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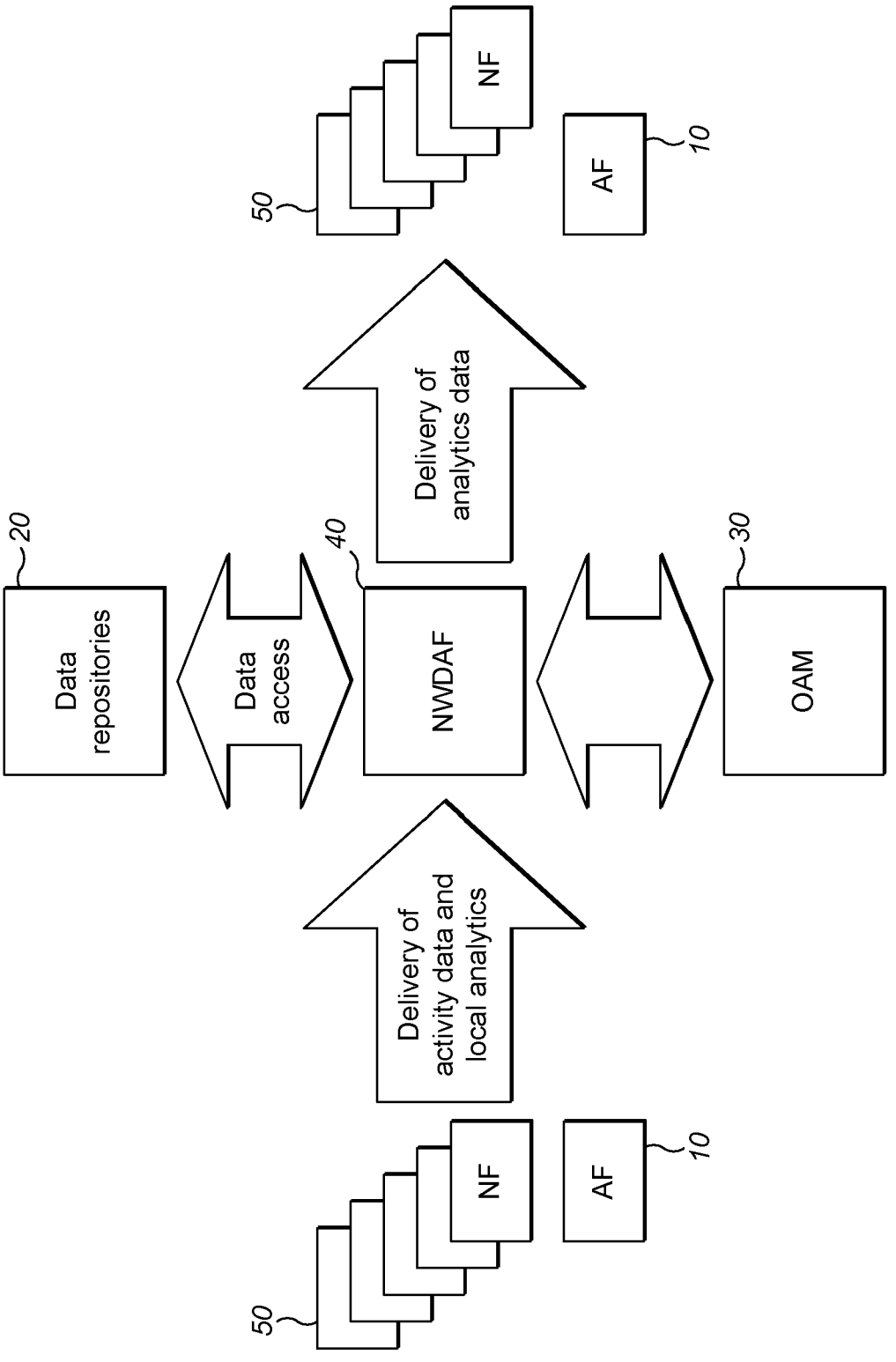
Data repositories
20
Data access
NWDAF
40
Delivery of analytics data
Delivery of activity data and local analytics
OAM
30
NF
AF
10
50
NF
AF
10
50

