling as defined in clause 4.2.2.2.2 of 3GPP TS 29.574 [15]

If the DCCF determines that no subscriptions need to be created or modified (e.g. because all the data can be made available either via pre-existing subscriptions or because of the historical data handling) then step 4a and step 5a are skipped.

3aa. The DCCF may respond to the Ndccf_DataManagement_Subscribe service operation with HTTP "201 Created" status code with the message body containing a representation of the created subscription if the DCCF add the new NF service consumer to the list of NF service consumers that are subscribed, or if error case happened may respond with corresponding error information.

4a If the analytics requested at step 1 are not already available yet, the DCCF shall invoke the Nnwdaf_EventsSubscription_Subscribe service operation by sending an HTTP POST request message request to the NWDAF targeting the resource "NWDAF Events Subscriptions" to subscribe to a new analytics exposure subscription, or if the analytics subscribed in step 1 partially matches an analytics that is already being collected by the DCCF from an NWDAF, and a modification of this subscription to the NWDAF would satisfy both the existing analytics subscriptions as well as the newly requested analytics, by sending an HTTP PUT request to the resource "Individual Analytics Exposure Subscription" to replace an existing analytics exposure subscription. The request includes the subscribed event(s) and event filter information received from the NF service consumer, mapping to the parameters as defined in clause 5.1 of 3GPP TS 29.520 [5].

NOTE: If the NWDAF instance or NWDAF Set is not identified by the NF service consumer, the DCCF determines the NWDAF instances that can provide analytics. If the consumer requested storage of analytics in an ADRF but an ADRF ID is not provided by the NF service consumer, or the collected analytics is to be stored in an ADRF according to configuration on the DCCF, the DCCF selects an ADRF to store the collected analytics data.

5a The NWDAF responds to the Nnwdaf_EventsSubscription_Subscribe service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

Upon receipt of the HTTP PUT request, if the subscription is accepted to be updated, the NWDAF responds to the DCCF with "200 OK" or "204 No Content" status code.

3b If the historical analytics data handling is applicable, and the DCCF determine to retrieve analytics data from the ADRF, the DCCF shall determine which ADRF instances might provide the analytics.

4b In order to retrieve the historical analytics data from the ADRF, the DCCF shall invoke the Nadrf_DataManagement_RetrievalSubscribe service operation by sending an HTTP POST request message targeting the resource "ADRF Data Retrieval Subscriptions", the HTTP POST message shall include the NadrfDataRetrievalSubscription data structure as request body with parameters as defined in clause 5.1.6 of 3GPP TS 29.575 [16].

5b The ADRF responds to the Nadrf_DataManagement_RetrievalSubscribe service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the ADRF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

3c If the historical analytics data handling is applicable, and the DCCF determine to retrieve analytics data from the NWDAF, the DCCF shall determine which NWDAF instances might provide the analytics as described and proceed step 4c.

4c In order to retrieve the historical analytics data from the NWDAF, the DCCF may invoke the Nnwdaf_EventsSubscription_Subscribe service operation by sending an HTTP POST request message targeting the resource "NWDAF Events Subscriptions", the HTTP POST message shall include the NnwdafEventsSubscription data structure as request body with parameters as defined in clause 5.1.6 of 3GPP TS 29.520 [5] or Nnwdaf_AnalyticsInfo_Request request by sending an HTTP GET request message targeting the resource "NWDAF Analytics" with parameters as defined in clause 5.2.3.2.3.1 of 3GPP TS 29.520 [5].

5c The NWDAF responds to the Nnwdaf_EventsSubscription_Subscribe or Nnwdaf_AnalyticsInfo_Request service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

6. The DCCF responds to the Ndccf_DataManagement_Subscribe service operation with HTTP "201 Created" status code with the message body containing a representation of the created subscription.

7a. (conditional)When the analytics are available, the NWDAF invokes the Nnwdaf_EventsSubscription_Notify service operation by sending an HTTP POST request message to notify the analytics information to the DCCF.

8a. The DCCF responds to the Nnwdaf_EventsSubscription_Notify service operation with HTTP "204 No Content" status code.

7b. (conditional)When the historical analytics data are available in the ADRF, the ADRF shall invoke the Nadrf_DataManagement_RetrievalNotify service operation by sending an HTTP POST request message to notify the historical analytics or Fetch Instructions to the DCCF.

8b. The DCCF responds to the Nadrf_DataManagement_RetrievalNotify service operation with HTTP "204 No Content" status code.

7c. (conditional)When the historical analytics data are available in the NWDAF, the NWDAF may invoke the Nnwdaf_EventsSubscription_Notify service operation by sending an HTTP POST request message to notify the historical analytics data to the DCCF.

8c. The DCCF responds to the Nnwdaf_EventsSubscription_Notify service operation with HTTP "204 No Content" status code.

9. Upon the delivery option "Delivery via DCCF" configured on the DCCF. the DCCF invokes the Ndccf_DataManagement_Notify service operation by sending HTTP POST request message(s) to send the analytics data to all notification endpoints indicated in step 1. Analytics sent to notification endpoints may be processed and formatted by the DCCF so they conform to delivery requirements for each NF service consumer or notification endpoint.

NOTE: According to Formatting Instructions provided by the NF service consumer, multiple notifications from a NWDAF can be combined in a single Ndccf_DataManagement_Notify so many notifications from an NWDAF results in fewer notifications (or one notification) to the NF service consumer. Alternatively, a notification can instruct the analytics notification endpoint to fetch the analytics from the DCCF.

10. The NF service consumer responds to the Ndccf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

11. (conditional) The NF service consumer invokes the Ndccf_DataManagement_Fetch service operation by sending an HTTP GET request message to fetch the analytics from the DCCF before an expiry time, if received the fetch instruction in NdccfDataManagement_Notify service operation in step 9.

12. The NF service consumer responds to the Ndccf_DataManagement_Fetch service operation with HTTP "204 No Content" status code.

13. When the NF service consumer no longer need the subscription to the analytics requested in step 1, shall invoke the Ndccf_DataManagement_Unsubscribe service operation by sending an HTTP DELETE request message with "{xxx}" as Resource URI, where "{subscriptionId}" is the event subscriptionId of the existing subscription that is to be deleted., using the Subscription Correlation Id received in response to its subscription in step 1. The DCCF removes the NF service consumer from the list of NF service consumers that are subscribed for these analytics.

14. The DCCF responds to the Ndccf_DataManagement_Unsubscribe service operation with HTTP "204 No Content" status code, upon removed the NF service consumer from the list of NF service consumers that are subscribed for these analytics

15a. If there are no other NF service consumers subscribed to the analytics, the DCCF invokes the Nnwdaf_EventsSubscription_Unsubscribe service operation by sending an HTTP DELETE request message to the NWDAF.

16a. The NWDAF responds to the Nnwdaf_EventsSubscription_Unsubscribe service operation with HTTP "204 No Content" status code, upon the analytics event(s) subscription is removed.

15b. If DCCF determines that no other NF service consumers requiring the historical analytics data from the ADRF, the DCCF may invoke the Nadrf_DataManagement_RetrievalUnSubscribe service operation by sending an HTTP DELETE request message to the ADRF.

16b. The ADRF responds to the Nadrf_DataManagement_RetrievalUnSubscribe service operation with HTTP "204 No Content" status code, upon the analytics data retrieval subscription is removed.

5.2.5 Analytics Exposure via DCCF and MFAF

This procedure is used by NF service consumer(s) based on local configuration, to subscribe/unsubscribe to NWDAF analytics event(s) via the DCCF, and upon the delivery option "Delivery via Messaging Framework " configured on the DCCF, 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 for analytics information delivery to the NF service consumer(s) subscribed notification endpoint(s).

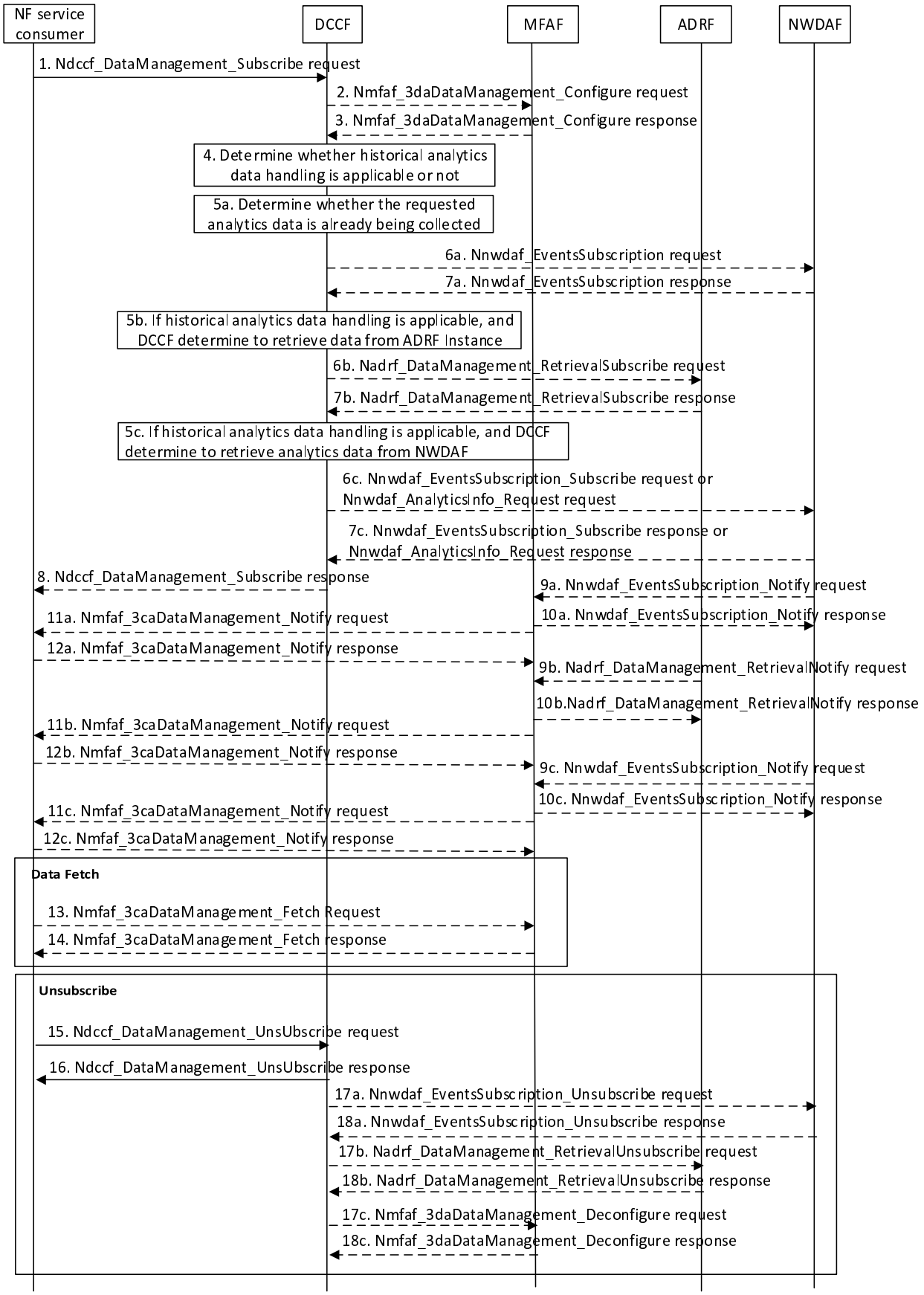

Figure 5.2.5-1: Analytics Exposure via DCCF and Messaging Framework

1. In order to subscribe to notification(s) of analytics exposure via the DCCF based on local configuration, the NF service consumer invokes the Ndccf_DataManagement_Subscribe service operation by sending an HTTP POST request message targeting the resource "DCCF Analytics Subscriptions", the HTTP POST message shall include the NdccfAnalyticsSubscription data structure as request body with parameters as defined in clause 5.1.6.2.2 of 3GPP TS 29.574 [15].

2. Upon the delivery option "Delivery via MFAF" configured on the DCCF, in order to create configuration of mapping data in the MFAF, the DCCF shall invoke the Nmfaf_3daDataManagement_Configure service operation by sending an HTTP POST request message targeting the resource "MFAF Configurations", the HTTP POST message shall include the MfafConfiguration data structure as request body with parameters as defined in clause 5.1.6 of 3GPP TS 29.576 [17].

3. The MFAF responds to the Nmfaf_3daDataManagement_Configure service operation.

   Upon receipt of the HTTP POST request, if the configuration is accepted to be created, the MFAF responds to the DCCF with "201 Created", and the URI of the created configuration is included in the Location header field.

4. The DCCF keeps track of the analytics actively being collected for the Analytics Subscription it is coordinating. The NWDAF or ADRF may register the analytics data profile (may include the analytics data collection related service operation, Analytics Specification, NWDAF ID or ADRF ID) with the DCCF. The DCCF may then determine whether certain historical analytics data may be available in the NWDAF or ADRF based on the analytics data profile and the request time window.

   If the historical analytics data handling is not applicable or not supported, the DCCF shall proceed step 5a, skip step 5b step 6b, step 7b, step 5c step 6c and step 7c.

   If the historical analytics data is available in an ADRF, the DCCF shall proceed step 5a and step 5b, skip step 5c, step 6c and step 7c.

   If the historical data is available in an NWDAF, the DCCF shall proceed step 5a and step 5c, skip step 5b, step 6b and step 7b.

5a. The DCCF shall determine whether the analytics data requested in step 1 are already being collected.

   If the analytics data requested are already being collected by an NF service consumer, the DCCF adds the NF service consumer to the list of analytics consumers that are subscribed for these data.

   If the DCCF cannot handle the subscription request, shall take the error handling as defined in clause 4.2.2.2.2 of 3GPP TS 29.574 [15]

   If the DCCF determines that no subscriptions need to be created or modified (e.g. because all the data can be made available either via pre-existing subscriptions or because of the historical data handling) then step 6a and step 7a are skipped.

5aa. The DCCF may respond to the Ndccf_DataManagement_Subscribe service operation with HTTP "201 Created" status code with the message body containing a representation of the created subscription if the DCCF adds the new NF service consumer to the list of NF service consumers that are subscribed, or if error case happened may respond with corresponding error information.

6a If the requested data at step 1 are not already available yet, the DCCF shall invoke the Nnwdaf_EventsSubscription_Subscribe service operation by sending an HTTP POST request message request to the NWDAF targeting the resource "NWDAF Events Subscriptions" to subscribe to a new analytics exposure subscription, or if the analytics subscribed in step 1 partially matches an analytics that is already being collected by the DCCF from an NWDAF, and a modification of this subscription to the NWDAF would satisfy both the existing analytics subscriptions as well as the newly requested analytics, by sending an HTTP PUT request to the resource "Individual Analytics Exposure Subscription" to replace an existing analytics exposure subscription. The request includes the subscribed event(s) and event filter information received from the NF service consumer, mapping to the parameters as defined in clause 5.1 of 3GPP TS 29.520 [5].

NOTE 1: If the NWDAF instance or NWDAF Set is not identified by the NF service consumer, the DCCF determines the NWDAF instances that can provide analytics. If the consumer requested storage of analytics in an ADRF but an ADRF ID is not provided by the NF service consumer, or the collected analytics is to be stored in an ADRF according to configuration on the DCCF, the DCCF selects an ADRF to store the collected data.

7a The NWDAF responds to the Nnwdaf_EventsSubscription_Subscribe service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

Upon receipt of the HTTP PUT request, if the subscription is accepted to be updated, the NWDAF responds to the DCCF with "200 OK" or "204 No Content" status code.

5b If the historical analytics data handling is applicable, and the DCCF determine to retrieve analytics data from the ADRF, the DCCF shall determine which ADRF instances might provide the analytics.

6b In order to retrieve the historical analytics data from the ADRF, the DCCF shall invoke the Nadrf_DataManagement_RetrievalSubscribe service operation by sending an HTTP POST request message targeting the resource "ADRF Data Retrieval Subscriptions", the HTTP POST message shall include the NadrfDataRetrievalSubscription data structure as request body with parameters as defined in clause 5.1.6 of 3GPP TS 29.575 [16].

7b The ADRF responds to the Nadrf_DataManagement_RetrievalSubscribe service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the ADRF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

5c If the historical data handling is applicable, and the DCCF determines to retrieve analytics data from the NWDAF, the DCCF shall determine which NWDAF instances might provide the analytics as described and proceed step 6c.

6c In order to retrieve the historical analytics data from the NWDAF, the DCCF may invoke the Nnwdaf_EventsSubscription_Subscribe service operation by sending an HTTP POST request message targeting the resource "NWDAF Events Subscriptions", the HTTP POST message shall include the NnwdafEventsSubscription data structure as request body with parameters as defined in clause 5.1.6 of 3GPP TS 29.520 [5] or Nnwdaf_AnalyticsInfo_Request request by sending an HTTP GET request message targeting the resource "NWDAF Analytics" with parameters as defined in clause 5.2.3.2.3.1 of 3GPP TS 29.520 [5].

7c The NWDAF responds to the Nnwdaf_EventsSubscription_Subscribe or Nnwdaf_AnalyticsInfo_Request service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF responds to the DCCF with "201 Created", and the URI of the created subscription is included in the Location header field.

8. The DCCF responds to the Ndccf_DataManagement_Subscribe service operation with HTTP "201 Created" status code with the message body containing a representation of the created subscription.

9a. (conditional)When the analytics are available, the NWDAF invokes the Nnwdaf_EventsSubscription_Notify service operation by sending an HTTP POST request message to notify the analytics information to the MFAF.

10a. The MFAF responds to the Nnwdaf_EventsSubscription_Notify service operation with HTTP "204 No Content" status code.

11a. The MFAF invokes the Nmfaf_3caDataManagement_Notify service operation by sending HTTP POST request message(s) to send the analytics data to all notification endpoints indicated in step 1. Analytics data sent to notification endpoints may be processed and formatted by the MFAF so that they conform to delivery requirements for each NF service consumer and/or notification endpoint.

NOTE 2: According to Formatting Instructions provided by the NF service consumer, multiple notifications from the NWDAF can be combined in a single Nmfaf_3caDataManagement_Notify so that many notifications from an NWDAF result in fewer notifications (or one notification) to the NF service consumer and/or the subscribed notification endpoint(s). Alternatively, a notification can instruct the analytics data notification endpoint to fetch the analytics data from the MFAF.

12a.The NF service consumer responds to the Nmfaf_3caDataManagement_Notify service operation with HTTP "204 No Content" status code.

9b. (conditional)When the historical analytics data are available in the ADRF, the ADRF shall invoke the Nadrf_DataManagement_RetrievalNotify service operation by sending an HTTP POST request message to notify the historical analytics or Fetch Instructions to the MFAF.

10b. The MFAF responds to the Nadrf_DataManagement_RetrievalNotify service operation with HTTP "204 No Content" status code.

11b. The MFAF invokes the Nmfaf_3caDataManagement_Notify service operation by sending HTTP POST request message(s) to send the analytics data to all notification endpoints indicated in step 1. Analytics data sent to notification endpoints may be processed and formatted by the MFAF so that they conform to delivery requirements for each NF service consumer or notification endpoint.

NOTE 3: According to Formatting Instructions provided by the NF service consumer, multiple notifications from an ADRF can be combined in a single Nmfaf_3caDataManagement_Notify so many notifications from an ADRF results in fewer notifications (or one notification) to the NF service consumer and/or the subscribed notification endpoint(s). Alternatively, a notification can instruct the analytics data notification endpoint to fetch the analytics data from the MFAF.

12b.The NF service consumer responds to the Nmfaf_3caDataManagement_Notify service operation with HTTP "204 No Content" status code.

9c. (conditional)When the historical analytics data are available in the NWDAF, the NWDAF may invoke the Nnwdaf_EventsSubscription_Notify service operation by sending an HTTP POST request message to notify the historical analytics data to the MFAF.

10c. The MFAF responds to the Nnwdaf_EventsSubscription_Notify service operation with HTTP "204 No Content" status code.

11c. The MFAF invokes the Nmfaf_3caDataManagement_Notify service operation by sending HTTP POST request message(s) to send the analytics data to all notification endpoints indicated in step 1. Analytics data sent to notification endpoints may be processed and formatted by the MFAF so they conform to delivery requirements for each NF service consumer or notification endpoint.

NOTE 4: According to Formatting Instructions provided by the NF service consumer, multiple notifications from a NWDAF can be combined in a single Nmfaf_3caDataManagement_Notify so many notifications from an NWDAF results in fewer notifications (or one notification) to the NF service consumer and/or the subscribed notification endpoint(s). Alternatively, a notification can instruct the analytics data notification endpoint to fetch the analytics data from the MFAF.

12c. The NF service consumer responds to the Nmfaf_3caDataManagement_Notify service operation with HTTP "204 No Content" status code.

13. (conditional) The NF service consumer invoke the Nmfaf_3caDataManagement_Fetch service operation by sending an HTTP GET request message to fetch the data from the MFAF before an expiry time, if received the fetch instruction in Nmfaf_3caDataManagement_Notify service operation in step 11a, step 11b or step 11c.

14. The MFAF responds to the Nmfaf_3caDataManagement_Fetch service operation with HTTP "200 OK" status code with the message body containing the NmfafResourceRecord data structure.

15. When the NF service consumer no longer need the subscription to the requested data in step 1, shall invoke the Ndccf_DataManagement_Unsubscribe service operation by sending an HTTP DELETE request message with "{apiRoot}/nnwdaf-datamanagement/v1/subscriptions/{subscriptionId}" as Resource URI, where "{subscriptionId}" is the event subscriptionId of the existing subscription that is to be deleted., using the Subscription Correlation Id received in response to its subscription in step 1. The DCCF removes the NF service consumer from the list of NF service consumers that are subscribed for these analytics data.

16. The DCCF responds to the Ndccf_DataManagement_Unsubscribe service operation with HTTP "204 No Content" status code, upon removed the NF service consumer from the list of NF service consumers that are subscribed for these analytics data.

17a. If there are no other NF service consumers subscribed to the analytics data, the DCCF invoke the Nnwdaf_EventsSubscription_Unsubscribe service operation by sending an HTTP DELETE request message to the NWDAF.

18a. The DWDAF responds to the Nnwdaf_EventsSubscription_Unsubscribe service operation with HTTP "204 No Content" status code, upon the analytics event(s) subscription is removed.

17b. If DCCF determines that no other NF service consumers requiring the historical analytics data from the ADRF, the DCCF may invoke the Nadrf_DataManagement_RetrievalUnSubscribe service operation by sending an HTTP DELETE request message to the ADRF.

18b. The ADRF responds to the Nadrf_DataManagement_RetrievalUnSubscribe service operation with HTTP "204 No Content" status code, upon the data retrieval subscription is removed.

17c. When DCCF determines that NF service consumer mapping has to be removed from MFAF, the DCCF may invoke the Nmfaf_3daDataManagement_Deconfigure service operation by sending an HTTP DELETE request message to the MFAF.

18c. The MFAF responds to the Nmfaf_3daDataManagement_Deconfigure service operation with HTTP "204 No Content" status code, upon removing the individual resource linked to the delete request.

5.2.6 Procedure for Analytics Exposure in Roaming Case

5.2.6.1 Analytics Exposure from HPLMN to VPLMN for inbound roaming users

The procedure depicted in Figure 5.2.6.1-1 is used by the V-RE-NWDAF as service consumer to subscribe/unsubscribe to notifications about analytics exposure from the HPLMN for inbound roaming users.

The procedure depicted in Figure 5.2.6.1-1 is used by the V-RE-NWDAF as service consumer to subscribe/unsubscribe to notifications about analytics exposure from the HPLMN for inbound roaming users.

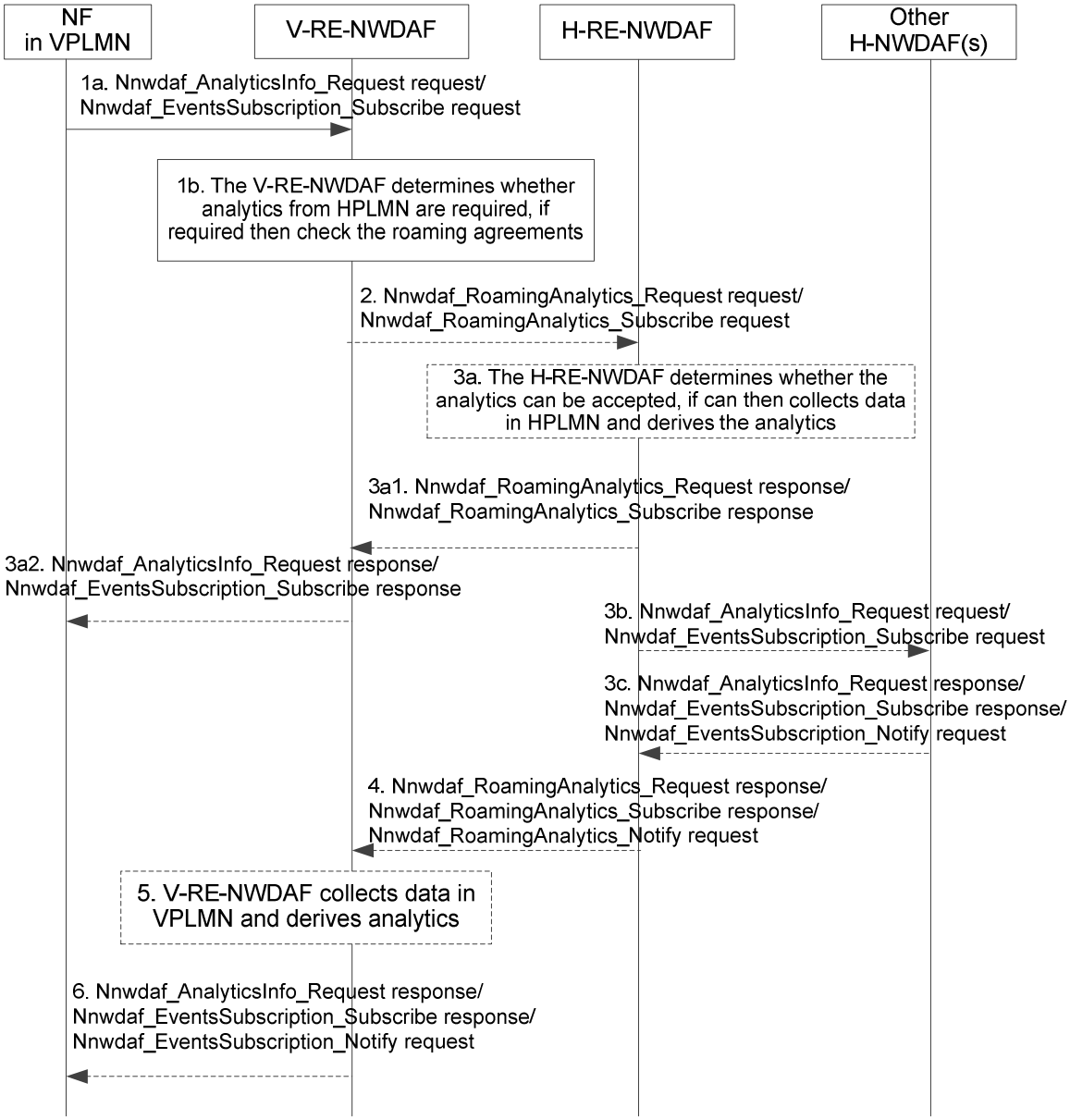

Figure 5.2.6.1-1: Procedure for analytics exposure from HPLMN to VPLMN

1a. The consumer NF in VPLMN (e.g. AMF) discovers a V-RE-NWDAF as described in clause 5.2.8.3 and invoke Nnwdaf_AnalyticsInfo_Request or Nnwdaf_EventsSubscription_Subscribe service operation to the V-RE-NWDAF. For the inbound roaming user(s) indicated in the Target of Analytics Reporting, The V-RE-NWDAF determines based on operator configuration and the requested analytics whether analytics from the HPLMN are required, or the analytics can be derived locally.

NOTE 1: It is possible that the Target of Analytics Reporting sent by the Consumer NF to the V-RE-NWDAF includes both inbound roaming user(s) and non-roaming user(s).

1b. The V-RE-NWDAF checks the roaming agreements related to analytics from HPLMN to determine if the roaming analytics request/subscribe can be accepted or must be rejected. If the request is rejected, the following steps are skipped.

2. The V-RE-NWDAF discovers a H-RE-NWDAF as described in clause 5.8.2.3 if the V-RE-NWDAF determines the roaming analytics request/subscribe can be accepted, then invoke Nnwdaf_RoamingAnalytics_Request or Nnwdaf_RoamingAnalytics_Subscribe service operation as described in clause 4.9.2.2 and clause 4.9.2.3 of 3GPP TS 29.520 [5], based on the Analytics request/subscribe received from the Consumer NF in VPLMN. The

Target of Analytics Reporting sent by the V-RE-NWDAF to the H-RE-NWDAF only contains the inbound roaming user(s).

NOTE 2: The inbound roaming user(s) are distinguished by the V-RE-NWDAF according to UE ID(s) (i.e. SUPI(s)).

3a. The H-RE-NWDAF checks the roaming agreements between the HPLMN and the VPLMN, and user consent for analytics if needed, to determine if the roaming analytics request/subscribe can be accepted or must be rejected. If the roaming analytics request/subscribe is rejected, the following steps are skipped.

If the H-RE-NWDAF supports to generate the requested analytics, it collects data from the NF(s) and/or OAM in HPLMN and derives the requested analytics, then steps 3a1 and 3a2 are followed; otherwise steps 3b and 3c are executed.

3a1-3a2 The H-RE-NWDAF may respond with Nnwdaf_RoamingAnalytics_Request response or Nnwdaf_RoamingAnalytics_Subscribe response to the V-RE-NWDAF then responds to the consumer NF.

3b-3c. [Optional] If the H-RE-NWDAF does not support to generate the requested analytics, it may request/subscribe to other NWDAF(s) in the HPLMN (if available) by invoking Nnwdaf_AnalyticsInfo_Request or Nnwdaf_EventsSubscription_Subscribe service operation for the analytics and get corresponding response/notification by Nnwdaf_AnalyticsInfo_Request response, Nnwdaf_EventsSubscription_Subscribe response or Nnwdaf_EventsSubscription_Notify service operation.

4. The H-RE-NWDAF sends the HPLMN analytics information to the V-RE-NWDAF using either Nnwdaf_RoamingAnalytics_Request response, Nnwdaf_RoamingAnalytics_Subscribe response or Nnwdaf_RoamingAnalytics_Notify request message as described in clause 4.9.2.2 and clause 4.9.2.3 of 3GPP TS 29.520 [5], depending on the service used in step 2. The H-RE-NWDAF may restrict the exposed analytics information based on HPLMN operator polices.

5. If the Consumer NF also indicates request or subscription of analytics information available in the VPLMN (e.g. via Target of Analytics Reporting) in step 1, the V-RE-NWDAF collects data from the NF(s) and/or OAM in VPLMN and derives the requested analytics. These steps can be executed in parallel with steps 3-4.

6. The V-RE-NWDAF sends the HPLMN analytics information received in step 4, or the aggregated analytics information if step 5 are performed, to the Consumer NF in VPLMN using either Nnwdaf_AnalyticsInfo_Request response, Nnwdaf_EventsSubscription_Subscribe or Nnwdaf_EventsSubscription_Notify request message described in clause 4.2.2 of 3GPP TS 29.520 [5] depending on the service used in step 1.

NOTE 3: The present document describes that the RE-NWDAF may perform analytics aggregation for roaming scenario, but whether and how the RE-NWDAF performs analytics aggregation for roaming scenario are up to implementation.

NOTE 4: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify, Nnwdaf_AnalyticsInfo_Request and/or Nnwdaf_RoamingAnalytics_Subscribe/Unsubscribe/Notify/Request service operations refer to 3GPP TS 29.520 [5].

5.2.6.2 Analytics Exposure from VPLMN to HPLMN for outbound roaming users

The procedure depicted in Figure 5.2.6.2-1 is used by the H-RE-NWDAF as service consumer to subscribe/unsubscribe to notifications about analytics exposure from the VPLMN for outbound roaming users.

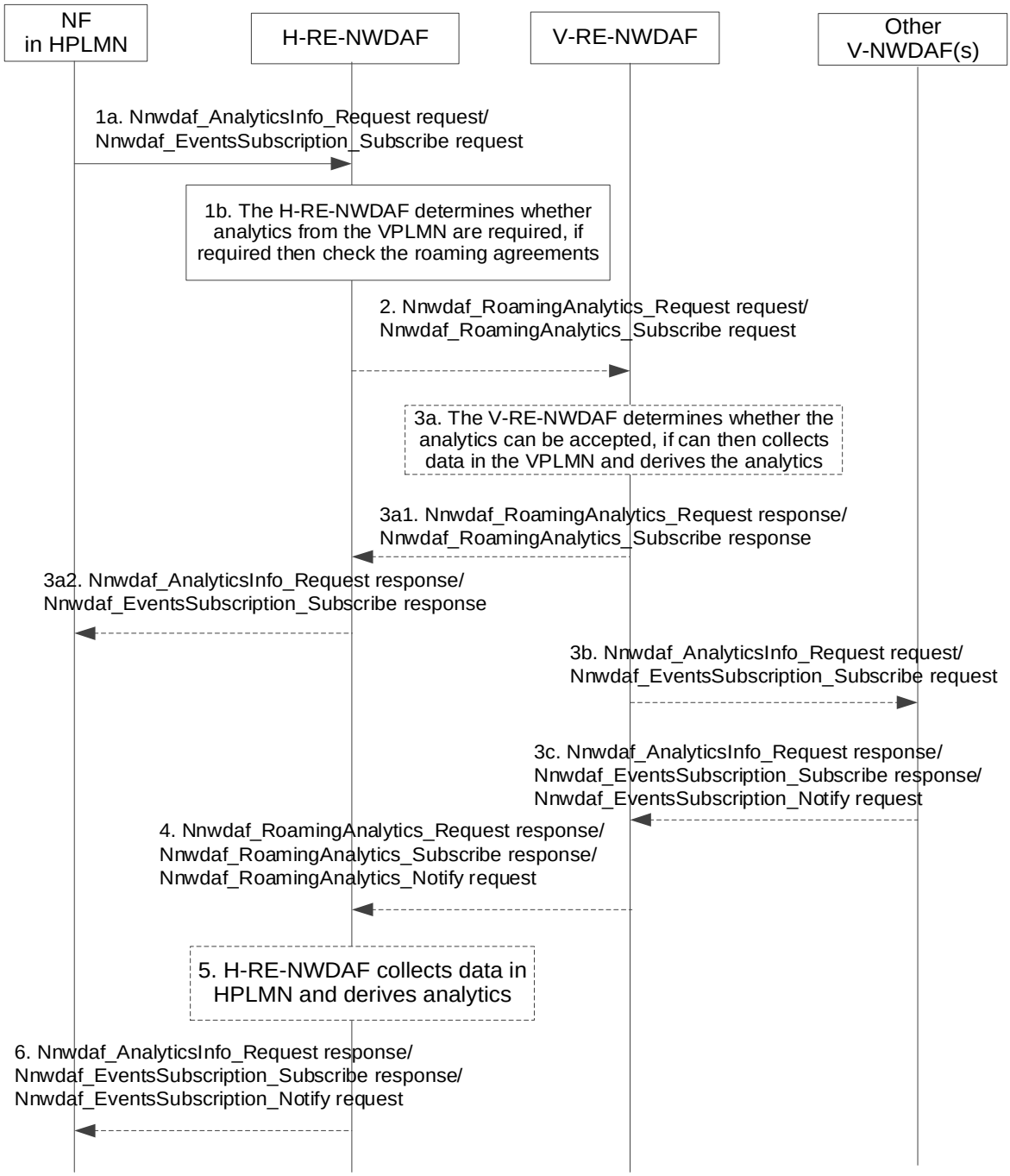

Figure 5.2.6.2-1: Procedure for analytics exposure from VPLMN to HPLMN

1a. Upon the Consumer NF is aware that the UE(s) indicated in Target of Analytics Reporting is/are roaming, Consumer NF in HPLMN (e.g. H-PCF) discovers a H-RE-NWDAF as described in clause 5.2.8.3 and invoking a Nnwdaf_AnalyticsInfo_Request or a Nnwdaf_EventsSubscription_Subscribe service operation. For the outbound roaming user(s) indicated in the Target of Analytics Reporting, the H-RE-NWDAF determines based on operator configuration and the requested analytics whether analytics or input data from the VPLMN are required, or the analytics can be derived locally.

NOTE 1: It is possible that the Target of Analytics Reporting sent by the Consumer NF to the H-RE-NWDAF includes both outbound roaming user(s) and non-roaming user(s).

1b. The H-RE-NWDAF checks user consent and roaming agreements between the HPLMN and the VPLMN to determine if the roaming analytics request/subscription can be accepted or must be rejected. If the request is rejected, the following steps are skipped.

2. The H-RE-NWDAF discovers the V-RE-NWDAF as described in clause 5.8.2.3 if the H-RE-NWDAF determines the roaming analytics request/subscribe can be accepted.

   The H-RE-NWDAF invoke a Nnwdaf_RoamingAnalytics_Request or a Nnwdaf_RoamingAnalytics_Subscribe service operation, based on the Analytics request/subscribe received from the Consumer NF in HPLMN. The Target of Analytics Reporting sent by the H-RE-NWDAF to the V-RE-NWDAF only contains the outbound roaming user(s).

3a. The V-RE-NWDAF checks the roaming agreements between the HPLMN and the VPLMN, to determine if the roaming analytics request/subscribe can be accepted or must be rejected. If the roaming analytics request/subscribe is rejected, the following steps are skipped.

   If the V-RE-NWDAF supports to generate the requested analytics, it collects data from the NF(s) serving the roaming UE(s) and/or OAM in VPLMN and derives the analytics, then steps 3a1 and 3a2 are followed; otherwise steps 3b and 3c are executed.

3a1-3a2 The V-RE-NWDAF may respond with Nnwdaf_RoamingAnalytics_Request response or Nnwdaf_RoamingAnalytics_Subscribe response to the H-RE-NWDAF then responds to the consumer NF.

3b-3c. If the V-RE-NWDAF does not support to generate the requested analytics, it may request/subscribe to other NWDAF(s) in the VPLMN (if available) for the analytics and get corresponding response/notification(s) by invoking Nnwdaf_AnalyticsInfo_Request or Nnwdaf_EventsSubscription_Subscribe service operation for the analytics and get corresponding response/notification by Nnwdaf_AnalyticsInfo_Request response, Nnwdaf_EventsSubscription_Subscribe response or Nnwdaf_EventsSubscription_Notify service operation.

4. The V-RE-NWDAF may sends the VPLMN analytics information to the H-RE-NWDAF using either Nnwdaf_RoamingAnalytics_Request response, Nnwdaf_RoamingAnalytics_Subscribe or Nnwdaf_RoamingAnalytics_Notify request message as described in clause 4.9.2.2 and clause 4.9.2.3 of 3GPP TS 29.520 [5], depending on the service used in step 2. The V-RE-NWDAF may restrict the exposed analytics information based on VPLMN operator polices.

5. If the Consumer NF also indicates request or subscription of analytics information available in the HPLMN (e.g. via Target of Analytics Reporting) in step 1, H-RE-NWDAF collects data from the NF(s) and/or OAM in HPLMN and derives the analytics. These steps can be executed in parallel with steps 3-6. The H-RE-NWDAF may perform analytics aggregation with the analytics information received from the V-RE-NWDAF and analytics information generated by itself, based on the analytics request or subscription.

6. H-RE-NWDAF sends the VPLMN analytics information received in step 4, or the aggregated analytics information if step 5 are performed, to the Consumer NF in HPLMN using either Nnwdaf_AnalyticsInfo_Request response, Nnwdaf_EventsSubscription_Subscribe response or Nnwdaf_EventsSubscription_Notify service operation as described in clause 4.2.2 of 3GPP TS 29.520 [5] depending on the service used in step 1, depending on the service used in step 1.

NOTE 2: The present document describes that the RE-NWDAF may perform analytics aggregation for roaming scenario, but whether and how the RE-NWDAF performs analytics aggregation for roaming scenario are up to implementation.

NOTE 3: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify, Nnwdaf_AnalyticsInfo_Request and/or Nnwdaf_RoamingAnalytics_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.3 Analytics Aggregation from Multiple NWDAFs

5.3.1 General

Analytics Aggregation refers to the case in which an NWDAF with respective capabilities aggregates the analytics provided by other NWDAFs to serve a request from an NF service consumer.

If multiple NWDAFs are deployed, an NWDAF instance may be specialized to provide Analytics for one or more Analytics event(s). Each NWDAF instance may serve a certain Area of Interest or TAI(s) and multiple NWDAFs may be needed to serve a particular Analytics event collectively. An NWDAF may have the capability to aggregate the Analytics (per Analytics event) received from the other NWDAFs and/or the Analytics generated by itself. Analytics aggregation applies to scenarios where NWDAF service consumer requests or subscribes to analytics with or without provisioning of Area of Interest.

5.3.2 Analytics aggregation with provisioning of Area of Interest

This procedure is used by the service consumer to request Analytics event(s) for an Area of Interest, in which multiple NWDAFs are required to serve the request collectively.

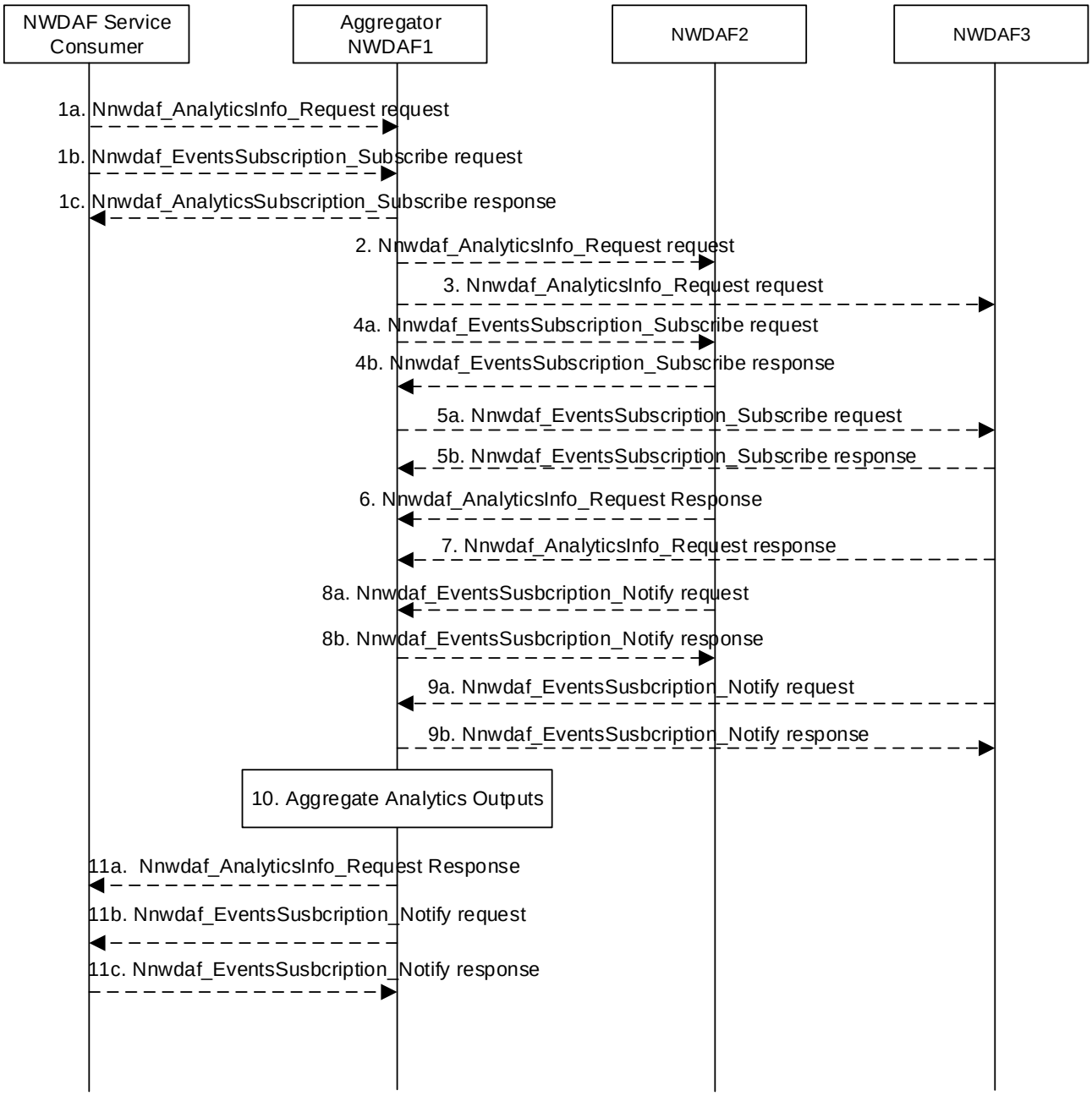

Figure 5.3.2-1: Analytics aggregation with provisioning of Area of Interest

1a-1c. In order to obtain the specific network data analytics, the NF service consumer selects an NWDAF (e.g. NWDAF1) with aggregation capability according to the results returned by NRF or available information obtained by other means. The NWDAF service consumer invokes Nnwdaf_AnalyticsInfo_Request or

Nnwdaf_EventsSubscription_Subscribe service operations as described in clause 5.2.3.1 and clause 5.2.2.1 to the selected NWDAF.

In the request message, the analytics event, analytics filter information including the Area of Interest (e.g. TAI-1, TAI-2, TAI-n, if available) and the Target of Analytics Reporting are provided. The NWDAF service consumer may indicate the time when the analytics is needed in "timeAnaNeeded" attribute, which needs to be equal or greater than the supported Analytics Delay per Analytics event of the Aggregator NWDAF.

2-5b. The Aggregator NWDAF selects the other NWDAF instances, which collectively can cover the area of interest indicated in the request, according to the results returned by the NRF and/or the UDM, or available information obtained by other means. The Aggregator NWDAF invokes Nnwdaf_AnalyticsInfo_Request or Nnwdaf_EventsSubscription_Subscribe service operations to each selected NWDAF (e.g. NWDAF2, NWDAF3) as described in clause 4.2.2.2 or clause 4.3.2.2 of 3GPP TS 29.520 [5].

6-9b. The selected NWDAFs send response or notification containing the requested analytics to the Aggregator NWDAF. If the selected NWDAFs (e.g. NWDAF 2 and/or NWDAF 3) cannot reply or notify the requested analytics before the expiry of the time that the Aggregator NWDAF has indicated, they may send an error response or error notification to the Aggregator NWDAF including a "revised waiting time" in "rvWaitTime" attribute.

10. The Aggregator NWDAF aggregates the analytics received from the selected NWDAFs and the analytics of its own.

11a-11c. The Aggregator NWDAF sends a response or notification containing the aggregated output analytics for the requested Analytics event(s) to the NWDAF service consumer.

If the Aggregator NWDAF cannot reply or notify the requested analytics before the expiry of the time that the consumer has indicated in "timeAnaNeeded" attribute, it may sends an error response or error notification to the consumer including a "revised waiting time" in "rvWaitTime" attribute.

5.3.3 Analytics aggregation without provisioning of Area of Interest

This procedure is used by the service consumer to request Analytics event(s) without providing an Area of Interest, in which multiple NWDAFs are required to serve the request collectively.

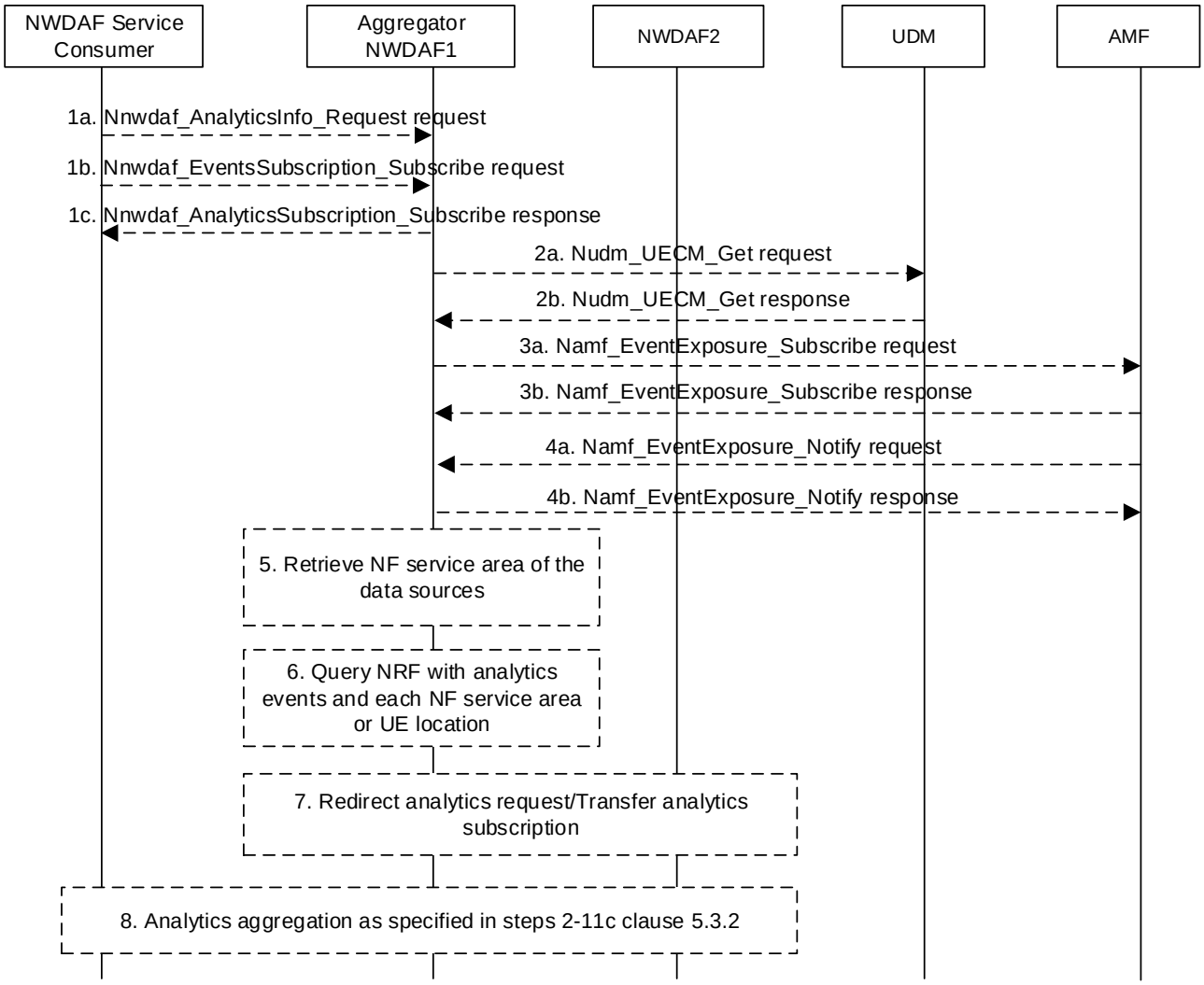

Figure 5.3.3-1: Analytics aggregation without provisioning of Area of Interest

1a-1c. In order to obtain the specific network data analytics, the NF service consumer selects an NWDAF (e.g. NWDAF1) with aggregation capability according to the results returned by NRF or available information obtained by other means. The NWDAF service consumer invokes Nnwdaf_AnalyticsInfo_Request or Nnwdaf_EventsSubscription_Subscribe service operations as described in clause 5.2.3.1 and clause 5.2.2.1 to the selected NWDAF. If not, the NWDAF service consumer should select a NWDAF with large serving area from the candidate NWDAFs which supports analytics aggregation, e.g. NWDAF1.

2a-4b. If the requested analytics requires UE location information, e.g. for the Analytics events "UE_MOBILITY", "ABNORMAL_BEHAVIOUR", or "USER_DATA_CONGESTION", then:

- 2a-2b: The Aggregator NWDAF may query UDM to discover the NWDAF serving the UE by invoking Nudm_UECM_Get service operation as described in clause 5.3.2.5.12 of 3GPP TS 29.503 [22], if it is supported.

- 3a-4b: The Aggregator NWDAF may determine the AMF serving the UE, then requests UE location information from the AMF by invoking Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18]. The AMF notifies the UE location information by invoking Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4.

5. If the requested analytics does not require UE location information, e.g. for the Analytics events "SERVICE_EXPERIENCE", "NF_LOAD", or "UE_COMM", the Aggregator NWDAF can determine the NFs to be contacted for data collection.

6. With the data obtained in step 3a-5, the Aggregator NWDAF may query the NRF for discovering the required NWDAF, by sending an NF discovery request including UE location or NF serving area as a filter to NRF, and obtains candidates target NWDAF(s) that can provide the required analytics.