FIG. 1

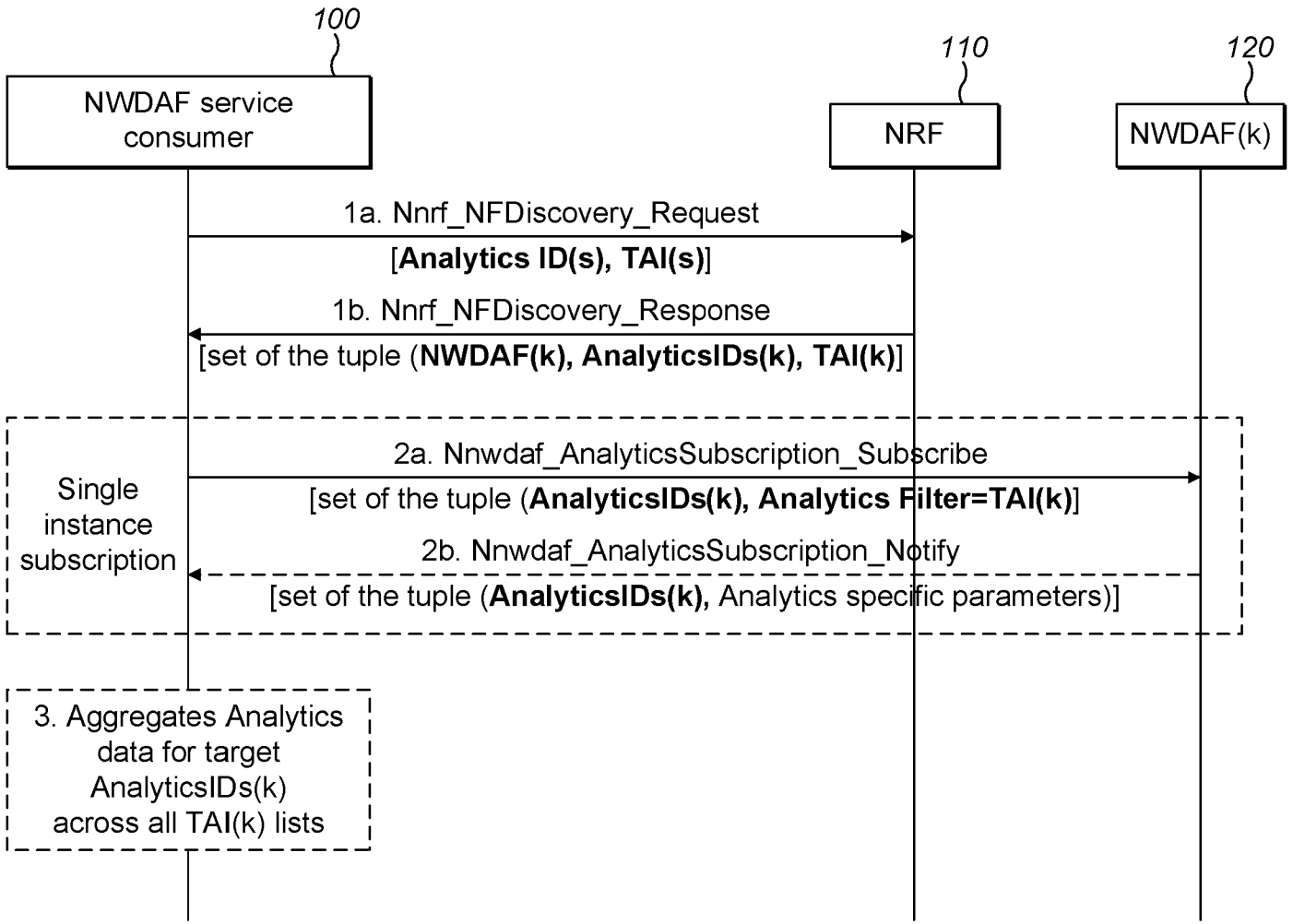
100
110
120
NWDAF service consumer
NRF
NWDAF(k)
1a. Nnrf_NFDiscovery_Request
[Analytics ID(s), TAI(s)]
1b. Nnrf_NFDiscovery_Response
[set of the tuple (NWDAF(k), AnalyticsIDs(k), TAI(k)]
Single instance subscription
2a. Nnwdaf_AnalyticsSubscription_Subscribe
[set of the tuple (AnalyticsIDs(k), Analytics Filter=TAI(k)]
2b. Nnwdaf_AnalyticsSubscription_Notify
[set of the tuple (AnalyticsIDs(k), Analytics specific parameters)]
3. Aggregates Analytics data for target AnalyticsIDs(k) across all TAI(k) lists