7. If a single target NWDAF (e.g. NWDAF2) can provide the requested analytics data, the Aggregator NWDAF can redirect the Nnwdaf_AnalyticsInfo_Request to that target NWDAF or request an analytics subscription transfer to that target NWDAF.

8. If the Aggregator NWDAF decides to request analytics from one or more target NWDAFs, the steps 2-9b of the analytics aggregation procedure in clause 5.3.2 are executed.

5.4 Procedures for Analytics Transferring

5.4.1 Analytics context transfer initiated by target NWDAF selected by the NWDAF service consumer

The procedure in below figure is used when an NWDAF service consumer decides to select a new NWDAF instance due to internal or external triggers, e.g. the NWDAF service consumer starts serving a UE with analytics subscription information received upon UE context transfer procedure as described in 3GPP TS 23.502 [3], or the NWDAF service consumer starts to request NF related analytics, or the NWDAF service consumer receives a "Termination Request" for an existing analytics subscription from an NWDAF. The NWDAF service consumer sends to the target NWDAF information about the NWDAF previously used for analytics subscription, if available, in Nnwdaf_EventsSubscription_Subscribe service operation. The target NWDAF may initiate the transfer of the analytics context, using the Nnwdaf_AnalyticsInfo_ContextTransfer.

The procedure in below figure is also used when an Aggregator NWDAF, as the NWDAF service consumer, decides to select a new NWDAF to request output analytics for analytics aggregation. For example, upon receiving a Termination Request from one of the NWDAFs that are collectively serving a request for analytics subscription, the Aggregator NWDAF queries the NRF or UDM to select a target NWDAF using information e.g. the UE location, the 5GC NFs (identified by their NF Set IDs or NF types) serving the UE or to be contacted for data collection (if Area of Interest is not provisioned for the requested analytics), or the subset of AoI (if Area of Interest is provisioned for the requested analytics). Then, the Aggregator NWDAF sends information about the NWDAF previously used for analytics subscription, if available, in Nnwdaf_EventsSubscription_Subscribe service operation towards the selected target NWDAF.

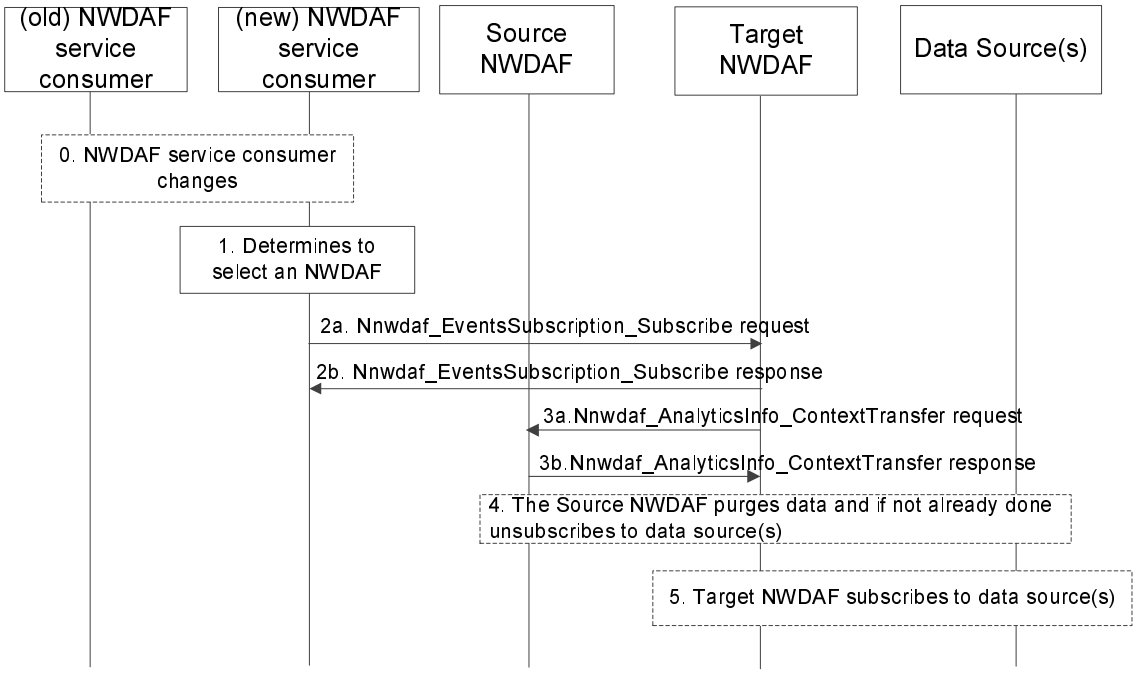

Figure 5.4.1-1: Analytics context transfer initiated by target NWDAF selected by the NWDAF service consumer

0. When the NWDAF service consumer (e.g. AMF) changes, the new NWDAF service consumer may receive the old subscription information from the old NWDAF service consumer.

1. The NWDAF service consumer determines to select an NWDAF instance. The NWDAF service consumer discovers and selects the target NWDAF as specified in clause 5.8.

2. To send a request for analytics subscription to the target NWDAF, the NWDAF service consumer invokes Nnwdaf_EventsSubscription_Subscribe service operation by sending the HTTP POST request message targeting the resource "NWDAF Events Subscriptions" to the target NWDAF. The NWDAF service consumer includes information on the previous analytics subscription (e.g., NWDAF ID and Subscription ID) which relates to the requested analytics subscription, if available. If the target NWDAF accepts the analytics subscription request, it responds with HTTP "201 Created" to the NWDAF service consumer. Details are described in clause 4.2.2.2 of 3GPP TS 29.520 [5].

   If the target NWDAF does not receive information of previous analytics subscription in step 2, for UE related Analytics, the target NWDAF may discover previously used NWDAF in UDM as specified in clause 5.8.

NOTE: If the selected target NWDAF instance is the same as the source NWDAF instance (as received from the other consumer in step 0), the new NWDAF service consumer invokes Nnwdaf_EventsSubscription_Subscribe service operation by sending the HTTP PUT request message targeting the resource "Individual NWDAF Event Subscription" to the target NWDAF, and the target NWDAF will update the existing analytics subscription to the new NWDAF service consumer. Following steps are skipped.

3. If the target NWDAF decides to request an analytics context transfer from the previously used NWDAF, it invokes the Nnwdaf_AnalyticsInfo_ContextTransfer service operation by sending the HTTP GET request message targeting the resource "NWDAF Context" to the source NWDAF as described in clause 4.3.2.3 of 3GPP TS 29.520 [5].

   Target NWDAF is now ready to generate analytics information by taking into account the information received in step 3.

4. [Optional] Source NWDAF may purge analytics context after completion of step 3a, if performed, and if not already done, unsubscribes from the data source(s) and/or model source(s) that are no longer needed for the remaining analytics subscriptions.

5. [Optional] Target NWDAF may subscribe to relevant data source(s) and/or model source(s), if it is not yet subscribed to the data source(s) and/or model source(s).

5.4.2 Analytics Subscription Transfer initiated by source NWDAF

The procedure in below figure is used by a source NWDAF instance to request the transfer of analytics subscription(s) to another target NWDAF instance, using the Nnwdaf_EventsSubscription_Transfer service operation.

If the source NWDAF discovers that the NWDAF service consumer may change concurrently to this procedure, the source NWDAF should not perform the procedure. In such a case, the source NWDAF may send a message to indicate to the NWDAF service consumer that it will not serve this subscription anymore.

NOTE 1: To discover the possible change of NWDAF service consumer, if the Analytics Event is UE related, the source NWDAF takes actions responding to external trigger (such as UE mobility), for example, checking if the Target of Analytics Reporting is still within the serving area of the analytics consumer, if the serving area information is available.

NOTE 2: Handling of overload situation or preparation for a graceful shutdown are preferably executed inside an NWDAF Set, when available, therefore, not requiring an analytics subscription transfer as described in this clause. Below procedure is applicable for analytics subscription transfer across NF Sets or if the NWDAF is not deployed in a Set.

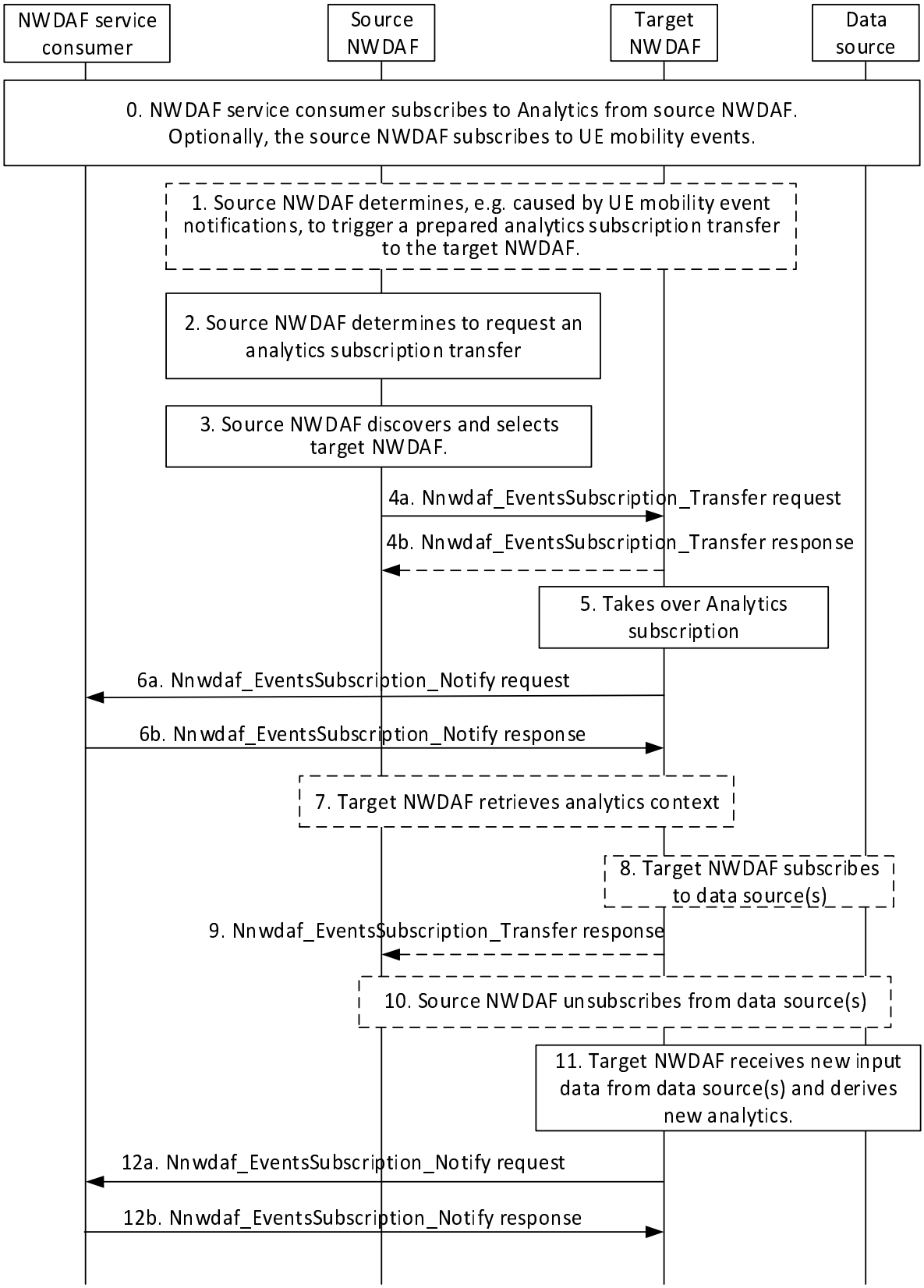

Figure 5.4.2-1: Analytics subscription transfer initiated by source NWDAF

0. The NWDAF service consumer subscribes to analytics from source NWDAF. The NWDAF service consumer may send its NF ID or serving area, enabling the source NWDAF to determine whether the following analytics subscription transfer procedure is applicable. Optionally the source NWDAF subscribes to UE mobility events.

1. [Optional] Source NWDAF determines, e.g. triggered by a UE mobility event notification, to prepare an analytics subscription transfer to target NWDAF(s) as described in clause 5.4.3 with steps 0-1, 5- 6 will be followed.

2. Source NWDAF determines, e.g. based on the UE location information received and the analytics consumer's serving area either directly received in step 0 or indirectly received via NRF, to perform an analytics subscription transfer to target NWDAF(s). Therefore, the source NWDAF determines the analytics subscription(s) to be transferred to a target NWDAF.

3. Source NWDAF performs an NWDAF discovery and selects the target NWDAF. NWDAF discovery may be skipped if the target NWDAF had already been discovered as part of a prepared analytics subscription transfer. In the case of aggregated analytics from multiple NWDAFs, the source NWDAF may use the set of NWDAF identifiers related to aggregated analytics to preferably select a target NWDAF that is already serving the consumer.

4. Source NWDAF requests, using Nnwdaf_EventsSubscription_Transfer service operation, a transfer of the analytics subscription(s) determined in step 2 to the target NWDAF as described in clause 4.2.2.5 of 3GPP TS 29.520 [5], the response message in step 4b is optional.

5. Target NWDAF accepts the analytics subscription transfer and takes over the analytics generation based on the information received from the source NWDAF.

   The ML model related information namely ModelInfo may be provided by the source NWDAF in the Nnwdaf_EventsSubscription_Transfer request message.

   - If the instance ID or set ID of NWDAF(s) containing MTLF is provided in the Nnwdaf_EventsSubscription_Transfer, target NWDAF may request or subscribe to the ML model(s) from the indicated NWDAF(s).

NOTE 3: If the provided ID(s) of NWDAF(s) containing MTLF are not part of the locally configured ID(s) of NWDAFs containing MTLF, the target NWDAF discovers the NWDAF(s) containing MTLF as described in clause 5.8.2.3.

   - When the source NWDAF itself provides the ML models, the address of ML model files may be provided, and the target NWDAF retrieves the ML model(s) from the indicated address.

   Target NWDAF may use the above retrieved ML models and the ML models retrieved from the locally configured NWDAFs containing MTLF for the transferred analytics subscription.

NOTE 4: If not yet done during a prepared analytics subscription transfer, the target NWDAF allocates a new Subscription ID to the received analytics subscriptions.

NOTE 5: The target NWDAF might already have received information on some/all of the analytics subscriptions as part of the prepared analytics subscription transfer request received in step 1 and, thus, might already have started to prepare for the analytics generation, e.g. by having already subscribed to relevant event notifications.

6. Target NWDAF informs the NWDAF service consumer about the successful analytics subscription transfer using a Nnwdaf_EventsSubscription_Notify request message. A new Subscription ID, which was assigned by the target NWDAF, is provided in the Subscription ID and the old Subscription Id, which was allocated by the source NWDAF, is provided in the Old Subscription ID parameter of this message.

NOTE 6: Notification correlation information in the Nnwdaf_EventsSubscription_Notify message allows the NWDAF service consumer to correlate the notifications to the initial subscription request made with the source NWDAF in step 0.

NOTE 7: The existing Analytics context in the source NWDAF is not deleted directly but will be purged first when it was collected by the target NWDAF.

NOTE 8: If this subscription is used as input for analytics aggregation by the NWDAF service consumer, the NWDAF service consumer may inform the other NWDAFs instance participating in this analytics aggregation that the Set of NWDAF identifiers of NWDAF instances used by the NWDAF service consumer for this analytics aggregation has changed using the Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 4.2.2.2 of 3GPP TS 29.520 [5].

7. [Conditional] If "analytics context identifier(s)" had been included in the Nnwdaf_EventsSubscription_Transfer Request received in step 4, the target NWDAF requests the "analytics context" by invoking the Nnwdaf_AnalyticsInfo_ContextTransfer service operation as described in clause 4.3.2.3 of 3GPP TS 29.520 [5].

8. [Optional] Target NWDAF subscribes to relevant data source(s), if it is not yet subscribed to the data source(s) for the data required for the Analytics.

9. [Optional] Target NWDAF confirms the analytics subscription transfer to the source NWDAF by sending Nnwdaf_EventsSubscription_Transfer response message as described in clause 4.2.2.5 of 3GPP TS 29.520 [5], if the response has not been sent in step 4b.

10. [Optional] Source NWDAF unsubscribes with the data source(s) that are no longer needed for the remaining analytics subscriptions. In addition, Source NWDAF unsubscribes with the NWDAF(s) containing MTLF, if exist, which are no longer needed for the remaining analytics subscriptions.

NOTE 9: At this point, the analytics subscription transfer is deemed completed, i.e. the source NWDAF can delete all information related to the successfully transferred analytics subscription.

11-12. Target NWDAF at some point derives new output analytics based on new input data and notifies the NWDAF service consumer about the new analytics using a Nnwdaf_EventsSubscription_Notify message as described in clause 4.2.2.4 of 3GPP TS 29.520 [5].

5.4.3 Prepared analytics subscription transfer

The procedure in below figure is used by a NWDAF instance to request another NWDAF instance for a prepared analytics subscription transfer from the source NWDAF instance, using the Nnwdaf_EventsSubscription_Transfer service operation.

NOTE 1: The source NWDAF might determine that it needs to prepare to transfer analytics to another NWDAF instance, e.g. when the source NWDAF estimates for UE related analytics subscription that the UE might enter an area which is not covered by the source NWDAF (e.g., by subscribing to AMF event exposure service for UE mobility event notifications, by performing UE mobility analytics, or by subscribing to another NWDAF providing UE mobility analytics). If the source NWDAF discovers that the analytics consumer may change concurrently to this procedure, the source NWDAF does not perform the procedure. If the procedure makes use of predictions to determine the candidate NWDAFs, care must be taken with regards to load and signalling cost when sending data to an NWDAF that will not eventually start serving the UE.

NOTE 2: The source NWDAF might also determine that it needs to prepare to transfer analytics subscriptions to another NWDAF instance, as the source NWDAF wants to resolve an internal load situation or prepare for a graceful shutdown.

NOTE 3: Handling of overload situation or preparation for a graceful shutdown are preferably executed inside an NWDAF Set, when available.

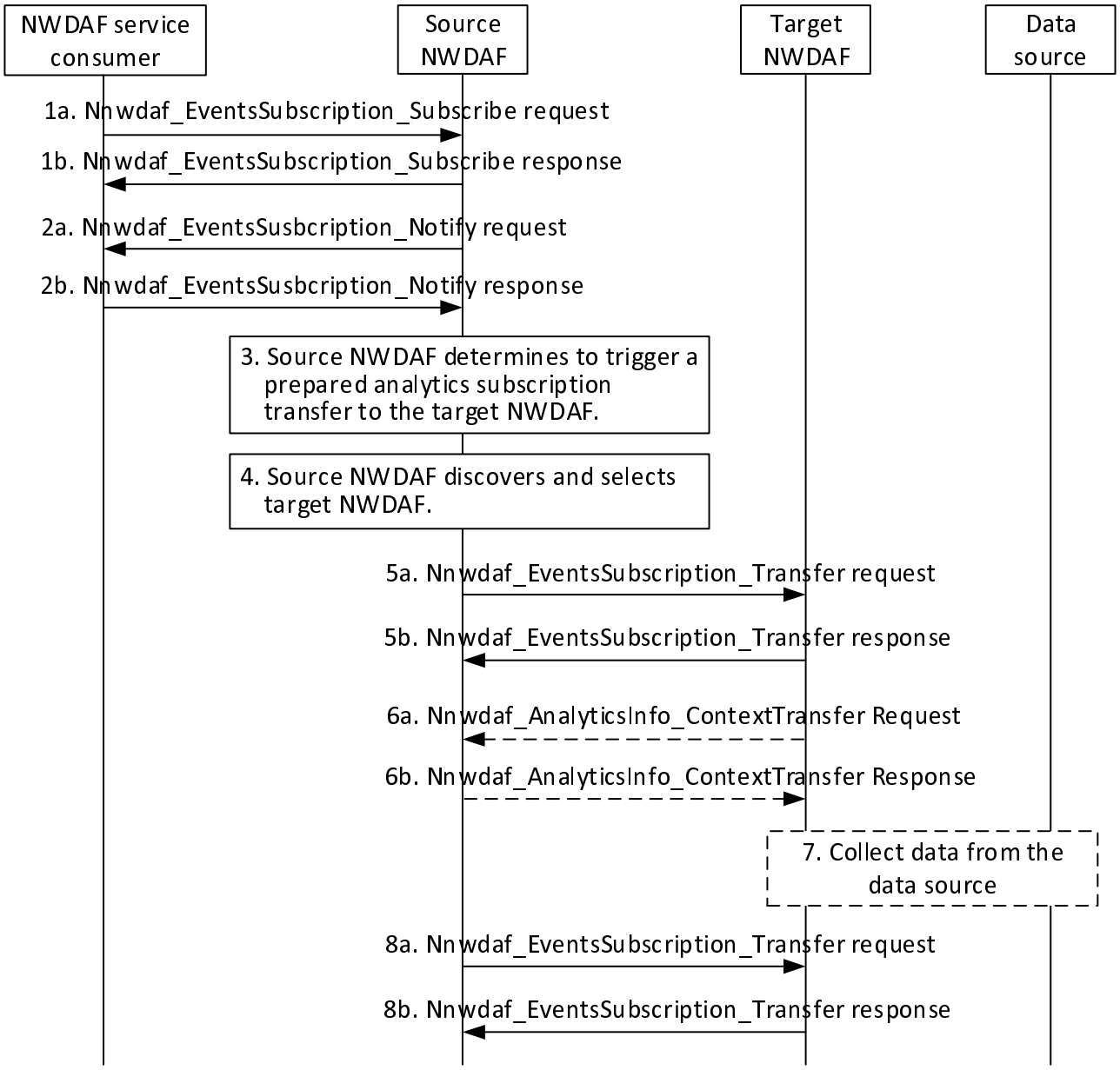

Figure 5.4.3-1: Prepared analytics subscription transfer

1a-1b. The NWDAF service consumer subscribes to analytics from source NWDAF by invoking Nnwdaf_EventsSubscription_Subscribe service operation. The source NWDAF responses to Nnwdaf_EventsSusbcription_Subscribe service operation.

2a-2b. The source NWDAF generates the requested analytics and notify the NWDAF service consumer by invoking the Nnwdaf_EventsSusbcription_Notify service operation. The NWDAF service consumer responses to the Nnwdaf_EventsSusbcription_Notify service operation.

3. The source NWDAF determines that it needs to prepare to transfer the analytics subscription to another NWDAF instance.

4. The source NWDAF discovers and selects the target NWDAF as described in clause 5.8.2.3.

5a-5b. The source NWDAF invokes Nnwdaf_EventsSubscription_Transfer service operation by sending an HTTP POST request to the target NWDAF and the "transReqType" attribute in the request message is set to "PREPARE". The target NWDAF sends an HTTP "201 Created" to the source NWDAF.

6a-6b. If analytics context identifier information had been included in the Nnwdaf_EventsSubscription_Transfer request message, the target NWDAF requests the analytics context information from the source NWDAF by

invoking the Nnwdaf_AnalyticsInfo_ContextTransfer service operation by sending the HTTP GET request message targeting the resource "NWDAF Context" to the source NWDAF.

7. The target NWDAF collect the data required for the analytics from the relevant data source(s), if it is not yet collected.

8a-8b. The source NWDAF invokes the Nnwdaf_EventsSubscription_Transfer service operation by sending either an HTTP PUT request to the target NWDAF as described in 4.2.2.5.3 of 3GPP TS 29.520 [5] or an HTTP DELETE request to cancel the prepared analytics subscritpiton transfer as described in clause 4.2.2.5.4 of 3GPP TS 29.520 [5]. In the case of HTTP PUT with the "transReqType" attribute set to "TRANSFER", the analytics subscription transfer is completed as described in clause 5.4.2 from step 4 onwards. In the case of HTTP PUT with the "transReqType" attribute set to "PREPARE", steps 4-7 of this procedure are repeated. In the case of HTTP DELETE, the target NWDAF sends response to the source NWDAF and deletes the analytics data that is no longer needed. If the target NWDAF had already subscribed to entities to collect data or ML models during the analytics subscription preparation, it unsubscribes from those entities if the subscriptions are not needed for other active analytics subscriptions.

5.5 Data Collection

5.5.1 Procedure for Data Collection from NFs

5.5.1.1 Data Collection from NFs

The procedure in Figure 5.5.1.1-1 is used by NWDAF to subscribe/unsubscribe at NFs in order to be notified for data collection on related event(s), using Event Exposure Services as listed in Table 6.2.2.1-1 defined in TS 23.288 [2] clause 6.2.2.

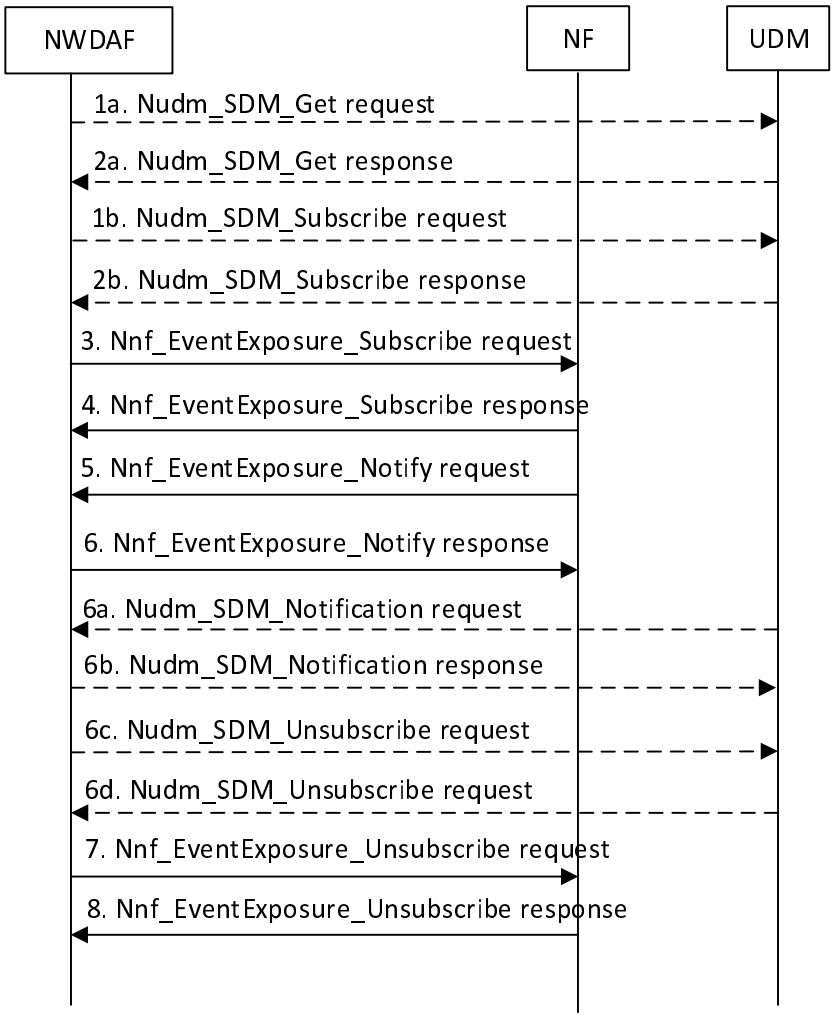

Figure 5.5.1.1-1: Event Exposure Subscribe/Unsubscribe for NFs

1a. If data is to be collected for a user, the user consent has not been checked by the data consumer, if the local policy and regulations require to check user consent, the NWDAF shall invoke the Nudm_SDM_Get service operation by sending an HTTP GET request as described in clause 5.2.2.2.24 and clause 6.1.3.32 of 3GPP TS 29.503 [22]. Otherwise, the procedure begins with step 3.

2a. The UDM responds to the Nudm_SDM_Get service operation. If the request is accepted, the response includes the requested data with "200 OK". In subsequent steps, the NWDAF excludes the SUPI or GPSI from requests to collect data for users for whom the user consent is not granted.

1b. For the users for which the user consent is granted, the NWDAF subscribes to notifications of changes of the user consent by invoking the Nudm_SDM_Subscribe service operation by sending an HTTP POST request targeting the resource "SdmSubscriptions" to the UDM as described in clause 5.2.2.3 of 3GPP TS 29.503 [22].

2b. The UDM responds to the Nudm_SDM_Subscribe service operation. If the request is accepted, the UDM responds with "201 Created".

3. In order to subscribe to notifications (or to modify subscriptions to notifications) of data events from the data source NF (e.g. UDM, AMF, SMF, NEF, AF), the NWDAF invokes the Nnf_EventExposure_Subscribe service operation by sending an HTTP POST (or PUT, for modification) request targeting the resource representing event exposure subscriptions of that NF, e.g. as described in clause 5.5.2.2 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.2 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.2 of 3GPP TS 29.517 [12] for the AF.

4. The NF responds to the Nnf_EventExposure_Subscribe service operation. Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NF responds to the NWDAF with "201 Created", and the URI of the created subscription is included in the Location header field.

5. If the NF observes the subscribed event(s), the NF invokes Nnf_EventExposure_Notify service operation to report the event(s) by sending an HTTP POST request, e.g. as described in clause 5.5.2.4 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.4 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.2 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.4 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.4 of 3GPP TS 29.517 [12] for the AF.

6a. If the user consent changes and the NWDAF has subscribed to UDM to notifications of user consent change for a user, the UDM invokes Nudm_SDM_Notification service operation by sending an HTTP POST request as described in clause 5.2.2.5 of 3GPP TS 29.503 [22].

6b. The NWDAF responds to the Nudm_SDM_Notification service operation with "204 No Content".

6c. The NWDAF may invoke Nudm_SDM_Unsubscribe service operation by sending an HTTP DELETE request as described in clause 5.2.2.4 of 3GPP TS 29.503 [22] to unsubscribe from UDM to be notified of user consent change for each user whose user consent is revoked.

6d. If the deletion request is accepted, the UDM responds to the Nudm_SDM_Unsubscribe service operation with "204 No Content".

7. If the user consent is no longer granted or the data collection is no longer required, the NWDAF unsubscribes to the notifications of data events from the NF. The NWDAF invokes Nnf_EventExposure_Unsubscribe service operation by sending an HTTP DELETE request targeting the resource that represents the previously created individual event exposure subscription, e.g. as described in clause 5.5.2.3 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.3 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.4 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.3 of 3GPP TS 29.591 [11] for the NEF, clause 4.2.3 of 3GPP TS 29.517 [12] for the AF. The request includes the event subscriptionId of the existing subscription that is to be deleted.

8. The NF responds to the Nnf_EventExposure_Unsubscribe service operation. If the subscription deletion is accepted, the NF responds with "204 No Content".

5.5.2 Data collection profile registration

This procedure depicted in Figure 5.5.2-1 is used by NWDAF or ADRF to register/update a data collection profile to the DCCF during/after the procedure of data collection.

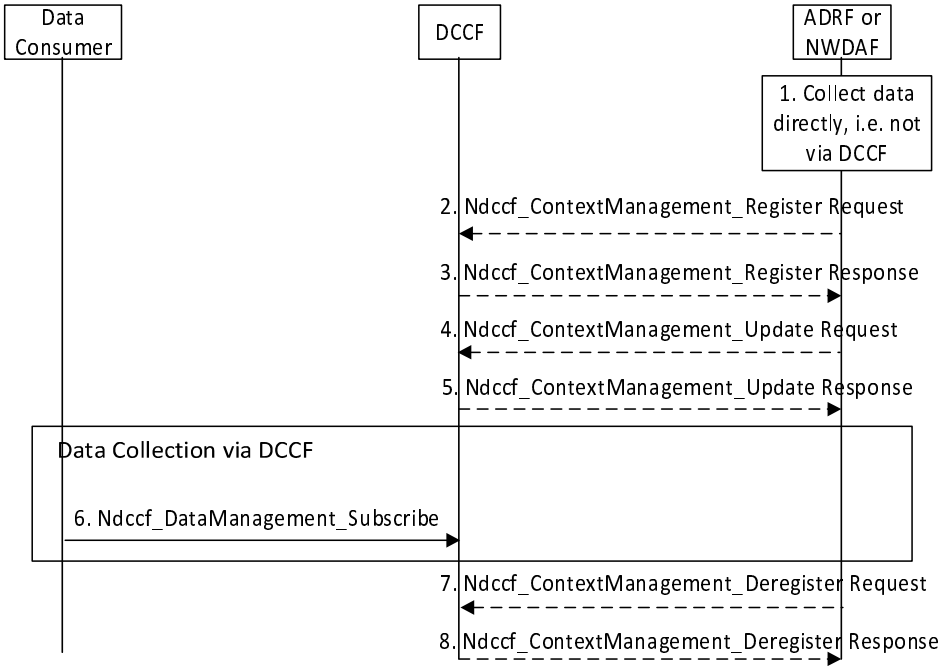

Figure 5.5.2-1: Procedure for the NWDAF or ADRF to register data profile to DCCF

1. An ADRF or NWDAF instance is collecting or has collected data directly, e.g. from collocated NF.
2. In order to register a data collection profile, the ADRF or NWDAF invokes the Ndccf_ContextManagement_Register service operation by sending an HTTP POST request targeting the resource "DCCF Data Collection Profiles" as described in clause 4.3.2.2 of 3GPP TS 29.574 [15].
3. The DCCF responds to the Ndccf_ContextManagement_Register service operation. Upon receipt of the HTTP POST request, if the data profile is accepted to be created, the DCCF responds to the ADRF or NWDAF with "201 Created", and the URI of the created profile is included in the Location header field.
4. In order to update a data collection profile, the Data Consumer invokes the Ndccf_ContextManagement_Update service operation by sending an HTTP PUT request targeting the resource "Individual DCCF Data Collection Profile" as described in clause 4.3.2.3 of 3GPP TS 29.574 [15].
5. The DCCF responds to the Ndccf_ContextManagement_Update service operation. Upon receipt of the HTTP PUT request, if the data profile is accepted to be updated, the DCCF responds to the ADRF or NWDAF with "200 OK" with a response body containing a representation of the updated data profile or "204 No Content".
6. To obtain historical data and if the data consumer is configured to collect data via the DCCF using the Ndccf_DataManagement_Subscribe service operation, the data consumer uses the procedures described in clause 5.5.3.
7. The ADRF or NWDAF requests to delete a registered data collection profile at the DCCF invoking the Ndccf_ContextManagement_Deregister service operation by sending a HTTP DELETE request targeting the "Individual DCCF Data Collection Profile" resource of the DCCF as described in clause 4.3.2.4 of 3GPP TS 29.574 [15].
8. The DCCF responds to the Ndccf_ContextManagement_Deregister service operation with HTTP "204 No Content" status code, if the data collection profile is successfully removed.

5.5.3 Procedure for Data Collection using DCCF

5.5.3.1 Data Collection via DCCF

The procedure depicted in Figure 5.5.3.1-1 is used by a data consumer (e.g. NWDAF) to obtain data and be notified of events via the DCCF using the Ndccf_DataManagement_Subscribe service operation. Whether the data consumer directly contacts the Data Source or goes via the DCCF is based on configuration of the data consumer.

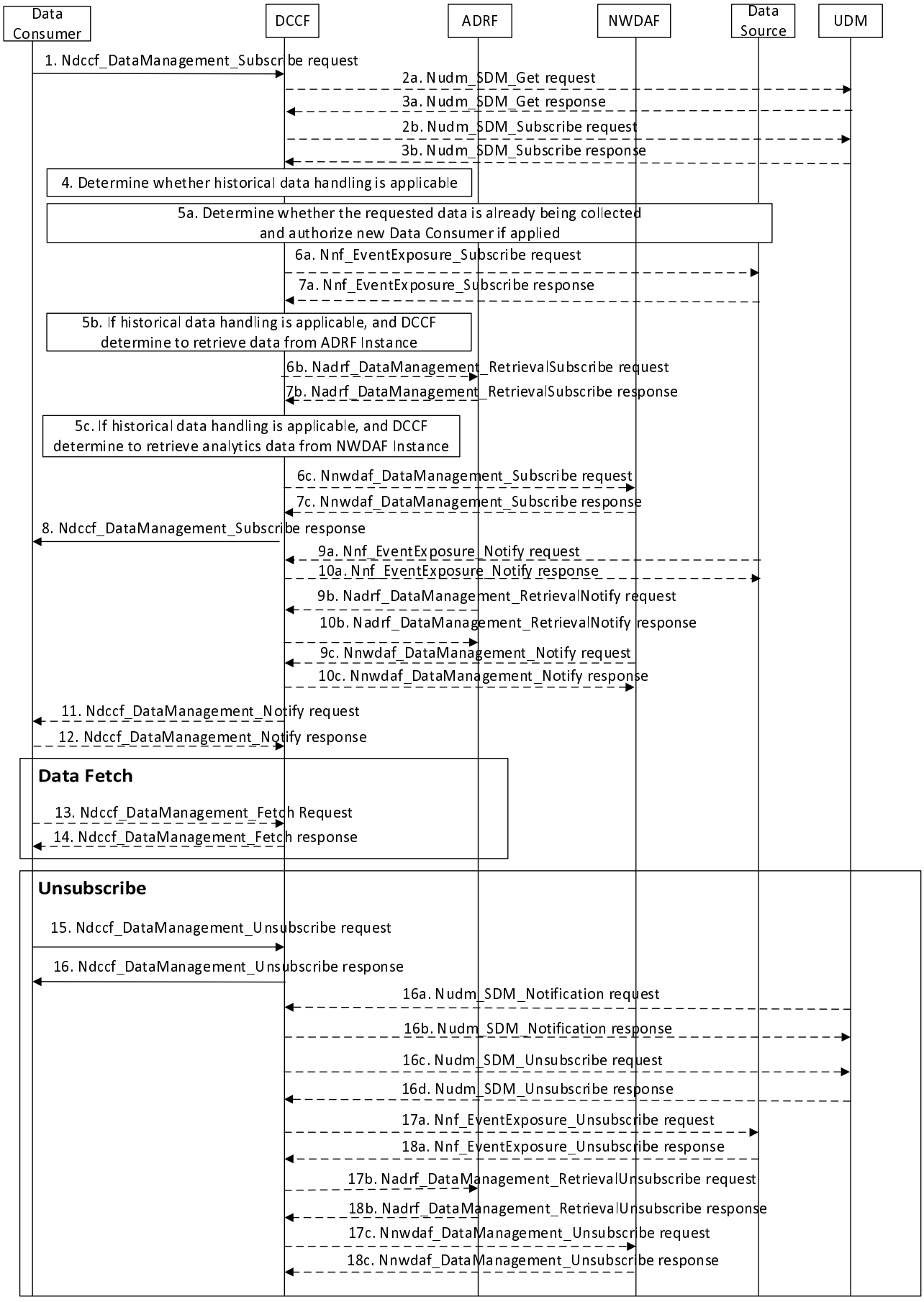

Figure 5.5.3.1-1: Data Collection via DCCF

1. In order to subscribe to notification(s) of events exposure via the DCCF based on local configuration, the Data Consumer invokes the Ndccf_DataManagement_Subscribe service operation by sending an HTTP POST request targeting the resource "DCCF Data Subscriptions" as described in clause 4.2.2.2.4 of 3GPP TS 29.574 [15].

2a. If data is to be collected for a user, the user consent has not been checked by the data consumer, if the local policy and regulations require to check user consent, the DCCF shall invoke the Nudm_SDM_Get service operation by sending an HTTP GET request as described in clause 5.2.2.2.24 and clause 6.1.3.32 of 3GPP TS 29.503 [22]. Otherwise the procedure continues with step 4.

3a. The UDM responds to the Nudm_SDM_Get service operation. If the request is accepted, the response includes the requested data with "200 OK". In subsequent steps, the DCCF excludes the SUPI or GPSI from requests to collect data for users for whom the user consent is not granted.

2b. For the users for which the user consent is granted, the DCCF subscribes to notifications of changes of the user consent by invoking the Nudm_SDM_Subscribe service operation by sending an HTTP POST request targeting the resource "SdmSubscriptions" at the UDM as described in clause 5.2.2.3 of 3GPP TS 29.503 [22].

3b. The UDM responds to the Nudm_SDM_Subscribe service operation. If the request is accepted, the UDM responds with "201 Created" status code.

4. The DCCF determines the NF type(s) and/or OAM to retrieve the data based on the Service Operation requested in step 1. 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 TS 23.288 [2] clause 5A.2 and clause 6.2.2.2. 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.

   The DCCF keeps track of the data actively being collected from the Data Sources it is coordinating. The NWDAF or ADRF may register the data collection profile (including the data collection related Service Operation, Analytics/Data Specification, NWDAF ID or ADRF ID) with the DCCF. The DCCF may then determine whether certain historical data may be available in the NWDAF or ADRF based on the data collection profile and the request time window.

   If the historical data handling is not applicable or not supported, the DCCF shall proceed with step 5a and skip step 5b, step 6b, step 7b, step 5c, step 6c, and step 7c.

   If the historical data is available in an ADRF, the DCCF shall proceed with step 5a and step 5b, and skip step 5c, step 6c, and step 7c.

   If the historical data is available in an NWDAF, the DCCF shall proceed with step 5a and step 5c, and skip step 5b, step 6b, and step 7b.

5a. The DCCF shall determine whether the data requested in step 1 are already being collected by an existing subscription or can be collected by modifying an existing subscription.

6a. If the data requested in step 1 can be collected neither by an existing subscription nor by modifying an existing subscription, the DCCF shall invoke the Nnf_EventExposure_Subscribe service operation by sending an HTTP POST request message request to the NF targeting the resource representing event exposure subscriptions to subscribe to a new event exposure subscription, e.g. as described in clause 5.5.2.2 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.2 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.2 of 3GPP TS 29.517 [12] for the AF.

   Otherwise, the DCCF shall send a request to the individual event exposure subscription resource to update an existing event exposure subscription, e.g. as described in clause 5.5.2.5 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2.3 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3.3 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.2.3 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.2.3 of 3GPP TS 29.517 [12] for the AF.

NOTE 1: If the contents of the subscription already perfectly match the new request then the update is performed simply to authorize the new source NF as described in clause 6.7.5.2 of 3GPP TS 29.500 [13].

7a. The NF responds to the Nnf_EventExposure_Subscribe service operation by an existing subscription or can be collected by modifying an existing subscription.

5b. If the historical data handling is applicable, and the DCCF determines to retrieve data from the ADRF, the DCCF shall determine which ADRF instances might provide the data.

6b. In order to retrieve the historical data from the ADRF, the DCCF shall invoke the Nadrf_DataManagement_RetrievalSubscribe service operation by sending an HTTP POST request message targeting the resource "ADRF Data Retrieval Subscriptions" as described in clause 4.2.2.6 of 3GPP TS 29.575 [16].

7b. The ADRF responds to the Nadrf_DataManagement_RetrievalSubscribe service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the ADRF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

5c. If the historical data handling is applicable, and the DCCF determines to retrieve data from the NWDAF, the DCCF shall determine which NWDAF instances might provide the requested data.

6c. In order to retrieve the historical data from the NWDAF, the DCCF shall invoke the Nnwdaf_DataManagement_Subscribe service operation by sending an HTTP POST request message targeting the resource "NWDAF Data Management Subscriptions", as described in clause 4.4.2.2 of 3GPP TS 29.520 [5].

7c. The NWDAF responds to the Nnwdaf_DataManagement_Subscribe service operation.

Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

8. The DCCF responds to the Ndccf_DataManagement_Subscribe service operation with HTTP "204 No Content" status code.

9a. When the data are available, the NF invokes the Nnf_EventExposure_Notify service operation by sending an HTTP POST request message to notify the data events to the DCCF, e.g. as described in clause 5.5.2.4 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.4 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.2 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.4 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.4 of 3GPP TS 29.517 [12] for the AF.

10a. The DCCF responds to the Nnf_EventExposure_Notify service operation with HTTP "204 No Content" status code.

9b. When the historical data are available in the ADRF, the ADRF shall invoke the Nadrf_DataManagement_RetrievalNotify service operation by sending an HTTP POST request message to notify the historical data or Fetch Instructions to the DCCF as described in clause 4.2.2.8 of 3GPP TS 29.575 [16].

10b. The DCCF responds to the Nadrf_DataManagement_RetrievalNotify service operation with HTTP "204 No Content" status code.

9c. When the historical data are available in the NWDAF, the NWDAF shall invoke the Nnwdaf_DataManagement_Notify service operation by sending an HTTP POST request message to notify the historical data to the DCCF as described in clause 4.4.2.4 of 3GPP TS 29.520 [5].

10c. The DCCF responds to the Nnwdaf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

11. If the DCCF is configured to deliver the data itself (and not via the MFAF), the DCCF invokes the Ndccf_DataManagement_Notify service operation by sending HTTP POST request message(s) to send the data to all notification endpoints indicated in step 1. Data sent to notification endpoints may be processed and formatted by the DCCF, so they conform to delivery requirements for each NF service consumer or notification endpoint.

NOTE 2: According to Formatting Instructions provided by the NF service consumer, multiple notifications from a NF can be combined in a single Ndccf_DataManagement_Notify so that many notifications from an NF result in fewer notifications (or one notification) to the Data Consumer. Alternatively, a notification can instruct the data notification endpoint to fetch the data from the DCCF.

12. The NF service consumer responds to the Ndccf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

13. The Data Consumer invokes the Ndccf_DataManagement_Fetch service operation by sending an HTTP POST request message as described in clause 4.2.2.5 of 3GPP TS 29.574 [15] to fetch the data from the DCCF before an expiry time, if the fetch instruction was previously received via the NdccfDataManagement_Notify service operation in step 11.

14. The DCCF responds to the Ndccf_DataManagement_Fetch service operation with HTTP "200 OK" status code with the message body containing the data received earlier from the data source.

15. When the NF service consumer no longer needs the subscription to the requested data in step 1, it shall invoke the Ndccf_DataManagement_Unsubscribe service operation by sending an HTTP DELETE request message as described in clause 4.2.2.3.3 of 3GPP TS 29.574 [15]. The DCCF removes the NF service consumer from the list of NF service consumers that are subscribed for these data.

16. The DCCF responds to the Ndccf_DataManagement_Unsubscribe service operation with HTTP "204 No Content" status code, if the NF service consumer is successfully removed from the list of NF service consumers that are subscribed for these data.

16a. If the user consent changes and the DCCF has subscribed to UDM to notifications of user consent change for a user, the UDM invokes Nudm_SDM_Notification service operation by sending an HTTP POST request as described in clause 5.2.2.5 of 3GPP TS 29.503 [22].

16b. The DCCF responds to the Nudm_SDM_Notification service operation with "204 No Content".

16c. The DCCF may invoke Nudm_SDM_Unsubscribe service operation by sending an HTTP DELETE request as described in clause 5.2.2.4 of 3GPP TS 29.503 [22] to unsubscribe from UDM to be notified of user consent change for each user whose user consent is revoked.

16d. If the deletion request is accepted, the UDM responds to the Nudm_SDM_Unsubscribe service operation with "204 No Content".

17a. If there are no other NF service consumers subscribed to the data or the user consent for a user, i.e. for a SUPI or GPSI, is no longer granted, the DCCF invokes the Nnf_EventExposure_Unsubscribe service operation by sending an HTTP DELETE request message to the Data Source, e.g. as described in clause 5.5.2.3 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.3 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.4 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.3 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.3 in 3GPP TS 29.517 [12] for the AF.

18a. The Data Source responds to the Nnf_EventExposure_Unsubscribe service operation with HTTP "204 No Content" status code, if the data event(s) subscription is successfully removed.

17b. If the DCCF determines that no other NF service consumers require the historical data from the ADRF, the DCCF invokes the Nadrf_DataManagement_RetrievalUnsubscribe service operation by sending an HTTP DELETE request message to the ADRF as described in clause 4.2.2.7 of 3GPP TS 29.575 [16].

18b. The ADRF responds to the Nadrf_DataManagement_RetrievalUnsubscribe service operation with HTTP "204 No Content" status code, if the data retrieval subscription is successfully removed.

17c. If DCCF determines that no other NF service consumers require the historical data from the NWDAF, the DCCF invokes the Nnwdaf_DataManagement_Unsubscribe service operation by sending an HTTP DELETE request message to the NWDAF as described in clause 4.4.2.3 of 3GPP TS 29.520 [5].

18c. The NWDAF responds to the Nnwdaf_DataManagement_Unsubscribe service operation with HTTP "204 No Content" status code, if the data subscription is successfully removed.

5.5.3.2 Data Collection via Messaging Framework

This procedure depicted in Figure 5.5.3.2-1 is used by a data consumer (e.g. NWDAF) to 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 Messaging Framework. Whether the data consumer directly contacts the Data Source or goes via the DCCF is based on configuration.

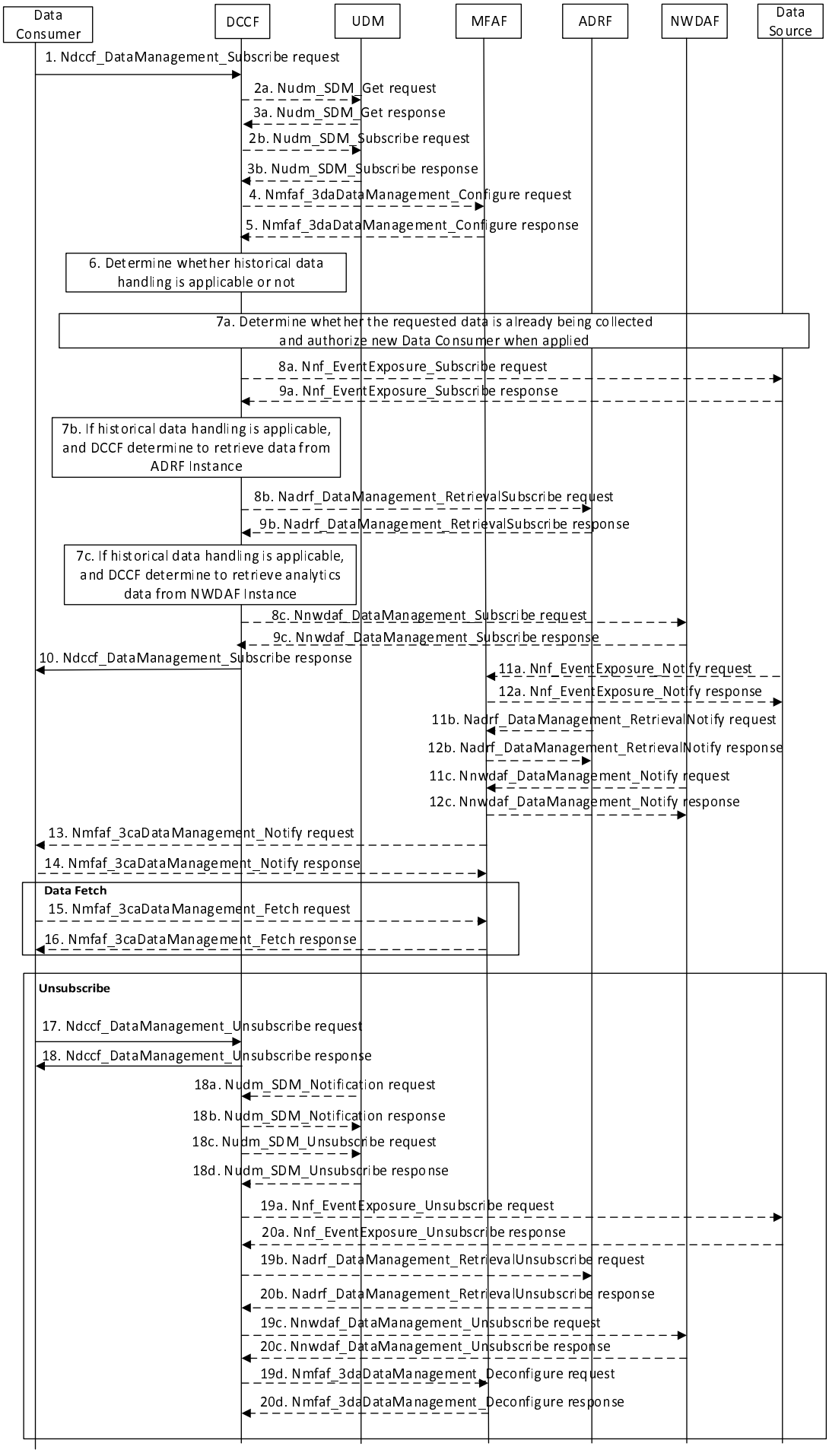
Data Consumer
DCCF
UDM
MFAF
ADRF
NWDAF
Data Source
1. Ndccf_DataManagement_Subscribe request
2a. Nudm_SDM_Get request
3a. Nudm_SDM_Get response
2b. Nudm_SDM_Subscribe request
3b. Nudm_SDM_Subscribe response
4. Nmfaf_3daDataManagement_Configure request
5. Nmfaf_3daDataManagement_Configure response
6. Determine whether historical data handling is applicable or not
7a. Determine whether the requested data is already being collected and authorize new Data Consumer when applied
8a. Nnf_EventExposure_Subscribe request
9a. Nnf_EventExposure_Subscribe response
7b. If historical data handling is applicable, and DCCF determine to retrieve data from ADRF Instance
8b. Nadrf_DataManagement_RetrievalSubscribe request
9b. Nadrf_DataManagement_RetrievalSubscribe response
7c. If historical data handling is applicable, and DCCF determine to retrieve analytics data from NWDAF Instance
8c. Nnwdaf_DataManagement_Subscribe request
9c. Nnwdaf_DataManagement_Subscribe response
10. Ndccf_DataManagement_Subscribe response
11a. Nnf_EventExposure_Notify request
12a. Nnf_EventExposure_Notify response
11b. Nadrf_DataManagement_RetrievalNotify request
12b. Nadrf_DataManagement_RetrievalNotify response
11c. Nnwdaf_DataManagement_Notify request
12c. Nnwdaf_DataManagement_Notify response
13. Nmfaf_3caDataManagement_Notify request
14. Nmfaf_3caDataManagement_Notify response
Data Fetch
15. Nmfaf_3caDataManagement_Fetch request
16. Nmfaf_3caDataManagement_Fetch response
Unsubscribe
17. Ndccf_DataManagement_Unsubscribe request
18. Ndccf_DataManagement_Unsubscribe response
18a. Nudm_SDM_Notification request
18b. Nudm_SDM_Notification response
18c. Nudm_SDM_Unsubscribe request
18d. Nudm_SDM_Unsubscribe response
19a. Nnf_EventExposure_Unsubscribe request
20a. Nnf_EventExposure_Unsubscribe response
19b. Nadrf_DataManagement_RetrievalUnsubscribe request
20b. Nadrf_DataManagement_RetrievalUnsubscribe response
19c. Nnwdaf_DataManagement_Unsubscribe request
20c. Nnwdaf_DataManagement_Unsubscribe response
19d. Nmfaf_3daDataManagement_Deconfigure request
20d. Nmfaf_3daDataManagement_Deconfigure response

Figure 5.5.3.2-1: Data Collection via DCCF and via Messaging Framework

1. In order to subscribe to notification(s) of events exposure via the DCCF based on local configuration, the Data Consumer invokes the Ndccf_DataManagement_Subscribe service operation by sending an HTTP POST request message targeting the resource "DCCF Data Subscriptions", as described in clause 4.2.2.2.4 of 3GPP TS 29.574 [15].