FIG. 2

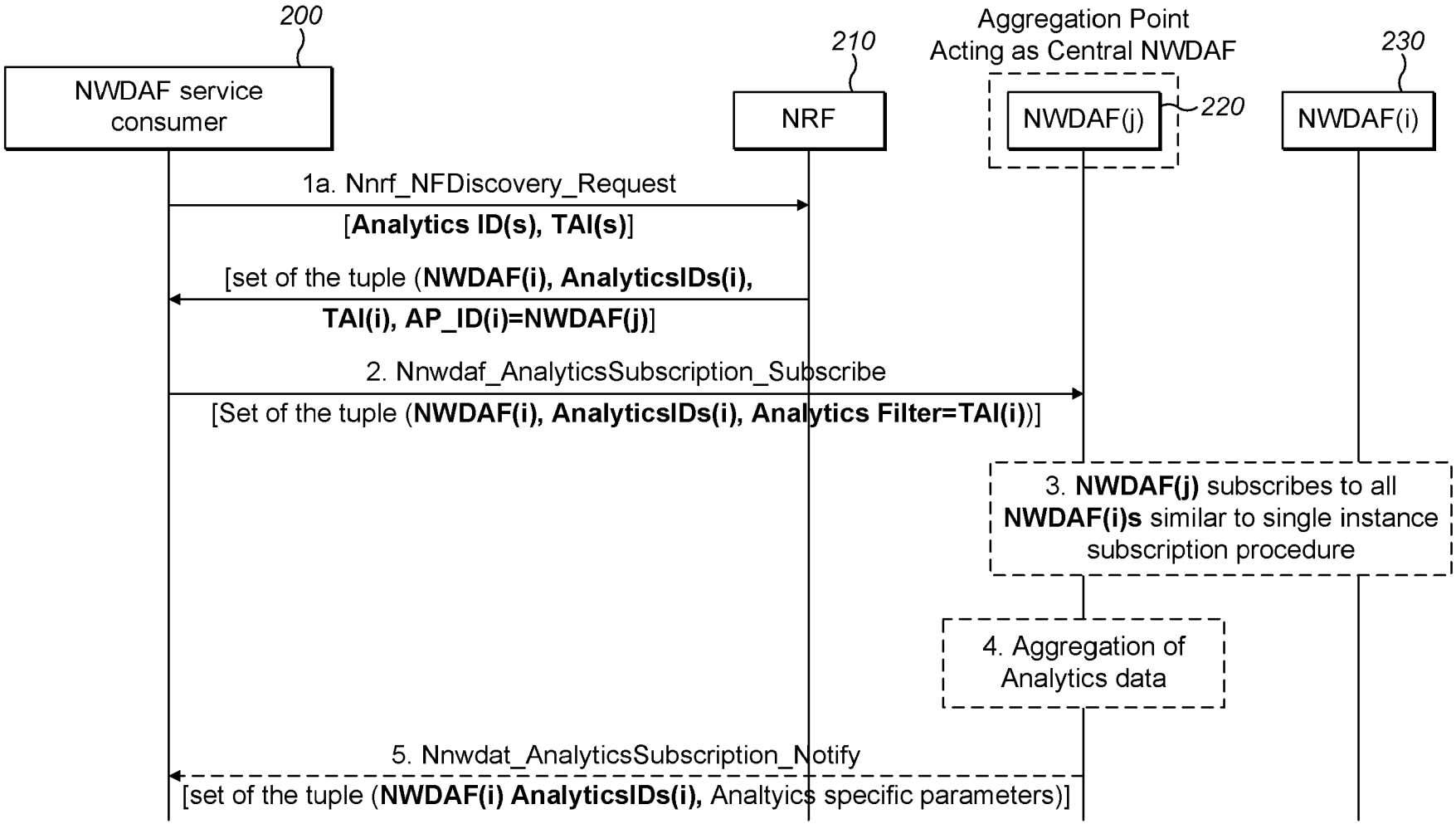
200
NWDAF service consumer
210
NRF
Aggregation Point Acting as Central NWDAF
NWDAF(j)
220
230
NWDAF(i)
1a. Nnrf_NFDiscovery_Request
[Analytics ID(s), TAI(s)]
[set of the tuple (NWDAF(i), AnalyticsIDs(i), TAI(i), AP_ID(i)=NWDAF(j)]
2. Nnwdaf_AnalyticsSubscription_Subscribe
[Set of the tuple (NWDAF(i), AnalyticsIDs(i), Analytics Filter=TAI(i))]
3. NWDAF(j) subscribes to all NWDAF(i)s similar to single instance subscription procedure
4. Aggregation of Analytics data
5. Nnwdat_AnalyticsSubscription_Notify
[set of the tuple (NWDAF(i) AnalyticsIDs(i), Analtyics specific parameters)]

FIG. 3

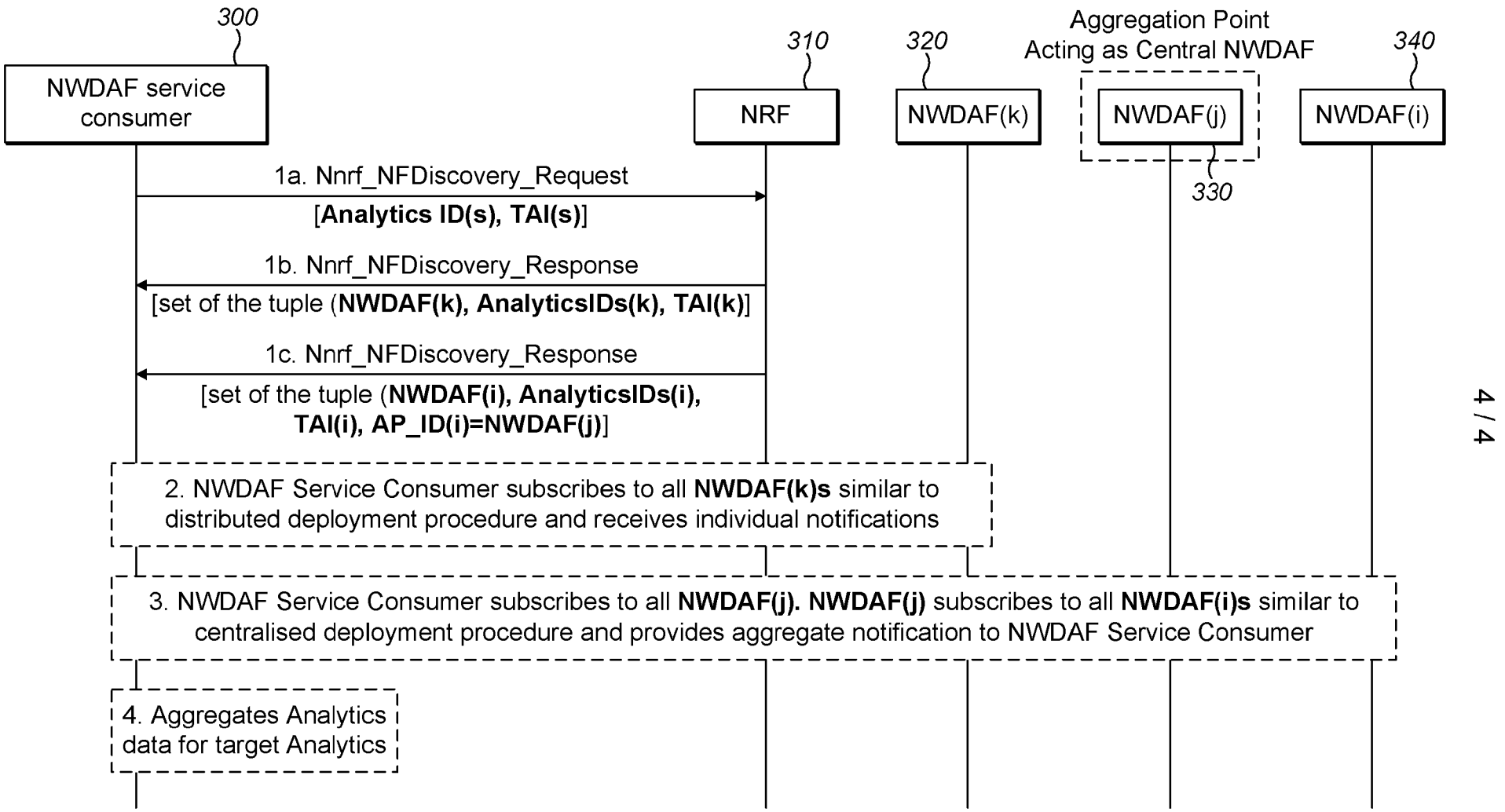
300
NWDAF service consumer
310
NRF
320
NWDAF(k)
Aggregation Point
Acting as Central NWDAF
NWDAF(j)
330
340
NWDAF(i)
1a. Nnrf_NFDiscovery_Request
[Analytics ID(s), TAI(s)]
1b. Nnrf_NFDiscovery_Response
[set of the tuple (NWDAF(k), AnalyticsIDs(k), TAI(k)]
1c. Nnrf_NFDiscovery_Response
[set of the tuple (NWDAF(i), AnalyticsIDs(i), TAI(i), AP_ID(i)=NWDAF(j)]
2. NWDAF Service Consumer subscribes to all NWDAF(k)s similar to distributed deployment procedure and receives individual notifications
3. NWDAF Service Consumer subscribes to all NWDAF(j). NWDAF(j) subscribes to all NWDAF(i)s similar to centralised deployment procedure and provides aggregate notification to NWDAF Service Consumer
4. Aggregates Analytics data for target Analytics

FIG. 4

Improvements in and relating to Data Analytics in a telecommunication network

The present invention relates to the acquisition, processing and use of data analytics in a telecommunication network. It particularly, but not exclusively, relates to Fifth Generation networks, although this is exemplary and other network may benefit similarly.

There is an increasing desire to improve network automation for 5G telecommunication networks, known as enabling Network Automation (eNA). As a part of this, Network Data Analytics Function (NWDAF) are defined as part of a Service Based Architecture (SBA) using mechanisms and interfaces specified for 5G Core and Operations Administration and Maintenance (OAM).

In a service-based architecture, each network function (NF) comprises a set of services that interfaces it (as the producer of such services) to other NFs (as the consumer of those services) over a common bus known as service-based interface (SBI).

Figure 1 shows a general schematic overview illustrating various element in a 5G network automation scheme. Only those parts relevant of the automation are shown, for clarity. This shows that activity data and analytics are provided from a first group of NFs 50 or Application Functions (AFs) 10 to NWDAF 40. NWDAF 40 also interfaces to OAM 30 and data repositories 20. NWDAF 40 analyses the data from these sources and delivers analytics data to a second group of NFs 50 or AFs 10. The second group of NFs 50 may include some or all of the first group of NFs 50 or AFs 10.