2a. If data is to be collected for a user, the user consent has not been checked by the data consumer, if the local policy and regulations require to check user consent, the DCCF shall invoke the Nudm_SDM_Get service operation by sending an HTTP GET request as described in clause 5.2.2.2.24 and clause 6.1.3.32 of 3GPP TS 29.503 [22]. Otherwise the procedure continues with step 4.

3a. The UDM responds to the Nudm_SDM_Get service operation. If the request is accepted, the response includes the requested data with "200 OK" status code. In subsequent steps, the DCCF excludes the SUPI or GPSI from requests to collect data for users for whom the user consent is not granted.

2b. For the users for which the user consent is granted, the DCCF subscribes to notifications of changes of the user consent by invoking the Nudm_SDM_Subscribe service operation by sending an HTTP POST request message targeting the resource "SdmSubscriptions" at the UDM as described in clause 5.2.2.3 of 3GPP TS 29.503 [22].

3b. The UDM responds to the Nudm_SDM_Subscribe service operation. If the request is accepted, the UDM responds with "201 Created" status code.

4. If the DCCF is configured to perform data delivery via the MFAF, in order to create configuration of mapping data in the MFAF, the DCCF shall invoke the Nmfaf_3daDataManagement_Configure service operation by sending an HTTP POST request message targeting the resource "MFAF Configurations", as described in clause 4.2.2.2.2 of 3GPP TS 29.576 [17].

   In order to update configuration of mapping data in the MFAF, the DCCF shall invoke the Nmfaf_3daDataManagement_Configure service operation by sending an HTTP PUT request message targeting the resource "Individual MFAF Configuration", as described in clause 4.2.2.2.3 of 3GPP TS 29.576 [17].

5. The MFAF responds to the Nmfaf_3daDataManagement_Configure service operation.

   Upon receipt of the HTTP POST request message, if the configuration is accepted to be created, the MFAF responds to the DCCF with "201 Created" status code, and the URI of the created configuration is included in the Location header field.

   Upon receipt of the HTTP PUT request message, if the configuration is accepted to be updated, the MFAF responds to the DCCF with "200 OK" or "204 No Content" status code.

6. The DCCF determines the NF type(s) and/or OAM to retrieve the data based on the Service Operation requested in step 1. 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 TS 23.288 [2] clause 5A.2 and clause 6.2.2.2. 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.

   The DCCF keeps track of the data actively being collected from the Data Sources it is coordinating. The NWDAF or ADRF may register the data collection profile (including the data collection related Service Operation, Analytics/Data Specification, NWDAF ID or ADRF ID) with the DCCF. The DCCF may then determine whether certain historical data may be available in the NWDAF or ADRF based on the data collection profile and the request time window.

   If the historical data handling is not applicable or not supported, the DCCF shall proceed with step 7a, and skip step 7b, step 8b, step 9b, step 7c, step 8c, and step 9c.

   If the historical data is available in an ADRF, the DCCF shall proceed with step 7a and step 7b, and skip step 7c, step 8c, and step 9c.

   If the historical data is available in an NWDAF, the DCCF shall proceed with step 7a and step 7c, and skip step 7b, step 8b, and step 9b.

7a. The DCCF shall determine whether the data requested in step 1 are already being collected by an existing subscription or can be collected by modifying an existing subscription.

8a. If data requested in step 1 can be collected neither by an existing subscription nor by modifying an existing subscriptionare, the DCCF shall invoke the Nnf_EventExposure_Subscribe service operation by sending an HTTP POST request message request to the NF targeting the resource representing event exposure subscriptions to subscribe to a new event exposure subscription, e.g. as described in clause 5.5.2.2 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.2 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.2 of 3GPP TS 29.517 [12] for the AF.

Otherwise, the DCCF shall send a request to the individual event exposure subscription resource to update an existing event exposure subscription, e.g. as described in clause 5.5.2.5 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2.3 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3.3 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.2.3 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.2.3 of 3GPP TS 29.517 [12] for the AF.

NOTE 1: If the contents of the subscription already perfectly match the new request then the update is performed simply to authorize the new source NF as described in clause 6.7.5.2 of 3GPP TS 29.500 [13].

Otherwise, if the requested data subscribed in step 1 partially matches data that is already being collected by the DCCF from an NF, and a modification of this subscription to the NF would satisfy both the existing data subscriptions as well as the newly requested data, the DCCF shall send a request to the individual event exposure subscription resource to update an existing event exposure subscription, e.g. as described in clause 5.5.2.5 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2.3 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3.3 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.2.3 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.2.3 of 3GPP TS 29.517 [12] for the AF.

9a. The NF responds to the Nnf_EventExposure_Subscribe service operation.

Upon receipt of the HTTP POST request message, if the subscription is accepted to be created, the NF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

Upon receipt of the HTTP PUT request message, if the subscription is accepted to be updated, the NF responds to the DCCF with "200 OK" or "204 No Content" status code.

7b. If the historical data handling is applicable, and the DCCF determines to retrieve data from the ADRF, the DCCF shall determine which ADRF instances might provide the data.

8b. In order to retrieve the historical data from the ADRF, the DCCF shall invoke the Nadrf_DataManagement_RetrievalSubscribe service operation by sending an HTTP POST request message targeting the resource "ADRF Data Retrieval Subscriptions", as described in clause 4.2.2.6 of 3GPP TS 29.575 [16].

9b. The ADRF responds to the Nadrf_DataManagement_RetrievalSubscribe service operation.

Upon receipt of the HTTP POST request message, if the subscription is accepted to be created, the ADRF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

7c. If the historical data handling is applicable, and the DCCF determines to retrieve data from the NWDAF, the DCCF shall determine which NWDAF instances might provide the data.

8c. In order to retrieve the historical data from the NWDAF, the DCCF shall invoke the Nnwdaf_DataManagement_Subscribe service operation by sending an HTTP POST request message targeting the resource "NWDAF Data Management Subscriptions", as described in clause 4.4.2.2 of 3GPP TS 29.520 [5].

9c. The NWDAF responds to the Nnwdaf_DataManagement_Subscribe service operation.

Upon receipt of the HTTP POST request message, if the subscription is accepted to be created, the NWDAF responds to the DCCF with "201 Created" status code, and the URI of the created subscription is included in the Location header field.

10. The DCCF responds to the Ndccf_DataManagement_Subscribe service operation with HTTP "204 No Content" status code.

11a. When the data are available, the NF invokes the Nnf_EventExposure_Notify service operation by sending an HTTP POST request message to notify the data events to the MFAF, e.g. as described in clause 5.5.2.4 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.4 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.2 of

3GPP TS 29.508 [6] for the SMF, clause 4.2.2.4 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.4 of 3GPP TS 29.517 [12] for the AF.

12a. The MFAF responds to the Nnf_EventExposure_Notify service operation with HTTP "204 No Content" status code.

11b. When the historical data are available in the ADRF, the ADRF shall invoke the Nadrf_DataManagement_RetrievalNotify service operation by sending an HTTP POST request message to notify the historical data or Fetch Instructions to the MFAF as described in clause 4.2.2.8 of 3GPP TS 29.575 [16].

12b. The MFAF responds to the Nadrf_DataManagement_RetrievalNotify service operation with HTTP "204 No Content" status code.

11c. When the historical data are available in the NWDAF, the NWDAF shall invoke the Nnwdaf_DataManagement_Notify service operation by sending an HTTP POST request message to notify the historical data to the MFAF as described in clause 4.4.2.4 of 3GPP TS 29.520 [5].

12c. The MFAF responds to the Nnwdaf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

13. The MFAF invokes the Nmfaf_3caDataManagement_Notify service operation by sending HTTP POST request message(s) to send the data to all notification endpoints indicated in step 1. Data sent to notification endpoints may be processed and formatted by the MFAF so they conform to delivery requirements for each NF service consumer or notification endpoint.

NOTE 2: According to Formatting Instructions provided by the NF service consumer, multiple notifications from a NF can be combined in a single Nmfaf_3caDataManagement_Notify so that many notifications from an NF results in fewer notifications (or one notification) to the Data Consumer. Alternatively, a notification can instruct the data notification endpoint to fetch the data from the MFAF.

14. The NF service consumer responds to the Nmfaf_3caDataManagement_Notify service operation with HTTP "204 No Content" status code.

15. The Data Consumer invokes the Nmfaf_3caDataManagement_Fetch service operation by sending an HTTP GET request message as described in clause 4.2.2.5 of 3GPP TS 29.574 [15] to fetch the data from the DCCF before an expiry time, if the fetch instruction was received in Nmfaf_3caDataManagement_Notify service operation in step 13.

16. The MFAF responds to the Nmfaf_3caDataManagement_Fetch service operation with HTTP "200 OK" status code with the message body containing the NmfafResourceRecord data structure.

17. When the NF service consumer no longer needs the subscription to the requested data in step 1, it shall invoke the Ndccf_DataManagement_Unsubscribe service operation by sending an HTTP DELETE request message as described in clause 4.2.2.3.3 of 3GPP TS 29.574 [15]. The DCCF removes the NF service consumer from the list of NF service consumers that are subscribed for these data.

18. The DCCF responds to the Ndccf_DataManagement_Unsubscribe service operation with HTTP "204 No Content" status code, if the NF service consumer is successfully from the list of NF service consumers that are subscribed for these data.

18a. If the user consent changes and the DCCF has subscribed to UDM to notifications of user consent change for a user, the UDM invokes Nudm_SDM_Notification service operation by sending an HTTP POST request as described in clause 5.2.2.5 of 3GPP TS 29.503 [22].

18b. The DCCF responds to the Nudm_SDM_Notification service operation with "204 No Content".

18c. The DCCF may invoke Nudm_SDM_Unsubscribe service operation by sending an HTTP DELETE request as described in clause 5.2.2.4 of 3GPP TS 29.503 [22] to unsubscribe from UDM to be notified of user consent change for each user whose user consent is revoked.

18d. If the deletion request is accepted, the UDM responds to the Nudm_SDM_Unsubscribe service operation with "204 No Content".

19a. If there are no other NF service consumers subscribed to the data or the user consent for a user, i.e. for a SUPI or GPSI, is no longer granted, the DCCF invokes the Nnf_EventExposure_Unsubscribe service operation by sending an HTTP DELETE request message to the Data Source, e.g. as described in clause 5.5.2.3 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.3 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.4 of 3GPP TS 29.508 [6] for the SMF, clause 4.2.2.3 of 3GPP TS 29.591 [11] for the NEF, or clause 4.2.3 in 3GPP TS 29.517 [12] for the AF.

20a. The Data Source responds to the Nnf_EventExposure_Unsubscribe service operation with HTTP "204 No Content" status code, if the data event(s) subscription is successfully removed.

19b. If DCCF determines that no other NF service consumers requiring the historical data from the ADRF, the DCCF may invoke the Nadrf_DataManagement_RetrievalUnsubscribe service operation by sending an HTTP DELETE request message to the ADRF as described in clause 4.2.2.7 of 3GPP TS 29.575 [16].

20b. The ADRF responds to the Nadrf_DataManagement_RetrievalUnsubscribe service operation with HTTP "204 No Content" status code, upon the data retrieval subscription is removed.

19c. If DCCF determines that no other NF service consumers require the historical data from the NWDAF, the DCCF may invoke the Nnwdaf_DataManagement_Unsubscribe service operation by sending an HTTP DELETE request message to the NWDAF as described in clause 4.4.2.3 of 3GPP TS 29.520 [5].

20c. The NWDAF responds to the Nnwdaf_DataManagement_Unsubscribe service operation with HTTP "204 No Content" status code, upon the data subscription is removed.

19d. When the DCCF determines that an NF service consumer mapping has to be removed from MFAF, the DCCF invokes the Nmfaf_3daDataManagement_Deconfigure service operation by sending an HTTP DELETE request message to the MFAF as described in clause 4.2.2.3 of 3GPP TS 29.576 [17].

20d. The MFAF responds to the Nmfaf_3daDataManagement_Deconfigure service operation with HTTP "204 No Content" status code, if the individual resource linked to the delete request is successfully removed.

5.5.4 Procedure for Data Collection in Roaming Case

5.5.4.1 Data Collection by H-RE-NWDAF from V-RE-NWDAF for outbound roaming users

The procedure depicted in Figure 5.5.4.1-1 is used by the H-RE-NWDAF as service consumer to subscribe/unsubscribe to notifications about data event exposure from the VPLMN for outbound roaming users.

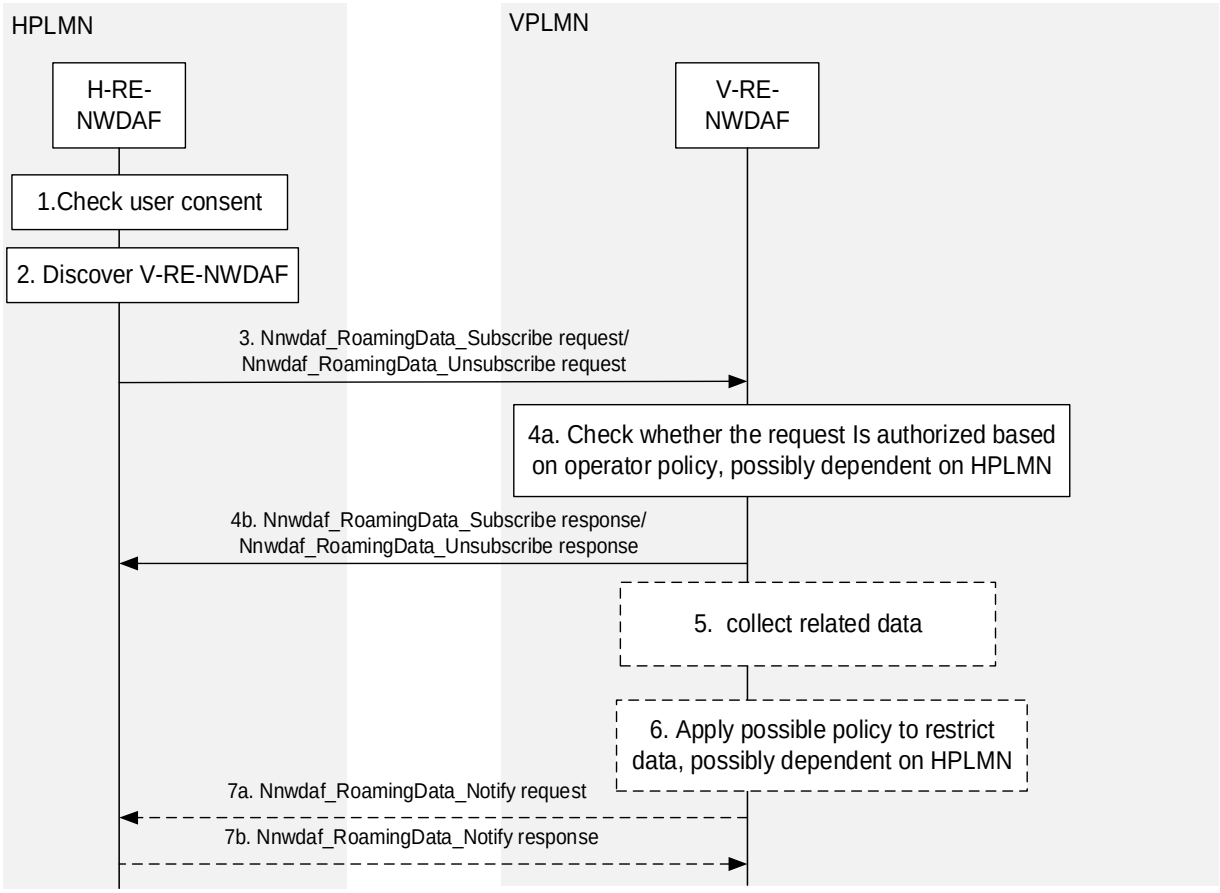

Figure 5.5.4.1-1: data collection by H-RE-NWDAF from V-RE-NWDAF for outbound roaming users

1. For subscription to collected data related to the outbound roaming UE(s), the H-RE-NWDAF checks the user consent of related users depending on local policy or regulations.

2. The H-RE-NWDAF of HPLMN discovers V-RE-NWDAF of VPLMN that supports the Nnwdaf_RoamingData service using the NRF as specified for roaming case in clause 5.8.2.3.

NOTE 1: The access to the Nnf_EventExposure services is expected to be restricted to NF service consumers within the same PLMN to prevent bypassing checks based on user consent and operator policy.

3. The H-RE-NWDAF subscribes/unsubscribes to notifications about data event exposure by invoking the Nnwdaf_RoamingData_Subscribe / Nnwdaf_RoamingData_Unsubscribe service operation message as described in clause 4.8.2.2 and clause 4.8.2.3 of 3GPP TS 29.520 [5].

4a. The V-RE-NWDAF checks whether the HPLMN is authorised to request the input data based on VPLMN operator polices (that may depend on the HPLMN and may indicate permissible or restricted input data and related parameters). If the HPLMN is not authorized to subscribe to the input data, the subscription request must be rejected to the H-RE-NWDAF and the following steps are skipped.

4b. The V-RE-NWDAF responds to the H-RE-NWDAF with Nnwdaf_RoamingData_Subscribe / Nnwdaf_RoamingData_Unsubscribe service operation message as described in clause 4.8.2.2 and clause 4.8.2.3 of 3GPP TS 29.520 [5].

5. The V-RE-NWDAF triggers new data collection from NF(s) as described in clause 5.5.1 or clause 5.5.3.

6. The V-RE-NWDAF may restrict the exposed input data based on VPLMN operator polices (that may depend on the HPLMN) and may store them for auditing.

7a-7b. The V-RE-NWDAF notifies with the subscribed available data to the H-RE-NWDAF as described in clause 4.8.2.4 of 3GPP TS 29.520 [5].

NOTE 2: For details of Nnwdaf_RoamingData_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.5.4.2 Data Collection by V-RE-NWDAF from H-RE-NWDAF for inbound roaming users

The procedure depicted in Figure 5.5.4.2-1 is used by the V-RE-NWDAF as service consumer to subscribe/unsubscribe to notifications about data event exposure from the HPLMN for inbound roaming users.

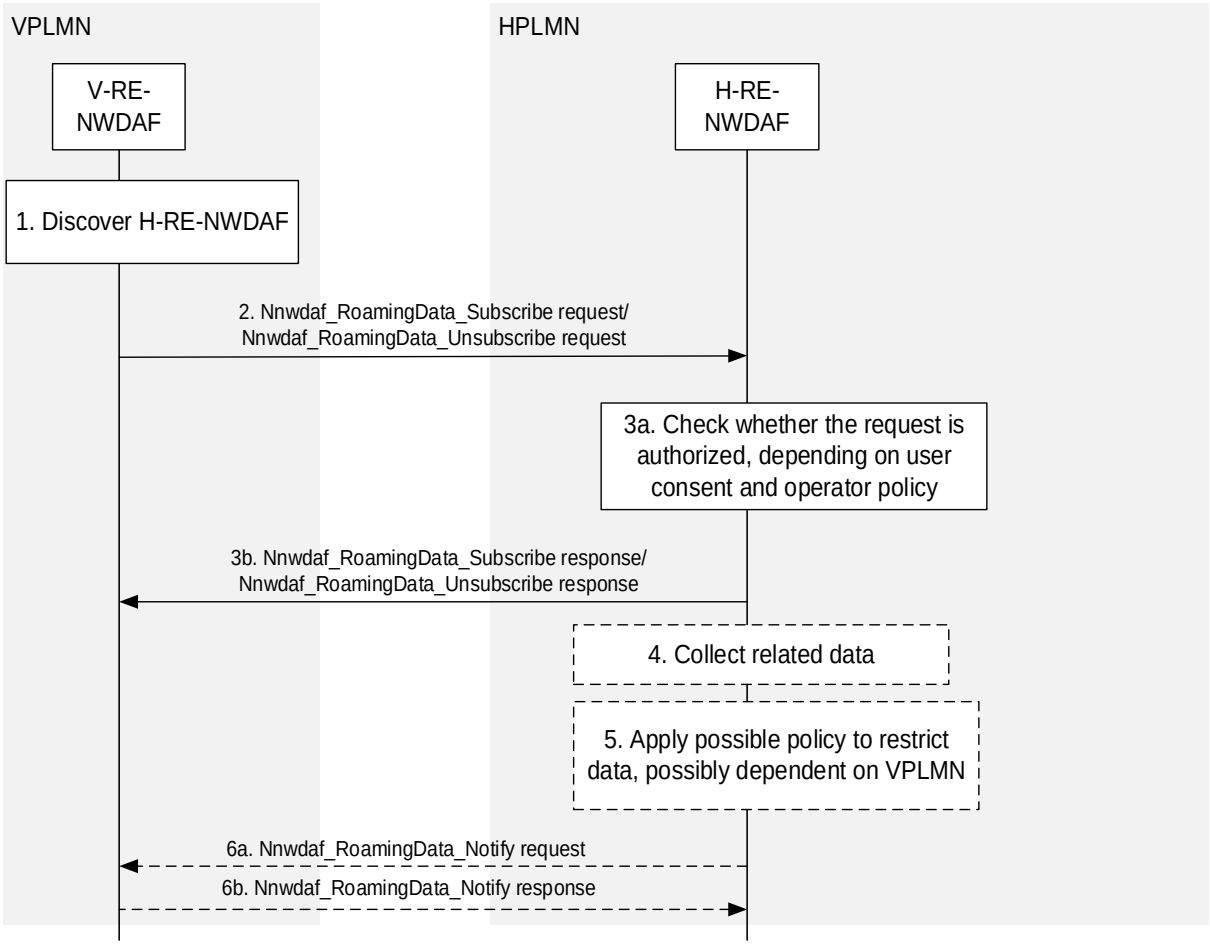

Figure 5.5.4.2-1: Data Collection by V-RE-NWDAF from H-RE-NWDAF for inbound roaming users

1. The V-RE-NWDAF of VPLMN discovers H-RE-NWDAF of HPLMN that supports the Nnwdaf_RoamingData service using the NRF as specified in clause 5.8.2.3.

NOTE 1: The access to the Nnf_EventExposure services is expected to be restricted to NF service consumers within the same PLMN to prevent bypassing checks based on user consent and operator policy.

2. The V-RE-NWDAF subscribes/unsubscribes to data event exposure by invoking Nnwdaf_RoamingData_Subscribe / Nnwdaf_RoamingData_Unsubscribe service operation message as described in clause 4.8.2.2 and clause 4.8.2.3 of 3GPP TS 29.520 [5].

3a. The H-RE-NWDAF checks if the VPLMN is authorised to subscribe to the indicated input data based on HPLMN operator polices (that may depend on the VPLMN and may indicate permissible or restricted input data and related parameters) and user consent of related users. If the VPLMN is not authorized to subscribe to the input data, the subscription request must be rejected to the V-RE-NWDAF and the following steps are skipped.

3b. The H-RE-NWDAF responds to the V-RE-NWDAF with Nnwdaf_RoamingData_Subscribe / Nnwdaf_RoamingData_Unsubscribe service operation message as described in clause 4.8.2.2 and clause 4.8.2.3 of 3GPP TS 29.520 [5].

4. The H-RE-NWDAF triggers new data collection if needed and monitors the requested input data, using procedures as described in clause 5.5.1 or clause 5.5.3.

5. The H-RE-NWDAF may restrict the exposed input data based on HPLMN operator polices (that may depend on the VPLMN) and may store them for auditing.

6a-6b. The H-RE-NWDAF notifies with the subscribed available data event to the V-RE-NWDAF as described in clause 4.8.2.4 of 3GPP TS 29.520 [5].

NOTE 2: For details of Nnwdaf_RoamingData_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.6 ML Model provisioning procedures

5.6.1 General

The ML Model provisioning procedures allow the NF service consumers to obtain the ML model information from an NWDAF containing MTLF.

5.6.2 ML Model Subscribe/Unsubscribe/Notify procedure

The procedure is used by an NF service consumer to subscribe to/unsubscribe the ML model information from the NWDAF containing MTLF, and also used by the NWDAF containing MTLF to notify the ML model information to the NF service consumer if it subscribed to the ML model information previously.

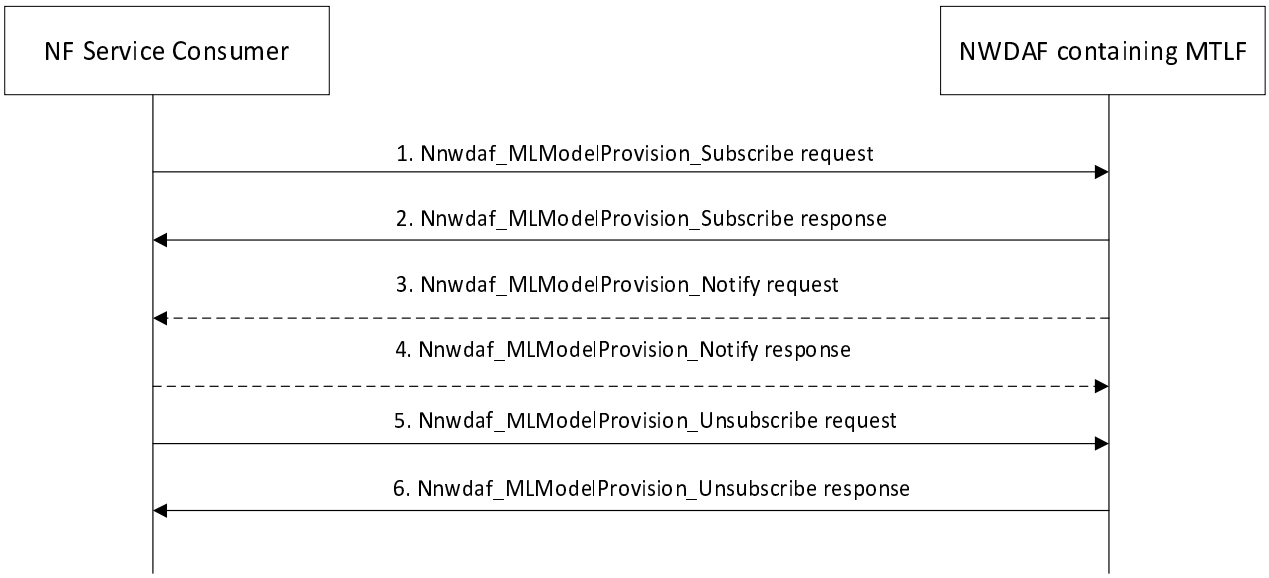

Figure 5.6.2-1: ML Model Subscribe/Unsubscribe/Notify procedure

1. In order to subscribe to ML model information, the NF service consumer invokes Nnwdaf_MLModelProvision_Subscribe service operation by sending an HTTP POST request targeting the resource "NWDAF ML Model Provision Subscriptions", as described in clause 4.5.2.2 of 3GPP TS 29.520 [5]. See 3GPP TS 29.520 [5] clause 5.4 for details.

   In order to modify the existing subscription, the NF service consumer invokes Nnwdaf_MLModelProvision_Subscribe service operation by sending an HTTP PUT request with Resource URI of the resource "Individual NWDAF ML Model Provision Subscription".

2. The NWDAF containing MTLF responds to the Nnwdaf_MLModelProvision_Subscribe service operation. Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF containing MTLF responds to the NF service consumer with "201 Created", and the URI of the created subscription is included in the Location header field.

Upon receipt of the HTTP PUT request, if the subscription is accepted to be updated, the NWDAF containing MTLF responds to the NF service consumer an HTTP "200 OK" with a response body containing a representation of the updated subscription or "204 No Content".

3. If the NWDAF containing MTLF determines that the subscribed ML model information is available, the NWDAF containing MTLF invokes Nnwdaf_MLModelProvision_Notify service operation to report the ML model information by sending an HTTP POST request to the NF service consumer identified by the notification URI received during the creation/modification of the subscriptions, as described in clause 4.5.2.4 of 3GPP TS 29.520 [5].

4. The NF service consumer responds to the NWDAF containing MTLF with an HTTP "204 No Content" message.

5. In order to unsubscribe from the notification(s) of the ML model information, the NF service consumer invokes Nnwdaf_MLModelProvision_Unsubscribe service operation by sending an HTTP DELETE request, which targets the resource "Individual NWDAF ML Model Provision Subscription", to the NWDAF containing MTLF.

6. If the request is accepted, the NWDAF containing MTLF deletes the subscription and responds to the NF service consumer with an HTTP "204 No Content" message.

NOTE: For details of Nnwdaf_MLModelProvision_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.6A ML Model Training procedures

5.6A.1 General

The ML Model training procedures allow the NF service consumers (i.e. NWDAF containing MTLF) to subscribe to another NWDAF (i.e. an NWDAF containing MTLF) for a trained ML model and/or the information about ML model training based on the ML model file or ML Model information provided by the consumer and the data for the training.

5.6A.2 ML Model Training Subscribe/Unsubscribe/Notify procedure

The procedure is used by an NF service consumer to subscribe to/unsubscribe from the ML model training, and also used by the NWDAF containing MTLF to notify the ML model and/or ML model training information to the NF service consumer if it subscribed to the ML model and/or ML model training information previously.

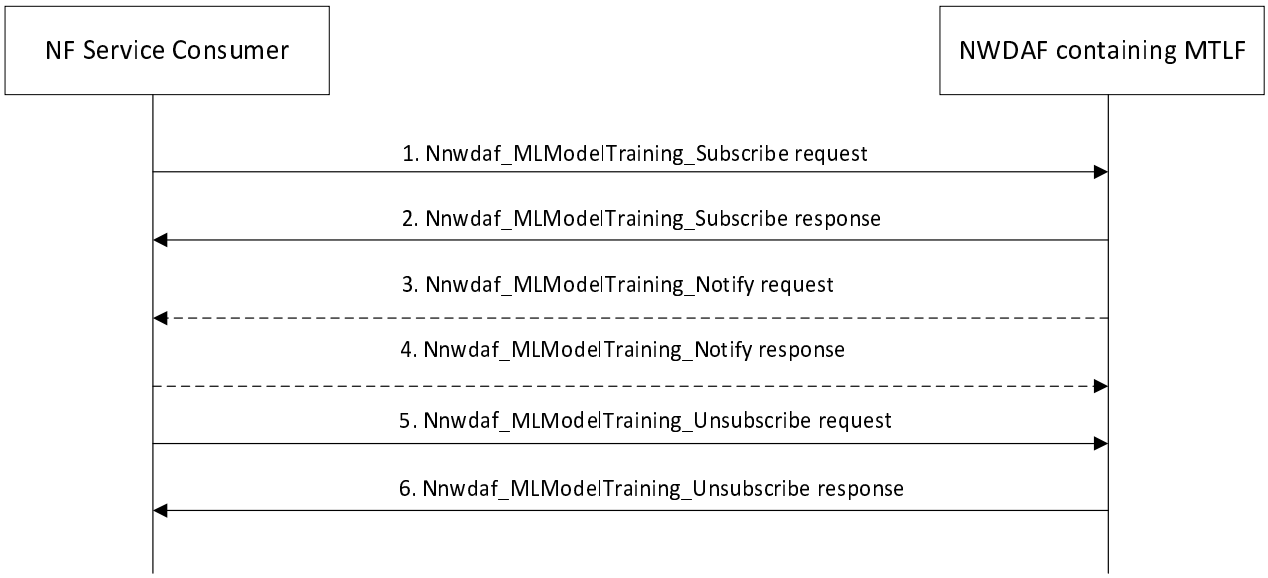

Figure 5.6A.2-1: ML Model Training Subscribe/Unsubscribe/Notify procedure

1. In order to subscribe to ML model and/or ML model training information, the NF service consumer invokes Nnwdaf_MLModelTraining_Subscribe service operation by sending an HTTP POST request targeting the

resource "NWDAF ML Model Training Subscriptions", as described in clause 4.6.2.2 of 3GPP TS 29.520 [5]. See 3GPP TS 29.520 [5] clause 5.5 for details.

In order to modify the existing subscription, the NF service consumer invokes Nnwdaf_MLModelTraining_Subscribe service operation by sending an HTTP PUT request or an HTTP PATCH request with Resource URI of the resource "Individual NWDAF ML Model Training Subscription".

2. The NWDAF containing MTLF responds to the Nnwdaf_MLModelTraining_Subscribe service operation. Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NWDAF containing MTLF responds to the NF service consumer with "201 Created", and the URI of the created subscription is included in the Location header field.

   Upon receipt of the HTTP PUT request or the HTTP PATCH request, if the subscription is accepted to be updated, the NWDAF containing MTLF responds to the NF service consumer an HTTP "200 OK" with a response body containing a representation of the updated subscription or "204 No Content".

3. If the NWDAF containing MTLF determines that the subscribed ML model and/or ML model training information is available, the NWDAF containing MTLF invokes Nnwdaf_MLModelTraining_Notify service operation to report the ML model and/or ML model training information by sending an HTTP POST request to the NF service consumer identified by the notification URI received during the creation/modification of the subscriptions, as described in clause 4.6.2.4 of 3GPP TS 29.520 [5].

4. The NF service consumer responds to the NWDAF containing MTLF with an HTTP "204 No Content" message.

5. In order to unsubscribe from the notification(s) of the ML model and/or ML model training information, the NF service consumer invokes Nnwdaf_MLModelTraining_Unsubscribe service operation by sending an HTTP DELETE request, which targets the resource "Individual NWDAF ML Model Training Subscription", to the NWDAF containing MTLF.

6. If the request is accepted, the NWDAF containing MTLF deletes the subscription and responds to the NF service consumer with an HTTP "204 No Content" message.

NOTE: For details of Nnwdaf_MLModelTraining_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.7 Procedures for Specific Network Data Analytics

5.7.1 General

Clause 5.7 specifies the detailed procedures for the NWDAF service consumer to obtain the specific Network Data Analytics.

5.7.2 Network Slice (Instance) load level Analytics

This procedure is used by the NF to obtain the network slice (instance) load level analytics which are calculated by the NWDAF based on the information collected from the NSSF, NSACF, NRF, AMF, SMF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

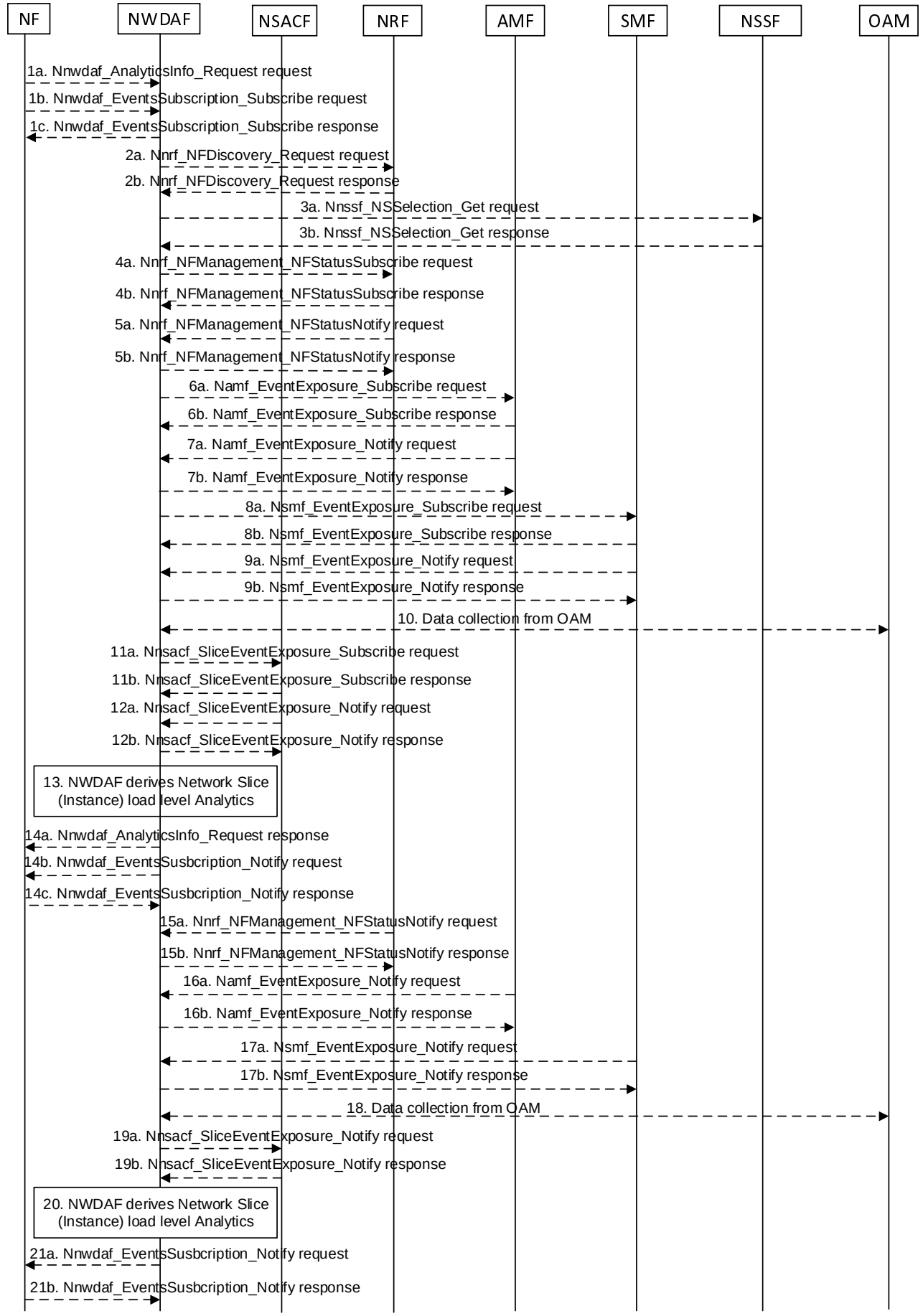

Figure 5.7.2-1: Procedure for Network Slice (Instance) load level Analytics

1a. In order to obtain the network slice (instance) load level analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to obtain the network slice (instance) load level analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a-2b. If the event is set to "LOAD_LEVEL_INFORMATION"/"SLICE_LOAD_LEVEL" or "NSI_LOAD_LEVEL", the NWDAF invokes Nnrf_NFDiscovery_Request service operation as described in clause 5.3.2.2 of 3GPP TS 29.510 [23] to discover the AMF, SMF and NSSF instance(s) relevant to the analytics filters provided in the subscription request. The NRF responds to the NWDAF an HTTP "200 OK" response.

3a-3b. (Only for "NSI_LOAD_LEVEL")The NWDAF may invoke Nnssf_NSSelection_Get service operation as described in clause 5.2.2.2 of 3GPP TS 29.531 [21] to obtain the NSI ID(s) corresponding to the S-NSSAI in the subscription request. The NSSF responds to the NWDAF an HTTP "200 OK" response.

4a-4b. (Only for "NSI_LOAD_LEVEL")The NWDAF may invoke Nnrf_NFManagement_NFStatusSubscribe service operation as described in clause 5.2.2.5 of 3GPP TS 29.510 [23] to subscribe to the resource usage information of a network slice instance obtained from its constituent NF instances. The NRF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. (Only for "NSI_LOAD_LEVEL") If step 4a and step 4b are performed, the NRF may invoke Nnrf_NFManagement_NFStatusNotify service operation as described in clause 5.2.2.6 of 3GPP TS 29.510 [23]. The NWDAF responds to the NRF an HTTP "204 No Content" response.

6a-6b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to subscribe to the notification of individual UE registration/deregistration registered to an S-NSSAI or to an S-NSSAI and NSI ID, or request the total number of UEs served by the AMF per S-NSSAI or per S-NSSAI and NSI ID. The AMF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

8a-8b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to the notification of individual PDU session established or PDU session released in an S-NSSAI or request the total number of PDU Sessions established in an S-NSSAI. The SMF responds to the NWDAF an HTTP "201 Created" response.

9a-9b. If step 8a and step 8b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

10. The NWDAF may collect "Performance measurement" to the OAM to get the mean number of UEs registered as described in clause 5.2.1 of TS 28.552 [27], mean number of PDU sessions established as described in clause 5.3.1 of TS 28.552 [27] and/or the resource usage information of a network slice instance obtained from its constituent NF instances as described in clause 6.2 of TS 28.552 [27]. (Obtaining the resource usage information of a network slice instance is only applicable for "NSI_LOAD_LEVEL" event).

11a-11b. The NWDAF may invoke Nnsacf_SliceEventExposure_Subscribe service operation as described in clause 5.3.2.2 of 3GPP TS 29.536 [20] to request the number of UEs registered to the network slice and/or the number of PDU sessions established to the network slice.

12a-12b. The NSACF may invoke Nnsacf_SliceEventExposure_Notify service operation as described in clause 5.3.2.4 of 3GPP TS 29.536 [20]. The NWDAF responds to the NSACF an HTTP "204 No Content" response.

13. The NWDAF calculates the network slice (instance) load level analytics based on the data collected from AMF, SMF, NRF, NSACF and/or OAM.

14a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

14b-14c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

15a-15b. The same as step 5a and step 5b.

16a-16b. The same as step 7a and step 7b.

17a-17b. The same as step 9a and step 9b.

18. The same as step 10.

19a-19b. The same as step 12a and step 12b.

20. The same as step 13.

21a-21b. The same as step 14b and step 14c.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.3 Observed Service Experience Analytics

This procedure is used by the NF to obtain the Service Experience analytics which are calculated by the NWDAF based on the information collected from the AMF, SMF, UPF, GMLC, AF, OAM and/or MDAF. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

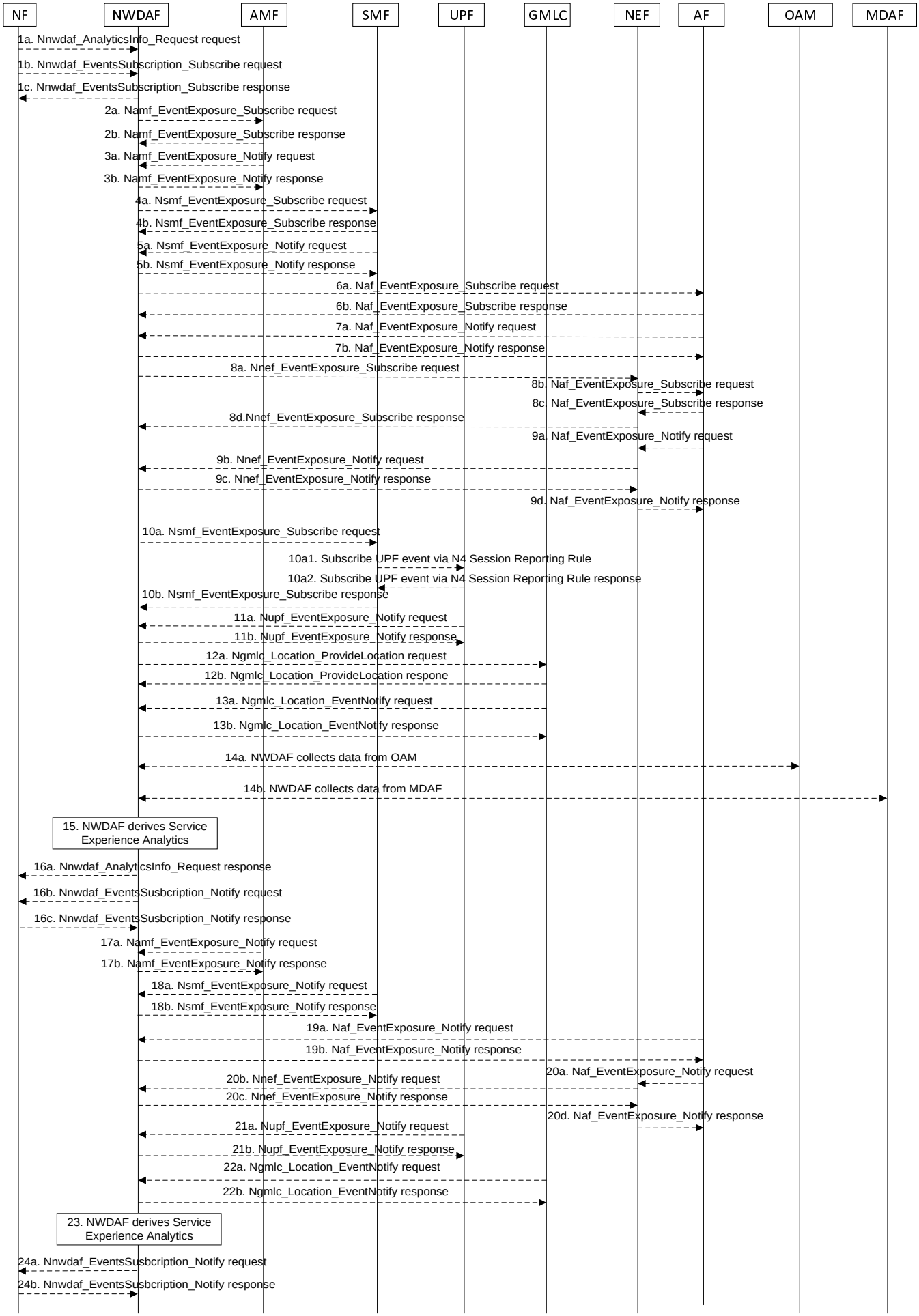
NF
NWDAF
AMF
SMF
UPF
GMLC
NEF
AF
OAM
MDAF
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Namf_EventExposure_Subscribe request
2b. Namf_EventExposure_Subscribe response
3a. Namf_EventExposure_Notify request
3b. Namf_EventExposure_Notify response
4a. Nsmf_EventExposure_Subscribe request
4b. Nsmf_EventExposure_Subscribe response
5a. Nsmf_EventExposure_Notify request
5b. Nsmf_EventExposure_Notify response
6a. Naf_EventExposure_Subscribe request
6b. Naf_EventExposure_Subscribe response
7a. Naf_EventExposure_Notify request
7b. Naf_EventExposure_Notify response
8a. Nnef_EventExposure_Subscribe request
8b. Naf_EventExposure_Subscribe request
8c. Naf_EventExposure_Subscribe response
8d.Nnef_EventExposure_Subscribe response
9a. Naf_EventExposure_Notify request
9b. Nnef_EventExposure_Notify request
9c. Nnef_EventExposure_Notify response
9d. Naf_EventExposure_Notify response
10a. Nsmf_EventExposure_Subscribe request
10a1. Subscribe UPF event via N4 Session Reporting Rule
10a2. Subscribe UPF event via N4 Session Reporting Rule response
10b. Nsmf_EventExposure_Subscribe response
11a. Nupf_EventExposure_Notify request
11b. Nupf_EventExposure_Notify response
12a. Ngmlc_Location_ProvideLocation request
12b. Ngmlc_Location_ProvideLocation respone
13a. Ngmlc_Location_EventNotify request
13b. Ngmlc_Location_EventNotify response
14a. NWDAF collects data from OAM
14b. NWDAF collects data from MDAF
15. NWDAF derives Service Experience Analytics
16a. Nnwdaf_AnalyticsInfo_Request response
16b. Nnwdaf_EventsSusbcription_Notify request
16c. Nnwdaf_EventsSusbcription_Notify response
17a. Namf_EventExposure_Notify request
17b. Namf_EventExposure_Notify response
18a. Nsmf_EventExposure_Notify request
18b. Nsmf_EventExposure_Notify response
19a. Naf_EventExposure_Notify request
19b. Naf_EventExposure_Notify response
20a. Naf_EventExposure_Notify request
20b. Nnef_EventExposure_Notify request
20c. Nnef_EventExposure_Notify response
20d. Naf_EventExposure_Notify response
21a. Nupf_EventExposure_Notify request
21b. Nupf_EventExposure_Notify response
22a. Ngmlc_Location_EventNotify request
22b. Ngmlc_Location_EventNotify response
23. NWDAF derives Service Experience Analytics
24a. Nnwdaf_EventsSusbcription_Notify request
24b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.3-1: Procedure for Service Experience Analytics

1a. In order to obtain the Service Experience analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to obtain the Service Experience analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a-2b. If the event is set to "SERVICE_EXPERIENCE", the NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to subscribe to the notification of UE ID and UE location. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to QFI allocation event. The SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to request the service data and performance data from AF directly. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10a-10b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6] to subscribe via the SMF to UPF information for a specific UE. The SMF subscribes to the UPF on behalf of the NWDAF via N4 Session Reporting Rule as described in clause 5.2.8 of 3GPP TS 29.244 [45] and, after having received the successful response from the UPF, it responds to the NWDAF with an HTTP "201 Created" response.

11a-11b. If step 10a and step 10b are performed, the UPF may invoke Nupf_EventExposure_Notify service operation as described in 3GPP TS 29.564 [40] by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 10a. The NWDAF responds to the UPF an HTTP "204 No Content" response.

12a-12b. If the NF requestes fine granularity location analytics information, the NWDAF may invoke Ngmlc_Location_ProvideLocation service operation to retrieve UE Location and UE Location Accuracy by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

13a-13b. If step 12a and step 12b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 12a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

14a. The NWDAF may collect Reference Signal Received Power and Reference Signal Received Quality as specified in clause 5.5 of TS 38.331 [33] and clause 5.5.5 of TS 36.331 [34], Signal-to-noise and interference ratio as specified in clause 5.1 of TS 38.215 [35], the mapping information between cell ID and frequency and/or Cell Energy Saving State data as specified in clauses 3.1 and 6.2 of TS 28.310 [36] from OAM. If the NF is AF or NEF requesting per application analytics with UE granularity, the NWDAF may collect the average UL/DL RAN throughput, the UL/DL RAN packet delay and the UL/DL RAN Packet loss rate as described in clause 5.2.1.1 and 5.4.1.1 of TS 37.320 [29]. If the NWDAF maps the provided Application ID as DASH, MTSI or VR in step 1a or step 1b, the NWDAF may act as an MnS Consumer to collect the QoE measurements data for all the UEs in the interested area from OAM as defined in TS 28.404 [48], TS 28.405 [49] and TS 28.406 [50].

NOTE 1: Care needs to be taken to avoid end to end excessive signalling for collecting the QoE measurements from the applications in the UE.

14b. The NWDAF may collect service experience and energy saving state analysis as specified in clause 8.4.2.1.3 and clause 8.4.4.3 of TS 28.104 [38] from MDAF. The information element of the analysis from MDAF include ServiceExperienceIssueType, AffectedObjects, ServiceExperienceStatistics, ServiceExperiencePredictions, and StatisticsOfCellsEsState.