It is an aim of embodiments of the present invention to address shortcomings in the acquisition, processing and use of data analytics, whether mentioned herein or not.

According to a first aspect of the present invention, there is provided a method of managing analytics data in a telecommunication network, wherein a consumer Network Function, NF, determines how analytics data from a plurality of individual sources is collected and analysed in one of: a) a distributed manner from a plurality of Network Data Analytics Functions, NWDAF; b) a centralised manner by aggregating analytics data from the plurality of NWDAFs, before analysing it at an Aggregator NWDAF; or c) a mixture of a) and b) above.

In an embodiment, in the case of a plurality of NWDAFs being provided in the telecommunication network, at least one has a specialised function and at least one has a general function.

In an embodiment, the specialised function is to aggregate analytics from plurality of areas of interest or plurality of target users, and the general function is to notify analytics per area of interest or per set of target users.

In an embodiment, capability information of any particular one of the plurality of NWDAFs having the specialised function is stored in a Network Repository Function, NRF.

In an embodiment, the capability information relates to analytics aggregation capability

In an embodiment, a consumer Network Function, NF, determines one or more NWDAFs from which to collect data, based on NWDAF capability information as part of its implemented internal selection criteria.

In an embodiment, implemented selection criteria comprises one or more of newly registered capabilities in NRF, determined based on the level of load per NWDAF, number of analytics IDs directly supported per NWDAF and other Key Performance Indicators (KPIs) pre-configured by the network Operator.

In an embodiment, an identifier, such as aggregation point identifier, AP ID, is defined per Aggregator NWDAF, as an assistance information registered in NRF wherein the identifier indicates which amongst NWDAFs are able to act as an aggregation point.

In an embodiment, the consumer NF autonomously determines how a plurality of NWDAFs operate together.

In an embodiment, the determination is based on selection criteria, whereby the consumer NF considers all NWDAFs identified by the NRF and based on the implemented selection criteria decides how to collect data from a combination of them.

In an embodiment, each of the plurality of NWDAFs pre-negotiates with one or more other Aggregator NWDAFs how many analytics IDs it supports and the Aggregator NWDAF advertises such extended set of supported analytics IDs within the NRF.

In an embodiment, further steps are provided: a network function service consumer sends a discovery request to a Network Repository Function, NRF, including all required Analytics ID(s) and an area of interest; the NRF responding with one or more distributed NWDAF instance IDs, each covering a set of Analytics ID(s), and at least part of the area of interest supported; the network function service consumer sends a subscription request to each distributed NWDAF;

each distributed NWDAF responds with analytics specific parameters per analytics ID; and per analytics ID, the network function service consumer itself aggregates the target of analytics reporting across distributed NWDAFs for corresponding areas of interest.

In an embodiment, further steps are provided: a network function service consumer sends a discovery request to a Network Repository Function, NRF, including all required Analytics ID(s) and an area of interest; the NRF responding with one or more of: a set of NWDAF instance IDs, each covering a set of Analytics ID(s), and at least part of the area of interest supported and AP ID, or other identifier, per Aggregator NWDAF instance(s) indicating possible aggregation point(s); the network function service consumer, based on its internal selection criteria, considering registered NWDAF capabilities and information from NRF, selects at least one NWDAF as Aggregator NWDAF; the network function service consumer sends a subscription request to Aggregator NWDAF to designate as an aggregation point, including Analytics IDs and area of interest per NWDAF to aggregate from; and either: a) Aggregator NWDAF identifies its designation as aggregation point; or b) Aggregator NWDAF based on configuration, implementation or queries to NRF decides on mapping to specific NWDAFs to aggregate analytics; Aggregator NWDAF subscribes to all NWDAFs ; NWDAFs notify with analytics specific parameters per analytics ID in the set of Analytics IDs; Per analytics ID, Aggregator NWDAF aggregates the target of analytics reporting across different NWDAFs for corresponding area of interest; and Aggregator NWDAF notifies to the network function service consumer with analytics specific parameters per analytics ID for all aggregated analytics IDs per NWDAF.