15. The NWDAF calculates the Service Experience analytics based on the data collected from AMF, SMF, UPF, GMLC, AF, OAM and/or MDAF.

16a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

16b-16c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

17a-17b. The same as step 3a and step 3b.

18a-18b. The same as step 5a and step 5b.

19a-19d. The same as step 7a and step 7b.

20a-20d. The same as step 9a and step 9b.

21a-21b. The same as step 11a and step 11b.

22a-22b. The same as step 13a and step 13b.

23. The same as step 15.

24a-24b. The same as step 16b and step 16c.

NOTE 2: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 3: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 4: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

5.7.4 NF load Analytics

This procedure is used by the NWDAF service consumer (may be an NF, or the OAM) to obtain the NF load analytics which are calculated by the NWDAF based on the information collected from the NRF and/or the OAM, may also collect UE input data via the AF (for the untrusted AF via the NEF). If target NF type is UPF, the NWDAF may collect the information from UPF.

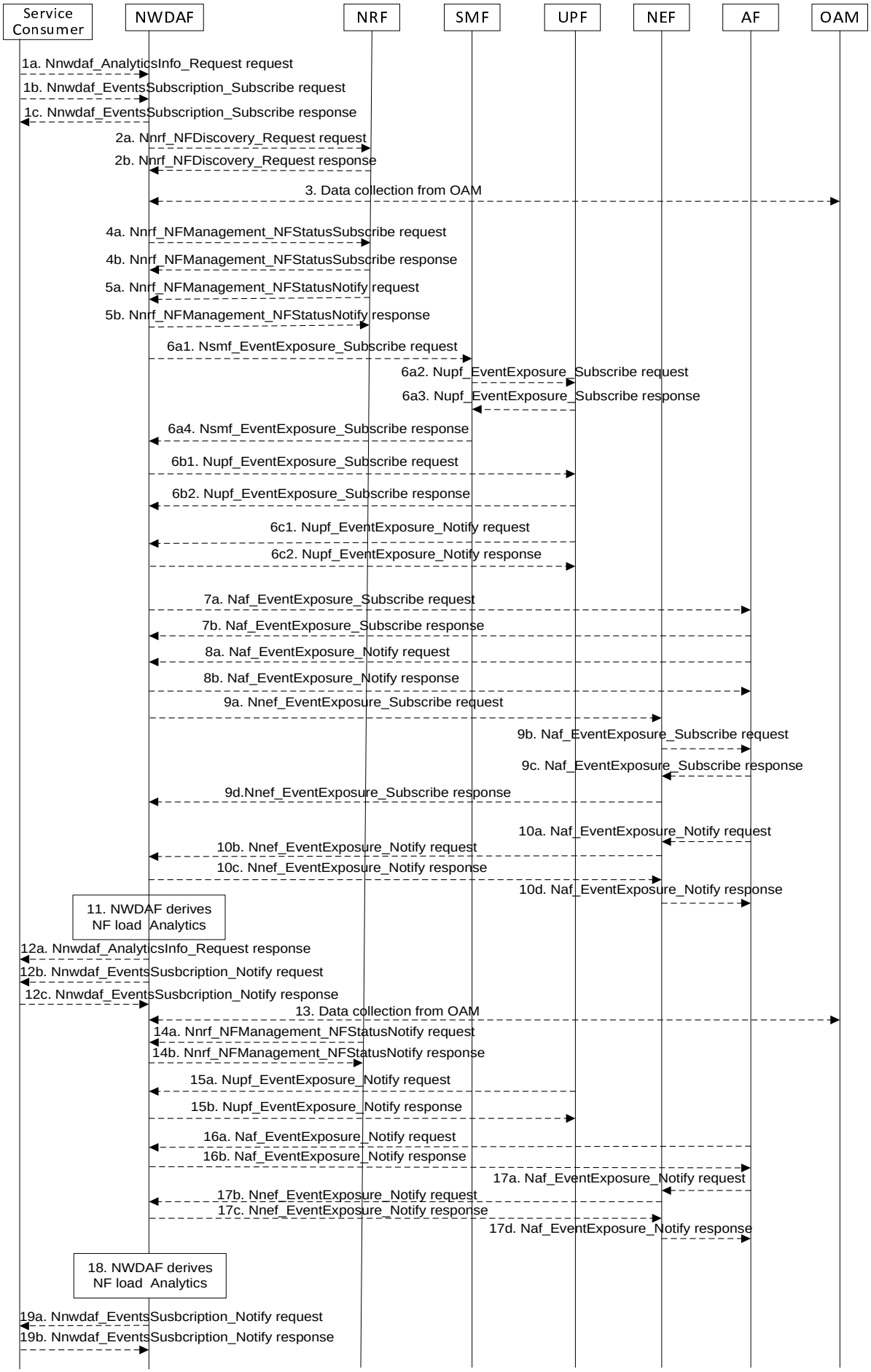
Service Consumer
NWDAF
NRF
SMF
UPF
NEF
AF
OAM
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Nnrf_NFDiscovery_Request request
2b. Nnrf_NFDiscovery_Request response
3. Data collection from OAM
4a. Nnrf_NFManagement_NFStatusSubscribe request
4b. Nnrf_NFManagement_NFStatusSubscribe response
5a. Nnrf_NFManagement_NFStatusNotify request
5b. Nnrf_NFManagement_NFStatusNotify response
6a1. Nsmf_EventExposure_Subscribe request
6a2. Nupf_EventExposure_Subscribe request
6a3. Nupf_EventExposure_Subscribe response
6a4. Nsmf_EventExposure_Subscribe response
6b1. Nupf_EventExposure_Subscribe request
6b2. Nupf_EventExposure_Subscribe response
6c1. Nupf_EventExposure_Notify request
6c2. Nupf_EventExposure_Notify response
7a. Naf_EventExposure_Subscribe request
7b. Naf_EventExposure_Subscribe response
8a. Naf_EventExposure_Notify request
8b. Naf_EventExposure_Notify response
9a. Nnef_EventExposure_Subscribe request
9b. Naf_EventExposure_Subscribe request
9c. Naf_EventExposure_Subscribe response
9d.Nnef_EventExposure_Subscribe response
10a. Naf_EventExposure_Notify request
10b. Nnef_EventExposure_Notify request
10c. Nnef_EventExposure_Notify response
10d. Naf_EventExposure_Notify response
11. NWDAF derives NF load Analytics
12a. Nnwdaf_AnalyticsInfo_Request response
12b. Nnwdaf_EventsSusbcription_Notify request
12c. Nnwdaf_EventsSusbcription_Notify response
13. Data collection from OAM
14a. Nnrf_NFManagement_NFStatusNotify request
14b. Nnrf_NFManagement_NFStatusNotify response
15a. Nupf_EventExposure_Notify request
15b. Nupf_EventExposure_Notify response
16a. Naf_EventExposure_Notify request
16b. Naf_EventExposure_Notify response
17a. Naf_EventExposure_Notify request
17b. Nnef_EventExposure_Notify request
17c. Nnef_EventExposure_Notify response
17d. Naf_EventExposure_Notify response
18. NWDAF derives NF load Analytics
19a. Nnwdaf_EventsSusbcription_Notify request
19b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.4-1: Procedure for NF load Analytics

1a. In order to obtain the NF load analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "NF_LOAD" with the supported feature "NfLoad".

1b-1c. In order to obtain the NF load analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "NF_LOAD" with the supported feature "NfLoad".

2a-2b. The NWDAF may invoke Nnrf_NFDiscovery_Request service operation as described in clause 5.3.2.2 of 3GPP TS 29.510 [23] for each NF, to obtain the initial NF profile which contains NF status and may contains NF load information. The NRF responds to the NWDAF an HTTP "200 OK" response.

3. The NWDAF may collect "Performance measurement" to the OAM to get the NF resource usage information as described in clause 5.7 of 3GPP TS 28.552 [27] and/or may collect the NF resource configuration change information as described in clause 5.2 of 3GPP TS 28.533 [28]. The NWDAF may also collect the MDT data information for UE as described in 3GPP TS 37.320 [29].

4a-4b. The NWDAF may invoke Nnrf_NFManagement_NFStatusSubscribe service operation as described in clause 5.2.2.5 of 3GPP TS 29.510 [23] to subscribe to the NF status and/or NF load information. The NRF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the NRF may invoke Nnrf_NFManagement_NFStatusNotify service operation as described in clause 5.2.2.6 of 3GPP TS 29.510 [23]. The NWDAF responds to the NRF an HTTP "204 No Content" response.

6. If the target NF type is UPF, the NWDAF may subscribe to collect traffic usage report information from UPF either via the SMF (by performing steps 6a1, 6a2, 6a3, and 6a4, which are the same as steps 3a, 4a, 4b, and 3b of clause 5.7.19) or directly to the UPF (by performing steps 6b1, 6b2, which are the same as steps 5a and 5b of clause 5.7.19). Then, by performing steps 6c1 and 6c2 the UPF may invoke the Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 6a1 or step 6b1 and the NWDAF responds to the UPF with an HTTP "204 No Content" response as described in 3GPP TS 29.564 [40].

7a-7b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the Collective Behaviour of UEs. The AF responds to the NWDAF an HTTP "201 Created" response.

8a-8b. If step 7a and step 7b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 7a. The NWDAF responds to the AF an HTTP "204 No Content" response.

9a-9d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the Collective Behaviour of UEs. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

10a-10d. If step 9a to step 9d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 9b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 9a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

11. The NWDAF calculates the NF load analytics based on the data collected from NRF, OAM, UPF and/or AF.

12a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

12b-12c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

13. The same as step 3.

14a-14b. The same as step 5a and step 5b.

15a-15b. The same as step 6c1and step 6c2.

16a-16b. The same as step 8a and step 8b.

17a-17d. The same as step 10a to step 10d.

18. The same as step 11.

19a-19b. The same as step 12b and step 12c.

NOTE 1: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 2: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 3: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.5 Network Performance Analytics

This procedure is used by the NF to obtain the network performance analytics which are calculated by the NWDAF based on the information collected from the AMF, NRF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

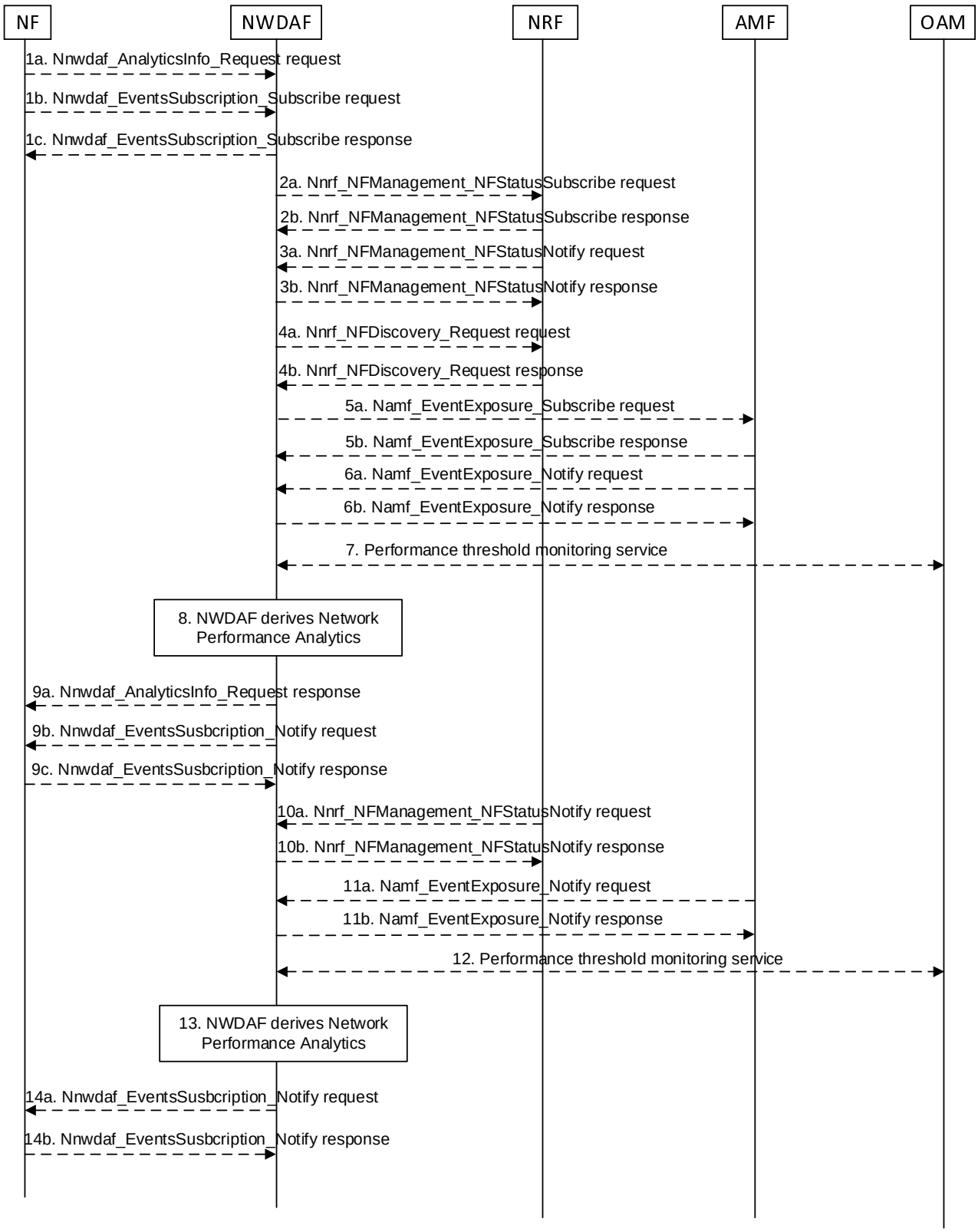

Figure 5.7.5-1: Procedure for Network Performance Analytics

1a. In order to obtain the network performance analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to obtain the network performance analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a-2b. If the event is set to "NETWORK_PERFORMANCE", the NWDAF may invoke Nnrf_NFManagement_NFStatusSubscribe service operation as described in clause 5.2.2.5 of 3GPP TS 29.510 [23] to subscribe to NF (e.g. SMF, UPF) load and status information. The NRF responds to the NWDAF an HTTP "200 OK" response.

3a-3b. If step 2a and step 2b are performed, the NRF may invoke Nnrf_NFManagement_NFStatusNotify service operation as described in clause 5.2.2.6 of 3GPP TS 29.510 [23]. The NWDAF responds to the NRF an HTTP "204 No Content" response.

4a-4b. If the event is set to "NETWORK_PERFORMANCE" and the type of network performance is set to "NUM_OF_UE", the NWDAF invokes Nnrf_NFDiscovery_Request service operation as described in clause 5.3.2.2 of 3GPP TS 29.510 [23] to discover the AMF(s) belonging to the AMF Region(s) that include(s) the Area of Interest. The NRF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to collect the number of UEs located in the Area of Interest from AMF. The AMF responds to the NWDAF an HTTP "201 Created" response.

6a-6b. If step 5a and step 5b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

7. The NWDAF may collect "Performance measurement" to the OAM to get the status and load information and the performance per Cell Id in the Area of Interest as described in clause 5.1 of TS 28.552 [27].

8. The NWDAF calculates the network performance analytics based on the data collected from AMF, NRF and/or OAM.

9a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

9b-9c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

10a-10b. The same as step 3a and step 3b.

11a-11b. The same as step 6a and step 6b.

12. The same as step 7.

13. The same as step 8.

14a-14b. The same as step 9b and step 9c.

NOTE: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.6 UE Mobility Analytics

This procedure is used by the NF to obtain UE mobility analytics, which is calculated by the NWDAF based on the information collected from the AMF, AF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

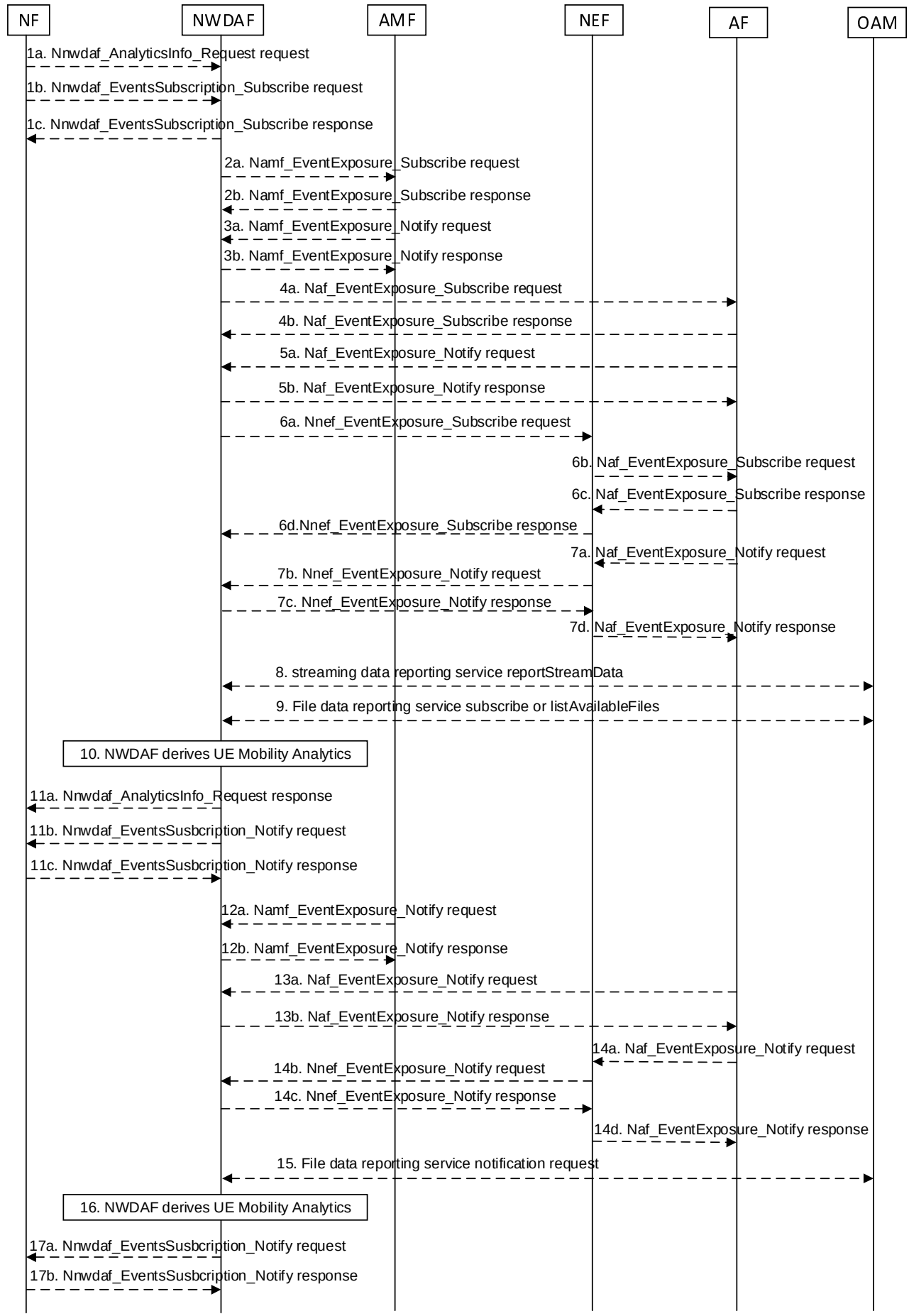
NF
NWDAF
AMF
NEF
AF
OAM
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Namf_EventExposure_Subscribe request
2b. Namf_EventExposure_Subscribe response
3a. Namf_EventExposure_Notify request
3b. Namf_EventExposure_Notify response
4a. Naf_EventExposure_Subscribe request
4b. Naf_EventExposure_Subscribe response
5a. Naf_EventExposure_Notify request
5b. Naf_EventExposure_Notify response
6a. Nnef_EventExposure_Subscribe request
6b. Naf_EventExposure_Subscribe request
6c. Naf_EventExposure_Subscribe response
6d.Nnef_EventExposure_Subscribe response
7a. Naf_EventExposure_Notify request
7b. Nnef_EventExposure_Notify request
7c. Nnef_EventExposure_Notify response
7d. Naf_EventExposure_Notify response
8. streaming data reporting service reportStreamData
9. File data reporting service subscribe or listAvailableFiles
10. NWDAF derives UE Mobility Analytics
11a. Nnwdaf_AnalyticsInfo_Request response
11b. Nnwdaf_EventsSusbcription_Notify request
11c. Nnwdaf_EventsSusbcription_Notify response
12a. Namf_EventExposure_Notify request
12b. Namf_EventExposure_Notify response
13a. Naf_EventExposure_Notify request
13b. Naf_EventExposure_Notify response
14a. Naf_EventExposure_Notify request
14b. Nnef_EventExposure_Notify request
14c. Nnef_EventExposure_Notify response
14d. Naf_EventExposure_Notify response
15. File data reporting service notification request
16. NWDAF derives UE Mobility Analytics
17a. Nnwdaf_EventsSusbcription_Notify request
17b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.6-1: Procedure for UE Mobility analytics

1a. In order to obtain the UE mobility analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "UE_MOBILITY" with the supported feature "UeMobility".

1b-1c. In order to obtain the UE mobility analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "UE_MOBILITY" with the supported feature "UeMobility".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18]. This step may be skipped when e.g. the UE mobility information is available. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in clause 5.3.2.4 of 3GPP TS 29.518 [18]. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the AF an HTTP "204 No Content" response.

6a-6d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

7a-7d. If step 6a to step 6d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 6b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

8. The NWDAF may invoke "streaming data reporting service reportStreamData" service operation to the OAM as described in clause 12.5.1.1.5 of 3GPP TS 28.532 [19].

9. The NWDAF may invoke the "File data reporting service subscribe" service operation to the OAM as described in clause 12.6.1.1.3 of 3GPP TS 28.532 [19] or invoke "File data reporting service listAvailableFiles" service operation to the OAM as described in clause 12.6.1.1.2 of 3GPP TS 28.532 [19].

10. The NWDAF calculates the requested UE mobility analytics based on the data collected from AMF, AF and/or OAM.

11a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

11b-11c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

12a-12b. The same as step 3a and step 3b.

13a-13b. The same as step 5a and step 5b.

14a-14d. The same as step 7a and step 7d.

15. The same as step 9.

16. The same as step 10.

17a-17b. The same as step 11b and step 11c.

NOTE 1: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 2: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 3: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.7 UE Communication Analytics

This procedure is used by the NF to obtain UE communication analytics, which is calculated by the NWDAF based on the information collected from the AMF, SMF, UPF, and/or AF. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

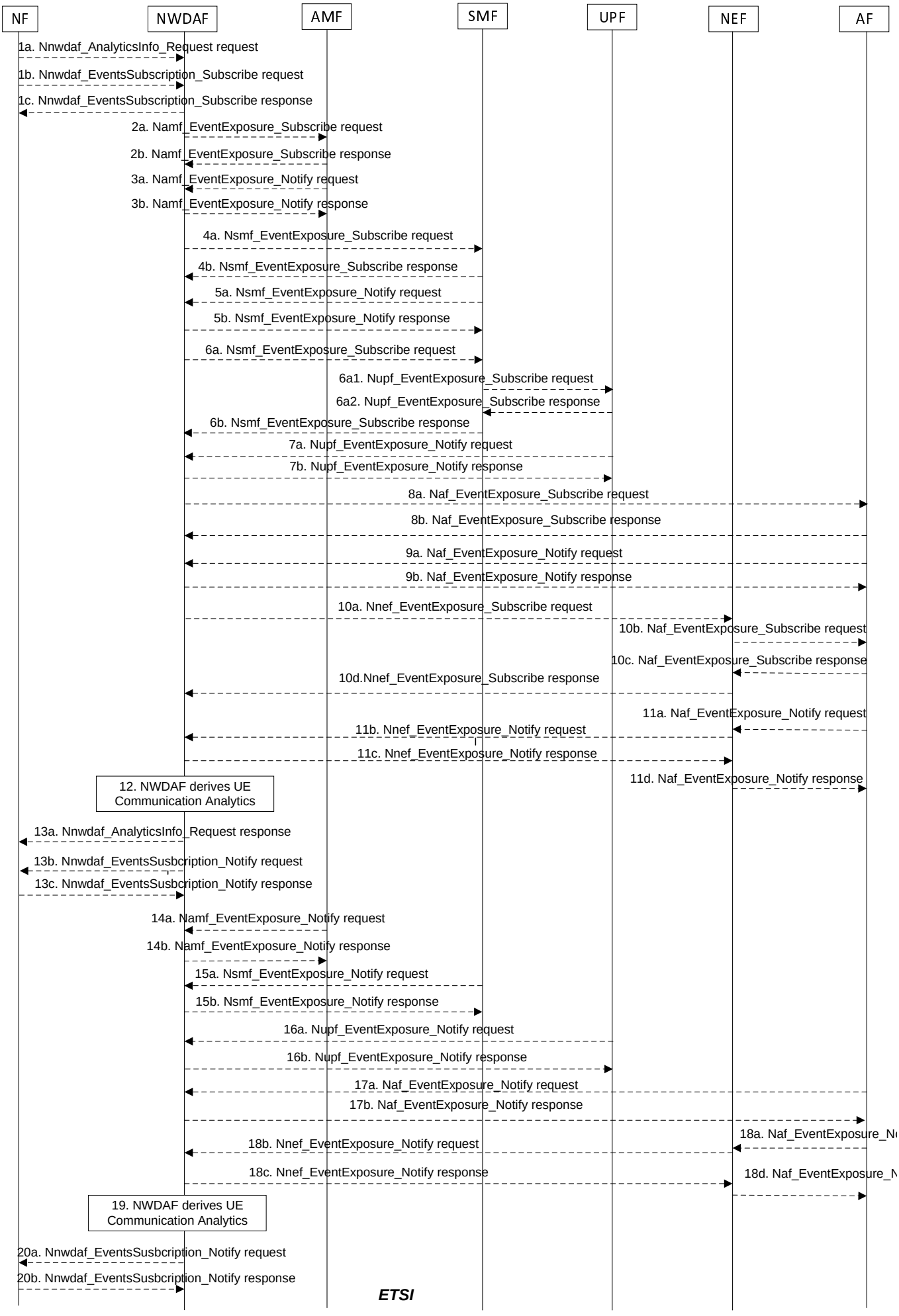
NF
NWDAF
AMF
SMF
UPF
NEF
AF
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Namf_EventExposure_Subscribe request
2b. Namf_EventExposure_Subscribe response
3a. Namf_EventExposure_Notify request
3b. Namf_EventExposure_Notify response
4a. Nsmf_EventExposure_Subscribe request
4b. Nsmf_EventExposure_Subscribe response
5a. Nsmf_EventExposure_Notify request
5b. Nsmf_EventExposure_Notify response
6a. Nsmf_EventExposure_Subscribe request
6a1. Nupf_EventExposure_Subscribe request
6a2. Nupf_EventExposure_Subscribe response
6b. Nsmf_EventExposure_Subscribe response
7a. Nupf_EventExposure_Notify request
7b. Nupf_EventExposure_Notify response
8a. Naf_EventExposure_Subscribe request
8b. Naf_EventExposure_Subscribe response
9a. Naf_EventExposure_Notify request
9b. Naf_EventExposure_Notify response
10a. Nnef_EventExposure_Subscribe request
10b. Naf_EventExposure_Subscribe request
10c. Naf_EventExposure_Subscribe response
10d.Nnef_EventExposure_Subscribe response
11a. Naf_EventExposure_Notify request
11b. Nnef_EventExposure_Notify request
11c. Nnef_EventExposure_Notify response
11d. Naf_EventExposure_Notify response
12. NWDAF derives UE Communication Analytics
13a. Nnwdaf_AnalyticsInfo_Request response
13b. Nnwdaf_EventsSusbcription_Notify request
13c. Nnwdaf_EventsSusbcription_Notify response
14a. Namf_EventExposure_Notify request
14b. Namf_EventExposure_Notify response
15a. Nsmf_EventExposure_Notify request
15b. Nsmf_EventExposure_Notify response
16a. Nupf_EventExposure_Notify request
16b. Nupf_EventExposure_Notify response
17a. Naf_EventExposure_Notify request
17b. Naf_EventExposure_Notify response
18a. Naf_EventExposure_N
18b. Nnef_EventExposure_Notify request
18c. Nnef_EventExposure_Notify response
18d. Naf_EventExposure_N
19. NWDAF derives UE Communication Analytics
20a. Nnwdaf_EventsSusbcription_Notify request
20b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.7-1: Procedure for UE Communication analytics

1a. In order to obtain the UE communication analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "UE_COMMUNICATION" with the supported feature "UeCommunication".

1b-1c. In order to obtain the UE communication analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "UE_COMMUNICATION" with the supported feature "UeCommunication".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve one or more Type Allocation codes, UE connection management state, UE access behaviour trends and UE location trends from AMF. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6] to request the information of the UE to calculate the analytics. The SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

6a-6b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6] to subscribe via the SMF to UPF information for a specific UE. The SMF subscribes to the UPF on behalf of the NWDAF using the Nupf_EventExposure_Subscribe service operation as described in 3GPP TS 29.564 [40] and, after having received the successful response from the UPF, it responds to the NWDAF with an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the UPF may invoke Nupf_EventExposure_Notify service operation as described in 3GPP TS 29.564 [40] by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 6a. The NWDAF responds to the UPF an HTTP "204 No Content" response.

8a-8b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to request the service data from AF directly. The AF responds to the NWDAF an HTTP "201 Created" response.

9a-9b. If step 8a and step 8b are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the AF an HTTP "204 No Content" response.

10a-10d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

11a-11d. If step 10a to step 10d are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 10b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 10a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

12. The NWDAF calculates the requested UE communication analytics based on the data collected from AMF, SMF, UPF and/or AF.

13a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

13b-13c. If step 1b and step 1c are performed, the NWDAF may invoke Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

14a-14b. The same as step 3a and step 3b.

15a-15b. The same as step 5a and step 5b.

16a-16b. The same as step 7a and step 7b.

17a-17b. The same as step 9a and step 9b.

18a-18d. The same as step 11a and step 11d.

19. The same as step 12.

20a-20b. The same as step 13b and step 13c.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 3: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 4: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.8 Expected UE behavioural Analytics

This procedure is used by the NF to obtain the expected UE behavioural parameters, which are calculated by the NWDAF based on the information collected from the AMF, SMF, UPF, AF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

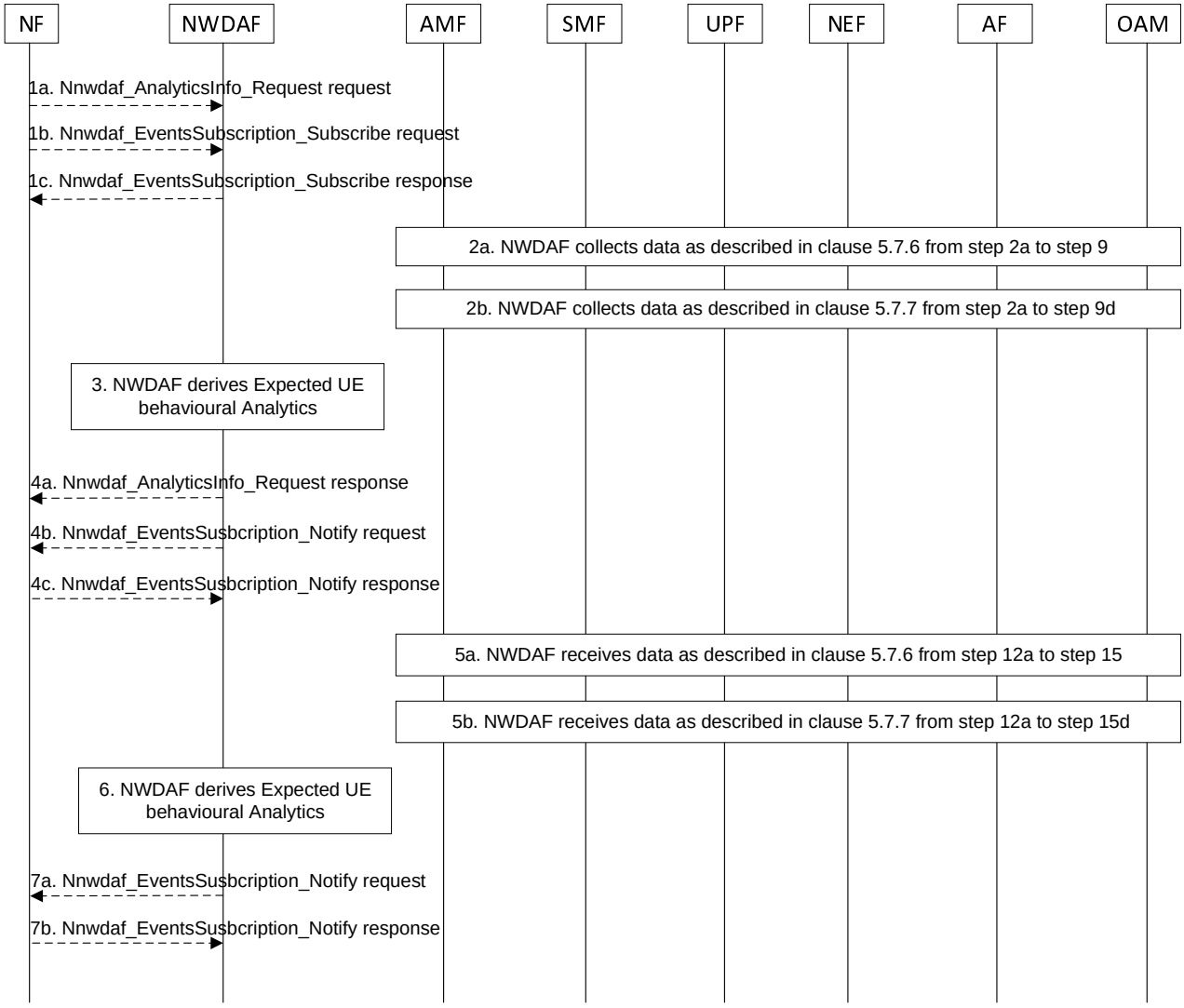

Figure 5.7.8-1: Procedure for Expected behavioural Analytics

1a. In order to obtain the expected UE behavioural parameters, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "UE_MOBILITY" with the supported feature "UeMobility", and/or "UE_COMMUNICATION" with the supported feature "UeCommunication".

1b-1c. In order to obtain expected UE behavioural parameters, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "UE_MOBILITY" with the supported feature "UeMobility", and/or "UE_COMMUNICATION" with the supported feature "UeCommunication".

2a. If the event is set to "UE_MOBILITY", the NWDAF collects data from AMF, AF and/or OAM as described in clause 5.7.6 from step 2a to step 9.

2b. If the event is set to "UE_COMM", the NWDAF collects data from AMF, SMF, UPF and/or AF as described in clause 5.7.7 from step 2a to step 9d.

3. The NWDAF calculates the expected UE behavioural parameters based on the collected data from AMF, SMF, AF and/or OAM.

4a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

4b-4c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

5a-5b. The AMF, SMF, AF and/or OAM send the notifications to the NWDAF if it has subscribed to the related events in step 2a or step 2b.

6. The same as step 3.

7a-7b. The same as step 4b and step 4c.

NOTE: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.9 Abnormal UE behavioural Analytics

This procedure is used by the NF to obtain the abnormal UE behavioural analytics which are calculated by the NWDAF based on the information collected from the AMF, SMF, AF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

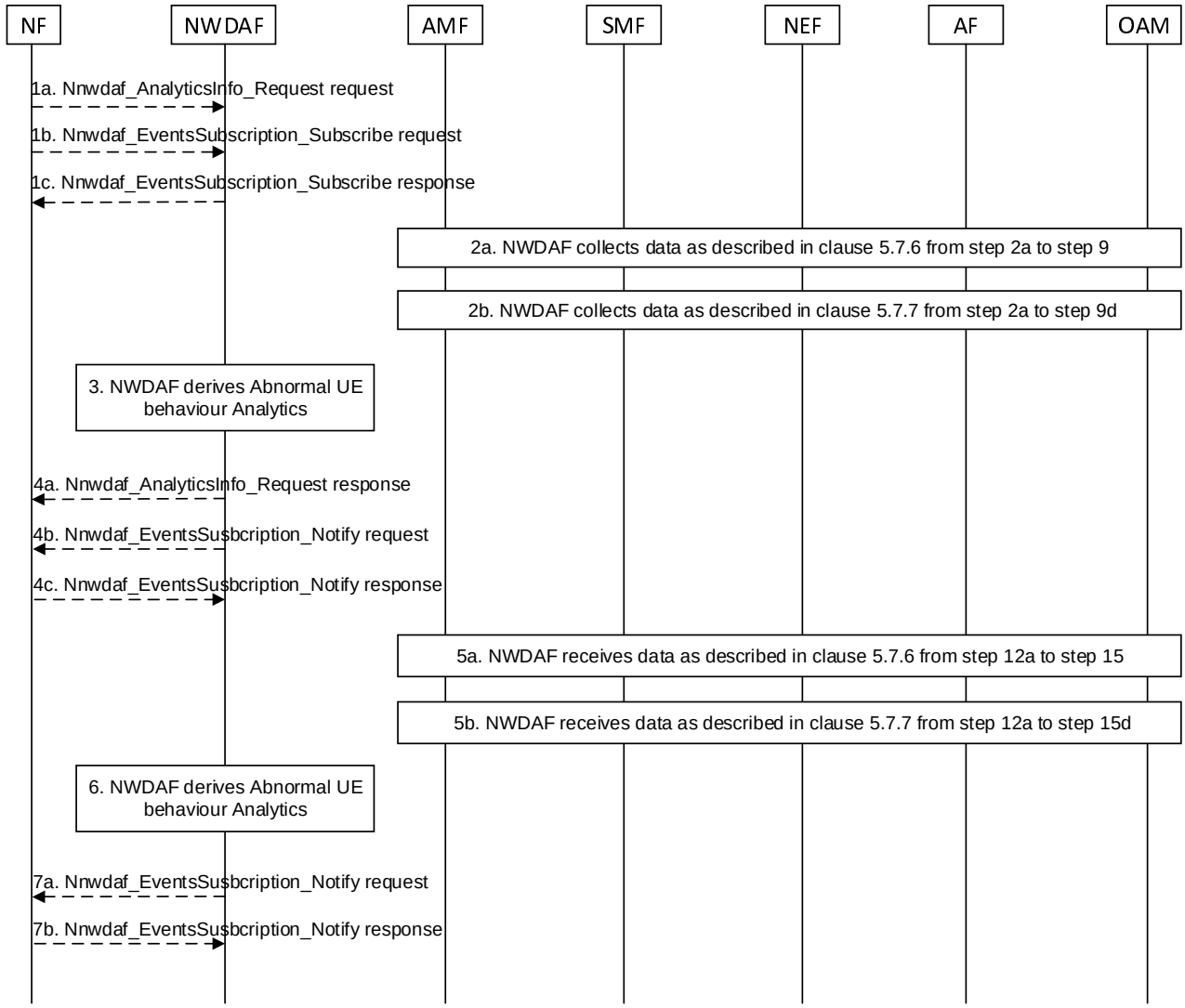

Figure 5.7.9-1: Procedure for Abnormal UE behavioural Analytics

1a. In order to obtain the abnormal UE behavioural parameters, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to obtain abnormal UE behavioural parameters, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a. If the event is set to "ABNORMAL_BEHAVIOUR" and the expected UE analytics type is set to "MOBILITY" or "MOBILITY_AND_COMMUN", or the list of exception IDs includes "UNEXPECTED_UE_LOCATION",

"PING_PONG_ACROSS_CELLS", "UNEXPECTED_RADIO_LINK_FAILURES", or "UNEXPECTED_WAKEUP", the NWDAF collects data from AMF, AF and/or OAM as described in clause 5.7.6 from step 2a to step 9.

2b. If the event is set to "ABNORMAL_BEHAVIOUR" and the expected UE analytics type is set to "COMMUN" or "MOBILITY_AND_COMMUN", or the list of exception IDs includes "SUSPICION_OF_DDOS_ATTACK", "UNEXPECTED_LONG_LIVE_FLOW", "UNEXPECTED_LARGE_RATE_FLOW", "WRONG_DESTINATION_ADDRESS", "TOO_FREQUENT_SERVICE_ACCESS" or "UNEXPECTED_WAKEUP", the NWDAF collects data from AMF, SMF and/or AF as described in clause 5.7.7 from step 2a to step 9d.

3. The NWDAF calculates the abnormal UE behavioural parameters based on the collected data from AMF, SMF, AF and/or OAM.

4a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

4b-4c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

5a-5b. The AMF, SMF, AF and/or OAM send the notifications to the NWDAF if it has subscribed to the related events in step 2a or step 2b.

6. The same as step 3.

7a-7b. The same as step 4b and step 4c.

NOTE: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.10 User Data Congestion Analytics

This procedure is used by the NWDAF service consumer (may be an NF e.g. NEF, AF, or PCF) to obtain the User Data Congestion analytics which are calculated by the NWDAF based on the information collected from the AMF, OAM, UPF and/or AF. If the NWDAF service consumer is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

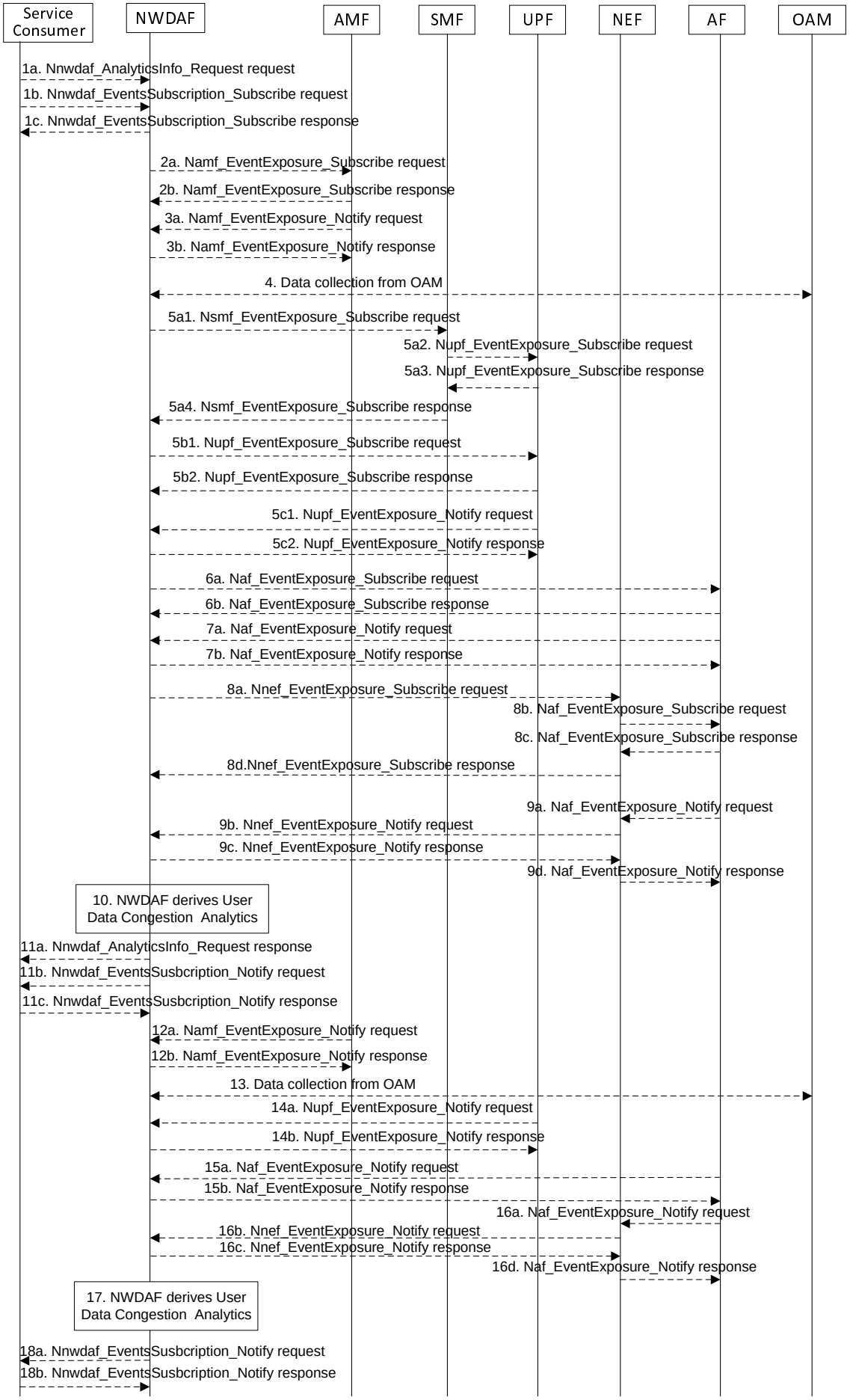
Service Consumer
NWDAF
AMF
SMF
UPF
NEF
AF
OAM
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Namf_EventExposure_Subscribe request
2b. Namf_EventExposure_Subscribe response
3a. Namf_EventExposure_Notify request
3b. Namf_EventExposure_Notify response
4. Data collection from OAM
5a1. Nsmf_EventExposure_Subscribe request
5a2. Nupf_EventExposure_Subscribe request
5a3. Nupf_EventExposure_Subscribe response
5a4. Nsmf_EventExposure_Subscribe response
5b1. Nupf_EventExposure_Subscribe request
5b2. Nupf_EventExposure_Subscribe response
5c1. Nupf_EventExposure_Notify request
5c2. Nupf_EventExposure_Notify response
6a. Naf_EventExposure_Subscribe request
6b. Naf_EventExposure_Subscribe response
7a. Naf_EventExposure_Notify request
7b. Naf_EventExposure_Notify response
8a. Nnef_EventExposure_Subscribe request
8b. Naf_EventExposure_Subscribe request
8c. Naf_EventExposure_Subscribe response
8d.Nnef_EventExposure_Subscribe response
9a. Naf_EventExposure_Notify request
9b. Nnef_EventExposure_Notify request
9c. Nnef_EventExposure_Notify response
9d. Naf_EventExposure_Notify response
10. NWDAF derives User Data Congestion Analytics
11a. Nnwdaf_AnalyticsInfo_Request response
11b. Nnwdaf_EventsSusbcription_Notify request
11c. Nnwdaf_EventsSusbcription_Notify response
12a. Namf_EventExposure_Notify request
12b. Namf_EventExposure_Notify response
13. Data collection from OAM
14a. Nupf_EventExposure_Notify request
14b. Nupf_EventExposure_Notify response
15a. Naf_EventExposure_Notify request
15b. Naf_EventExposure_Notify response
16a. Naf_EventExposure_Notify request
16b. Nnef_EventExposure_Notify request
16c. Nnef_EventExposure_Notify response
16d. Naf_EventExposure_Notify response
17. NWDAF derives User Data Congestion Analytics
18a. Nnwdaf_EventsSusbcription_Notify request
18b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.10-1: Procedure for User Data Congestion Analytics

1a. In order to obtain the User Data Congestion analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "USER_DATA_CONGESTION" with the supported feature "UserDataCongestion".

1b-1c. In order to obtain the User Data Congestion analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "USER_DATA_CONGESTION" with the supported feature "UserDataCongestion".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve the UE location information. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4. The NWDAF may collect "Performance measurement" to the OAM to get the Performance Measurements that will be used by the NWDAF to determine congestion levels. Performance Measurements are related to information transfer over the user plane and/or the control plane (e.g. UE Throughput, DRB Setup Management, RRC Connection Number, PDU Session Management, and Radio Resource Utilization as defined in 3GPP TS 28.552 [27]). The NWDAF may obtain measurements by invoking management services that are defined in 3GPP TS 28.532 [19] and 3GPP TS 28.550 [31].

5. The NWDAF may subscribe to collect data related to User Data Congestion analytics information from UPF either via the SMF (by performing steps 5a1, 5a2, 5a3, and 5a4, which are the same as steps 3a, 4a, 4b, and 3b of clause 5.7.19) or directly to the UPF (by performing steps 5b1, 5b2, which are the same as steps 5a and 5b of clause 5.7.19). Then, by performing steps 5c1 and 5c2 the UPF may invoke the Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 5a1 or step 5b1 and the NWDAF responds to the UPF with an HTTP "204 No Content" response as described in 3GPP TS 29.564 [40].

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the data related to User Data Congestion analytics information. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the data related to User Data Congestion analytics information. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10. The NWDAF calculates the User Data Congestion analytics based on the data collected from AMF, OAM, UPF and/or AF.

11a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

11b-11c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

12a-12b. The same as step 3a and step 3b.

13. The same as step 4.

14a-14b. The same as step 5c1 and step 5c2.

15a-15b. The same as step 7a and step 7b.

16a-16d. The same as step 9a to step 9d.

17. The same as step 10.

18a-18b. The same as step 11b and step 11c.

NOTE 1: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 2: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 3: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.11 QoS Sustainability Analytics

This procedure is used by the NWDAF service consumer (maybe an NF, e.g. AF) to obtain the QoS Sustainability analytics, which are calculated by the NWDAF based on the information collected from the OAM, AMF, SMF, UPF, UDM and GMLC, for a path of interest or for an area of interest with coarse granularity (i.e. TAIs or Cell IDs) or fine granularity (e.g. smaller than a cell). If the NWDAF service consumer is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

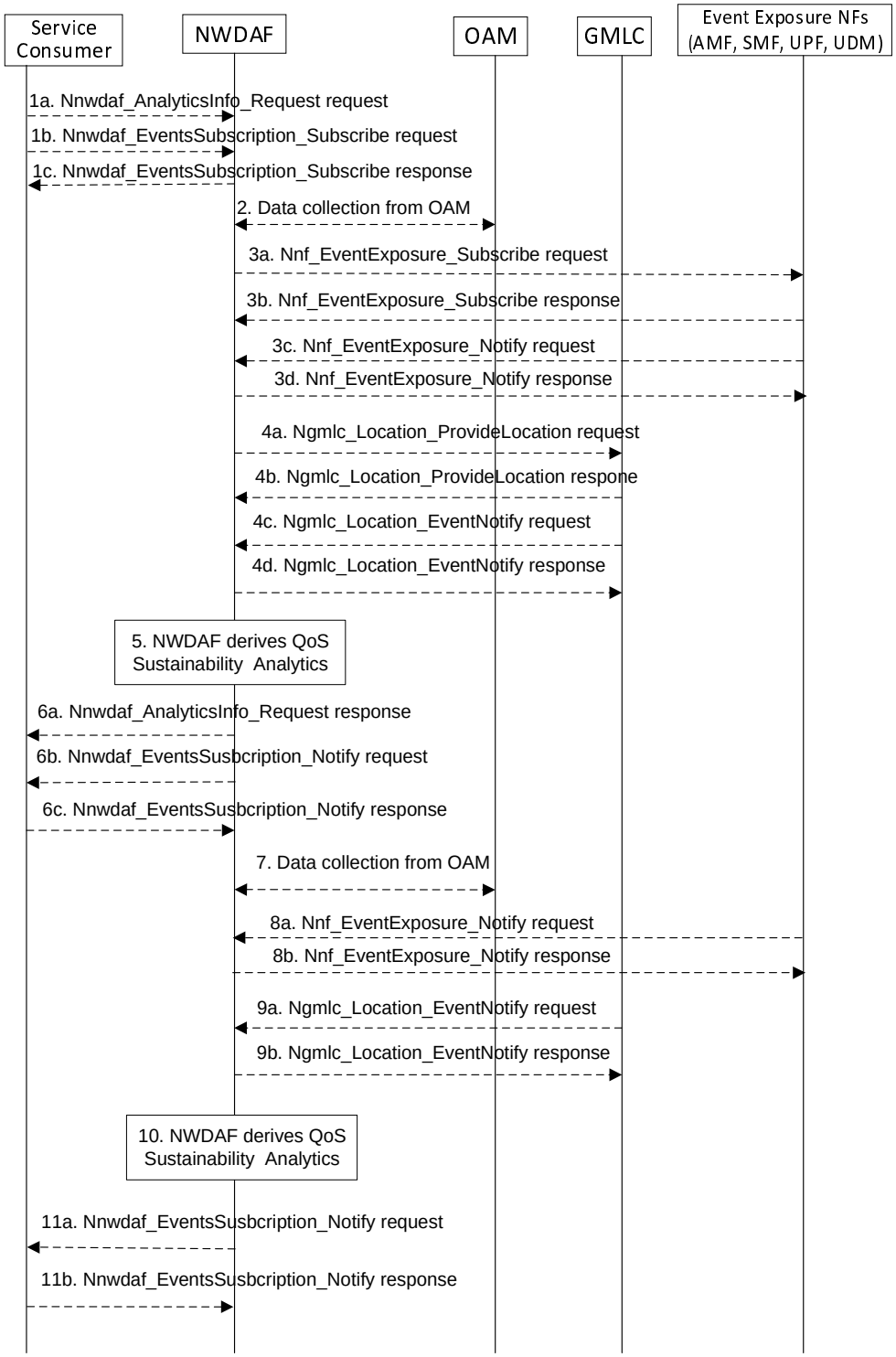

Figure 5.7.11-1: Procedure for QoS Sustainability Analytics

1a. In order to obtain the QoS sustainability analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is sent to "QOS_SUSTAINABILITY" with the supported feature "QoSSustainability".

1b-1c. In order to obtain the QoS sustainability analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "QOS_SUSTAINABILITY" with the supported feature "QoSSustainability".

2. The NWDAF may collect "Performance measurement" to the OAM to get the RAN UE Throughput in clause 6.3.6 of 3GPP TS 28.554 [30], QoS flow Retainability information as described in clause 6.5.1 of 3GPP TS 28.554 [30]. If the "QoSSustainabilityExt_eNA" feature is supported, the NWDAF may collect the average UL/DL packet transmission delay through RAN part to the UE as described in clause 6.3.1.2 of 3GPP TS 28.554 [30], the UL/DL packet delay on GTP path on N3 for non-GBR traffic, the UL/DL capacity measurement from UPF to NG-RAN or from UE to UPF based on GTP path, and the UL/DL available capacity measurement from UPF to NG-RAN or from UE to UPF based on GTP path as described in clause 5.1 and clause 5.4 of 3GPP TS 28.552 [27].

3a-3b. For the fine granularity data collection, the NWDAF may invoke Nnf_EventExposure_Subscribe service operations (as described in clause 5.5.2.2 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.2 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.3 of 3GPP TS 29.508 [6] for the SMF, clause 5.2.2.2 of 3GPP TS 29.564 [40] for the UPF), to subscribe to related data collection event(s) exposure. If the QoS information collected from UPF , the NWDAF may invoke Nsmf_EventExposure_Subscribe service operation as described in 3GPP TS 29.508 [6] and the SMF may subscribe to the UPF on behalf of the NWDAF via N4 Session Reporting Rule as described in clause 5.2.8 of 3GPP TS 29.244 [45]. The NF responds to the NWDAF an HTTP "201 Created" response.

3c-3d. If step 3a and step 3b are performed, the NF invokes Nnf_EventExposure_Notify service operation (as described in clause 5.5.2.4 of 3GPP TS 29.503 [22] for the UDM, clause 5.3.2.4 of 3GPP TS 29.518 [18] for the AMF, clause 4.2.2 of 3GPP TS 29.508 [6] for the SMF, clause 5.2.2.3 of 3GPP TS 29.564 [40] for the UPF). The NWDAF responds to the NF an HTTP "204 No Content" response.

4a-4b. For the fine granularity data collection, the NWDAF may invoke Ngmlc_Location_ProvideLocation service operation by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

4c-4d. If step 4a and step 4b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

5. The NWDAF calculates the QoS sustainability analytics based on the data collected from OAM for coarse granularity or based on the data collected from OAM, AMF, SMF, UDM and/or GMLC for fine granularity.

6a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

6b-6c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

7. The same as step 2.

8a-8b. The same as step 3c-3d.

9a-9b. The same as step 4c-4d.

10. The same as step 5.

11a-11b. The same as step 6b and step 6c.

NOTE 1: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

NOTE 2: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

5.7.12 Dispersion Analytics

This procedure is used by the NWDAF service consumer to obtain the dispersion analytics which are calculated by the NWDAF based on the information collected from the AMF, SMF, UPF and/or AF. If the NWDAF service consumer is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

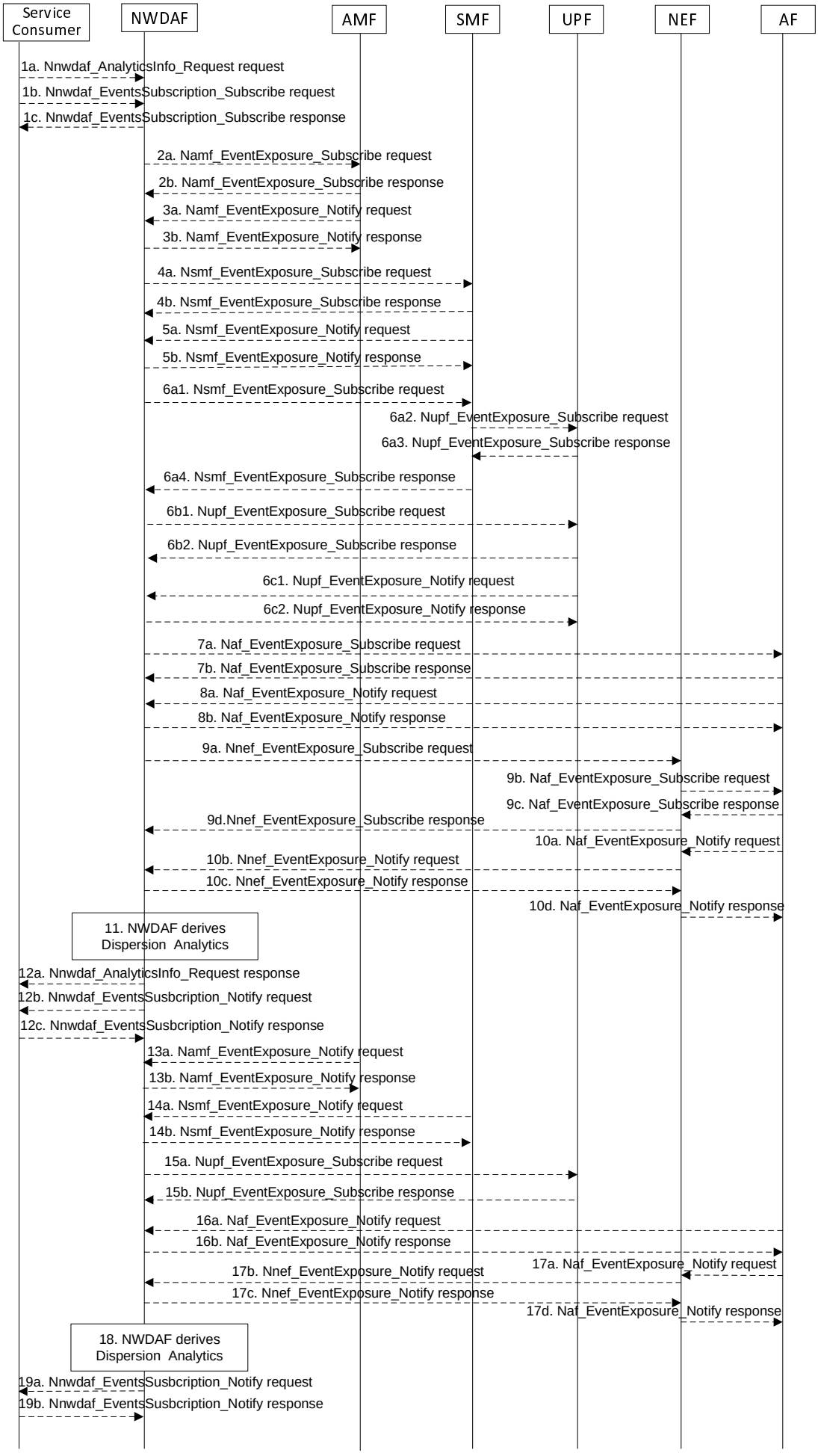
Service Consumer
NWDAF
AMF
SMF
UPF
NEF
AF
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Namf_EventExposure_Subscribe request
2b. Namf_EventExposure_Subscribe response
3a. Namf_EventExposure_Notify request
3b. Namf_EventExposure_Notify response
4a. Nsmf_EventExposure_Subscribe request
4b. Nsmf_EventExposure_Subscribe response
5a. Nsmf_EventExposure_Notify request
5b. Nsmf_EventExposure_Notify response
6a1. Nsmf_EventExposure_Subscribe request
6a2. Nupf_EventExposure_Subscribe request
6a3. Nupf_EventExposure_Subscribe response
6a4. Nsmf_EventExposure_Subscribe response
6b1. Nupf_EventExposure_Subscribe request
6b2. Nupf_EventExposure_Subscribe response
6c1. Nupf_EventExposure_Notify request
6c2. Nupf_EventExposure_Notify response
7a. Naf_EventExposure_Subscribe request
7b. Naf_EventExposure_Subscribe response
8a. Naf_EventExposure_Notify request
8b. Naf_EventExposure_Notify response
9a. Nnef_EventExposure_Subscribe request
9b. Naf_EventExposure_Subscribe request
9c. Naf_EventExposure_Subscribe response
9d.Nnef_EventExposure_Subscribe response
10a. Naf_EventExposure_Notify request
10b. Nnef_EventExposure_Notify request
10c. Nnef_EventExposure_Notify response
10d. Naf_EventExposure_Notify response
11. NWDAF derives Dispersion Analytics
12a. Nnwdaf_AnalyticsInfo_Request response
12b. Nnwdaf_EventsSusbcription_Notify request
12c. Nnwdaf_EventsSusbcription_Notify response
13a. Namf_EventExposure_Notify request
13b. Namf_EventExposure_Notify response
14a. Nsmf_EventExposure_Notify request
14b. Nsmf_EventExposure_Notify response
15a. Nupf_EventExposure_Subscribe request
15b. Nupf_EventExposure_Subscribe response
16a. Naf_EventExposure_Notify request
16b. Naf_EventExposure_Notify response
17a. Naf_EventExposure_Notify request
17b. Nnef_EventExposure_Notify request
17c. Nnef_EventExposure_Notify response
17d. Naf_EventExposure_Notify response
18. NWDAF derives Dispersion Analytics
19a. Nnwdaf_EventsSusbcription_Notify request
19b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.12-1: Procedure for Dispersion Analytics

1a. In order to obtain the Dispersion analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "DISPERSION" with the supported feature "Dispersion".

1b-1c. In order to obtain the Dispersion analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "DISPERSION" with the supported feature "Dispersion".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve the location and/or slice based UE transactions dispersion information. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to the notification of UE transactions dispersion information which may be slice based. The SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

6a-6c. The NWDAF may subscribe to collect UE data volume dispersion information from the serving UPF either via the SMF (by performing steps 6a1, 6a2, 6a3, and 6a4, which are the same as steps 3a, 4a, 4b, and 3b of clause 5.7.19) or directly to the UPF (by performing steps 6b1, 6b2, which are the same as steps 5a and 5b of clause 5.7.19). Then, the UPF may invoke the Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 6a1 or step 6b1 and the NWDAF responds to the UPF with an HTTP "204 No Content" response as described in 3GPP TS 29.564 [40].

7a-7b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the UE data volume dispersion information. The AF responds to the NWDAF an HTTP "201 Created" response.

8a-8b. If step 7a and step 7b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 7a. The NWDAF responds to the AF an HTTP "204 No Content" response.

9a-9d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the UE data volume dispersion information. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

10a-10d. If step 9a to step 9d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 9b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 9a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

11. The NWDAF calculates the Dispersion analytics based on the data collected from AMF, SMF, UPF and/or AF.

12a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

12b-12c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

13a-13b. The same as step 3a and step 3b.

14a-14b. The same as step 5a and step 5b.

15a-15b. The same as step 6c1and step 6c2.

16a-16b. The same as step 8a and step 8b.

17a-17d. The same as step 10a to step 10d.

18. The same as step 11.

19a-19b. The same as step 12b and step 12c.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 3: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 4: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.13 WLAN Performance Analytics

This procedure is used by the NWDAF service consumer to obtain the WLAN performance analytics which are calculated by the NWDAF based on the information collected from the SMF, UPF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

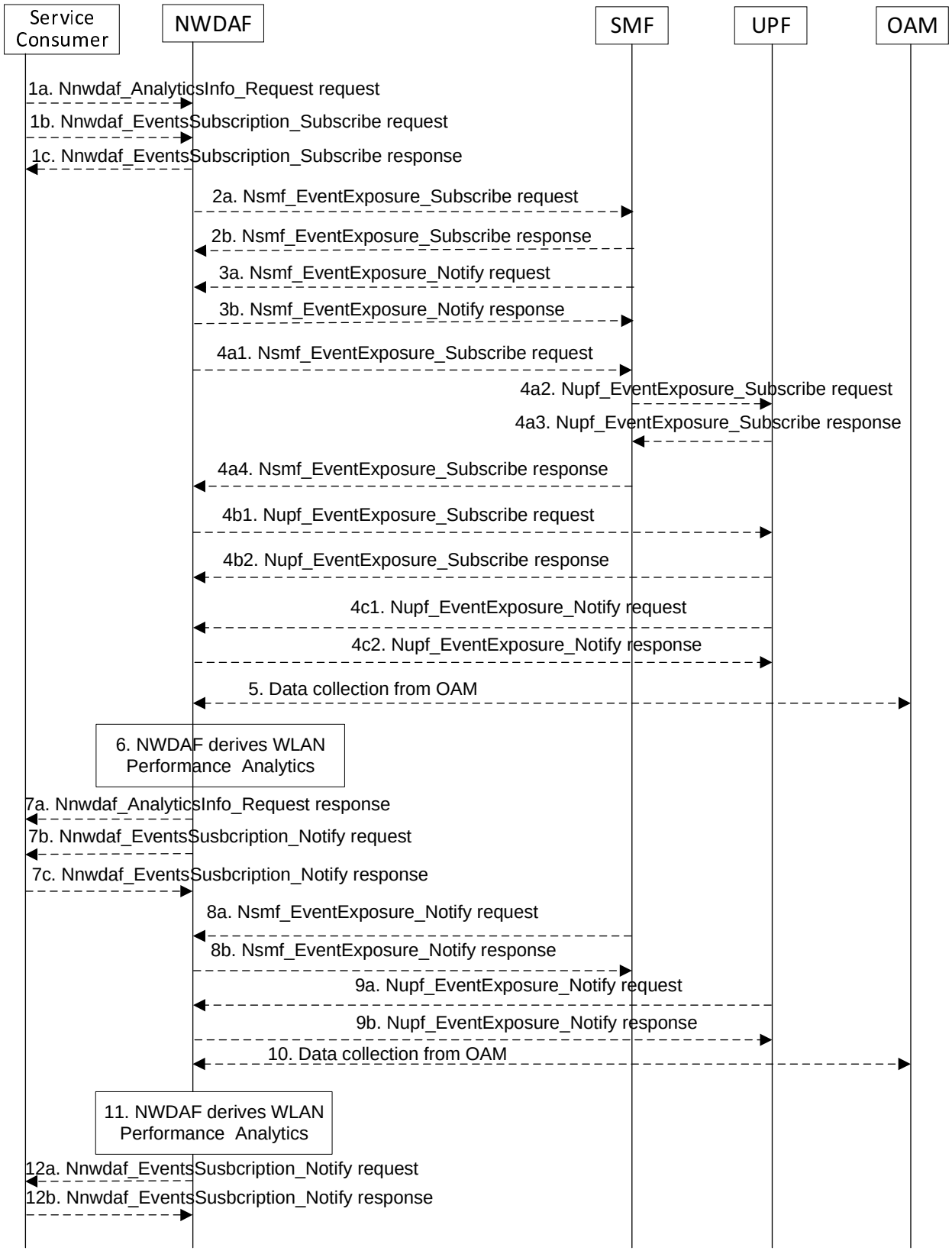

Figure 5.7.13-1: Procedure for WLAN Performance Analytics

1a. In order to obtain the WLAN performance analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "WLAN_PERFORMANCE" with the supported feature "WlanPerformance".

1b-1c. In order to obtain the WLAN performance analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "WLAN_PERFORMANCE" with the supported feature "WlanPerformance".

2a-2b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to the notification of Information on PDU Session for WLAN. The SMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 2a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

4. The NWDAF may subscribe to collect UE communications information for WLAN from the UPF either via the SMF (by performing steps 4a1, 4a2, 4a3, and 4a4, which are the same as steps 3a, 4a, 4b, and 3b of clause 5.7.19) or directly to the UPF (by performing steps 4b1, 4b2, which are the same as steps 5a and 5b of clause 5.7.19). Then, the UPF may invoke the Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 4a1 or step 4b1 and the NWDAF responds to the UPF with an HTTP "204 No Content" response as described in 3GPP TS 29.564 [40].

5. The NWDAF may collect WLAN measurement results from the OAM. The WLAN measurement data from OAM is collected via MDT and aligned with the WLAN measurement reporting list described in clause 5.1.1.3.3 of TS 37.320 [29].

6. The NWDAF calculates the WLAN performance analytics based on the data collected from SMF, UPF and/or OAM.

7a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

7b-7c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

8a-8b. The same as step 3a and step 3b.

9a-9b. The same as step 4c1and step 6c2.

10. The same as step 5.

11. The same as step 6.

12a-12b. The same as step 7b and step 7c.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.14 Session Management Congestion Control Experience Analytics

This procedure is used by the NWDAF service consumer e.g. SMF to obtain the Session Management Congestion Control Experience Analytics which are calculated by the NWDAF based on the information collected from the SMF.

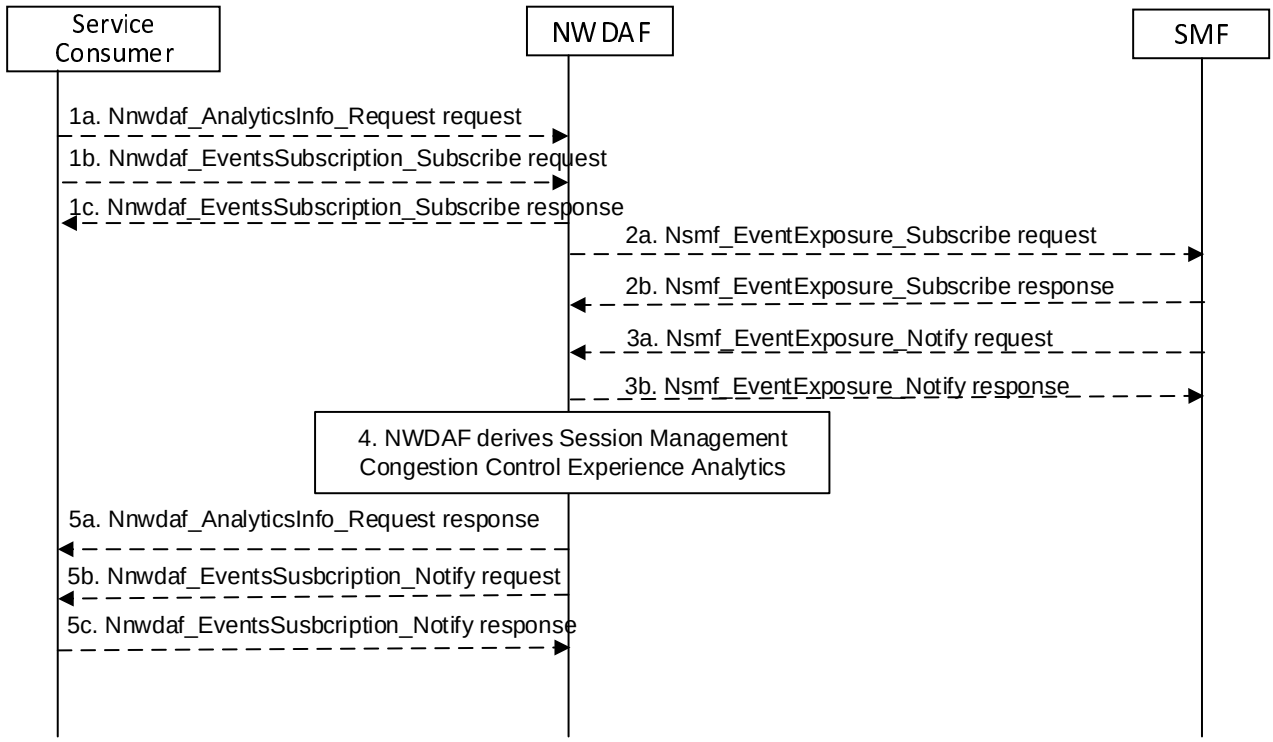

Figure 5.7.14-1: Procedure for Session Management Congestion Control Experience Analytics

1a. In order to obtain the SMCCE (Session Management Congestion Control Experience) analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "SM_CONGESTION" with the supported feature "SMCCE".

1b-1c. In order to obtain the SMCCE (Session Management Congestion Control Experience) analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "SM_CONGESTION" with the supported feature "SMCCE".

2a-2b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to the notification of Information on UE ID and SMCC experience for PDU Session. The SMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 2a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

4. The NWDAF calculates the Session Management Congestion Control Experience analytics based on the data collected from SMF.

5a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

5b-5c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify and Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.15 Redundant Transmission Experience Analytics

This procedure is used by the NWDAF service consumer (may be an NF e.g. SMF) to obtain the Redundant Transmission Experience Analytics which are calculated by the NWDAF based on the information collected from the AMF, AF, SMF, UPF OAM and/or MDAF.

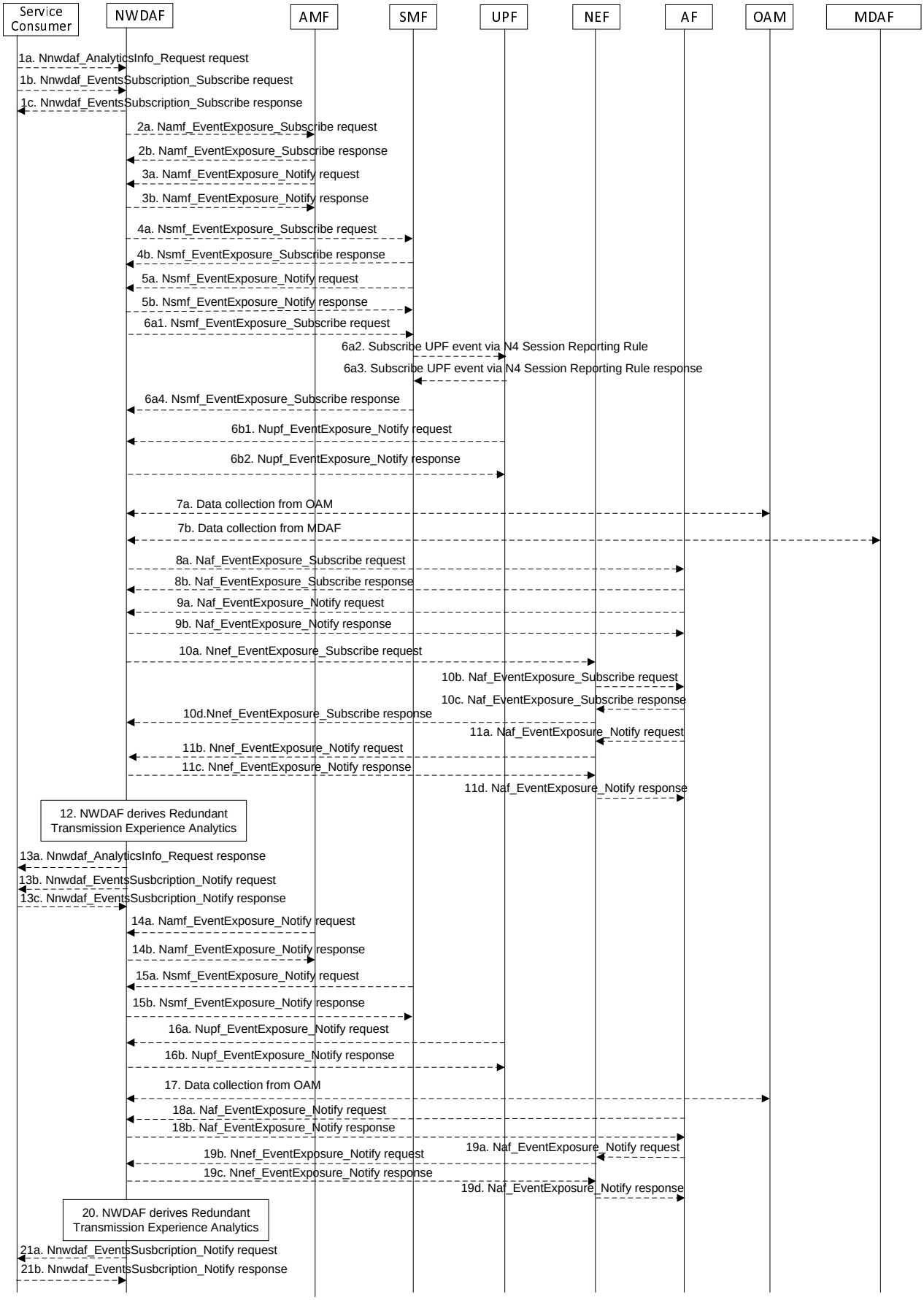

Figure 5.7.15-1: Procedure for Redundant Transmission Experience Analytics

1a. In order to obtain the Redundant Transmission Experience Analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "RED_TRANS_EXP" with the supported feature "RedundantTransmissionExp".

1b-1c. In order to obtain the Redundant Transmission Experience Analytics, the NWDAF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "RED_TRANS_EXP" with the supported feature "RedundantTransmissionExp".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve the UE Mobility information. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to the notification of Information related to PDU Session established with redundant transmission. The SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

6. The NWDAF may collect data related to packet delay measurement information from UPF via the SMF by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6], the SMF subscribes to the UPF on behalf of the NWDAF via N4 Session Reporting Rule as described in clause 5.2.8 of 3GPP TS 29.244 [45]. Then, the UPF may invoke the Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 6a1 and the NWDAF responds to the UPF with an HTTP "204 No Content" response as described in 3GPP TS 29.564 [40].

7a. The NWDAF may collect "Performance measurement" to the OAM to get the UL/DL packet drop rate on GTP path on N3, UL/DL packet delay measurement on GTP path on N3 and/or UL/DL packet drop/loss rate of RAN part measurement refer to clause 5.1 of TS 28.552 [27] for the performance measurement in NG-RAN.

7b. The NWDAF may collect end-to-end analysis as specified in clause 8.4.2.4.3 of TS 28.104 [38] from MDAF. The information element of the analysis from MDAF include E2ELatencyIssueType and AffectedObjects.

8a-8b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the service data related to UE mobility information. The AF responds to the NWDAF an HTTP "201 Created" response.

9a-9b. If step 8a and step 8b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the AF an HTTP "204 No Content" response.

10a-10d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the service data related to UE mobility information. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

11a-11d. If step 10a to step 10d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 10b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 10a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

12. The NWDAF calculates the Redundant Transmission Experience Analytics based on the data collected from AMF, AF SMF, UPF OAM and/or MDAF.

13a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

13b-13c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

14a-14b. The same as step 3a and step 3b.

15a-15b. The same as step 5a and step 5b.

16a-16b. The same as step 6c1 and step 6c2.

17. The same as step 7.

18a-18b. The same as step 9a and step 9b.

19a-18d. The same as step 11a and step 11d.

20. The same as step 12.

21a-21b. The same as step 13b and step 13c.

NOTE 1: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 2: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 3: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.16 DN Performance Analytics

This procedure is used by the NF to obtain DN performance analytics, which is calculated by the NWDAF based on the information collected from the AMF, SMF, AF, UPF and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

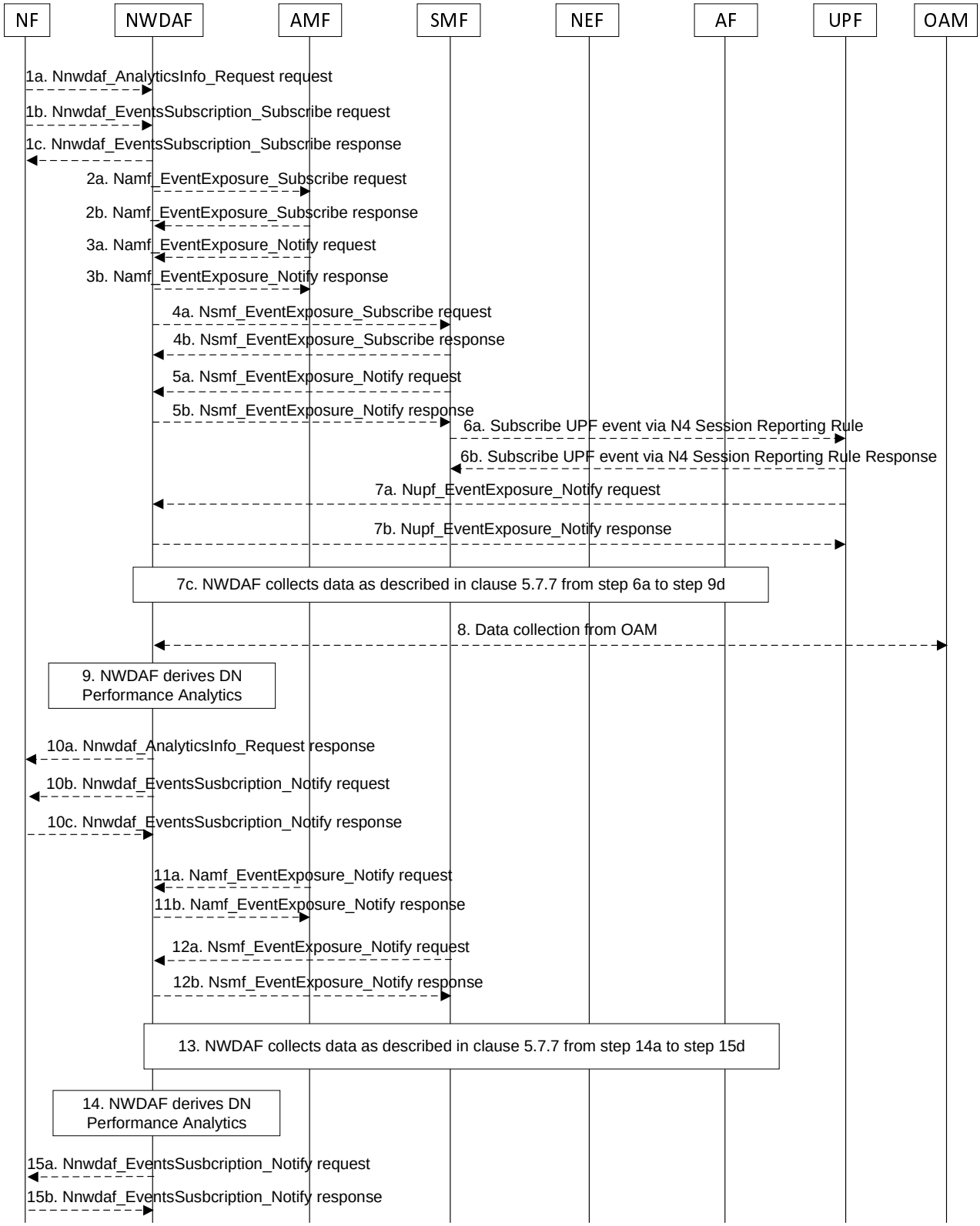

Figure 5.7.16-1: Procedure for DN Performance Analytics

1a. In order to obtain the DN performance analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "DN_PERFORMANCE" with the supported feature "DnPerformance".

1b-1c. In order to obtain the DN performance analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "DN_PERFORMANCE" with the supported feature "DnPerformance".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve the UE location information and SUPI(s) from AMF. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" to subscribe to QFI allocation event. The SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

6a-6b. To collect QoS flow bit rate, QoS flow packet delay, packet transmission and packet retransmission information from UPF, after step 5 was performed, the SMF may subscribe to the UPF on behalf of the NWDAF via N4 Session Reporting Rule as described in clause 5.2.8 of 3GPP TS 29.244 [45].

7a-7b. The UPF invokes Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the UPF an HTTP "204 No Content" response.

7c. The NWDAF may collect performance data from AF as described in clause 5.7.7 from step 6a to step 9d.

8. The NWDAF may collect Reference Signal Received Power and Reference Signal Received Quality as specified in clause 5.5 of TS 38.331 [33] and clause 5.5.5 of TS 36.331 [34], Signal-to-noise and interference ratio as specified in clause 5.1 of TS 38.215 [35], the mapping information between cell ID and frequency and Cell Energy Saving State data as specified in clauses 3.1 and 6.2 of TS 28.310 [36] from OAM.

9. The NWDAF calculates the DN performance analytics based on the data collected from AMF, SMF, AF, UPF and/or OAM.

10a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

10b-10c. If step 1b and step 1c are performed, the NWDAF may invoke Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

11a-11b. The same as step 3a and step 3b.

12a-12b. The same as step 5a and step 5b.

13. The same as step 6.

14. The same as step 9.

15a-15b. The same as step 10b and step 10c.

NOTE 1: For details of N4 Session Reporting Report refer to 3GPP TS 29.244 [45].

NOTE 2: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 3: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.17 PFD Determination Analytics

This procedure is used by the NWDAF service consumer e.g. NEF(PFDF) to obtain PFD determination analytics for the know application(s), which is calculated by the NWDAF based on the information collected from the UPF and the NEF(PFDF).

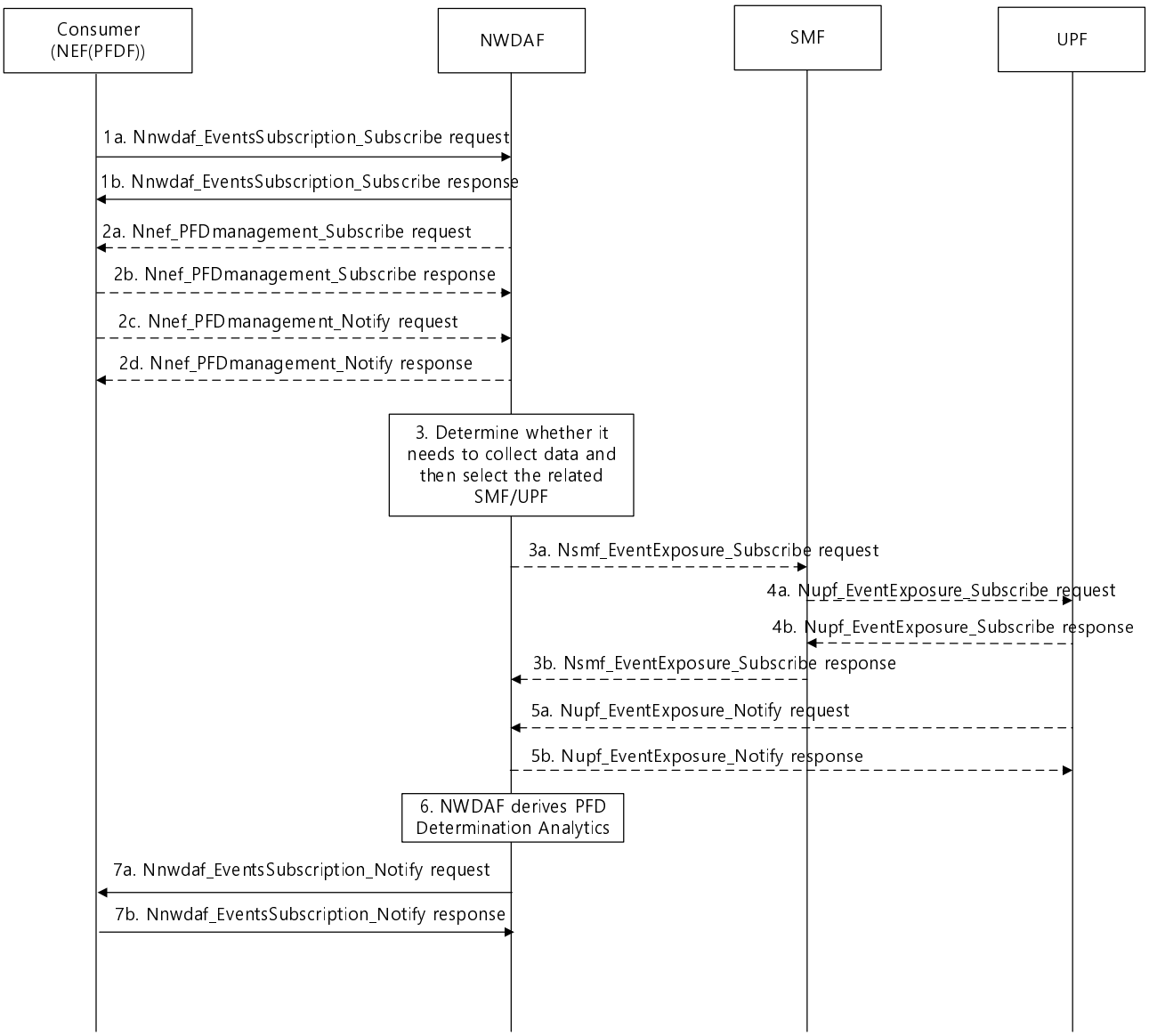

Figure 5.7.17-1: Procedure for PFD Determination Analytics

1a-1b. In order to obtain the PFD determination analytics, the consumer NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "PFD_DETERMINATION" with the supported feature "PfdDetermination".

2a-2b. The NWDAF may invoke Nnef_PFDmanagement_Subscribe service operation as described in clause 4.2.3 of 3GPP TS 29.551 [39] by sending an HTTP POST request targeting the resource "PFD subscriptions" to subscribe to retrieve PFDs for an Application Identifier(s) from the NEF (PFDF). The NEF (PFDF) responds to the NWDAF an HTTP "201 Created" response.

2c-2d. The NEF (PFDF) may invoke Nnef_PFDmanagement_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 2a. The NWDAF responds to the NEF (PFDF) an HTTP "204 No Content" response.

3. The NWDAF determines whether it needs to collect data.

3a-3b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6] to subscribe via the SMF to UPF to retrieve the application traffic flow related information for the application. The SMF responds to the NWDAF an HTTP "201 Created" response after having received HTTP "201 Created" response from the UPF.

4a-4b. The SMF subscribes to the UPF on behalf of the NWDAF by invoking Nupf_EventExposure_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.564 [40] to retrieve the application traffic flow related information from the UPF. The UPF responds to the SMF an HTTP "201 Created" response.

5a-5b. The UPF invokes Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the UPF an HTTP "204 No Content" response.

6. The NWDAF calculates the PFD determination analytics based on the data collected from UPF and NEF (PFDF).

7a-7b. The NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1 containing the PFD determination analytics information in the case that the NWDAF decides the PFD information for the existing Application ID is new or to be updated.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

NOTE 3: For details of Nnef_PFDManagement_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.551 [39].

NOTE 4: For details of Nupf_EventExposure_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.564 [40].

5.7.18 E2E data volume transfer time analytics

This procedure is used by the NWDAF service consumer (may be an NF e.g. AF or NEF) to obtain E2E (end-to-end) data volume transfer time analytics, which is calculated by the NWDAF based on the information collected from the AMF, SMF, UPF, AF, LCS via GMLC and/or OAM. If the NF is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

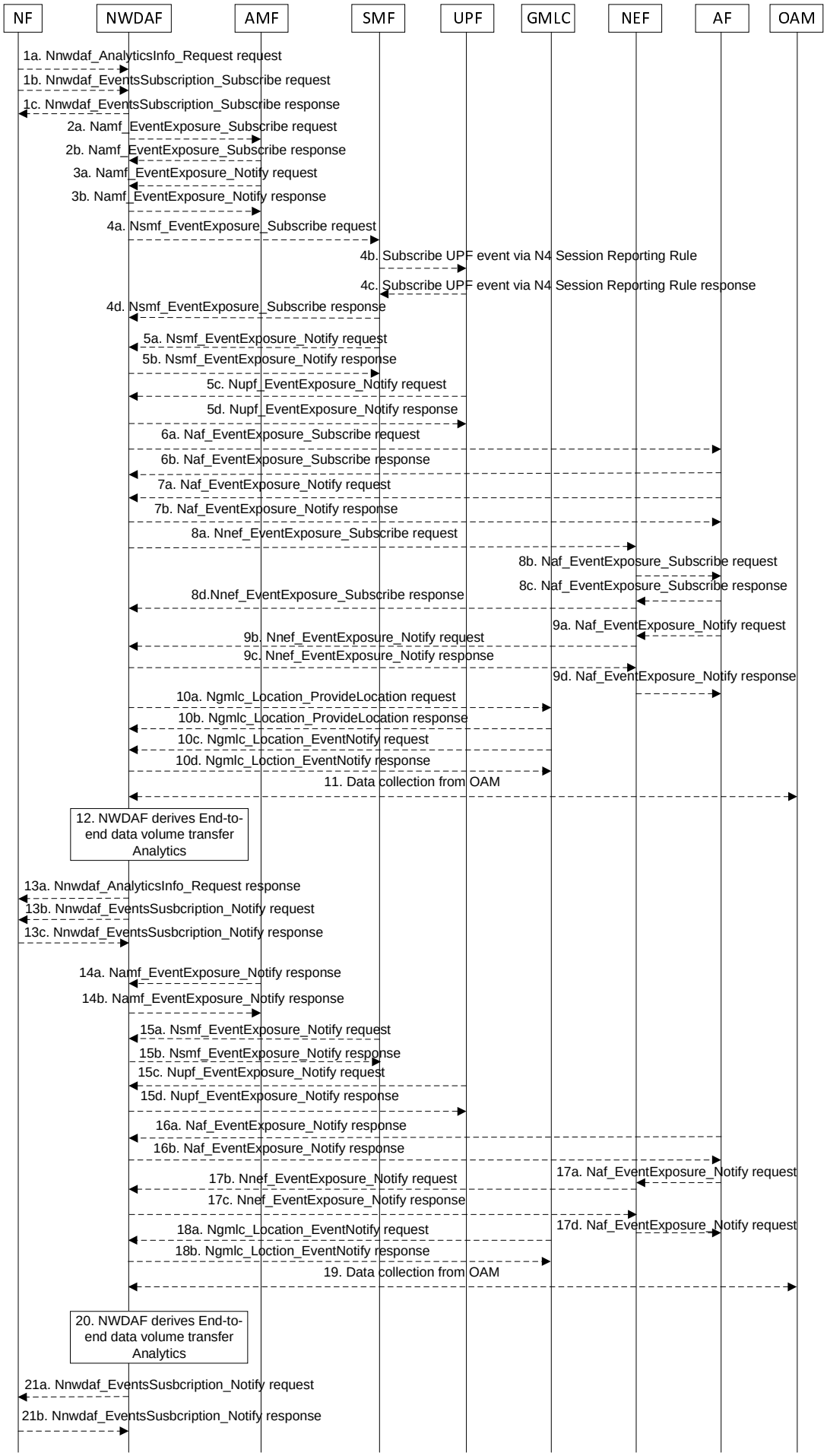
NF
NWDAF
AMF
SMF
UPF
GMLC
NEF
AF
OAM
1a. Nnwdaf_AnalyticsInfo_Request request
1b. Nnwdaf_EventsSubscription_Subscribe request
1c. Nnwdaf_EventsSubscription_Subscribe response
2a. Namf_EventExposure_Subscribe request
2b. Namf_EventExposure_Subscribe response
3a. Namf_EventExposure_Notify request
3b. Namf_EventExposure_Notify response
4a. Nsmf_EventExposure_Subscribe request
4b. Subscribe UPF event via N4 Session Reporting Rule
4c. Subscribe UPF event via N4 Session Reporting Rule response
4d. Nsmf_EventExposure_Subscribe response
5a. Nsmf_EventExposure_Notify request
5b. Nsmf_EventExposure_Notify response
5c. Nupf_EventExposure_Notify request
5d. Nupf_EventExposure_Notify response
6a. Naf_EventExposure_Subscribe request
6b. Naf_EventExposure_Subscribe response
7a. Naf_EventExposure_Notify request
7b. Naf_EventExposure_Notify response
8a. Nnef_EventExposure_Subscribe request
8b. Naf_EventExposure_Subscribe request
8c. Naf_EventExposure_Subscribe response
8d.Nnef_EventExposure_Subscribe response
9a. Naf_EventExposure_Notify request
9b. Nnef_EventExposure_Notify request
9c. Nnef_EventExposure_Notify response
9d. Naf_EventExposure_Notify response
10a. Ngmlc_Location_ProvideLocation request
10b. Ngmlc_Location_ProvideLocation response
10c. Ngmlc_Location_EventNotify request
10d. Ngmlc_Loction_EventNotify response
11. Data collection from OAM
12. NWDAF derives End-to-end data volume transfer Analytics
13a. Nnwdaf_AnalyticsInfo_Request response
13b. Nnwdaf_EventsSusbcription_Notify request
13c. Nnwdaf_EventsSusbcription_Notify response
14a. Namf_EventExposure_Notify response
14b. Namf_EventExposure_Notify response
15a. Nsmf_EventExposure_Notify request
15b. Nsmf_EventExposure_Notify response
15c. Nupf_EventExposure_Notify request
15d. Nupf_EventExposure_Notify response
16a. Naf_EventExposure_Notify response
16b. Naf_EventExposure_Notify response
17a. Naf_EventExposure_Notify request
17b. Nnef_EventExposure_Notify request
17c. Nnef_EventExposure_Notify response
17d. Naf_EventExposure_Notify request
18a. Ngmlc_Location_EventNotify request
18b. Ngmlc_Loction_EventNotify response
19. Data collection from OAM
20. NWDAF derives End-to-end data volume transfer Analytics
21a. Nnwdaf_EventsSusbcription_Notify request
21b. Nnwdaf_EventsSusbcription_Notify response

Figure 5.7.18-1: Procedure for E2E data volume transfer time analytics

1a. In order to obtain the E2E data volume transfer time analytics, the NWDAF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "E2E_DATA_VOL_TRANS_TIME" with the supported feature "E2eDataVolTransTime".

1b-1c. In order to obtain the E2E data volume transfer time analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "E2E_DATA_VOL_TRANS_TIME" with the supported feature "E2eDataVolTransTime".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve the UE location information and SUPI(s) from AMF. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4d. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6], and the SMF may subscribe to the UPF on behalf of the NWDAF via N4 Session Reporting Rule as described in clause 5.2.8 of 3GPP TS 29.244 [45]. After having received the successful response from the UPF, the SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4d are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

5c-5d. If step 4b and step 4c are performed, the UPF may invoke Nupf_EventExposure_Notify service operation as described in 3GPP TS 29.564 [40] by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 4b. The NWDAF responds to the UPF an HTTP "204 No Content" response.

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the End-to-end data volume transfer time information. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the E2E data volume transfer time information. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10a-10b. The NWDAF may invoke Ngmlc_Location_ProvideLocation service operation to retrieve UE Location and UE Location Accuracy by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

10c-10d. If step 10a and step 10b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 10a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

11. The NWDAF may collect RAN part delay for DL and UL per 5QI and S-NSSAI as specified in clauses 6.3.1.2 and 6.3.1.7 of 3GPP TS 28.554 [30], RAN Throughput for DL and UL as specified in clauses 5.2.1.1 and 5.4.1.1 of 3GPP TS 37.320 [29], RAN Packet delay / Packet loss rate for DL and UL per UE including per DRB per UE packet delay / Packet loss rate as specified in clauses 5.4.1.1 of 3GPP TS 37.320 [29], the average of UL/DL packet delay between PSA UPF and UE per S-NSSAI as specified in clauses 5.4.9.1.1 and 5.4.9.2.1 of 3GPP TS 28.552 [27], the average DL/UL UE throughput in the gNB per QoS level (mapped 5QI) and per S-NSSAI as specified in clauses 5.1.1.3.1 and 5.1.1.3.3 of 3GPP TS 28.552 [27], per UE per supported S-NSSAI and per QoS level of RAN part delay, RAN Packet loss rate and average DL/UL UE throughput in gNB as specified in clause 6.3.1 of 3GPP TS 28.558 [45]; per UE per supported S-NSSAI and per QoS level of average UL/DL packet delay between PSA UPF and UE, between PSA UPF and RAN as specified in clause 6.2.2.1 of 3GPP TS 28.558 [46] from OAM.

12. The NWDAF calculates the End-to-end data volume transfer time analytics based on the data collected from AMF, SMF, UPF, AF, LCS via GMLC and/or OAM.

13a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

13b-13c. If step 1b and step 1c are performed, the NWDAF may invoke Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

14a-14b. Follow the same as step 3a and step 3b.

15a-15d. Follow the same as step 5a to step 5d.

16a-16b. Follow the same as step 7a and step 7b.

17a-17d. Follow the same as step 9a to 9d.

18a-18b. Follow the same as step 10c and step 10d.

19. Follow the same as step 11.

20. Follow the same as step 12.

21a-21b. Follow the same as step 13b and step 13c.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 3: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 4: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.7.19 PDU Session Traffic Analytics

This procedure is used by the NWDAF service consumer (e.g. PCF) to subscribe or request PDU Session Traffic analytics on whether traffic of UEs via one or multiple PDU Sessions is according to the information provided by the service consumer or not based on the information collected from the UPF either indirectly via the SMF, or directly from the UPF.

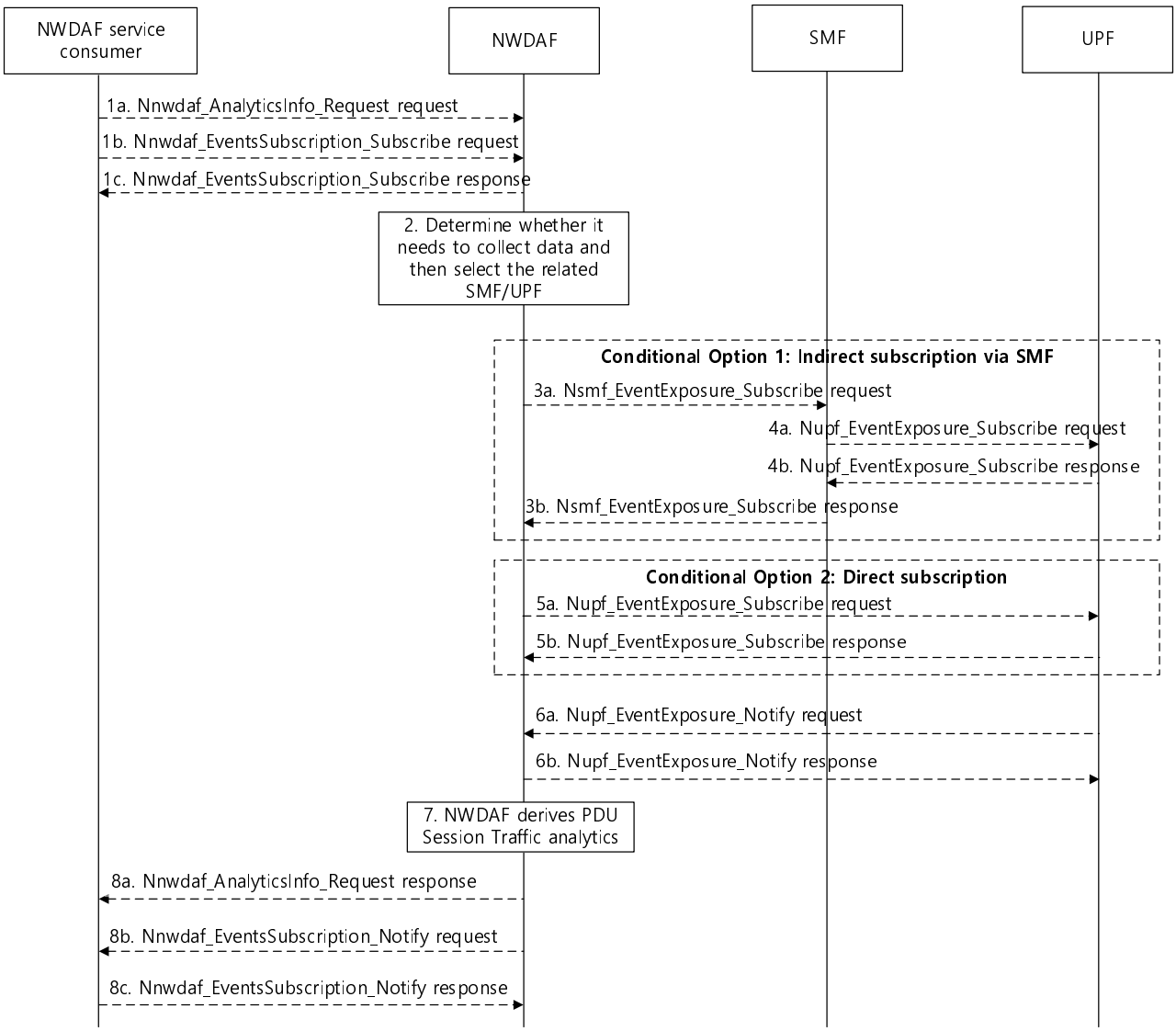

Figure 5.7.19-1: Procedure for PDU Session Traffic Analytics

1a. In order to obtain the PDU Session Traffic analytics, the NWDAF service consumer (e.g. PCF) may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "PDU_SESSION_TRAFFIC" with the supported feature "PduSesTraffic".