In an embodiment, further steps are provided: a network function service consumer sends a discovery request to a Network Repository Function, NRF, including all required Analytics ID(s) and an area of interest; the NRF responding with one or more of: at least one NWDAF instance ID; at least one NWDAF instance ID to be aggregated into at least one Aggregator NWDAF instance ID as registered in NRF; the network function service consumer subscribing to all NWDAFs, including aggregation points acting as central NWDAFs and receiving individual notifications; and per analytics ID, the network function service consumer aggregating analytics data from both distributed and (semi-) centralised NWDAF instances for corresponding points of interest.

According to a second aspect of the present invention, there is provided a telecommunication network operable to perform the method of the first aspect,

A single instance or multiple instances of NWDAF 40 may be deployed in a Public land mobile network (PLMN). In case multiple NWDAF 40 instances are deployed, embodiments of the

present invention support deploying the NWDAF 40 as a central NF, as a collection of distributed NFs, or as a combination of both (i.e. some centralised and some distributed).

When multiple NWDAFs exist, not all of them need to be able to provide the same type of analytics results. In other words, some of them can be specialised so to provide certain types of analytics only, and some may be more general in nature. Embodiments of the present invention define an Analytics ID information element, which is used to identify the type of supported analytics that a particular NWDAF can generate.

On the other hand, some of the NWDAFs in one network may be providing the same type of analytics, and so may assist each other for e.g. specific analytics for specific target UEs or specific analytics for specific area of interest.

The capabilities of a particular NWDAF instance are described in the NWDAF profile stored in the Network Repository Function (NRF).

In cases where multiple instances of NWDAF are deployed, some specialising in providing certain type of analytics, or in order for multiple NWDAFs to help each other to provide the same type analytics, a coordination mechanism is defined across the instances. More importantly, a consumer Network Function (NF) may need a flexible data collection mechanism and associated services, once it discovers corresponding NWDAF instances, to realise different deployment options (whether distributed, centralised or a mixture of the two).

Embodiments of the present invention provide a data collection mechanism in an environment comprising multiple NWDAFs to thereby flexibly support different deployment options.

According to the present invention there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

Although a few preferred embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

Throughout the embodiments of this invention, the terms “NWDAF” and “NWDAF instance” are used interchangeably.

In an embodiment of the invention for distributed data collection, a consumer NF decides on the set of NWDAFs (or NWDAF instances) from which to collect data, based on its implemented

selection criteria (e.g. the level of load per NWDAF, number of analytics IDs directly supported per NWDAF or other Key Performance Indicators (KPIs) pre-configured by the network Operator).

In an embodiment of the invention for (semi-)centralised data collection, a novel aggregation point identifier (AP ID) is defined per NWDAF indicating which other NWDAF can be a potential aggregation point for it. The identifier can be set, taking into account multiple factors including the level of load per NWDAF (or NWDAF instance), number of analytics IDs directly supported per NWDAF or other KPIs set by the network operator. NWDAF information maintained in NRF or any other designated Data Repository structures may hold this identifier per NWDAF. The consumer NF utilises the AP ID as assistance information in addition to its other implemented selection criteria to decide on how multiple NWDAF instances collaborate.

In an alternative embodiment of the invention for (semi-)centralised data collection, a consumer NF intelligently decides how multiple NWDAF instances collaborate without any other entities' intervention. The consumer NF considers all NWDAF instances (e.g. as discovered via NRF) and based on implemented selection criteria, similar to distributed data collection, decides how to collect data from a combination of them. NWDAF information maintained in NRF or any other designated Data Repository structures can be agnostic to aggregation information.