1b-1c. In order to obtain the PDU Session Traffic analytics, the NWDAF service consumer (e.g. PCF) may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "PDU_SESSION_TRAFFIC" with the supported feature "PduSesTraffic".

2. The NWDAF determines whether it needs to collect the data and, if needed, it collects the data either directly from the UPF or indirectly via the SMF and identifies the SMF(s) and/or UPF(s) to retrieve the data.

3a-3b. [Conditional Option 1] The NWDAF shall invoke the Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6] to subscribe via the SMF to UPF to retrieve "UserDataUsageMeasures" UPF event. The SMF responds to the NWDAF an HTTP "201 Created" response after having received HTTP "201 Created" response from the UPF.

4a-4b. The SMF subscribes to the UPF on behalf of the NWDAF by invoking Nupf_EventExposure_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.564 [40] to retrieve "USER_DATA_USAGE_MEASURES" UPF event from the UPF. The UPF responds to the SMF an HTTP "201 Created" response.

5a-5b. [Conditional Option 2] The NWDAF may directly invoke the Nupf_EventExposure_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.564 [40] to retrieve "USER_DATA_USAGE_MEASURES" UPF event from the UPF. The UPF responds to the NWDAF an HTTP "201 Created" response.

NOTE 1: The conditions for subscribing to UPF events directly at the UPF or via the SMF, i.e., the conditions for invoking step 3 or step 5 are described in 3GPP TS 29.564 [40].

6a-6b. The UPF invokes Nupf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a or step 5a. The NWDAF responds to the UPF an HTTP "204 No Content" response.

7. The NWDAF derives analytics indicating a list of UEs and their detected traffic that is matched according to the information provided by the consumer (i.e. Traffic Descriptor, S-NSSAI and DNN), including its volume and a list of UEs and their detected traffic that it is not matched according to the information provided by the consumer (i.e. Traffic Descriptor, S-NSSAI and DNN) including its volume.

8a. If step 1a is performed, the NWDAF sends the Nnwdaf_AnalyticsInfo_Request response containing the PDU Session Traffic analytics as described in clause 5.2.3.1.

8b-8c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation containing the PDU Session Traffic analytics as described in clause 5.2.2.1.

NOTE 2: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

NOTE 3: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

5.7.20 Relative Proximity Analytics

This procedure is used by the NWDAF service consumer e.g. NEF or AF to obtain Relative Proximity Analytics among UEs provided by NWDAF to assist more accurately localize a cluster (or a set) of UEs via provisioning statistics and/or prediction information related to their relative proximity based on the information collected from the AMF, GMLC, AF and/or OAM. If the NWDAF service consumer is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

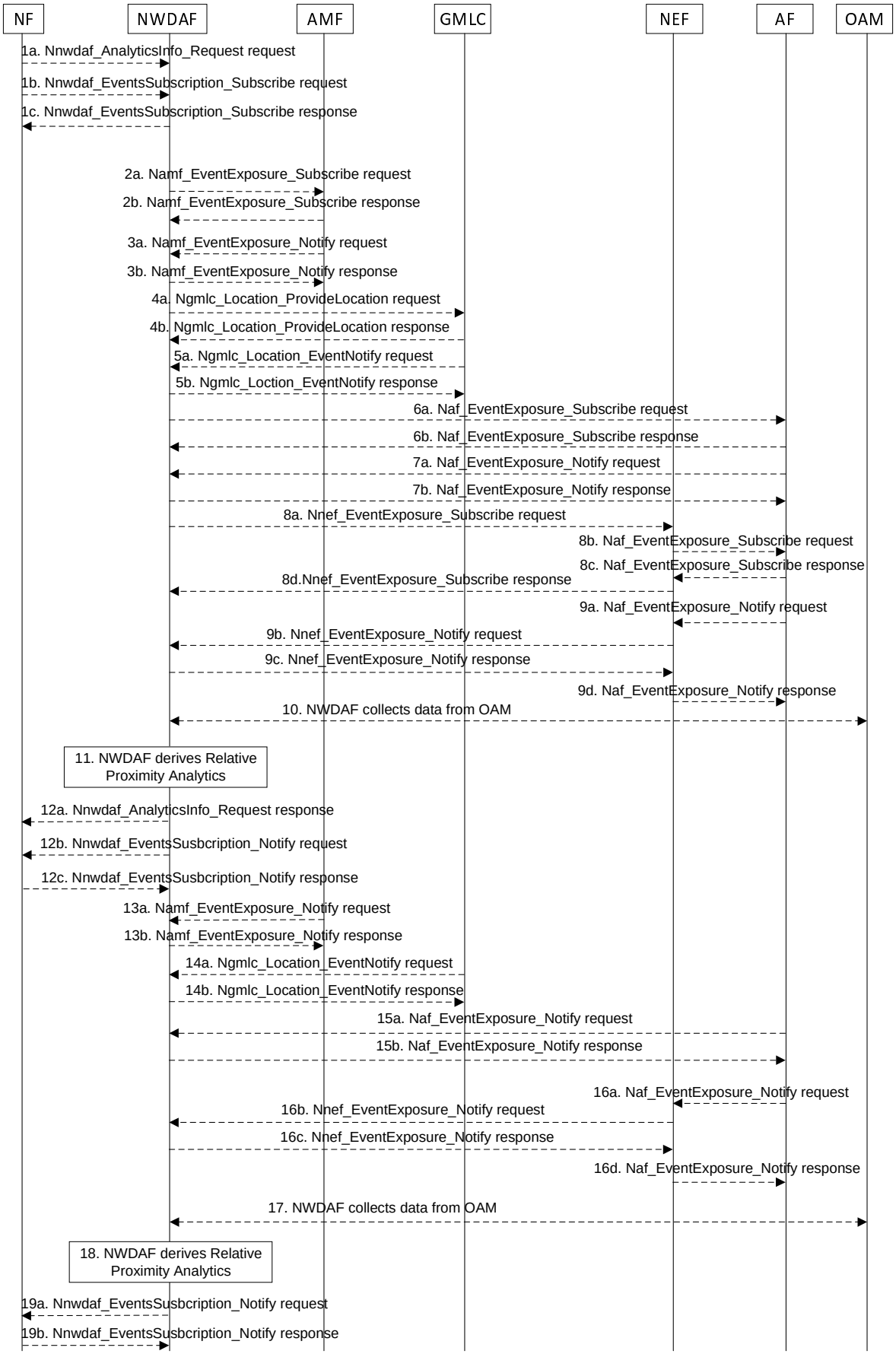

Figure 5.7.20-1: Procedure for Relative Proximity Analytics

1a. In order to obtain the Relative Proximity Analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to subscribe to the Relative Proximity Analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a-2b. If the event is set to "RELATIVE_PROXIMITY" and the subscription/request is authorized, the NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to subscribe to the notification of UE ID and UE location. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Ngmlc_Location_ProvideLocation service operation to retrieve UE Location and UE Location Accuracy by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

5a-5b. If step 4a and step 4b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to subscribe the Proximity attributes and/or Proximity related input data of UE(s) from AF directly. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10. The NWDAF may collect Per UE information of Speed and Orientation related input data as specified in clause 4.3.30 of TS 28.622 [42], clause 11.1 of TS 28.532 [19] and clause 5.10.29 of TS 32.422 [43].

11. The NWDAF derives the Relative Proximity Analytics based on the data collected from AMF, GMLC, (DC)AF, and/or OAM.

12a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

12b-12c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

13a-13b. The same as step 3a and step 3b.

14a-14b. The same as step 5a and step 5b.

15a-15b. The same as step 7a and step 7b.

16a-16d. The same as step 9a and step 9b.

17. The same as step 10.

18. The same as step 11.

19a-19b. The same as step 12b and step 12c.

NOTE 1: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

NOTE 2: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 3: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

5.7.21 Movement Behaviour Analytics

This procedure is used by the NWDAF service consumer e.g. NEF or AF to obtain Movement Behaviour Analytics provided by NWDAF regarding the location, direction and velocity of UEs during an analytics target period in a target area. If the NWDAF service consumer is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

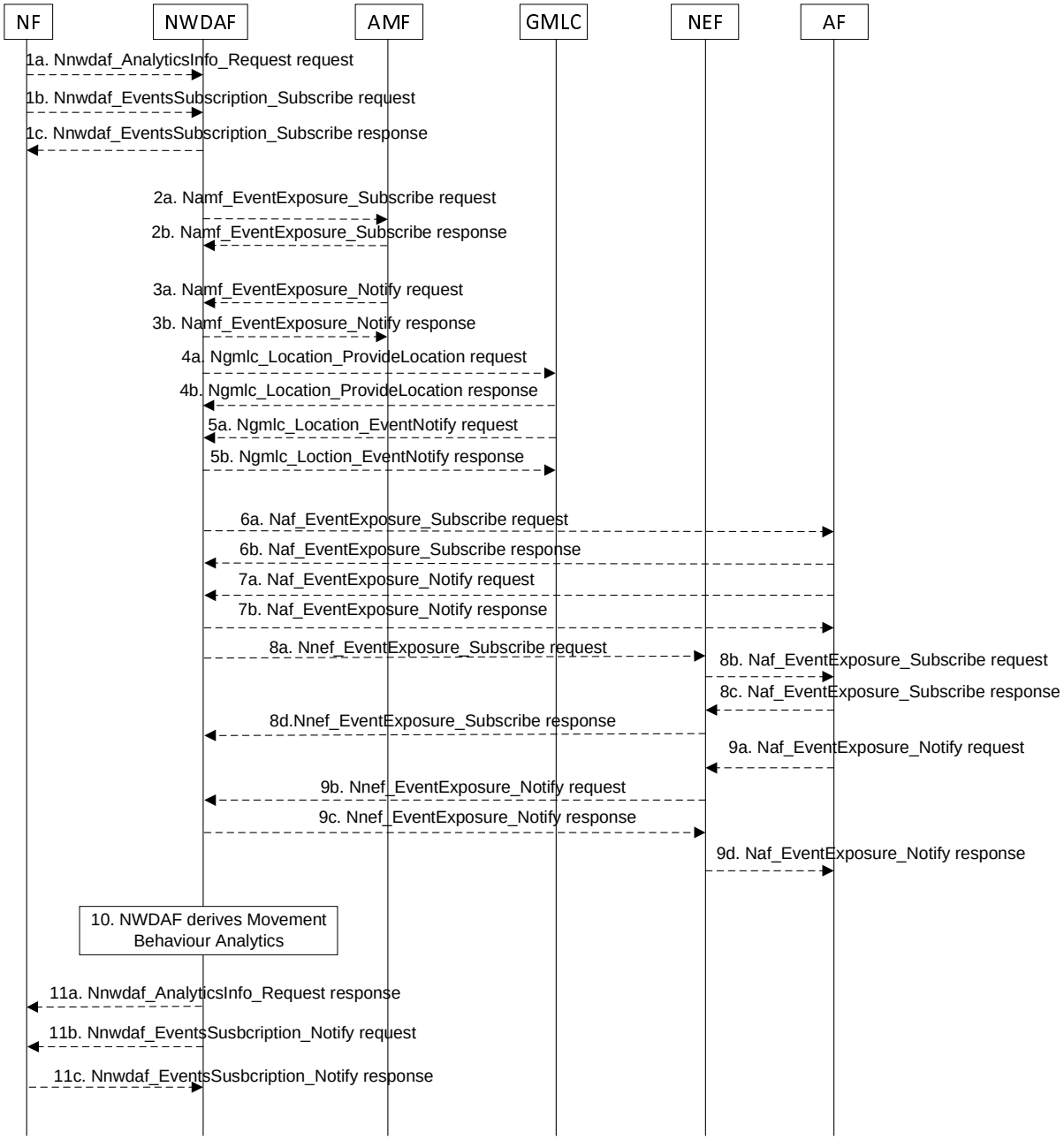

Figure 5.7.21-1: Procedure for Movement Behaviour Analytics

1a. In order to obtain the Movement Behaviour Analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to subscribe to the Movement Behaviour Analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a-2b. If the event is set to "MOVEMENT_BEHAVIOUR" and the subscription/request is authorized, the NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to subscribe to the notification of UE ID and UE positions. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Ngmlc_Location_ProvideLocation service operation to retrieve UE Fine granularity locations by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

5a-5b. If step 4a and step 4b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to request the altitude information of the UAV UE from AF directly. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10. The NWDAF derives the Movement Behaviour Analytics based on the data collected from AMF and/or GMLC.

11a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

11b-11c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

NOTE 1: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

NOTE 2: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 3: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

5.7.22 Location Accuracy Analytics

This procedure is used by the NWDAF service consumer e.g. LMF to obtain Location Accuracy Analytics provided by NWDAF based on the information collected from the AMF, LCS via GMLC and/or AF. If the service consumer NF is an untrusted AF, it will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

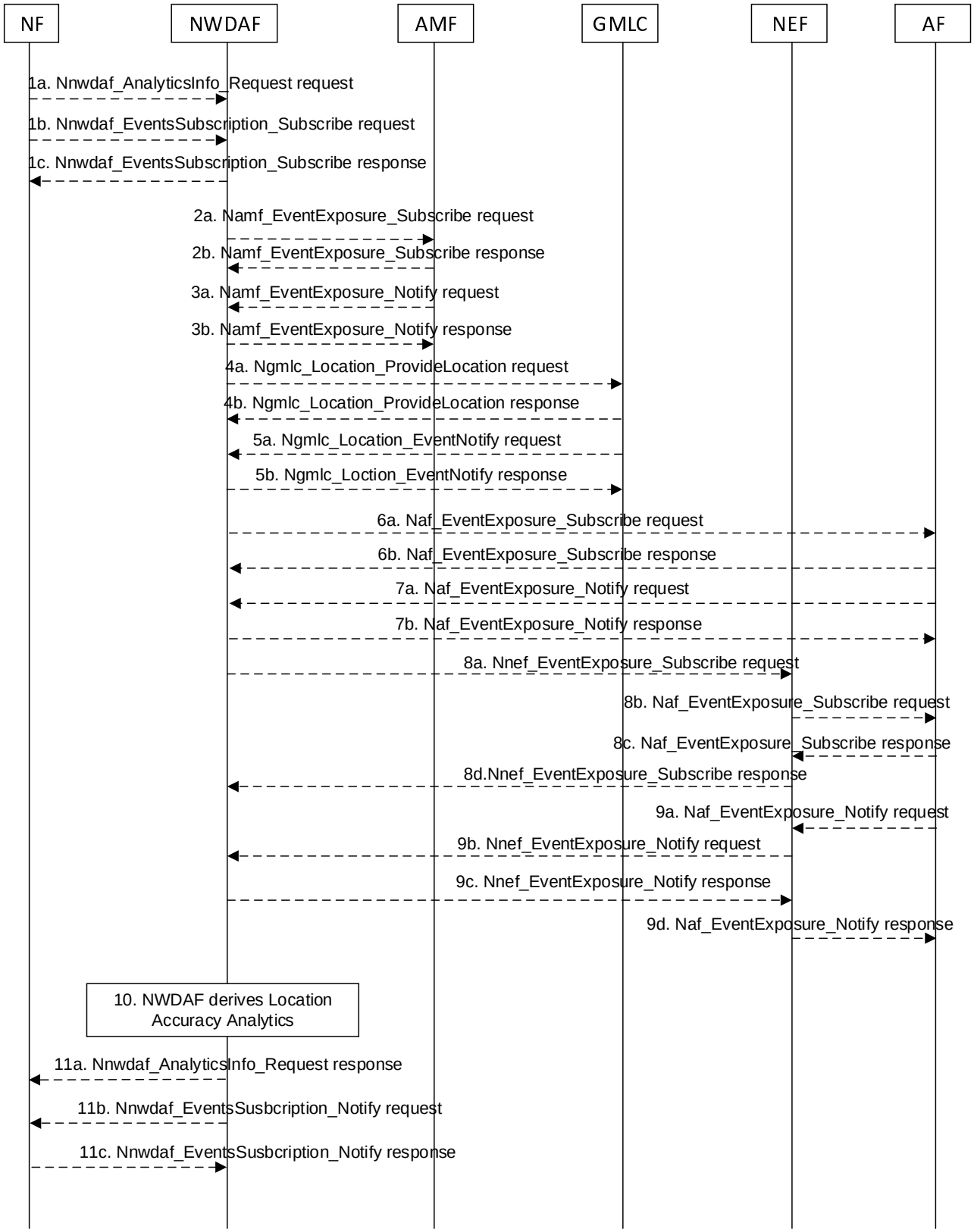

Figure 5.7.22-1: Procedure for Location Accuracy Analytics

Pre-condition: The NWDAF has a trained supervised ML Model for predicting the location accuracy. In the training phase, the NWDAF consumes input data as define in 3GPP TS 29.520 [5]. To pre-train the ML Model, the NWDAF may collect input data based on area of interest (AoI) which is determined by the NWDAF.

1a. In order to obtain the Location Accuracy Analytics, the NF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

1b-1c. In order to subscribe to the Location Accuracy Analytics, the NF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1.

2a-2b. If the event is set to "LOC_ACCURACY" and the subscription/request is authorized, the NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to subscribe to the notification of UE IDs with AoI as filtering criteria. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Ngmlc_Location_ProvideLocation service operation to retrieve UE location information by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

5a-5b. If step 4a and step 4b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to request the ground truth UE location information from AF directly. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions". The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10. The NWDAF derives the Location Accuracy Analytics based on the data collected from AMF and/or GMLC.

11. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

12. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

NOTE 1: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

NOTE 2: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 3: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

5.7.23 Signalling Storm Analytics

This procedure is used by the NWDAF service consumer to obtain Signalling Storm Analytics provided by NWDAF based on the information collected from AMF, SMF, PCF, NRF, AF, OAM, SCP and/or MDAF. If the NWDAF service

consumer is an AF which is untrusted, the AF will obtain analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

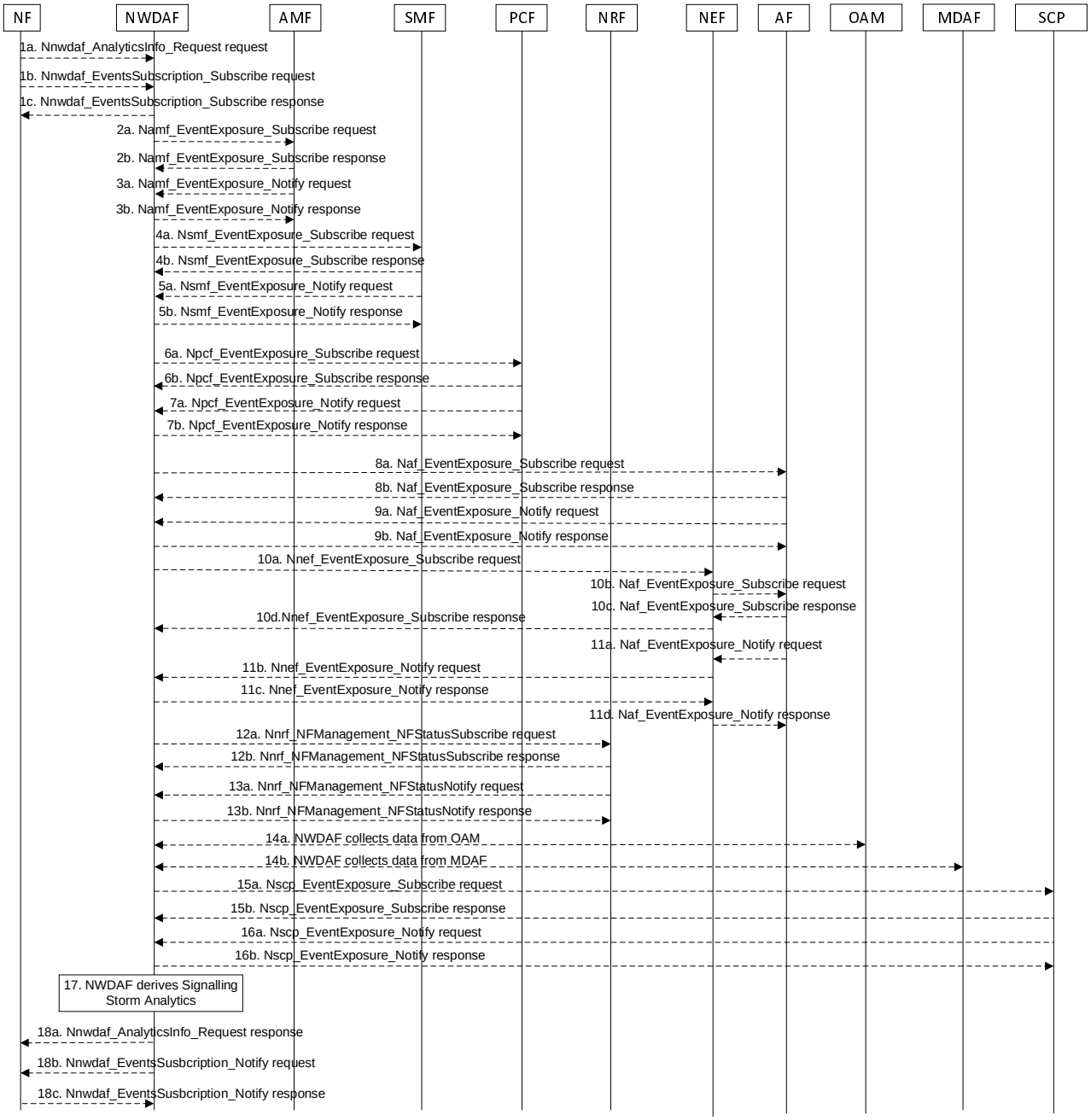

Figure 5.7.23-1: Procedure for Signalling Storm Analytics

1a. In order to obtain the Signalling Storm analytics, the NF may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "SIGNALLING_STORM" with the supported feature "SignallingStorm".

1b-1c. In order to obtain the Signalling Storm analytics, the NF may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "SIGNALLING_STORM" with the supported feature "SignallingStorm".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to subscribe to the notification of signalling information from the AMF. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF invokes Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4b. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation to subscribe to the notification of signalling information from the SMF. The SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4b are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

6a-6b. The NWDAF may invoke Npcf_EventExposure_Subscribe service operation to subscribe to the notification of signalling information from the PCF. The PCF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the PCF may invoke Npcf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the PCF an HTTP "204 No Content" response.

8a-8b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to subscribe to the notification of signalling information from the AF directly. The AF responds to the NWDAF an HTTP "201 Created" response.

9a-9b. If step 8a and step 8b are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the AF an HTTP "204 No Content" response.

10a-10d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF and then the NEF invokes Naf_EventExposure_Subscribe service operation to subscribe to the notification of signalling information from the AF via the NEF. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

11a-11d. If step 10a to step 10d are performed, the AF may invoke Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 10b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 10a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

12a-12b. The NWDAF may invoke Nnrf_NFManagement_NFStatusSubscribe service operation as described in clause 5.2.2.5 of 3GPP TS 29.510 [26] to subscribe to the notification of signalling information from the NRF. The NRF responds to the NWDAF an HTTP "201 Created" response.

13a-13b. If step 12a and step 12b are performed, the NRF may invoke Nnrf_NFManagement_NFStatusNotify service operation as described in clause 5.2.2.6 of 3GPP TS 29.510 [26]. The NWDAF responds to the NRF an HTTP "204 No Content" response.

14a. The NWDAF may collect Number of NF service registration requests, Number of NF service update requests and Number of NF discovery requests including successful and/or failed requests as specified in clause 5.10 of TS 28.552 [27] from OAM. The NWDAF may also collect NF load status information, capacity and priority information of NFs and NF Services from OAM if not available in NRF, and/or unexpected operational status occurs indication based on thresholds or rules configured by operator at the OAM.

14b. The NWDAF may collect control plane congestion analysis as specified in clause 8.4.7.1.3.3 of TS 28.104 [38] from MDAF. The information elements of the control plane congestion analysis include affectedObject and cPCongestionIssueID. The NWDAF may also collect failure prediction analysis as specified in clause 8.4.3.1.3 of TS 28.104 [38] from MDAF. The information elements of the failure prediction analysis include failurePrecictionObject, potentialFailureType, eventTime, issueID and perceivedSeverity.

15a-15b. The NWDAF may invoke Nscp_EventExposure_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.570 [52] to subscribe to the notification of SCP Signalling Information from the SCP. The SCP responds to the NWDAF an HTTP "201 Created" response.

16a-16b. If step 15a and step 15b are performed, the SCP invokes Nscp_EventExposure_Notify service operation as described in clause 5.2.2.4 of 3GPP TS 29.570 [52]. The NWDAF responds to the SCP an HTTP "204 No Content" response.

17. The NWDAF calculates the Signalling Storm analytics based on the data collected from AMF, SMF, PCF, NRF, AF, OAM, SCP and/or MDAF.

18a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

18b-18c. If step 1b and step 1c are performed, the NWDAF invokes Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

NOTE 1: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

NOTE 2: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 3: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 4: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 5: For details of Npcf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.523 [51].

5.7.24 QoS and Policy Assistance Analytics

This procedure is used by the NWDAF service consumer to obtain QoS and Policy Assistance Analytics provided by NWDAF based on the information collected from AMF, SMF, UPF, AF, GMLC and/or OAM. The known service consumer is PCF. If the NWDAF service consumer is an AF which is untrusted, the AF will request analytics via the NEF as described in clause 5.2.2.2 and clause 5.2.3.2.

- The input data defined for Observed Service Experience analytics as defined in clause 5.7.3 might be reused by QoS and Policy Assistance Analytics.

- The input data collected from the OAM for Network Performance analytics as defined in clause 5.7.5, e.g. the RAN status, load and performance per Cell Id for the traffic type of interest and in the Area of Interest.

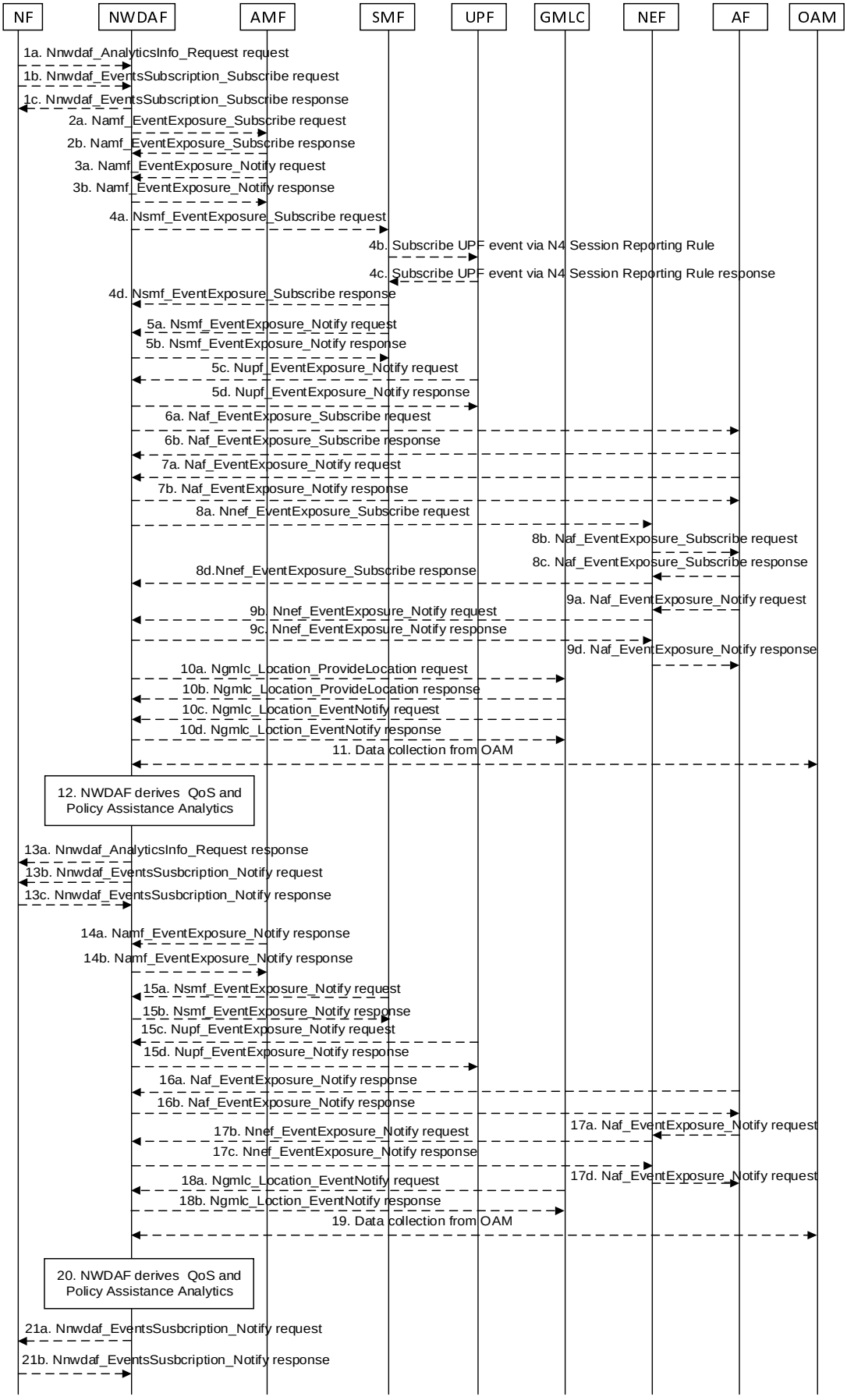

Figure 5.7.24-1: Procedure for QoS and Policy Assistance Analytics

1a. In order to obtain the QoS and Policy Assistance analytics, the NF service consumer may invoke Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1, the requested event is set to "QOS_POLICY_ASSISTANCE" with the supported feature "QoSPolicyAssist".

1b-1c. In order to obtain the QoS and Policy Assistance analytics, the NF service consumer may invoke Nnwdaf_EventsSubscription_Subscribe service operation as described in clause 5.2.2.1, the subscribed event is set to "QOS_POLICY_ASSISTANCE" with the supported feature "QoSPolicyAssist".

2a-2b. The NWDAF may invoke Namf_EventExposure_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.518 [18] to retrieve the UE location information and SUPI(s) from AMF. The AMF responds to the NWDAF an HTTP "201 Created" response.

3a-3b. If step 2a and step 2b are performed, the AMF may invoke Namf_EventExposure_Notify service operation as described in 3GPP TS 29.518 [18] clause 5.3.2.4. The NWDAF responds to the AMF an HTTP "204 No Content" response.

4a-4d. The NWDAF may invoke Nsmf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "SMF Notification Subscriptions" as described in 3GPP TS 29.508 [6], and the SMF may subscribe to the UPF on behalf of the NWDAF via N4 Session Reporting Rule as described in clause 5.2.8 of 3GPP TS 29.244 [45]. After having received the successful response from the UPF, the SMF responds to the NWDAF an HTTP "201 Created" response.

5a-5b. If step 4a and step 4d are performed, the SMF may invoke Nsmf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 4a. The NWDAF responds to the SMF an HTTP "204 No Content" response.

5c-5d. If step 4b and step 4c are performed, the UPF may invoke Nupf_EventExposure_Notify service operation as described in 3GPP TS 29.564 [40] by sending an HTTP POST request to the NWDAF identified by the notification URI provided in step 4b. The NWDAF responds to the UPF an HTTP "204 No Content" response.

6a-6b. If the AF is trusted, the NWDAF may invoke Naf_EventExposure_Subscribe service operation to the AF directly by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the End-to-end data volume transfer time information. The AF responds to the NWDAF an HTTP "201 Created" response.

7a-7b. If step 6a and step 6b are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 6a. The NWDAF responds to the AF an HTTP "204 No Content" response.

8a-8d. If the AF is untrusted, the NWDAF may invoke Nnef_EventExposure_Subscribe service operation to the NEF by sending an HTTP POST request targeting the resource "Network Exposure Event Subscriptions" and then the NEF invokes Naf_EventExposure_Subscribe service operation by sending an HTTP POST request targeting the resource "Application Event Subscriptions" to collect the E2E data volume transfer time information. The AF responds to the NEF an HTTP "201 Created" response and then the NEF responds to the NWDAF an HTTP "201 Created" response.

9a-9d. If step 8a to step 8d are performed, the AF invokes Naf_EventExposure_Notify service operation by sending an HTTP POST request to the NEF identified by the notification URI received in step 8b and the NEF invokes Nnef_EventExposure_Notify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 8a. The NWDAF responds to the NEF an HTTP "204 No Content" response and then the NEF responds to the AF an HTTP "204 No Content" response.

10a-10b. The NWDAF may invoke Ngmlc_Location_ProvideLocation service operation to retrieve UE Location and UE Location Accuracy by sending an HTTP POST request to the URI associated with the "provide-location" custom operation as described in 3GPP TS 29.515 [41] clause 5.2.2.2. The GMLC responds to the NWDAF an HTTP "200 OK" response.

10c-10d. If step 10a and step 10b are performed, the GMLC may invoke Ngmlc_Location_EventNotify service operation by sending an HTTP POST request to the NWDAF identified by the notification URI received in step 10a. The NWDAF responds to the GMLC an HTTP "204 No Content" response.

11. The NWDAF may collect the UL/DL GTP packet delay as defined in clause 5.4.7 of TS 28.552 [27] and Delay in RAN as defined in clause 5.1.1.1 of TS 28.552 [27] from OAM.

12. The NWDAF calculates the QoS and Policy Assistance Analytics based on the data collected from AMF, SMF, UPF, GMLC, AF and/or OAM.

13a. If step 1a is performed, the NWDAF responds to the Nnwdaf_AnalyticsInfo_Request service operation as described in clause 5.2.3.1.

13b-13c. If step 1b and step 1c are performed, the NWDAF may invoke Nnwdaf_EventsSusbcription_Notify service operation as described in clause 5.2.2.1.

14a-14b. The same as step 3a and step 3b.

15a-15d. The same as step 5a to step 5d.

16a-16b. The same as step 7a and step 7b.

17a-17d. The same as step 9a to 9d.

18a-18b. The same as step 10c and step 10d.

19. The same as step 11.

20. The same as step 12.

21a-21b. The same as step 13b and step 13c.

NOTE 1: For details of Nsmf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.508 [6].

NOTE 2: For details of Naf_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.517 [12].

NOTE 3: For details of Nnef_EventExposure_Subscribe/Notify service operations refer to 3GPP TS 29.591 [11].

NOTE 4: For details of Nnwdaf_EventsSubscription_Subscribe/Unsubscribe/Notify or Nnwdaf_AnalyticsInfo_Request service operations refer to 3GPP TS 29.520 [5].

5.8 Procedures for NWDAF Discovery and Selection

5.8.1 General

The NWDAF may be deployed in multiple configuration options. Not all these configurations require the same registration, discovery and selection procedures. The discovery and selection may depend on the NWDAF deployment option and the types of analytics (i.e., whether it is related to Network Functions or to UEs) and ML models it supports, or the data that it is able to collect from NFs.

5.8.2 Procedures related to NRF

5.8.2.1 General

5.8.2.2 NWDAF (De-)Registration in NRF

NWDAF (de-)registers in NRF as a regular network function. See TS 29.510 [23] for details.

5.8.2.3 Discovery and selection of NF or AF for analytics in NRF

A consumer of analytics services may use the NRF for discovering NF involved in analytics procedures (e.g. an NWDAF containing AnLF and/or MTLF, a DCCF, an ADRF, an AF with VFL capabilities, etc.).

If the NWDAF service consumer needs to discover an NF or AF with certain features or capabilities (e.g., NWDAF containing AnLF and/or MTLF, NWDAF containing MTLF that support HFL and/or VFL, AF that support VFL, etc.), the consumer may query NRF with the Nnrf_NFDiscovery_NFDiscover service operation. See 3GPP TS 29.510 [23] for details. Further requirements about NWDAF discovery and selection are provided in clause 5.2 of

3GPP TS 23.288 [2]. Further requirements about AF discovery and selection are provided in clause 5.5 of 3GPP TS 23.288 [2].

In the roaming architecture, a consumer in the same PLMN as the RE-NWDAF discovers the RE-NWDAF by querying for an NWDAF where the roaming exchange capability is indicated in its NRF profile. A consumer in a peer PLMN (i.e. RE-NWDAF) discovers the RE-NWDAF by querying for an NWDAF in the target PLMN that is supporting the specific services defined for roaming. A RE-NWDAF discovers the RE-NWDAF in a different PLMN (i.e. HPLMN or VPLMN) using the procedure defined in clause 4.17.5 (if delegated discovery is not used) or clause 4.17.10 (if delegated discovery is used) of TS 23.502 [3], where the detailed parameters are determined based on the analytics request or subscription from the consumer 5GC NF, operator policy, user consent and/or local configuration. See 3GPP TS 29.510 [23] for details.

5.8.3 Procedures related to UDM

5.8.3.1 General

5.8.3.2 NWDAF containing AnLF Registration/Deregistration in UDM

5.8.3.2.1 NWDAF containing AnLF Registration in UDM

For UE-related analytics or for analytics that involve UE-related data collection, an NWDAF containing AnLF may register in UDM using the Nudm_UECM_Register service operation (see TS 29.503 [22] clause 5.3.2.2.8). This is useful especially in scenarios of co-location of the NWDAF containing AnLF with other network functions (e.g., AMF, SMF) and in certain deployment models. Figure 5.8.3.2.1-1 illustrates the signalling flow.

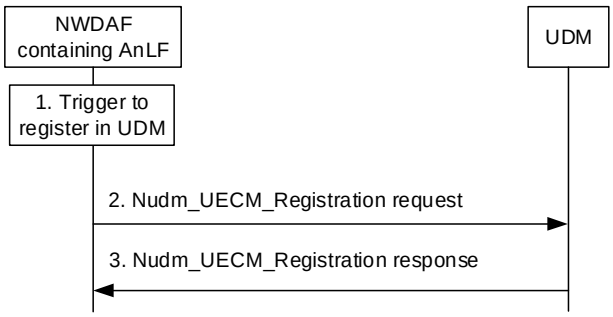

Figure 5.8.3.2.1-1: NWDAF containing AnLF registration in UDM

1. NWDAF containing AnLF triggers a registration in UDM, e.g. based on local configuration in the NWDAF containing AnLF, the reception of a new Analytics subscription request, start of collection of UE related data or an OAM configuration action.

2. The NWDAF containing AnLF registers into UDM for the served UE, by sending Nudm_UECM_Registration request (UE ID of the served user, NWDAF Instance ID, NF Set ID, Analytics ID(s)).

3. UDM sends a response to NWDAF containing AnLF. A successful response consists of a "200 OK" or "201 Created". If the operation is unsuccessful, UDM responds with proper error response code. See TS 29.503 [22] for details.

5.8.3.2.2 NWDAF containing AnLF Update of Registration in UDM

If an NWDAF containing AnLF has previously registered in UDM for one or more analytics IDs for a given UE, the NWDAF containing AnLF may modify the registration at any time. This may be due to, e.g., the NWDAF containing AnLF adds one or more Analytic IDs for the UE, or the NWDAF containing AnLF removes one or more Analytics IDs, but keep registered in UDM for at least one Analytic ID. The NWDAF containing AnLF sends an Nudm_UECM_Update service operation (NWDAF registration ID, added or removed Analytics ID(s)), see TS 29.503 [22] clause 5.3.2.6.4. Figure 5.8.3.2.2-1 illustrates the signalling flow.

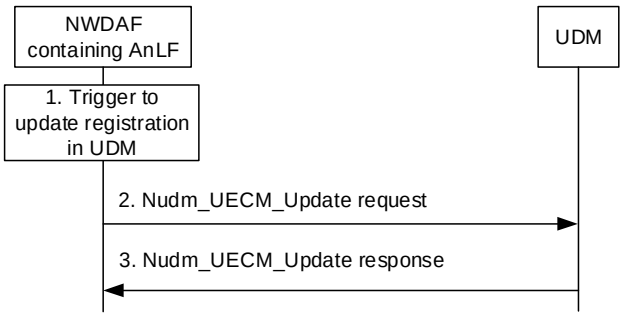

Figure 5.8.3.2.2-1: NWDAF containing AnLF registration update in UDM

1. If an NWDAF containing AnLF has previously registered one or more Analytics IDs for a UE in UDM, the NWDAF containing AnLF triggers an update of the registration in UDM, e.g. based on the NWDAF containing AnLF serving the UE of one or more additional Analytic ID(s) or based on the NWDAF containing AnLF not serving the UE for one or more Analytic ID(s) but serving the UE for at least one Analytic ID.

2. The NWDAF containing AnLF updates its registration in UDM for the served UE, by sending Nudm_UECM_Update request (NWDAF Registration Id, added or removed Analytic ID(s)).

3. Upon success UDM sends a "204 No Content" response to the NWDAF containing AnLF. If the operation is unsuccessful, UDM responds with proper error response code. See TS 29.503 [22] for details.

5.8.3.2.3 NWDAF containing AnLF De-Registration in UDM

If an NWDAF containing AnLF has previously registered in UDM for one or more analytics ID for a given UE, when the NWDAF containing AnLF no longer serves the UE, e.g., it does not collect data for the UE for that Analytics ID or does no keep produce analytic reports or does not keep any data related to the UE, the NWDAF containing AnLF should de-register from UDM by invoking the Nudm_UECM_Deregistration service operation (NWDAF registration ID, Analytics ID(s)), see TS 29.503 [22] clause 5.3.2.4.8). Figure 5.8.3.2.3-1 illustrates the signalling flow.

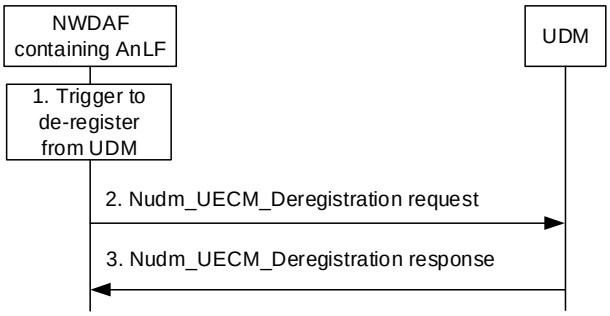

Figure 5.8.3.2.3-1: NWDAF containing AnLF deregistration from UDM

1. If an NWDAF containing AnLF has previously registered one or more Analytics IDs for a UE in UDM, the NWDAF containing AnLF triggers a complete deregistration from UDM, e.g. based on the NWDAF containing AnLF not collecting data any longer for the UE, or the NWDAF containing AnLF not producing analytics reports for the UE, or the NWDAF containing AnLF not keeping analytics data for the UE.

2. The NWDAF containing AnLF deregisters from UDM for the served UE, by sending Nudm_UECM_Deregistration request (NWDAF Registration Id).

3. UDM sends a "204 No Content" response to the NWDAF containing AnLF. See TS 29.503 [22] for details.

5.8.3.3 Consumer discovery and selection of NWDAF containing AnLF in UDM

For UE related analytics, if the NWDAF service consumer needs to discover an NWDAF containing AnLF that is serving or holds data for a UE, the NWDAF serving consumer may query UDM with the target SUPI and the Analytics ID. If the response from UDM indicates multiple candidate NWDAFs, the NWDAF service consumer may, e.g., determine an instance of an NWDAF containing AnLF that has registered in UDM (registrationTime attribute) around the time of interest of the data or analytics, and may also query NRF, as specified in clause 5.8.2.3 in order to determine the capabilities of these NWDAFs and select the most appropriate one. Figure 5.8.3.3-1 illustrates the signalling flow.

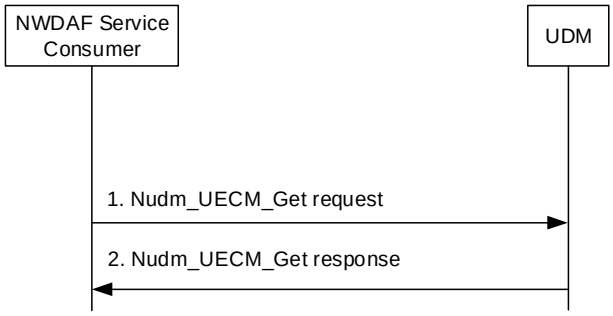

Figure 5.8.3.3-1: Discovery of NWDAF containing AnLF in UDM

1. The NWDAF service consumer sends an Nudm_UECM_Get request to the UDM (UE ID, Analytics ID(s), NF type = NWDAF).
2. Upon success, UDM sends a "200 OK" response to the service consumer including the NWDAF information registered for the UE ID. If the operation is unsuccessful, UDM responds with proper error response code. See TS 29.503 [22] for details.

5.8.4 Procedures for PCF learning NWDAF IDs for served UEs

PCF may receive from AMF and SMF the IDs of the NWDAFs containing AnLF that are used by AMF, SMF, and UPF, so that the PCF may select the same NWDAF containing AnLF being used for a specific UE.

When the AMF creates or updates an Access and Mobility Policy Association for a UE, the AMF may include the IDs of the NWDAF containing AnLF that are used by the AMF, along with their Analytic ID(s), in the Npcf_AMPolicyControl_Create/Update service operations, as illustrated in Figure 5.8.4-1. See details in TS 29.507 [24].

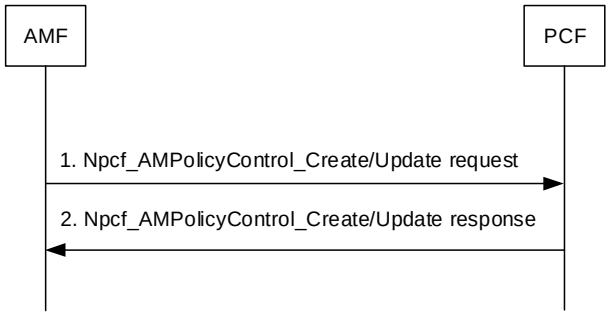

Figure 5.8.4-1: PCF learning the NWDAF information from the AMF

The PCF may select those NWDAF instances discovered through the Npcf_AMPolicyControl_Create/Update request as the ones to use for their associated analytic ID(s) for the UE for which those AM Policy Associations are related to.

When the SMF creates or updates a Session Management Policy Association for a UE, the SMF may include the IDs of the NWDAF containing AnLF that are used by the SMF and UPF, along with their Analytic ID(s), in the Npcf_SMPolicyControl_Create/Update service operations, as illustrated in Figure 5.8.4-2. See details in TS 29.512 [25].

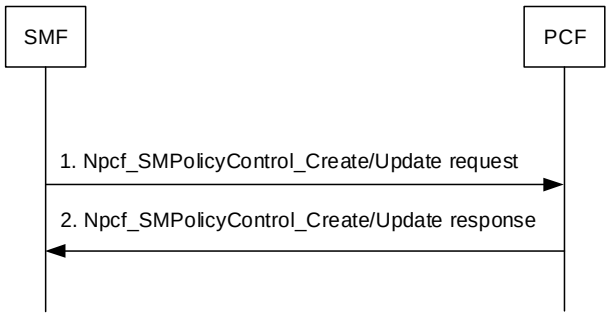

Figure 5.8.4-2: PCF learning the NWDAF information from the SMF and UPF

The PCF may select those NWDAF instances discovered through the Npcf_SMPoliycControl_Create/Update request as the ones to subscribe for their associated analytic ID(s) for the UE for which those SM Policy Associations are related to.

5.9 Analytics Data Repository procedures

5.9.1 General

The Analytics Data Repository procedures allow the NF service consumers (e.g. NWDAF, DCCF or MFAF) to store, retrieve or delete collected data and analytics in the ADRF.

5.9.2 Historical Data and Analytics Storage/Retrieval/Deletion procedure

The procedure is used by an NF service consumer (e.g. NWDAF, DCCF or MFAF) to store, retrieve or delete historical data and/or analytics, i.e. data and/or analytics related to past time period that has been obtained by the consumer.

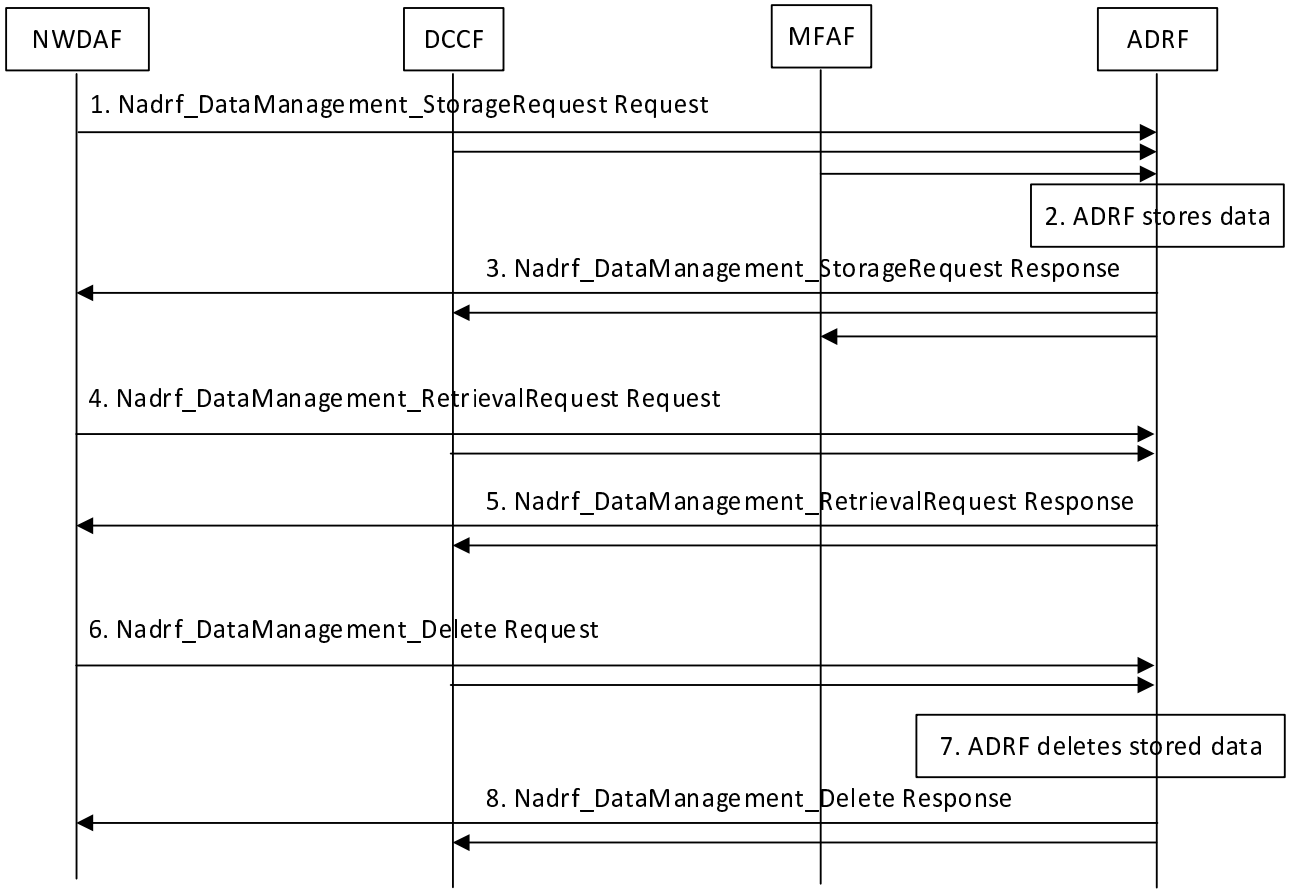

Figure 5.9.2-1: Historical Data and Analytics storage/retrieval/deletion procedure

1. In order to store data or analytics, the NF service consumer invokes Nadrf_DataManagement_StorageRequest service operation by sending an HTTP POST request targeting the resource "ADRF Data Store Records" in clause 4.2.2.2 of 3GPP TS 29.575 [16].

2. The ADRF stores the data or analytics sent by the consumer. The ADRF may, based on implementation, determines whether the same data or analytics is already stored or being stored based on the information sent in step 1 by the consumer and, if the data or analytics is already stored or being stored in the ADRF, the ADRF decides to not store again the data or analytics sent by the consumer.

3. If the data or analytics is stored, the ADRF sends Nadrf_DataManagement_StorageRequest Response message to the consumer with HTTP "201 Created" status code including a representation of the created record.

4. If the data is to be retrieved for specific SUPI, the user consent has not been checked by the data consumer, if the local policies and regulations require to check user consent, the NF service consumer shall check and enforce the user consent in the same way that it is described for the NWDAF in clause 5.5.1.1 step 1 and step 2. Then, in order to retrieve the stored data or analytics from the ADRF, the NF service consumer shall invoke the Nadrf_DataManagement_RetrievalRequest service operation by sending an HTTP GET request targeting the resource "ADRF Data Store Records" as described in clause 4.2.2.5 of 3GPP TS 29.575 [16].

5. If the requested data or analytics is found, the ADRF sends Nadrf_DataManagement_RetrievalRequest Response message to the consumer with HTTP "200 OK" status code including a representation of the matched record.

6. In order to delete the specified data or analytics from the ADRF, the NF service consumer shall invoke the Nadrf_DataManagement_Delete service operation by sending an HTTP DELETE request targeting the resource "Individual ADRF Data Store Record" as described in clause 4.2.2.9 of 3GPP TS 29.575 [16] if the NF service consumer delete the resource including the transaction identifier, or by sending an HTTP POST request including the time window in which the data to be deleted was collected and data or analytics specification.

7. The ADRF deletes the specified stored data or analytics requested by the consumer.

8. If the deletion is successful processed, the ADRF sends Nadrf_DataManagement_Delete Response message to the consumer with HTTP "204 No Content" status code.

5.9.3 Historical Data and Analytics Storage via Notifications

The procedure is used by an NF service consumer (e.g. NWDAF, DCCF) to store received notifications in the ADRF.

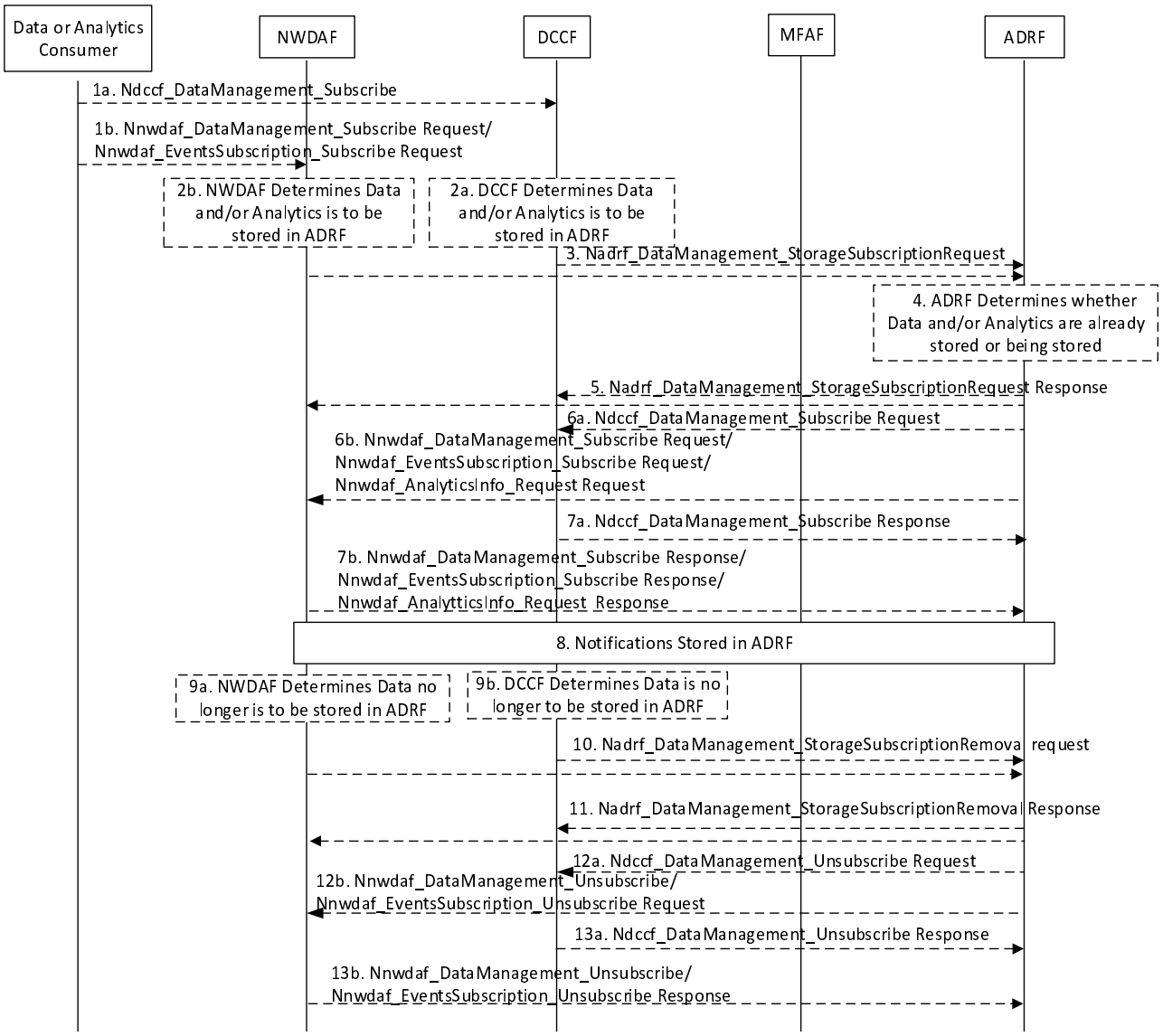

Figure 5.9.3-1: Historical Data and Analytics storage/deletion procedure

1-2. Based on reception of a DataManagement subscription request or Analytics subscription request (e.g. see clause 5.5.3.1 and clause 5.2.2) or based on local configuration, the NF service consumer (e.g. DCCF or NWDAF) determines that notifications are to be stored in the ADRF.

3. The NF service consumer invokes Nadrf_DataManagement_StorageSubscriptionRequest service operation by sending an HTTP POST request in clause 4.2.2.3 of 3GPP TS 29.575 [16].

4. The ADRF may, based on implementation, determines whether the same data or analytics is already stored or being stored based on the information sent in step 3 by the consumer.

5. If the request is successfully processed and accepted, the ADRF sends Nadrf_DataManagement_StorageSubscriptionRequest Response message to the consumer with HTTP "200 OK " status code including a transaction reference identifier. If the data and/or analytics is already stored or being stored in the ADRF, the ADRF sends Nadrf_DataManagement_StorageSubscriptionRequest Response message

to the consumer indicating that data or analytics is stored, and the following steps 6a-8 and steps 12a-13b are skipped.

6a. ADRF invokes Ndccf_DataManagement_Subscribe service operation to subscribe to the DCCF to receive analytics notifications by sending an HTTP POST request message targeting the resource "DCCF Analytics Subscriptions", the HTTP POST message shall include notification endpoint address and a notification correlation ID as defined in clause 4.2.2.2.2 of 3GPP TS 29.574 [15].

ADRF invokes Ndccf_DataManagement_Subscribe service operation to subscribe to the DCCF to receive data notifications by sending an HTTP POST request message targeting the resource "DCCF Data Subscriptions", the HTTP POST message shall include notification endpoint address and a notification correlation ID as defined in clause 4.2.2.2.4 of 3GPP TS 29.574 [15].

6b. ADRF invokes Nnwdaf_DataManagement_Subscribe service operation to subscribe to the NWDAF to receive data notifications by sending an HTTP POST request message targeting the resource "NWDAF Data Management Subscriptions", the HTTP POST message shall include notification endpoint address and a notification correlation ID as defined in clause 4.4.2.2 of 3GPP TS 29.520 [5].

ADRF invokes Nnwdaf_EventsSubscription_Subscribe service operation to subscribe to the NWDAF to receive analytics notifications by sending an HTTP POST request message targeting the resource "NWDAF Events Subscriptions", the HTTP POST message shall include notification endpoint address and a notification correlation ID as defined in clause 4.2.2.2 of 3GPP TS 29.520 [5].

ADRF invokes Nnwdaf_AnalyticsInfo_Request service operation to the NWDAF to request the analytics information by sending an HTTP GET request targeting the resource "NWDAF Analytics".

7a If the Subscription is successfully processed and accepted, the DCCF sends Ndccf_DataManagement_Subscribe Response message to the consumer with HTTP "201 Created" status code with the message body containing a representation of the created subscription.

7b If the Data Subscription is successfully processed and accepted, the NWDAF sends Nnwdaf_DataManagement_Subscribe Response message to the consumer with HTTP "201 Created" status code with the message body containing a representation of the created subscription.

If the Analytics Subscription is successfully processed and accepted, the NWDAF sends Nnwdaf_EventsSubscription_Subscribe Response message to the consumer with HTTP "201 Created" status code with the message body containing a representation of the created subscription.

If the Analytics Request is successfully accepted, the NWDAF sends Nnwdaf_AnalyticsInfo_Request Response message to the consumer with HTTP "200 OK" status code with the requested analytics information.

8. The NF service consumer (e.g. DCCF, MFAF or NWDAF) sends Analytics or Data notifications containing the notification correlation ID provided by the ADRF to ADRF notification endpoint address when the historical analytics data are available.

If the NWDAF is the service consumer in step 7 and data notifications are to be sent, the NWDAF invokes Nnwdaf_DataManagement_Notify service operation as defined in clause 4.4.2.4 of 3GPP TS 29.520 [5]. The ADRF stores the data notifications and responds to the Nnwdaf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

If the NWDAF is the service consumer in step 7 and analytics notifications are to be sent, the NWDAF invokes Nnwdaf_EventsSubscription_Notify service operation as defined in clause 4.2.2.4 of 3GPP TS 29.520 [5]. The ADRF stores the analytics notifications and responds to the Nnwdaf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

If the DCCF is used for data collection in step 7, the DCCF invokes Ndccf_DataManagement_Notify service operation as defined in clause 4.2.2.4 of 3GPP TS 29.574 [15]. The ADRF stores the notifications and responds to the Ndccf_DataManagement_Notify service operation with HTTP "204 No Content" status code.

If the Messaging Framework is used for data collection in step 7, the procedure defined in clause 5.5.3.2 is applicable.

9. The NF service consumer determines that notifications no longer need to be stored in the ADRF.

10. In order to request the ADRF to delete the specified data or analytics subscription, the NF service consumer shall invoke the Nadrf_DataManagement_StorageSubscriptionRemoval service operation by sending an HTTP POST request as described in clause 4.2.2.4 of 3GPP TS 29.575 [16], including the transaction reference identifier.

11. If the deletion is successful processed, the ADRF sends Nadrf_DataManagement_StorageSubscriptionRemoval Response message with HTTP "204 No Content" status code to the consumer.

12a. ADRF invokes Ndccf_DataManagement_Unsubscribe service operation to unsubscribe from analytics notifications by sending an HTTP DELETE request message targeting the resource "Individual DCCF Analytics Subscription" as defined in clause 4.2.2.3.2 of 3GPP TS 29.574 [15].

ADRF invokes Ndccf_DataManagement_Unsubscribe service operation to unsubscribe from data notifications by sending an HTTP DELETE request message targeting the resource "Individual DCCF Data Subscription" as defined in clause 4.2.2.3.3 of 3GPP TS 29.574 [15].

12b. ADRF invokes Nnwdaf_DataManagement_Unsubscribe service operation to unsubscribe from data notifications by sending an HTTP DELETE request message targeting the resource "Individual NWDAF Data Management Subscription" as defined in clause 4.4.2.3.2 of 3GPP TS 29.520 [5].

ADRF invokes Nnwdaf_EventsSubscription_Unsubscribe service operation to unsubscribe from analytics notifications by sending an HTTP DELETE request message targeting the resource "Individual NWDAF Event Subscription" as defined in clause 4.2.2.3.2 of 3GPP TS 29.520 [5].

13a If the removal of the corresponding subscription is successfully processed and accepted, the DCCF sends Ndccf_DataManagement_Unsubscribe Response message to the consumer with HTTP "204 No Content" status code.

13b If the removal of the corresponding data subscription is successfully processed and accepted, the NWDAF sends Nnwdaf_DataManagement_Unsubscribe Response message to the consumer with HTTP "204 No Content" status code.

If the removal of the corresponding analytics subscription is successfully processed and accepted, the NWDAF sends Nnwdaf_EventsSubscription_Unsubscribe Response message to the consumer with HTTP "204 No Content" status code.

5.10 Federated Learning among Multiple NWDAFs

5.10.1 General

The Federated Learning (FL) refers to the Horizontal Federated Learning (HFL) in this specification.

The NWDAF containing MTLF can leverage Federated Learning (FL) technique to train an ML model. To apply FL technique for ML model training, there is no need for input data transfer (e.g. centralized into one NWDAF) but only need for cooperation among multiple NWDAFs (MTLF) distributed in different areas, i.e. sharing of ML model(s) and of the learning results among multiple NWDAFs (MTLF).

The NWDAF containing MTLF determines to use FL to train an ML model either based on local configuration or when it receives the request from NWDAF containing AnLF as described in clause 5.3 of 3GPP TS 23.288 [2]. If the NWDAF containing MTLF can act as an FL server for the ML model training, then FL procedure is initiated by the NWDAF containing MTLF as FL server NWDAF directly, otherwise, the NWDAF containing MTLF should discover an FL server NWDAF as described in clause 5.3.2.2 of 3GPP TS 29.510 [23] and request the FL server NWDAF to provide the trained ML model as described in clause 5.10.2.1.

The NWDAF and the AF can leverage Vertical Federated Learning (VFL) technique to perform ML model training and inference without changing/sharing local data set.

The NWDAF containing MTLF determines to use VFL to train an ML model when it receives the request from analytics consumer NF as described in clause 5.4 of 3GPP TS 23.288 [2]. If the NWDAF containing MTLF can act as a VFL server for the ML model training, then VFL procedure is initiated by the NWDAF containing MTLF as VFL server NWDAF directly, otherwise, the NWDAF containing MTLF should discover a VFL server NWDAF or VFL server AF as described in clause 5.3.2.2 of 3GPP TS 29.510 [23] and request the VFL server NWDAF or VFL server AF to provide the trained ML model.

5.10.2 Procedures related to Federated Learning

5.10.2.1 General Procedure for Federated Learning among Multiple NWDAF Instances

This procedure is used by the NWDAF containing MTLF (FL Server NWDAF) to trigger FL among multiple NWDAF instances, by the multiple NWDAF containing MTLF (the FL Server NWDAF and FL Client NWDAF(s)) to execute Federated Learning in FL execution phase.

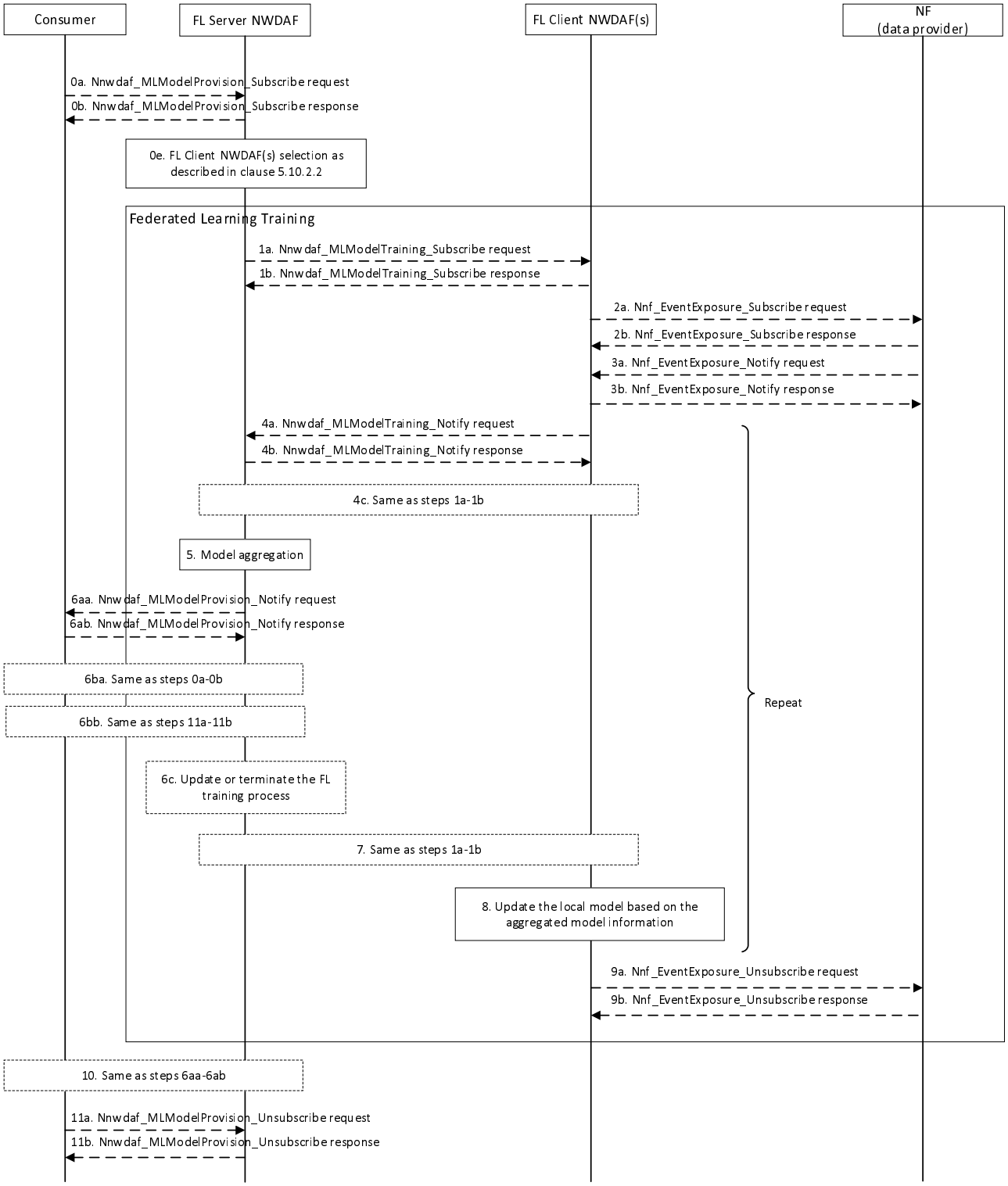

Figure 5.10.2.1-1: General procedure for FL among Multiple NWDAF

0a-0b. To send a request for ML model analytics events subscription to the NWDAF containing MTLF (the FL Server NWDAF), the NWDAF service consumer (NWDAF containing AnLF or NWDAF containing MTLF) invokes the Nnwdaf_MLModelProvision_Subscribe service operation by sending an HTTP POST request targeting the resource "NWDAF ML Model Provision Subscriptions".

The FL Server NWDAF responses to the Nnwdaf_MLModelProvision_Subscribe service operation. Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the FL Server NWDAF responds

to the NWDAF service consumer with "201 Created", and the URI of the created subscription is included in the Location header field. Details are described in clause 4.5.2.2 of 3GPP TS 29.520 [5].

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

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

0e. The FL Server NWDAF selects NWDAF(s) containing MTLF (FL Client NWDAF(s)) as described in clause 5.10.2.2.

1a-1b. To request the selected NWDAF containing MTLF (the FL Client NWDAF) to perform the local model training, the FL Server NWDAF may invoke Nnwdaf_MLModelTraining_Subscribe service operation by sending an HTTP POST request targeting the resource "NWDAF ML Model Training Subscriptions". The FL Client NWDAF responses to the Nnwdaf_MLModelTraining_Subscribe service operation with an HTTP "201 Created" status code to the FL Server NWDAF, as defined in clause 4.6.2.2 of 3GPP TS 29.520 [5].

2a-2b. To subscribe to notification (or to modify subscriptions to notifications) of data events from the data source NF, each FL Client NWDAF may invoke the Nnf_EventExposure_Subscribe service operation by sending an HTTP POST (or PUT, for modification) request targeting the resource representing event exposure subscriptions of that NF.

The data source NF responds to the Nnf_EventExposure_Subscribe service operation. Upon receipt of the HTTP POST request, if the subscription is accepted to be created, the NF responds to the FL Client NWDAF with "201 Created", and the URI of the created subscription is included in the Location header field.

3a-3b. If the data source NF observes the subscribed event(s), the NF invokes the Nnf_EventExposure_Notify service operation to report the event(s) by sending an HTTP POST request.

On success, the FL Client NWDAF sends an HTTP "204 No Content" response to the NF.

4. During FL training process, each FL Client NWDAF further trains the retrieved ML model from the FL Server NWDAF based on its own/collected data, and reports interim local ML model information to the FL Server NWDAF before the maximum response time elapses. Each FL Client NWDAF also computes local model metric and reports it to the FL Server NWDAF. The ML model information are exchanged between the FL Client NWDAF(s) and the FL Server NWDAF during the FL training process.

   4a-4b. To report the ML model training information, the FL Client NWDAF may invoke Nnwdaf_MLModelTraining_Notify service operation as defined in clause 4.6.2.4 of 3GPP TS 29.520 [5]. The FL Server NWDAF stores the notification and responds to the Nnwdaf_MLModelTraining_Notify service operation with an HTTP "204 No Content" status code to the FL Client NWDAF.

   4c. [Optional] If FL Server NWDAF receives notification that the FL Client NWDAF is not able to complete the training within the maximum response time, the FL Server NWDAF may send to the FL Client NWDAF an new maximum response time by invoking Nnwdaf_MLModelTraining_Subscribe, before which the FL Client NWDAF shall report the interim local ML model information to the FL Server NWDAF. Otherwise, the FL Server NWDAF may indicate FL Client NWDAF to skip reporting for this iteration.

5. The FL Server NWDAF aggregates all the local ML model information retrieved at step 4, to update the global ML model. The FL Server NWDAF may also compute the global model metric.

   - If the FL Server NWDAF provides the maximum response time for the FL Client NWDAFs to provide the interim local ML model information in step 1 or the new maximum response time in step 4, the FL Server NWDAF decides either to wait for the FL Client NWDAFs which have not yet provided their interim local ML model within the new maximum response time or to aggregate only the retrieved local ML model information instances to update global ML model. The FL Server NWDAF makes this decision, considering the notification from the FL Client NWDAF or, if the notification is not received, based on local configuration.

6a. [Optional] Based on the NWDAF service consumer request, the FL Server NWDAF updates the global ML model metric to the NWDAF service consumer periodically or dynamically when some pre-determined status (e.g. ML model accuracy threshold) is achieved.

6aa-6ab. To report the ML model training information, the FL Server NWDAF invokes Nnwdaf_MLModelProvision_Notify service operation as defined in clause 4.5.2.4 of 3GPP TS 29.520 [5]. The NWDAF service consumer stores the notification and responds to the Nnwdaf_MLModelProvision_Notify service operation with an HTTP "204 No Content" status code to the FL Server NWDAF.

6b. [Optional] The NWDAF service consumer decides whether the current model can fulfil the requirement. The NWDAF service consumer modifies subscription (stops or continues the training process) according to the NWDAF service consumer decision.

6ba. To modify the existing subscription, the NWDAF service consumer invokes Nnwdaf_MLModelProvision_Subscribe service operation by sending an HTTP PUT request with Resource URI of the resource "Individual NWDAF ML Model Provision Subscription". The FL Server NWDAF responds to the NWDAF service consumer with an HTTP "200 OK" or "204 No Content" status code, as defined in clause 4.5.2.2.3 of 3GPP TS 29.520 [5].

6bb. To unsubscribe the ML model, the NWDAF service consumer invokes Nnwdaf_MLModelProvision_Unsubscribe service operation by sending an HTTP DELETE request which targets the resource "Individual NWDAF ML Model Provision Subscription", to the FL Server NWDAF, as defined in clause 4.5.2.3 of 3GPP TS 29.520 [5]. If the request is accepted, the FL Server NWDAF deletes the subscription and responds to the NWDAF service consumer with an HTTP "204 No Content" message.

6c. [Optional] According to the request from the NWDAF service consumer, the FL Server NWDAF updates or terminates the current FL training process. If it terminates the current FL training process, steps 7 and 8 are skipped.

7. If the FL procedure continues, the FL Server NWDAF sends the aggregated ML model information to each FL Client NWDAF for next round model training.

   To modify the existing subscription, the FL Server NWDAF invokes Nnwdaf_MLModelTraining_Subscribe service operation by sending an HTTP PUT request or an HTTP PATCH request with Resource URI of the resource "Individual NWDAF ML Model Training Subscription". The FL Client NWDAF responds to the FL Server NWDAF an HTTP "200 OK" or "204 No Content" status code, as defined in clauses 4.6.2.2.3 and 4.6.2.2.4 of 3GPP TS 29.520 [5].

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

NOTE 2: The steps 4-8 should be repeated until the training termination condition (e.g. maximum number of iterations, or the result of loss function is lower than a threshold) is reached.

9a-9b. To unsubscribe to the notifications of data events from the data source NF, the FL Client NWDAF invokes the Nnf_EventExposure_Unsubscribe service operation by sending an HTTP DELETE request targeting the resource that represents the previously created individual event exposure subscription.

The data source NF responds to the Nnf_EventExposure_Unsubscribe service operation. If the subscription deletion is accepted, the NF responds with "204 No Content".

10. If the FL Server NWDAF determines that the subscribed ML model information is available, the FL Server NWDAF may invoke the Nnwdaf_MLModelProvision_Notify service operation or the Nnwdaf_MLModelTraining_Notify service operation to report the ML model information by sending an HTTP POST request to the NWDAF service consumer identified by the notification URI received during the creation/modification of the subscriptions. The NWDAF service consumer responds to the FL Server NWDAF with an HTTP "204 No Content" message.

11a-11b. To unsubscribe from the notification(s) of the ML model information, the NWDAF service consumer invokes the Nnwdaf_MLModelProvision_Unsubscribe service operation by sending an HTTP DELETE request, which targets the resource "Individual NWDAF ML Model Provision Subscription", to the FL Server NWDAF, as defined in clause 4.5.2.3 of 3GPP TS 29.520 [5].

If the request is accepted, the FL Server NWDAF deletes the subscription and responds to the NWDAF service consumer with an HTTP "204 No Content" message.

5.10.2.2 Preparation Procedure for Federated Learning

This procedure is used by the NWDAF containing MTLF (as FL Server NWDAF or FL Client NWDAF(s)) to register into NRF, discover the FL Server NWDAF and select FL Client NWDAF(s) for Federated Learning (FL).

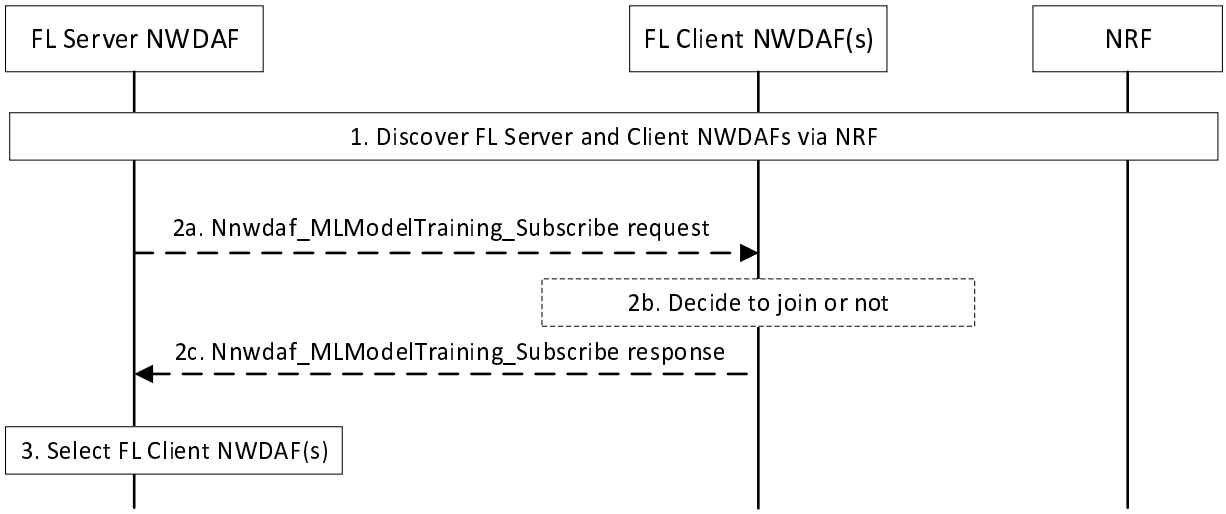

Figure 5.10.2.2-1: Preparation procedure for Federated Learning

The NWDAF containing MTLF as FL Server NWDAF or FL Client NWDAF(s) registered to NRF its NF profiles. Details are described in clause 5.2.2.2 of 3GPP TS 29.510 [23].

1. The FL Server NWDAF and FL Client NWDAF(s) are discovered via NRF. Details are described in clause 5.3.2.2 of 3GPP TS 29.510 [23].

2. The Nnwdaf_MLModelTraining service may be used for the preparation information exchange between the FL Server NWDAF and the FL Client NWDAF(s).

   2a. The FL Server NWDAF invokes Nnwdaf_MLModelTraining_Subscribe service operation by sending an HTTP POST request targeting the resource "NWDAF ML Model Training Subscriptions". The request shall include the "mLPreFlag" attribute and set to "true"

   2b. The FL Client NWDAF(s) checks if it meets the ML model training requirement and/or can successfully download the model if the model information is provided in the request, and decides whether to join the FL process based on operator policy (e.g. pre-configured list of ML models) and/or implementation.

   2c. The FL Client NWDAF responses or notifies to the Nnwdaf_MLModelTraining_Subscribe request to indicate its decision. Upon receipt of the HTTP POST request, if the preparation request is accepted, the FL Client NWDAF responds to the FL Server NWDAF with "201 Created".

NOTE 1: Step 2 can be skipped if the FL Server NWDAF can decide that the FL Client NWDAF(s) supports the FL procedure to be performed, e.g. based on information acquired from previous FL procedures or from the NRF, or based on local configuration.

3. The FL Server NWDAF determines the final list of FL Client NWDAF(s) to be involved in the FL procedures based on the information received in step 1 and other information received in step 2 (if available).

NOTE 2: For details of Nnwdaf_MLModelTraining_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.10.2.3 Procedure for Maintenance of Federated Learning Process

This procedure is used by the NWDAF containing MTLF (the FL Server NWDAF) to maintain a FL process in FL execution phase, including: the FL Server NWDAF triggers reselection, addition, or removal of FL Client NWDAF(s), discovery of new FL Client NWDAF(s) via NRF, and FL Client NWDAF(s) joins or leaves FL process dynamically.

In FL execution phase, the FL Server NWDAF monitors the status changes of FL Client NWDAF(s), and may reselect the FL Client NWDAF(s) based on the received information of status changes.

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

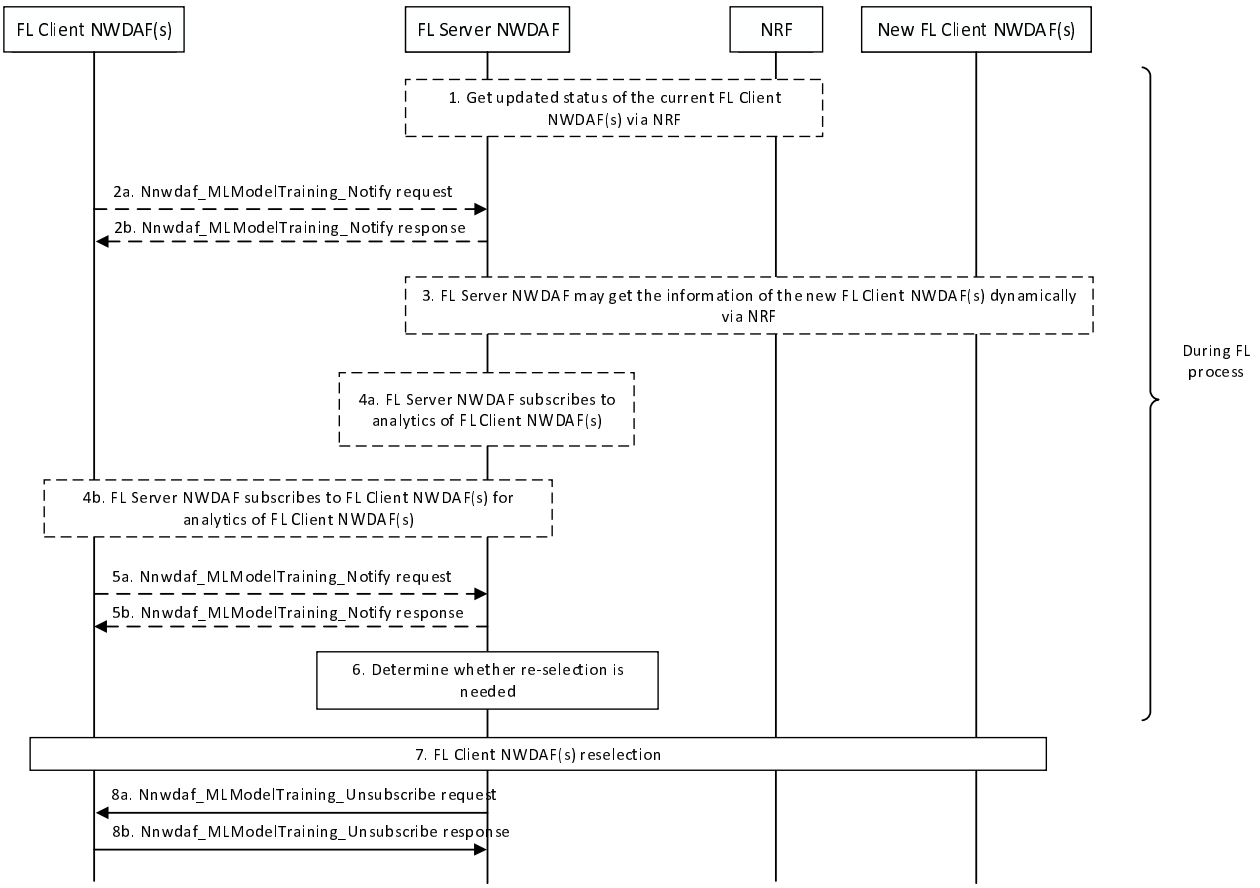

Figure 5.10.2.3-1: Procedure for Maintenance of Federated Learning Process in FL Execution Phase

The FL Server NWDAF registered to NRF by invoking the Nnrf_NFManagement_NFRegister_request service operation about the FL process, which includes Analytics ID.

1. The FL Server NWDAF may get the updated status of the current FL Client NWDAF(s) via NRF by using the Nnrf_NFManagement service in the FL execution phase. Details are described in clauses 5.2.2.5 and 5.2.2.6 of 3GPP TS 29.510 [23].

2. The current FL Client NWDAF(s) may inform the FL Server NWDAF to leave the FL process. The FL Client NWDAF(s) invokes Nnwdaf_MLModelTraining_Notify service operation by sending an HTTP POST request to the FL Server NWDAF identified by the notification URI received during the creation/modification of the subscriptions. Details are described in clause 4.6.2.4 of 3GPP TS 29.520 [5]. The FL Server NWDAF responds to the Nnwdaf_MLModelTraining_Notify service operation with an HTTP "204 No Content" status code to the FL Client NWDAF(s).

3. The FL Server NWDAF may get the information of the new FL Client NWDAF(s) dynamically via NRF. Details are described in clauses 5.2.2.5 and 5.2.2.6 of 3GPP TS 29.510 [23].

4. The FL Server NWDAF may subscribe to the FL Client NWDAF(s) for analytics.

5. The FL Client NWDAF(s) may send Status report of FL training and Global ML Model Accuracy Information. The FL Client NWDAF(s) invokes Nnwdaf_MLModelTraining_Notify service operation to the FL Server NWDAF. The FL Server NWDAF stores the notification and responds to the Nnwdaf_MLModelTraining_Notify service operation with an HTTP "204 No Content" status code to the FL Client NWDAF(s).

6. The FL Server NWDAF checks the FL Client NWDAF(s) status based on the received information, determines whether reselection of the FL Client NWDAF(s) for the next round(s) of FL is needed. The checking and determination are made according to the updated status of the FL Client NWDAF(s) received in steps 1-5.

7. If re-selection is needed as determined in step 6 and if step 3 is not performed, the FL Server NWDAF may discover new candidate FL Client NWDAF(s) via NRF by using the Nnrf_NFDiscovery services as described in clause 5.3.2.2 of 3GPP TS 29.510 [23]. The FL Server NWDAF reselects the FL Client NWDAF(s) from the current FL Client NWDAF(s) and the new candidate FL Client NWDAF(s).

8. The FL Server NWDAF sends termination request to the FL Client NWDAF(s) which will be removed from the FL process, and optionally indicating the reason. The FL Client NWDAF(s) terminates FL operations when receives a termination request from the FL Server NWDAF and may perform further action to be qualified in participation of FL training in the next cycles.

8a-8b. To send the termination request, the FL Server NWDAF may invoke the Nnwdaf_MLModelTraining_Unsubscribe service operation by sending an HTTP DELETE request, which targets the resource "Individual NWDAF ML Model Training Subscription", to the FL Client NWDAF(s). If the request is accepted, the FL Client NWDAF deletes the subscription and responds to the FL Server NWDAF service consumer with an HTTP "204 No Content" message..

NOTE: For details of Nnwdaf_MLModelTraining_Subscribe/Unsubscribe/Notify service operations refer to 3GPP TS 29.520 [5].

5.10.3 Procedures related to Vertical Federated Learning

5.10.3.1 General

The procedures defined in clause 5.10.3.2, clause 5.10.3.3 and clause 5.10.3.4 are used to perform VFL preparation, VFL training, and VFL inference respectively based on the procedures and the requirements of 3GPP TS 23.288 [2] clauses 6.2H.

5.10.3.2 Preparation procedures

5.10.3.2.1 General

The preparation procedures are triggered by VFL server and it is used to check whether the VFL Client(s) can meet the ML Model training requirement. The procedure includes the negotiation, between server and client(s) to enable interoperability, sample alignment and may include feature negotiation if the VFL Server did not learn the supported Feature IDs from each VFL Client using the discovery phase, alternatively the VFL Server may know the supported Feature IDs by a VFL Client based on configuration.

NOTE: The VFL preparation procedure may be skipped if the VFL Server can decide which VFL Client(s) support the VFL procedure to be performed, e.g. based on local configuration or offline procedures.

The preparation procedures in this clause include the following cases:

- subclause 5.10.3.2.2 specifies the preparation procedure when NWDAF or trusted AF is acting as VFL server while VFL client(s) can be NWDAF, AF, and/or untrusted AF;

- subclause 5.10.3.2.3 specifies the preparation procedure when untrusted AF is acting VFL server while VFL client(s) can be NWDAF.

5.10.3.2.2 Preparation Procedure for Vertical Federated Learning when NWDAF/trusted AF is acting as VFL server

This procedure describes the preparation process of VFL when NWDAF or trusted AF is the VFL server, while VFL client(s) can be NWDAF, AF, and/or untrusted AF.

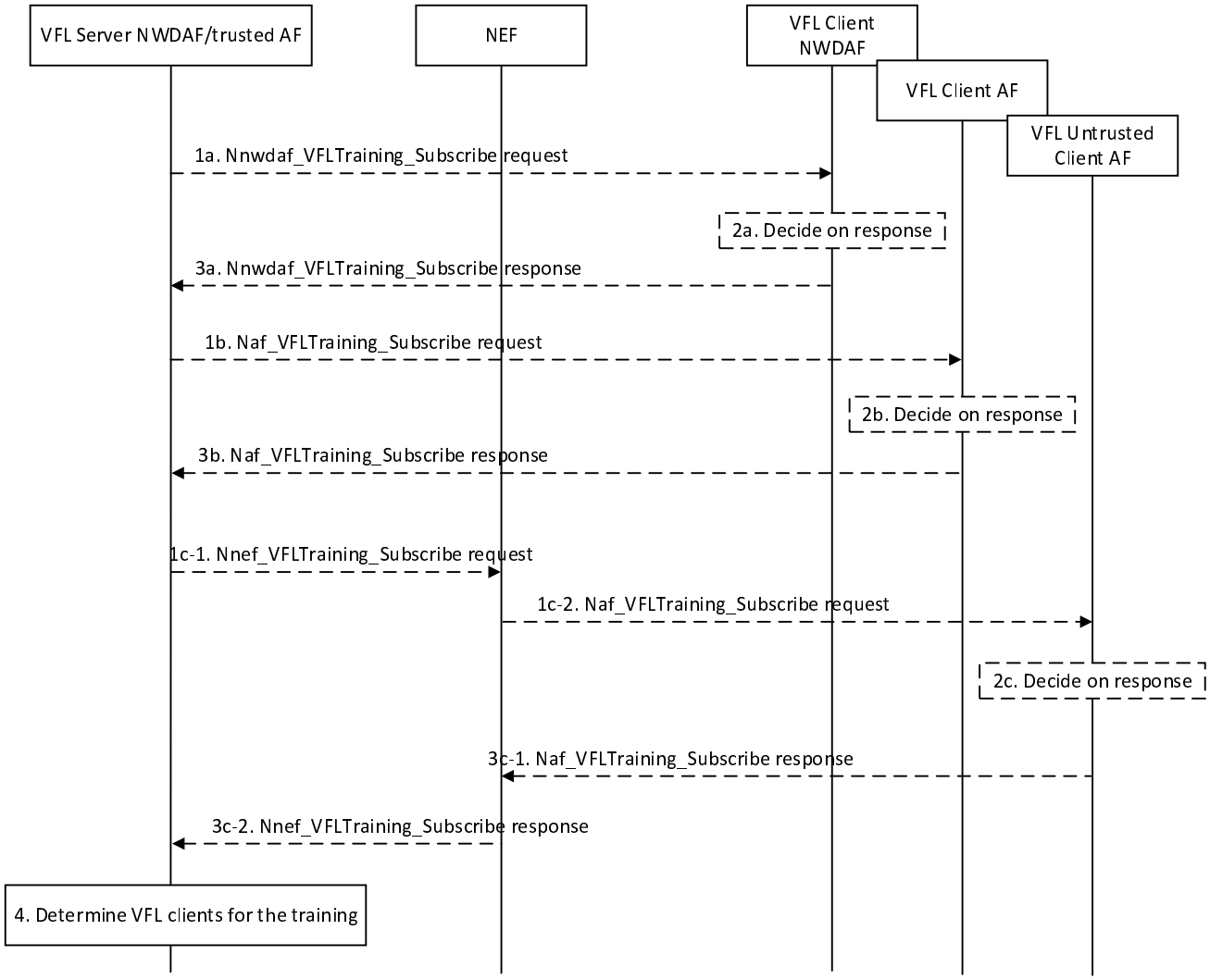

Figure 5.10.3.2.2-1: Preparation procedure for Vertical Federated Learning when NWDAF/trusted AF is the VFL Server

1. The NWDAF or trusted AF acting as VFL server sends a VFL preparation request to each VFL client.

   1a. If the VFL client is another instance of NWDAF, the NWDAF or trusted AF acting as VFL server invokes Nnwdaf_VFLTraining_Subscribe service operation as described in clause 4.10.2.2 of 3GPP TS 29.520 [5].

   1b. If VFL client is a trusted AF, the NWDAF or trusted AF acting as VFL server invokes Naf_VFLTraining_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.530 [53].

   1c-1-1c-2. If VFL client is an untrusted AF, the NWDAF or trusted AF acting as VFL server invokes Nnef_VFLTraining_Subscribe service operation as described in clause 4.8 of 3GPP TS 29.591 [11]. The NEF then invokes Naf_VFLTraining_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.530 [53].

2a-2c. Each VFL client checks whether it can meet the ML model training requirements and decide whether to participate in the training process as defined in clause 6.2H.2.2.1 of 3GPP TS 23.288 [2].

3. Each VFL client responds to the VFL server.

   3a. If the VFL client is another NWDAF instance, then it responds to the Nnwdaf_VFLTraining_Subscribe service operation as described in clause 4.10.2.2 of 3GPP TS 29.520 [5].

3b. If the VFL client is a trusted AF, then it responds to the Naf_VFLTraining_Subscribe service operation as described in clause 5.2.2.2 of 3GPP TS 29.530 [53].

3c-1-3c-2. If the VFL client is an untrusted AF, then it will send the response to the VFL server through NEF by invoking Naf_VFLTraining_Subscribe reponse as described in clause 5.2.2.2 of 3GPP TS 29.530 [53], and the NEF then invoking Nnef_VFLTraining_Subscribe response as described in clause 4.8 of 3GPP TS 29.591 [11].

4. The VFL server decides which VFL clients shall participate in the VFL training procedure according to the subscription(s) accepted.

5.10.3.2.3 Preparation Procedure for Vertical Federated Learning when untrusted AF is acting as VFL server

This procedure describes the preparation process of VFL when an untrusted AF is the VFL server and all VFL clients are NWDAF.

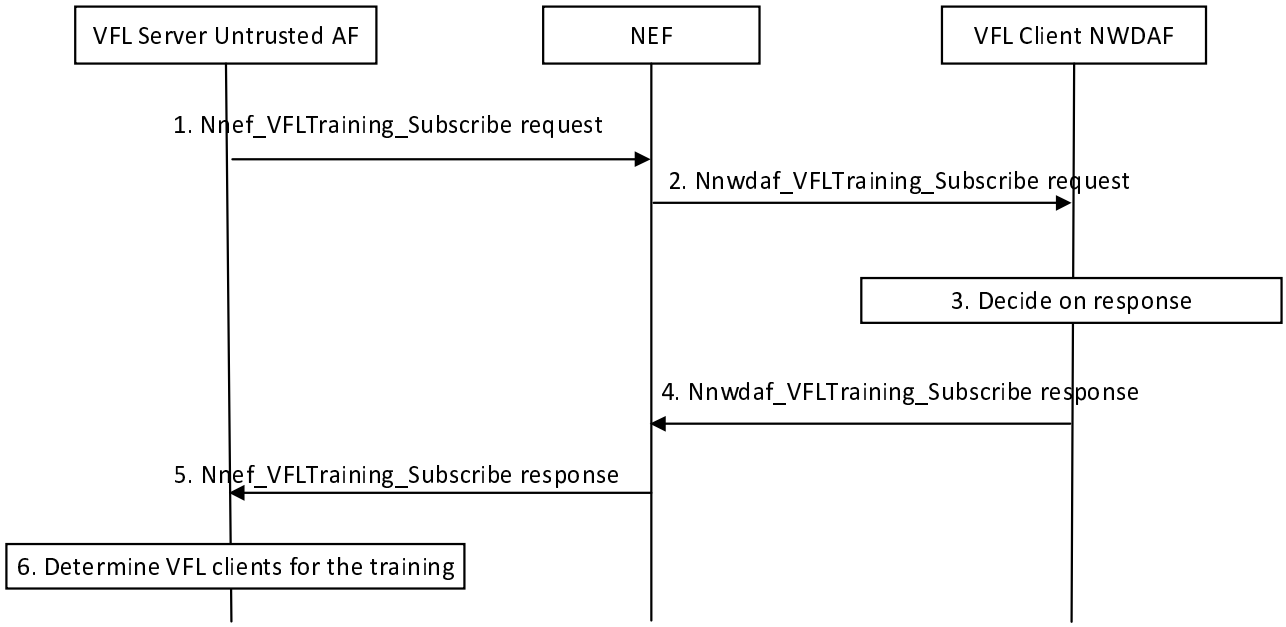

Figure 5.10.3.2.3-1: Preparation procedure for Vertical Federated Learning when untrusted AF is the VFL Server

1. To send a VFL preparation request to VFL clients, the untrusted AF acting as VFL server invokes Nnef_VFLTraining_Subscribe service operation to the NEF, indicating all associated VFL clients, i.e. NWDAF, as described in clause 4.4.50.2 of 3GPP TS 29.522 [10].

2. The NEF invokes training requests based on the request received from the untrusted AF acting as VFL server to VFL clients i.e., NWDAF instances. As defined in 3GPP TS 29.522 [10], the NEF maps the external identifiers to internal identifiers and sends the training request by invoking Nnwdaf_VFLTraining_Subscribe service operation as described in clause 4.10.2.2 of 3GPP TS 29.520 [5].

3. Each VFL client checks whether it can meet the ML model training requirements and decides whether to join in the training process as defined in clause 6.2H.2.2.1 of 3GPP TS 23.288 [2].

4. Each VFL client responds to the Nnwdaf_VFLTraining_Subscribe service operation as described in clause 4.10.2.2 of 3GPP TS 29.520 [5].

5. The NEF maps the internal identifiers to external identifiers and responds to the untrusted AF by invoking the Nnef_VFLTraining_Subscribe response as described in clause 4.4.50.2 of 3GPP TS 29.522 [10].

6. The VFL server decides which VFL client(s) shall participate in the VFL training procedure according to the subscription(s) accepted.

5.10.3.3 Training procedures

5.10.3.3.1 General

The training procedures are triggered by analytics consumer, NWDAF containing AnLF, or NWDAF containing MTLF. The VFL server (i.e., NWDAF, trusted AF, or untrusted AF) is determined during the preparation procedure as defined in clause 5.10.3.2. The VFL server repeats several rounds of VFL training process among multiple VFL clients until the VFL training process converges.

The training procedures in this clause include the following cases:

- subclause 5.10.3.3.2 specifies the training procedure when NWDAF or trusted AF is acting as VFL server while VFL client(s) can be NWDAF, AF, and/or untrusted AF.

- subclause 5.10.3.3.3 specifies the training procedure when untrusted AF is acting VFL server while VFL client(s) can be NWDAF.

5.10.3.3.2 Training procedure for vertical federated learning when NWDAF or trusted AF is acting as VFL server

The training procedure when trusted AF or NWDAF is acting as VFL server may be triggered by a request or subscription from a 5GC consumer NF, NWDAF containing AnLF, or NWDAF containing MTLF. This procedure is used by the VFL server (NWDAF or trusted AF) to trigger training procedure for Vertical Federated Learning among multiple NWDAF instances and/or AF(s) acting as VFL client.

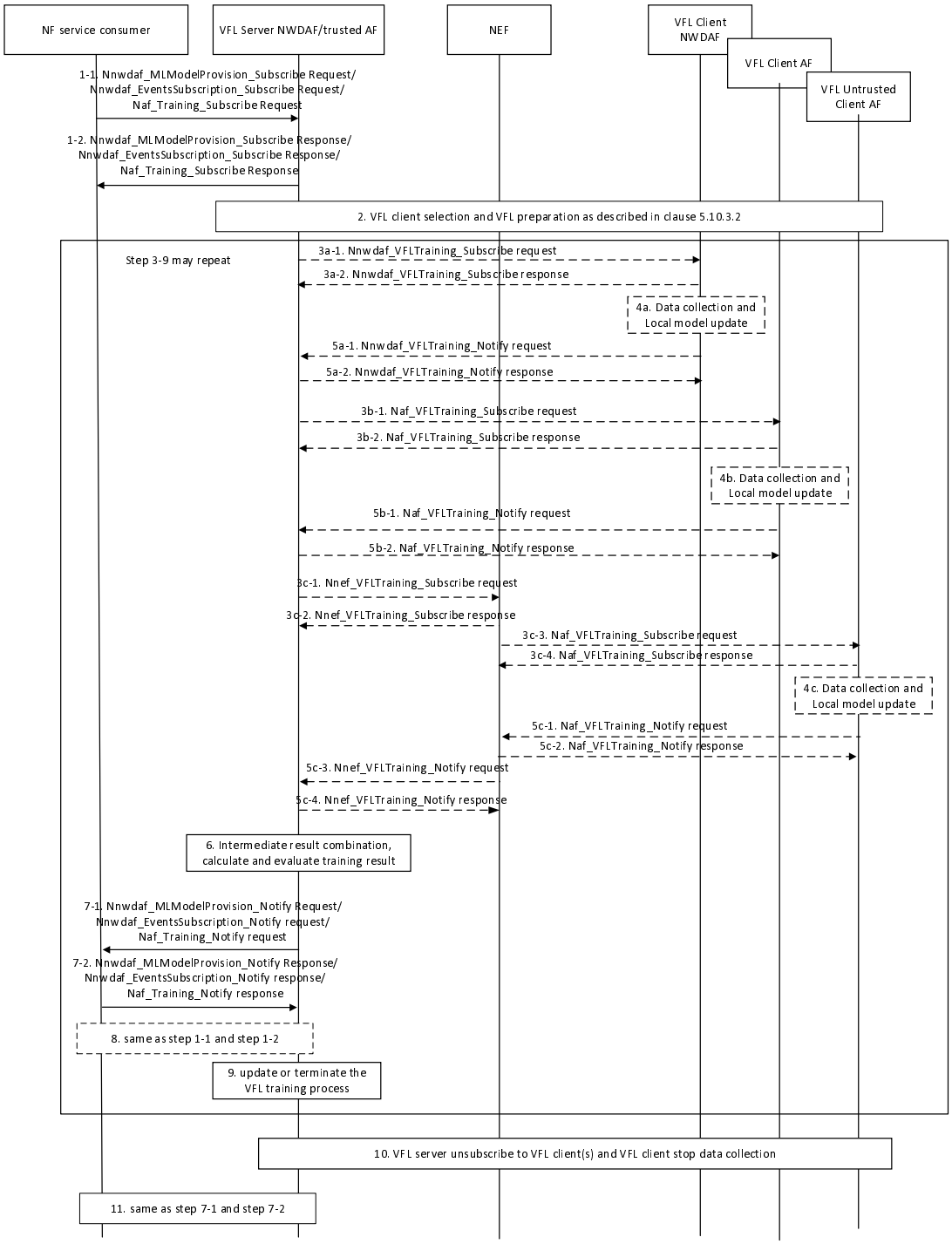

Figure 5.10.3.3.2-1: Training procedure for Vertical Federated Learning when NWDAF or Trusted AF is acting as VFL server

1. The NF service consumer (e.g. 5GC NF, NWDAF containing AnLF, NWDAF containing MTLF) determines the NWDAF or trusted AF acting as a VFL server.

   If trusted AF is selected as VFL server, the NF service consumer invokes the Naf_Training_Subscribe service operation to the VFL server AF as described in clause 5.4.2.2 of 3GPP TS 29.530 [53]. The procedure may also be triggered by an invocation of the Naf_Inference_Subscribe service operation, also described in 3GPP TS 29.530 [53].

   If NWDAF is selected as VFL server and the NF service consumer is 5GC NF, the 5GC NF invokes Nnwdaf_EventsSubscription_Subscribe service operation to VFL server NWDAF as described in clause 4.2.2.2 of 3GPP TS 29.520 [5]. If NWDAF is selected as VFL server and the NF service consumer is NWDAF

containing AnLF, the NWDAF containing AnLF invokes the Nnwdaf_MLModelProvision_Subscribe service operation to VFL server NWDAF as described in clause 4.5.2.2 of 3GPP TS 29.520 [5].

2. The NWDAF or trusted AF acting as VFL server performs the VFL preparation as described in clause 5.10.3.2.2.

3. The NWDAF or trusted AF acting as VFL server sends the VFL training request to each VFL client.

NOTE 1: When the trusted AF or untrusted AF is acting as VFL server, the VFL client can only be the NWDAF.

3a. If the VFL client is an NWDAF, the NWDAF or trusted AF acting as VFL server invokes Nnwdaf_VFLTraining_Subscribe service operation as described in clause 4.10.2.2.2 of 3GPP TS 29.520 [5]. If the Subscription is successfully processed and accepted, the VFL client sends Nnwdaf_VFLTraining_Subscribe Response message as described in clause 4.10.2.2.2 of 3GPP TS 29.520 [5].

3b. If the VFL client is a trusted AF, the NWDAF acting as VFL server invokes Naf_VFLTraining_Subscribe service operation as described in clause 5.2.2.2.2 of 3GPP TS 29.530 [53]. If the Subscription is successfully processed and accepted, VFL client sends Naf_VFLTraining_Subscribe response message as described in clause 5.2.2.2.2 of 3GPP TS 29.530 [53].

3c. If the VFL client is an untrusted AF, the NWDAF acting as VFL server invokes Nnef_VFLTraining_Subscribe service operation as described in clause 4.8.2.2 of 3GPP TS 29.591 [11]. The NEF invokes Naf_VFLTraining_Subscribe request as described in clause 5.2.2.2.2 of 3GPP TS 29.530 [53]. If the Subscription is successfully processed and accepted, VFL client sends Naf_VFLTraining_Subscribe response message as described in clause 5.2.2.2.2 of 3GPP TS 29.530 [53]. The NEF sends Nnef_VFLTraining_Subscribe response message to VFL server as described in clause 4.8.2.2 of 3GPP TS 29.591 [11].

4. Each VFL client collects its local data and trains the corresponding local ML model.

5. Each VFL client sends the ML model training information to the VFL server.

5a. If the VFL client is an NWDAF, then it sends the response to the VFL server by invoking Nnwdaf_VFLTraining_Notify service operation as described in clause 4.10.2.4.2 of 3GPP TS 29.520 [5].

5b. If the VFL client is a trusted AF, then it sends the response to the VFL server by invoking Naf_VFLTraining_Notify service operation as described in clause 5.2.2.4 of 3GPP TS 29.530 [53].

5c. If the VFL client is an untrusted AF, then it sends the response for the VFL server via the NEF by invoking Naf_VFLTraining_Notify service operation as described in clause 5.2.2.4 of 3GPP TS 29.530 [53]. For each untrusted AF VFL client, the NEF converts any external identifiers to internal identifiers and the NEF invoking Nnef_VFLTraining_Notify service operation as described in clause 4.8.2.4 of 3GPP TS 29.591 [11].

6. The VFL server combines all the ML model training information to update the global ML model. The VFL server may also calculate and evaluate the global model metric.

7. The VFL server sends the ML training information report to the consumer in step 1.

If the NWDAF is the VFL server in step 1 and the NF service consumer is 5GC NF, the VFL server NWDAF invokes Nnwdaf_EventsSubscription_Notify service operation to 5GC NF as described in clause 4.2.2.4 of 3GPP TS 29.520 [5]. The 5GC NF responds to the Nnwdaf_EventsSubscription_Notify service operation as described in clause 4.2.2.4 of 3GPP TS 29.520 [5].

If the NWDAF is the VFL server in step 1 and the NF service consumer is NWDAF containing AnLF, the VFL server NWDAF invokes Nnwdaf_MLModelProvision_Notify service operation to NWDAF containing AnLF as described in clause 4.5.2.4 of 3GPP TS 29.520 [5]. The 5GC NF responds to the Nnwdaf_MLModelProvision_Notify service operation as described in clause 4.5.2.4 of 3GPP TS 29.520 [5].

If the trusted AF is VFL server in step 1, the VFL server invokes Naf_Training_Notify service operation to the NF service consumer as described in clause 5.4.2.4 of 3GPP TS 29.530 [53]. The NF service consumer responds to the Naf_Training_Notify service operation as described in clause 5.4.2.4 of 3GPP TS 29.530 [53].

8. Same as step 1.

9. The VFL Server NWDAF updates or terminates the current VFL training process.

NOTE 2: The steps 3-9 can be repeated until the training termination condition (e.g. maximum number of iterations, or the result of loss function is lower than a threshold) is reached.

10. If the VFL server decides to terminate the VFL training process, the NWDAF or trusted AF acting as VFL server sends the VFL training unsubscription request to each VFL client.

    10a. If the VFL client is an NWDAF, the NWDAF or trusted AF acting as VFL server invokes Nnwdaf_VFLTraining_Unsubscribe service operation as described in clause 4.10.2.3.2 of 3GPP TS 29.520 [5]. If the Unsubscription is successfully processed and accepted, the VFL client sends Nnwdaf_VFLTraining_Unsubscribe Response message as described in clause 4.10.2.3.2 of 3GPP TS 29.520 [5].

    10b. If the VFL client is a trusted AF, the NWDAF acting as VFL server invokes Naf_VFLTraining_Unsubscribe service operation as described in clause 5.2.2.3.2 of 3GPP TS 29.530 [53]. If the Unsubscription is successfully processed and accepted, VFL client sends Naf_VFLTraining_Unsubscribe Response message as described in clause 5.2.2.3.2 of 3GPP TS 29.530 [53].

    10c. If NWDAF VFL client is an untrusted AF, the NWDAF acting as VFL server invokes Nnef_VFLTraining_Unsubscribe service operation as described in clause 4.8.2.3 of 3GPP TS 29.591 [11]. The NEF invokes Naf_VFLTraining_Unsubscribe by sending an HTTP POST request as described in clause 5.2.2.3.2 of 3GPP TS 29.530 [53]. If the Unsubscription is successfully processed and accepted, VFL client sends Naf_VFLTraining_Unsubscribe response message as described in clause 5.2.2.3.2 of 3GPP TS 29.530 [53]. The NEF sends Nnef_VFLTraining_Unsubscribe response message to VFL server as described in clause 4.8.2.3 of 3GPP TS 29.591 [11].

11. Same as step 7.

5.10.3.3.3 Training procedure for vertical federated learning when untrusted AF is acting as VFL server

This procedure is used by the untrusted AF as VFL Server to trigger training procedure for Vertical Federated Learning among multiple NWDAF instances.

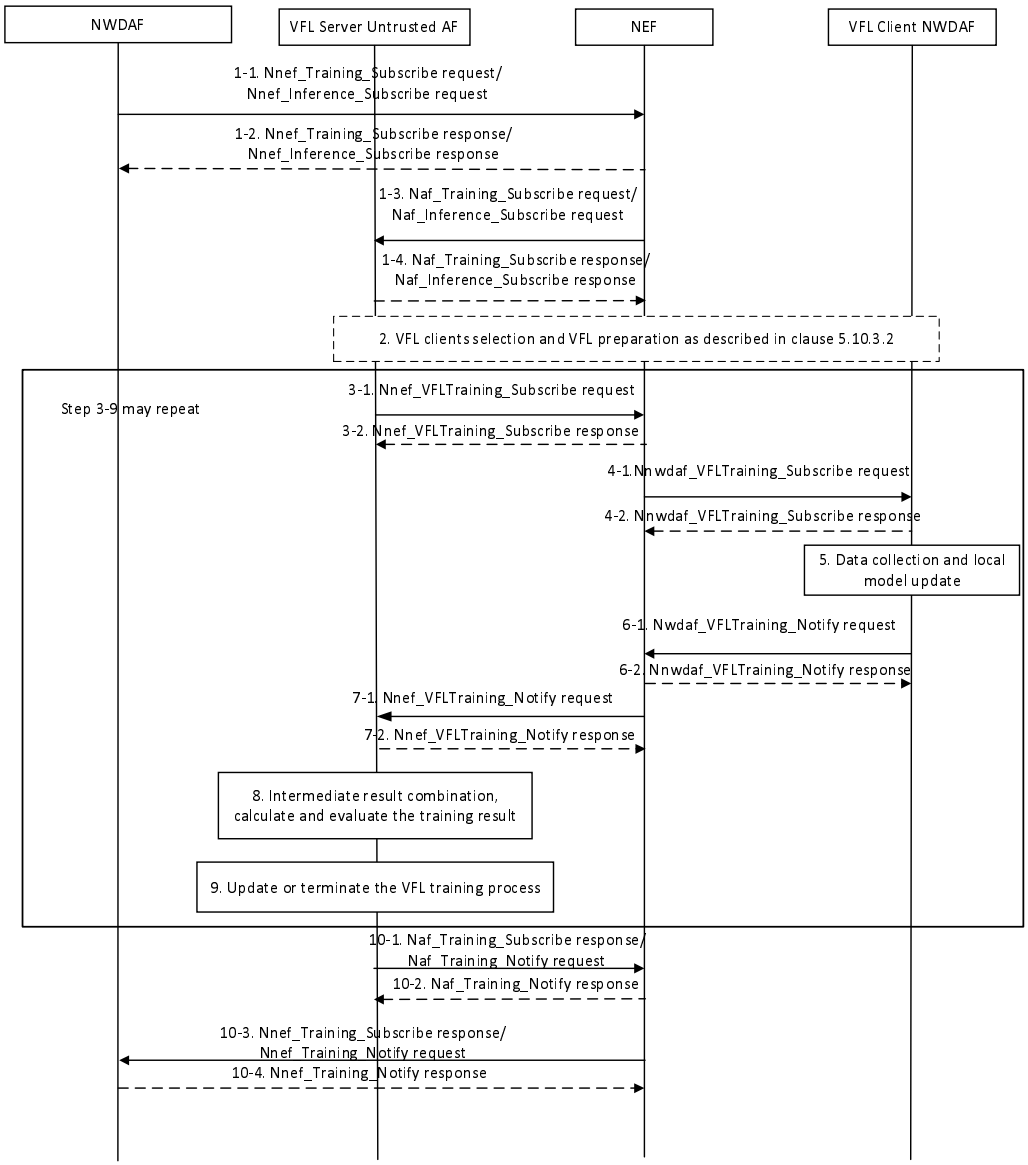

Figure 5.10.3.3.3-1: Training procedure for Vertical Federated Learning when untrusted AF is the VFL Server

1. The NWDAF as service consumer determines the untrusted AF acting as a VFL server. The NWDAF may invoke Nnef_Training_Subscribe service operation to NEF as described in clause 4.9.2.2 of 3GPP TS 29.591 [11] and then NEF forwards the subscription to the VFL server untrusted AF using Naf_Training_Subscribe service operation to perform the VFL training as described in clause 5.4.2.2 of 3GPP TS 29.530 [53].

2. The untrusted AF acting as VFL server performs the VFL preparation as described in clause 5.10.3.2.

3. The untrusted AF acting as VFL server sends a training request to VFL clients by invoking Nnef_VFLTraining_Subscribe service operation to all associated VFL clients i.e., NWDAF, as described in clause 4.4.50.2 of 3GPP TS 29.522 [10].

4. The NEF sends the training request received from the untrusted AF acting as VFL server to VFL clients i.e., NWDAF instances. As described in clause 4.4.50.2 of 3GPP TS 29.522 [10], the NEF maps the external identifiers to internal identifiers and invokes Nnwdaf_VFLTraining_Subscribe service operation.

5. Same as step 4 in clause 5.10.3.3.2.

6. Each VFL client responds to NEF with the client ML model training information by invoking the Nnwdaf_VFLTraining_Notify service operation as described in clause 4.10.2.4.2 of 3GPP TS 29.520 [5].

7. The NEF maps the internal identifiers to external identifiers and invokes Nnef_VFLTraining_Notify service operation to the untrusted AF acting as VFL server as described in clause 4.4.50.5 of 3GPP TS 29.522 [10].

8. Same as step 6 in clause 5.10.3.3.2.

9. Same as step 9 in clause 5.10.3.3.2.

NOTE: The steps 3-9 can be repeated until the training termination condition (e.g. maximum number of iterations, or the result of loss function is lower than a threshold) is reached.

10. The VFL server untrusted AF invokes the Naf_Training_Notify service operation to NEF as described in clause 5.4.2.4 of 3GPP TS 29.530 [53]. Then the NEF invokes Nnef_Training_Notify service operation to NWDAF as described in clause 4.9.2.4 of 3GPP TS 29.591 [11].

5.10.3.4 Inference procedures

5.10.3.4.1 General

The inference procedures are triggered by NWDAF containing AnLF. The NWDAF containing AnLF determines the VFL server (i.e., NWDAF, trusted AF, or untrusted AF) based on the VFL server discovery procedure as described in the clause 4.4.52.2 of 3GPP TS 29.522 [10], the VFL server identity on Nnwdaf_MLModelProvision_Subscribe Response as described in clause 5.4.6.2.3 of 3GPP TS 29.520 [5] if received from NWDAF containing MTLF or via the NRF. The VFL server generates and provides an aggregation result to NWDAF containing AnLF based on local inference results received from the VFL client(s).

The inference procedures in this clause include the following cases:

- subclause 5.10.3.4.2 specifies the inference procedure when NWDAF or trusted AF is acting as VFL server while VFL client(s) can be NWDAF, AF, and/or untrusted AF;

- subclause 5.10.3.4.3 specifies the inference procedure when untrusted AF is acting as VFL server while VFL client(s) can be NWDAF.

5.10.3.4.2 Inference procedure for vertical federated learning when NWDAF or Trusted AF is acting as VFL server

The inference procedure when trusted AF or NWDAF is acting as VFL server may be triggered by the NWDAF containing AnLF due to a request or subscription from a 5GC consumer NF or internal service logic of the AF acting as VFL server. This procedure is used by the VFL Server (trusted AF or NWDAF) to trigger inference procedure for Vertical Federated Learning among multiple NWDAF instances and/or AF acting as VFL client.

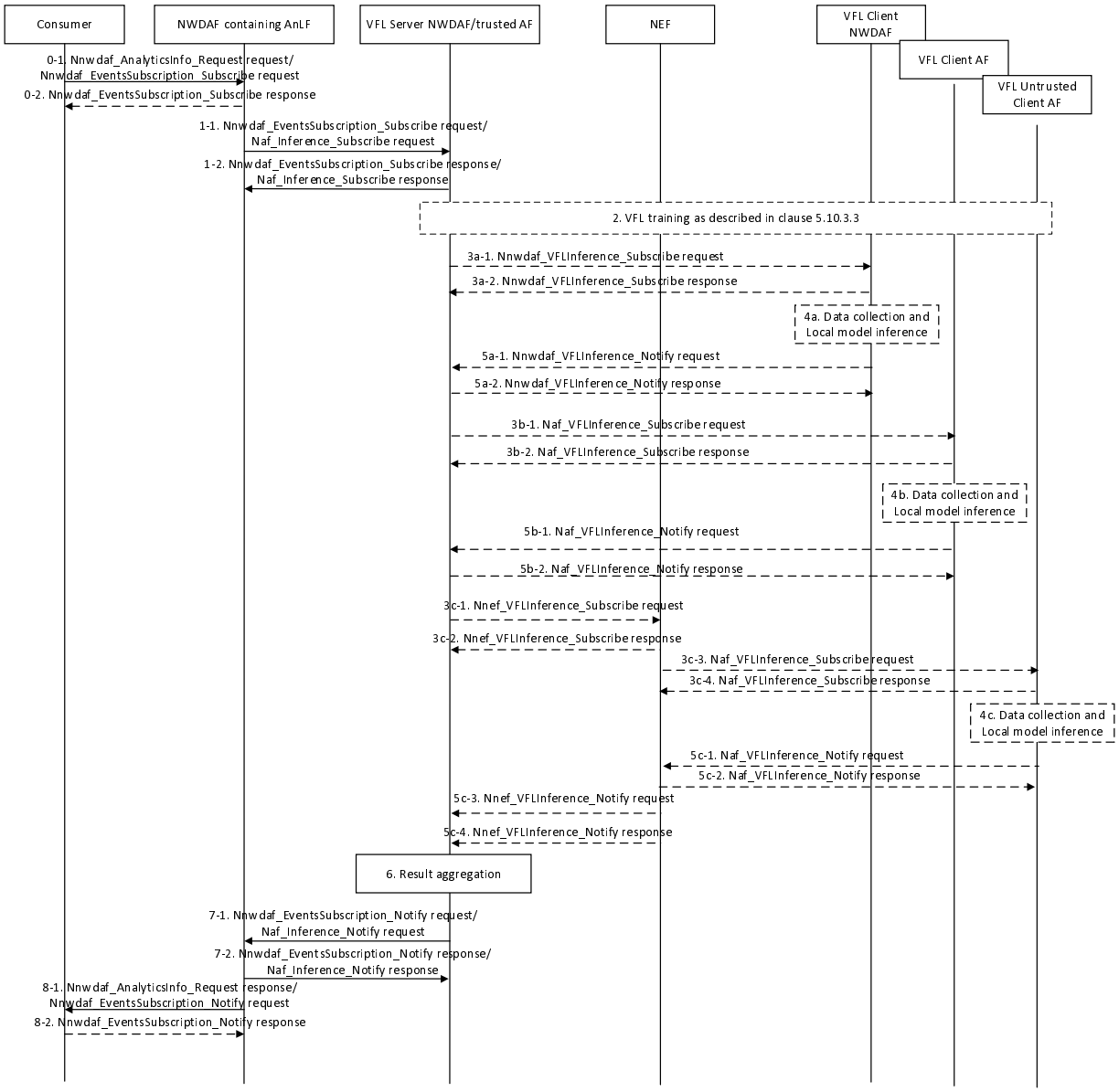

Figure 5.10.3.4.2-1: Inference procedure for Vertical Federated Learning when NWDAF or Trusted AF is acting as VFL server

0. To send a request for analytics events, the NWDAF service consumer invokes the Nnwdaf_EventsSubscription_Subscribe service operation to NWDAF containing AnLF as described in clause 4.2.2.2 of 3GPP TS 29.520 [5], or the NWDAF service consumer invokes Nnwdaf_AnalyticsInfo_Request service operation to NWDAF containing AnLF to request the analytics information as described in clause 4.3.2.2 of 3GPP TS 29.520 [5].

1. The NWDAF containing AnLF determines the NWDAF or trusted AF acting as a VFL server. If NWDAF is selected as VFL server, the NWDAF containing AnLF invokes the Nnwdaf_EventsSubscription_Subscribe service operation to VFL server NWDAF as described in clause 4.2.2.2 of 3GPP TS 29.520 [5]. If the trusted AF is selected as VFL server, the NWDAF containing AnLF invokes Naf_Inference_Subscribe service operation to VFL server trusted AF to perform the VFL inference as described in clause 5.5.2.2.2 of 3GPP TS 29.530 [53].

2. The VFL server and VFL clients may perform VFL training procedures as described in clause 5.10.3.3.

3. The NWDAF or trusted AF acting as VFL server sends the VFL inference request to each VFL client.

   3a. If the VFL client is an NWDAF, the NWDAF or trusted AF acting as VFL server invokes Nnwdaf_VFLInference_Subscribe service operation as described in clause 4.11.2.2.2 of 3GPP TS 29.520 [5]. If the Subscription is successfully processed and accepted, the VFL client sends

Nnwdaf_VFLInference_Subscribe Response message as described in clause 4.11.2.2.2 of 3GPP TS 29.520 [5].

3b. If the VFL client is a trusted AF, the NWDAF acting as VFL server invokes Naf_VFLInference_Subscribe service operation as described in clause 5.3.2.2.2 of 3GPP TS 29.530 [53]. If the Subscription is successfully processed and accepted, VFL client sends Naf_VFLInference_Subscribe Response message as described in clause 5.3.2.2.2 of 3GPP TS 29.530 [53].

3c. If the VFL client is an untrusted AF, the NWDAF acting as VFL server invokes Nnef_VFLInference_Subscribe service operation through NEF as described in clause 4.10.2.2 of 3GPP TS 29.591 [11]. The NEF invokes Naf_VFLInference_Subscribe by sending an HTTP POST request as described in clause 5.3.2.2.2 of 3GPP TS 29.530 [53]. If the Subscription is successfully processed and accepted, VFL client sends Naf_VFLInference_Subscribe response message as described in clause 5.3.2.2.2 of 3GPP TS 29.530 [53]. The NEF sends Nnef_VFLInference_Subscribe response message to VFL server as described in clause 4.8.2.2 of 3GPP TS 29.591 [11].

NOTE 1: For the trusted AF acting as VFL server, the VFL client can only be the NWDAF.

4. Each VFL client collects its local data. Based on the "vflCorrId" attribute received in step 1, each VFL Client determines the VFL local model to generate the intermediate local inference results.

5. Each VFL client sends the client intermediate local results to the VFL server.

   5a. If the VFL client is an NWDAF, then it sends the response to the VFL server by invoking Nnwdaf_VFLInference_Notify service operation as described in clause 4.11.2.4.2 of 3GPP TS 29.520 [5].

   5b. If the VFL client is a trusted AF, then it sends the response to the VFL server by invoking Naf_VFLInference_Notify service operation as described in clause 5.3.2.4 of 3GPP TS 29.530 [53].

   5c. If the VFL client is an untrusted AF, then it sends the response for the VFL server via the NEF by invoking Naf_VFLInference_Notify service operation as described in clause 5.3.2.4 of 3GPP TS 29.530 [53]. For each untrusted AF VFL client, the NEF converts any external identifiers to internal identifiers and the NEF invokes the Nnef_VFLInference_Notify service operation as described in clause 4.10.2.4 of 3GPP TS 29.591 [11].

6. The VFL server combines all the intermediate local results to generate the combined inference results.

7. If the NWDAF is the VFL server in step 1 and analytics notifications are to be sent, the VFL server NWDAF invokes Nnwdaf_EventsSubscription_Notify service operation to NWDAF containing AnLF as described in clause 4.2.2.4 of 3GPP TS 29.520 [5]. The NWDAF containing AnLF responds to the Nnwdaf_EventsSubscription_Notify service operation as described in clause 4.2.2.4 of 3GPP TS 29.520 [5].

   If the trusted AF is VFL server in step 1 and analytics notifications are to be sent, the VFL server AF invokes Naf_Inference_Notify service operation to NWDAF containing AnLF as described in clause 5.3.2.4 of 3GPP TS 29.530 [53]. The NWDAF containing AnLF responds to the Naf_Inference_Notify service operation as described in clause 5.3.2.4 of 3GPP TS 29.530 [53].

8. The NWDAF containing AnLF invokes the Nnwdaf_EventsSubscription_Notify service operation to the consumer as described in clause 4.2.2.4 of 3GPP TS 29.520 [5], or sends Nnwdaf_AnalyticsInfo_Request response message to the consumer as described in clause 4.3.2.2 of 3GPP TS 29.520 [5].

5.10.3.4.3 Inference procedure for vertical federated inference when untrusted AF is acting as VFL server

This procedure is used by the Untrusted AF acting as VFL Server to trigger inference procedure for Vertical Federated Learning among multiple NWDAF and/or AF instances acting as VFL client(s).

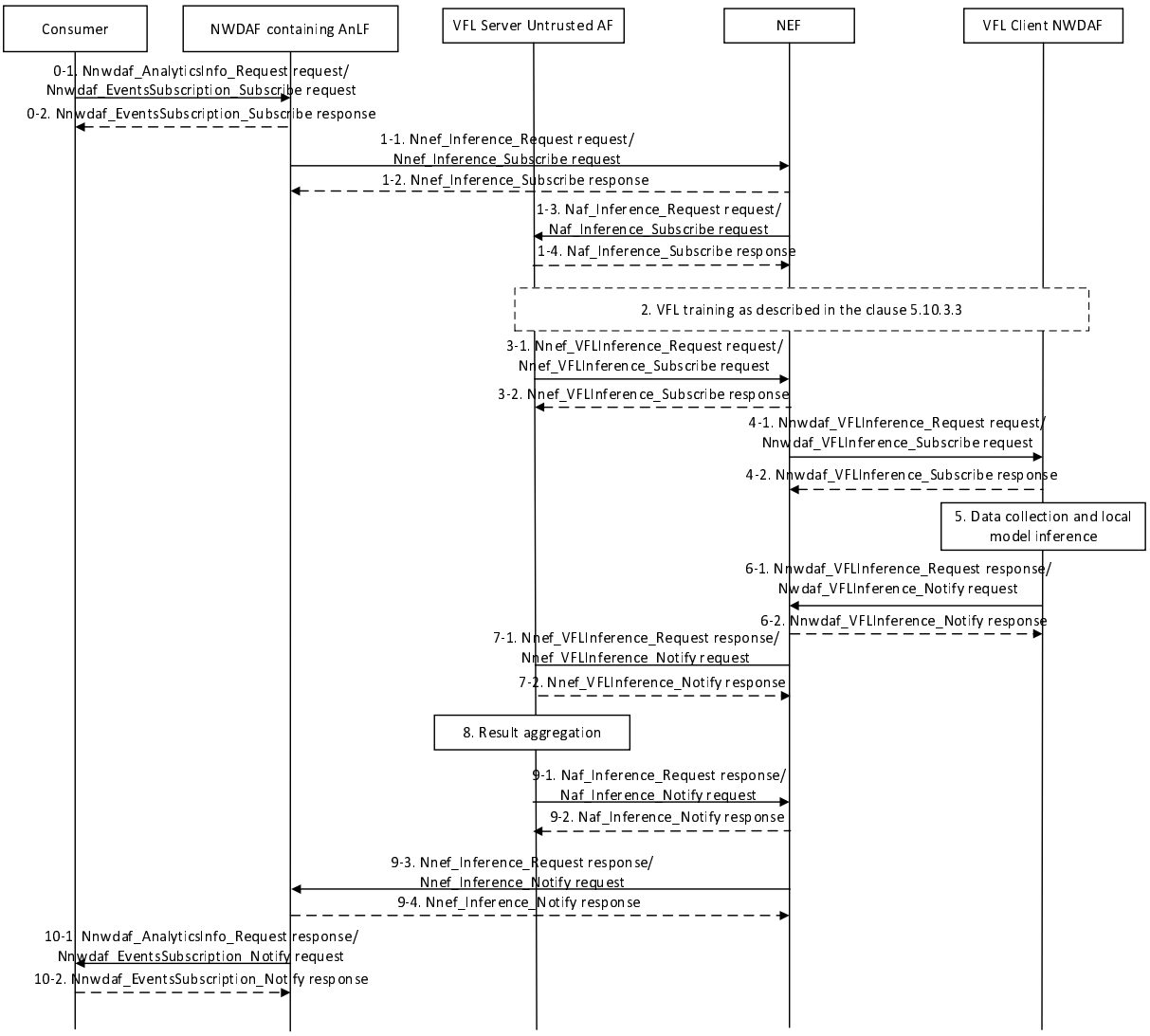

Figure 5.10.3.4.3-1: Inference procedure for Vertical Federated Learning when untrusted AF is the VFL Server

0. Same as step 0 in clause 5.10.3.4.2.

1. The NWDAF containing AnLF determines the untrusted AF acting as an VFL server. The NWDAF containing AnLF invokes Nnef_Inference_Subscribe service operation to NEF as described in clause 4.11.2.2 of 3GPP TS 29.591 [11] and then NEF forwards the subscription to the VFL server untrusted AF using Naf_Inference_Subscribe service operation to perform the VFL inference as described in clause 5.5.2.2 of 3GPP TS 29.530 [53].

2. The VFL server and VFL clients may perform VFL training procedures as described in clause 5.10.3.3.

3. The untrusted AF acting as VFL server sends an inference request to VFL clients by invoking Nnef_VFLInference_Subscribe service operation to all associated VFL clients i.e., NWDAF, as described in clause 4.4.51 of 3GPP TS 29.522 [10].

4. The NEF sends the inference request received from the untrusted AF acting as VFL server to VFL clients i.e., NWDAF instances. As described in clause 4.4.51 of 3GPP TS 29.522 [10], the NEF maps the external identifiers to internal identifiers and invokes the Nnwdaf_VFLInference_Subscribe service operation as described in clause 4.11.2.2.2 of 3GPP TS 29.520 [5].

5. Same as step 4 in clause 5.10.3.4.2. Additionally, an NWDAF VFL client which is interacting with additional NWDAF VFL client(s) receives responses from each of those client(s) and then aggregates the intermediate result.

6. Each VFL client responds to NEF with the client intermediate local results by invoking the Nnwdaf_VFLInference_Notify service operation as described in clause 4.11.2.4.2 of 3GPP TS 29.520 [5].

7. The NEF maps the internal identifiers to external identifiers and provides the results to the untrusted AF by invoking Nnef_VFLInference_Notify service operation to the untrusted AF acting as VFL server as described in clause 4.4.51.5 of 3GPP TS 29.522 [10].

8. Same as step 6 in clause 5.10.3.4.2.

9. The VFL server untrusted AF invokes the Naf_Inference_Notify service operation to NEF as described in clause 5.5.2.4 of 3GPP TS 29.530 [53]. Then the NEF invokes Nnef_Inference_Notify service operation to NWDAF containing AnLF as described in clause 4.11.2.4 of 3GPP TS 29.591 [11].

10. Same as step 8 in clause 5.10.3.4.2.

5.11 Analytics Accuracy Monitoring Procedures

5.11.1 General

The services defined in 3GPP TS 29.520 [5], 3GPP TS 29.574 [15], 3GPP TS 29.575 [16], 3GPP TS 29.503 [22], and 3GPP TS 28.104 [38] may be used to perform analytics accuracy monitoring based on the procedures and the requirements of 3GPP TS 23.288 [2] clauses 6.2D, 6.1.1.1 step 2, and 6.1.1.2 step 4.

5.12 ML Model Accuracy Monitoring Procedures

5.12.1 General

The services defined in 3GPP TS 29.520 [5], 3GPP TS 29.574 [15], 3GPP TS 29.575 [16], 3GPP TS 29.503 [22], and 3GPP TS 28.104 [38] may be used to perform ML Model accuracy monitoring based on the procedures and the requirements of 3GPP TS 23.288 [2] clauses 6.2E, 6.1.1.1 step 2, and 6.1.1.2 step 4.

5.13 DCCF Change Procedures

5.13.1 DCCF (re-)selection initiated by the data consumer

The procedure depicted in Figure 5.13.1-1 is used by a data consumer (e.g. NWDAF or DCCF) to obtain data related to UE(s), to be notified by the DCCF when the DCCF can no longer serve the UE(s) and to then reselect the DCCF.

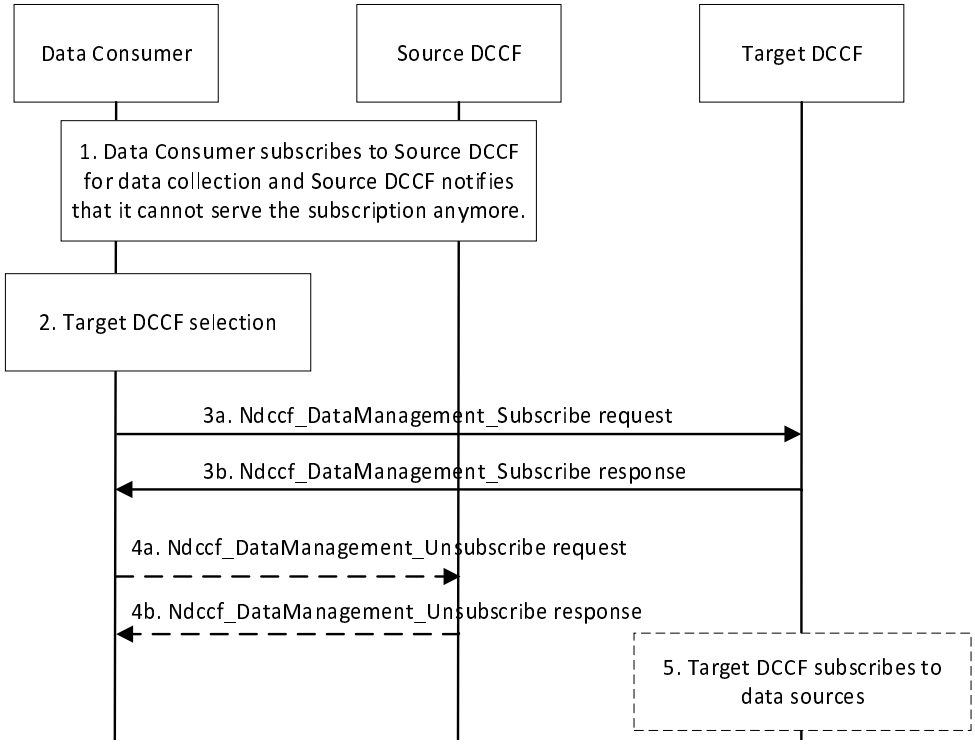

Figure 5.13.1-1: Procedure for DCCF relocation initiated by consumer

1. The data consumer subscribes to the source DCCF for data collection as described in clause 5.5.3 and the data consumer may receive a Ndccf_DataManagement_Notify message from the source DCCF containing a subscription termination request as described in 3GPP TS 29.574 [15].
2. The data consumer for the DCCF selects a new DCCF instance. The data consumer may perform the DCCF selection due to internal triggers, the reception of a notification of a UE mobility event, or the reception of the susbcription termination request in step 1.
3. The data consumer subscribes to the target DCCF using Ndccf_DataManagement_Subscribe as described in 3GPP TS 29.574 [15].
4. The data consumer may unsubscribe from the source DCCF using Ndccf_DataManagement_Unsubscribe as described in 3GPP TS 29.574 [15].
5. Target DCCF may subscribe to relevant data source(s), if not yet subscribed, as described in step 6 and step 7 of clause 5.5.3.1.

Annex A (informative): Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2021-04	CT3#115e					TS skeleton for TS 29.552.	0.0.0
2021-04	CT3#115e					Inclusion of documents agreed in CT3#115e: C3-212120, C3-212389	0.1.0
2021-05	CT3#116e					Inclusion of document agreed in CT3#116e: C3-213373	0.2.0
2021-08	CT3#117e					Inclusion of document agreed in CT3#117e: C3-214475, C3-214476, C3-214162	0.3.0
2021-10	CT3#118e					Inclusion of document agreed in CT3#118e: C3-215481, C3-215482, C3-215220, C3-215221.	0.4.0
2021-11	CT3#119e					Inclusion of document agreed in CT3#119e: C3-216463,C3-216428,C3-216241,C3-216242,C3-216243,C3-216244,C3-216464	0.5.0
2022-01	CT3#119bis-e					Inclusion of document agreed in CT3#119bis-e: C3-220495, C3-220356, C3-220090, C3-220091, C3-220336, C3-220332, C3-220333, C3-220357, C3-220358, C3-220338.	0.6.0
2022-02	CT3#120e					Inclusion of document agreed in CT3#120e: C3-221470, C3-221477, C3-221481, C3-221622, C3-221623, C3-221624, C3-221625, C3-221591, C3-221285, C3-221680, C3-221296, C3-221683, C3-221685.	0.7.0
2022-03	CT#95e	CP-220158				Presentation to TSG CT for approval	1.0.0
2022-03	CT#95e	CP-220158				Approved by TSG CT	17.0.0
2022-06	CT#96	CP-221132	0001	1	F	Adding “Prepared analytics subscription transfer” signalling flows.	17.1.0
2022-06	CT#96	CP-221131	0002	1	F	Correction Nnwdaf_MLModelProvision Service notification	17.1.0
2022-06	CT#96	CP-221132	0003	1	B	Update procedure for Analytics Exposure via DCCF	17.1.0
2022-06	CT#96	CP-221130	0004	1	B	Update Data Collection Reference Architecture	17.1.0
2022-06	CT#96	CP-221130	0005	1	B	Update Analytics Exposure Reference Architecture	17.1.0
2022-06	CT#96	CP-221130	0006	1	B	Resolve editor’s note in Analytics Exposure via DCCF	17.1.0
2022-06	CT#96	CP-221130	0007	1	B	Resolve editor’s note in Analytics Exposure via DCCF and MFAF	17.1.0
2022-06	CT#96	CP-221132	0010	1	F	Update Analytics Exposure via DCCF	17.1.0
2022-06	CT#96	CP-221132	0011	1	F	Update Analytics Exposure via DCCF and MFAF	17.1.0
2022-06	CT#96	CP-221133	0012	1	F	Update Analytics context transfer initiated by target NWDAF	17.1.0
2022-06	CT#96	CP-221133	0013	1	F	Update Analytics aggregation with provisioning of Area of Interest	17.1.0
2022-06	CT#96	CP-221132	0014	1	F	Update Data Collection via DCCF	17.1.0
2022-06	CT#96	CP-221132	0015	1	F	Update Data Collection via Messaging Framework	17.1.0
2022-06	CT#96	CP-221132	0016	1	B	SMCCE analytics supports Nnwdaf_EventsSubscription_Subscribe service operation	17.1.0
2022-06	CT#96	CP-221130	0017		B	Remove the redundant description for discovery and selection of NWDAF containing AnLF	17.1.0
2022-06	CT#96	CP-221131	0018	1	B	Introducing the Analytics Data Repository procedures	17.1.0
2022-06	CT#96	CP-221136	0020	1	F	Update of transferring ML model during analytics transfer	17.1.0
2022-06	CT#96	CP-221134	0021		B	Remove the ENs about when the DCCF sends the response to the consumer	17.1.0
2022-06	CT#96	CP-221135	0022	1	B	Update the Analytics context transfer and Analytics Subscription transfer	17.1.0
2022-06	CT#96	CP-221135	0023	1	F	Correction to Analytics context transfer initiated by target NWDAF	17.1.0
2022-09	CT#97e	CP-222103	0025	1	F	Remove EN about using Nadrf_DataManagement_RetrievalRequest in DCCF procedures	17.2.0
2022-09	CT#97e	CP-222102	0026	1	F	Add NSACF to the data source list of the NWDAF	17.2.0
2022-09	CT#97e	CP-222102	0027	1	F	Support prepared analytics subscription transfer	17.2.0
2022-09	CT#97e	CP-222102	0030	1	F	Update the content of Nadrf_DataManagement_RetrievalNotify	17.2.0
2022-12	CT#98e	CP-223173	0031	1	F	User consent corrections in data collection procedures	17.3.0
2022-12	CT#98e	CP-223172	0037		F	Update historical data and analytics storage via Notifications	17.3.0
2023-03	CT#99	CP-230146	0042	2	F	Update for Analytics Exposure via DCCF procedure	17.4.0
2023-03	CT#99	CP-230148	0043	1	F	Support of user consent change for data collection procedures	18.0.0
2023-06	CT#100	CP-231126	0045	4	B	Procedures for Federated Learning among Multiple NWDAFs in 5GC	18.1.0
2023-06	CT#100	CP-231124	0046	2	B	Procedures related to NRF for Federated Learning	18.1.0
2023-06	CT#100	CP-231124	0047	2	B	Updates to ML Model Provisioning Procedures for FL and Model Sharing	18.1.0
2023-06	CT#100	CP-231124	0049	2	B	Update to Reference Architecture for Data Collection from MDAF	18.1.0
2023-06	CT#100	CP-231124	0050	2	B	Support Data Collection from MDAF/MDAS for Service Experience Analytics	18.1.0
2023-06	CT#100	CP-231124	0051	2	B	Support Data Collection from MDAF for Redundant Transmission Experience Analytics	18.1.0

2023-06	CT#100	CP-231137	0052	1	F	Addition of Abbreviations	18.1.0
2023-06	CT#100	CP-231124	0053		B	Enhancements on QoS Sustainability analytics with coarse granularity	18.1.0
2023-06	CT#100	CP-231125	0055	1	B	Support of PFD determination analytics	18.1.0
2023-06	CT#100	CP-231137	0056	1	B	Updates to Procedures for NWDAF Discovery and Selection	18.1.0
2023-06	CT#100	CP-231137	0057	1	B	Update NRF procedure for NWDAF discovery supporting ML model provisioning	18.1.0
2023-06	CT#100	CP-231127	0058		B	Enhancements on service experience analytics	18.1.0
2023-06	CT#100	CP-231159	0060	1	A	Correcting the NF that validates the user consent	18.1.0
2023-06	CT#100	CP-231128	0061	1	B	Signalling flow Support of End-to-end data volume transfer time analytics	18.1.0
2023-06	CT#100	CP-231126	0062	1	B	Preparation and Maintenance Procedures for Federated Learning in 5GC	18.1.0
2023-06	CT#100	CP-231125	0063	1	F	Remove Detail Parameters in ML Model Provisioning Procedures	18.1.0
2023-09	CT3#101	CP-232082	0064	1	B	Adding GMLC to the possible data sources for analytics	18.2.0
2023-09	CT3#101	CP-232095	0065		B	Adding UPF to the possible data sources for analytics	18.2.0
2023-09	CT3#101	CP-232082	0066	1	B	Update to the General Procedure for Federated Learning	18.2.0
2023-09	CT3#101	CP-232082	0067	1	B	Update to the Preparation Procedure for Federated Learning	18.2.0
2023-09	CT3#101	CP-232081	0068		B	Enhancement of Redundant Transmission Experience analytics for NWDAF-assisted URSP	18.2.0
2023-09	CT3#101	CP-232082	0069	1	B	Procedures for PDU Session Traffic Analytics	18.2.0
2023-12	CT#102	CP-233224	0070	1	B	Analytics feedback information handing at the NWDAF	18.3.0
2023-12	CT#102	CP-233249	0071	1	B	Using UPF Exposure in UE communications procedure	18.3.0
2023-12	CT#102	CP-233249	0072	1	B	Using UPF Exposure in Dispersion analytics procedure	18.3.0
2023-12	CT#102	CP-233225	0073	2	B	Updates to PFD Determination Analytics	18.3.0
2023-12	CT#102	CP-233225	0074	1	B	Procedures for Relative Proximity Analytics	18.3.0
2023-12	CT#102	CP-233225	0075	1	B	Procedures for Movement Behaviour Analytics	18.3.0
2023-12	CT#102	CP-233226	0076	2	F	Update to Procedures for Federated Learning	18.3.0
2023-12	CT#102	CP-233225	0077	2	B	Update to ML Model Training Procedures	18.3.0
2023-12	CT#102	CP-233249	0078	1	B	Updates with UPF Exposure	18.3.0
2023-12	CT#102	CP-233236	0079	1	B	Updates to WLAN Performance Analytics	18.3.0
2023-12	CT#102	CP-233226	0080	1	B	Updates to Service Experience Analytics	18.3.0
2023-12	CT#102	CP-233226	0081	1	B	Updates to Analytics Data Collection from MDAF	18.3.0
2023-12	CT#102	CP-233226	0082	1	B	Data Collection in Roaming Case	18.3.0
2023-12	CT#102	CP-233226	0083	1	B	Analytics Exposure in Roaming Case	18.3.0
2023-12	CT#102	CP-233246	0084	1	F	Corrections to data collection from OAM procedures	18.3.0

2024-03	CT#103	CP-240199	0086	1	A	User Consent check before ADRF data retrieval	18.4.0
2024-03	CT#103	CP-240184	0087		F	UE Communication analytics correction	18.4.0
2024-03	CT#103	CP-240174	0088	1	B	Updates to E2E data volume transfer time analytics	18.4.0
2024-03	CT#103	CP-240163	0089	1	B	Updates to PFD Determination Analytics	18.4.0
2024-03	CT#103	CP-240184	0090	1	B	Updates with UPF Exposure procedures	18.4.0
2024-03	CT#103	CP-240161	0091		F	Update Consumer in the ML Model Provisioning Procedures	18.4.0
2024-06	CT#104	CP-241101	0092		F	Analytics Subscription Transfer corrections	18.5.0
2024-06	CT#104	CP-241114	0093	1	F	Corrections on collecting data from UPF for DN Performance Analytics	18.5.0
2024-06	CT#104	CP-241078	0094	3	F	Corrections on the procedure of PFD Determination Analytics	18.5.0
2024-06	CT#104	CP-241105	0096	1	A	Corrections to user consent for data collection using DCCF	18.5.0
2024-06	CT#104	CP-241101	0097		F	Corrections to data collection	18.5.0
2024-06	CT#104	CP-241091	0098	1	B	Updates to procedures of E2E data volume transfer time analytics	18.5.0
2024-06	CT#104	CP-241079	0106	1	B	Analytics accuracy monitoring procedures	18.5.0
2024-06	CT#104	CP-241078	0107	1	B	ML model accuracy monitoring procedures	18.5.0
2024-06	CT#104	CP-241079	0108	1	B	DCCF change procedures	18.5.0
2024-06	CT#104	CP-241114	0109		F	Corrections to QoS Monitoring related UPF event exposure procedures	18.5.0
2024-06	CT#104	CP-241114	0110	1	B	Updates to UPF event exposure procedures in PDU Session Traffic Analytics	18.5.0
2024-06	CT#104	CP-241092	0111	1	F	Corrections to procedures of E2E data volume transfer time analytics	18.5.0
2024-06	CT#104	CP-241078	0112		F	Corrections on the status code of GMLC related services	18.5.0
2024-06	CT#104	CP-241078	0113	1	B	Define the Location Accuracy Analytics procedure	18.5.0
2024-09	CT#105	CP-242155	0114	2	F	Correction to procedure of ADRF Storage via Notifications	18.6.0
2024-09	CT#105	CP-242128	0117	1	A	Corrections on the attribute name	18.6.0
2024-09	CT#105	CP-242119	0118	1	F	Corrections to procedures of QoS Sustainability Analytics	18.6.0
2024-09	CT#105	CP-242124	0115		F	Corrections to Analytics Subscribe and Request procedures	19.0.0
2024-12	CT#106	CP-243095	0120	3	B	Support the discovery of NWDAF for VFL	19.1.0
2024-12	CT#106	CP-243093	0122		A	Corrections on the attribute name	19.1.0
2024-12	CT#106	CP-243088	0123	1	F	Miscellaneous corrections on FL procedure	19.1.0
2024-12	CT#106	CP-243095	0126	1	B	Support for LMF to retrieve ML Model of AIML based positioning	19.1.0
2024-12	CT#106	CP-243095	0128	2	B	Support of signalling storm mitigation and prevention	19.1.0
2024-12	CT#106	CP-243089	0129	1	F	Procedure for Data Collection from the UE Application	19.1.0
2024-12	CT#106	CP-243089	0131	1	F	NWDAF Analytics Storage in ADRF via Notifications	19.1.0
2024-12	CT#106	CP-243088	0132		F	Corrections to roaming procedures	19.1.0
2024-12	CT#106	CP-243089	0133	1	F	Removal of UPF info subscription from SMF	19.1.0
2024-12	CT#106	CP-243084	0134	2	F	Incorrect UPEAS event name in analytics procedure	19.1.0
2024-12	CT#106	CP-243095	0135	1	B	Clarification for Horizontal Federated Learning	19.1.0
2024-12	CT#106	CP-243095	0136	2	B	Adding LMF as LM model training and performance monitoring data source	19.1.0
2024-12	CT#106	CP-243089	0137		B	Updates to Service Experience Analytics to support QoE measurements collection	19.1.0
2024-12	CT#106	CP-243089	0138	1	F	Corrections to Roaming Analytics procedures	19.1.0
2024-12	CT#106	CP-243089	0139	1	F	Corrections to Roaming Data Collection procedures	19.1.0
2024-12	CT#106	CP-243083	0140	1	F	Clarification regarding PDU Session Traffic analytics	19.1.0
2024-12	CT#106	CP-243095	0141	1	B	Procedure for Vertical Federated Learning when NWDAF is acting as VFL server	19.1.0
2025-03	CT#107	CP-250083	0144		B	Adding PCF as data source	19.2.0
2025-03	CT#107	CP-250083	0145	1	B	Updates to Signalling Storm Analytics	19.2.0
2025-03	CT#107	CP-250084	0147	1	F	Correction to Network Slice load level Analytics procedure	19.2.0
2025-03	CT#107	CP-250083	0150	1	B	Clarification on VFL procedures	19.2.0
2025-06	CT#108	CP-251086	0151	1	F	Wrong event names	19.3.0
2025-06	CT#108	CP-251086	0152	3	B	Procedure definition for QoS and Policy Assistance Analytics	19.3.0
2025-06	CT#108	CP-251088	0153	1	F	Corrections to analytics roaming procedures	19.3.0
2025-06	CT#108	CP-251088	0154		F	Corrections to PFD Determination Analytics	19.3.0
2025-06	CT#108	CP-251088	0155	1	F	Blank clause 5.7.1	19.3.0
2025-06	CT#108	CP-251088	0156		F	Update of clause 5.1	19.3.0
2025-06	CT#108	CP-251086	0157	1	B	Add SCP as the analytics data source of NWDAF	19.3.0
2025-06	CT#108	CP-251088	0159	1	F	Corrections on the analytics data source of NWDAF	19.3.0
2025-09	CT#109	CP-252072	0161	1	F	Corrections to signalling storm analytics	19.4.0
2025-09	CT#109	CP-252082	0162		F	Clarification on analytics procedure for untrusted AF	19.4.0
2025-09	CT#109	CP-252082	0163		F	Corrections on the TS reference number and HTTP method	19.4.0
2025-09	CT#109	CP-252072	0164	1	B	Support of VFL preparation procedures	19.4.0
2025-09	CT#109	CP-252072	0165	1	B	Support of VFL inference procedures	19.4.0
2025-12	CT#110	CP-253042	0166		B	Updates to Movement Behaviour Analytics	19.5.0
2025-12	CT#110	CP-253040	0167	1	F	Corrections to events in procedures	19.5.0
2025-12	CT#110	CP-253040	0168	2	F	Correction to General clause	19.5.0
2025-12	CT#110	CP-253040	0169		F	Corrections to data collection	19.5.0
2025-12	CT#110	CP-253023	0171	1	F	Resolve EN on general clause for VFL	19.5.0
2025-12	CT#110	CP-253023	0172	1	B	Support of VFL Training procedure	19.5.0
2025-12	CT#110	CP-253024	0173	2	F	Correction on VFL inference procedure	19.5.0

2025-12	CT#110	CP-253023	0175		F	Wrong NF name	19.5.0
2025-12	CT#110	CP-253023	0176	1	F	Wrong references and EN resolution for VFL preparation procedure	19.5.0
2025-12	CT#110	CP-253040	0177	1	F	Corrections on Historical data and analytics via notification procedure	19.5.0
2025-12	CT#110	CP-253040	0178		F	Incorrect step references	19.5.0
2026-03	CT#111	CP-260066	0179	1	F	VFL Training procedure corrections for NWDAF or AF as VFL server	19.6.0
2026-03	CT#111	CP-260066	0180	1	F	VFL Training procedure corrections for Untrusted AF as VFL server	19.6.0
2026-03	CT#111	CP-260066	0181	1	F	VFL Inference procedure corrections for NWDAF or AF as VFL server	19.6.0
2026-03	CT#111	CP-260066	0182	1	F	VFL Inference procedure corrections for Untrusted AF as VFL server	19.6.0
2026-06	CT#112	CP-261179	0187		F	Corrections to Federated Learning procedures	19.7.0

History

Version	Date	Status
V19.4.0	February 2026	Publication
V19.5.0	February 2026	Publication
V19.6.0	March 2026	Publication
V19.7.0	July 2026	Publication