In an alternative embodiment of the invention for (semi-)centralised data collection, each NWDAF instance pre-negotiates the number of analytics IDs it may support (either directly or indirectly) with other NWDAF instances (e.g. via NRF discovery) and it advertises such extended set of supporting analytics IDs (direct plus indirect ones) within NRF. NWDAF information maintained in NRF or any other designated Data Repository structures may explicitly differentiate directly supported analytics IDs from indirect ones. The consumer NF utilises the direct versus indirect supporting analytics IDs as assistance information in addition to its other implemented selection criteria to decide how multiple NWDAF instances collaborate.

In an embodiment of the invention for mixed mode data collection, a combination of embodiments for distributed and (semi-)centralised data collection is adopted by the consumer NF.

Although a few preferred embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example only, to the accompanying diagrammatic drawings in which:

Figure 1 shows a general representation of a 5G network automation framework;

Figure 2 shows a message exchange and method according to a first embodiment of the present invention;

Figure 3 show a message exchange and method according to a second embodiment of the present invention; and

Figure 4 shows a message exchange and method according to a third embodiment of the present invention.

Figure 2 illustrates a scenario where there is a consumer NF 100, NRF 110, NWDAF(k) 120 forming at least part of a system. This also shows the various processes and messaging between respective elements.

It is assumed that index (k) shows the NWDAF instance ID in a multi-instance deployment. Each instance NWDAF(k) is specialised in a set of data analytics types, identified by AnalyticsIDs(k); some overlapping across different instances and some are mutually exclusive. Instances with overlapping analytic IDs may help each other e.g. to cover different sets of UEs as the target of analytics reporting or to cover different set of Tracking Areas within the area of interest. Tracking Area Indicators – TAI(k) refers to such areas of interest that could be covered by NWDAF(k).

Case A: Distributed Data Collection Model

In a first embodiment of the invention, the Consumer NF 100, based on its implemented selection criteria, e.g. network configuration or pre-configured network operator's preference, may decide to consume different NWDAFs' services in a distributed manner.

The details of each step shown in Figure 2 are as follows:

1. NWDAF service consumer 100 sends NF discovery request (1a) to NRF 110 including all required Analytics ID(s) and the area of interest (e.g. in form of TAIs). The request may also include extra information, e.g. Network Slice Selection Assistance Information (i.e. Single-NSSAI or S-NSSAI). The NRF 110 response (1b) may include multiple NWDAF instance IDs, NWDAF(k), each covering a set of Analytics ID(s), AnalyticsIDs(k), and (part of) the area of interest supported by instance (k), identified as TAI(k).

2. NWDAF service consumer 100 sends a subscription request (2a) to each NWDAF(k) 120 including AnalyticsIDs(k) and TAI(k) (e.g. as Analytics Filter). The request can be as the set of tuple of (AnalyticsIDs(k), Analytics Filter=TAI(k)) as shown in step 2a to differentiate the area of interest per analytics ID. NWDAF(k) 120 notifies with analytics specific parameters per analytics ID as shown in step 2b.

3. The service consumer NF 100 may aggregate the target of analytics reporting across NWDAF(k)s for AnalyticsIDs(k) for corresponding areas of interest TAI(k).

Case B: (Semi-) Centralised Data Collection Model with AP ID

In second embodiment of the invention, based on Figure 3, the Consumer NF 200 based on AP ID as assistance information in addition to its implemented selection criteria decides to consume different NWDAFs' services in a (semi-)centralised manner, designating one (set of) NWDAF(s) as aggregation point(s).

In this case, when registering an aggregation point like NWDAF (j) 220 into NRF 210 in addition to the set of analytics IDs to be supported by NWDAF (j) 220 and area of interest to be covered by NWDAF (j) 220, the AP ID is also configured equivalent to NWDAF(j) 220 ID. This also identifies NWDAF(j) 220 as an aggregation point.

When registering a distributed NWDAF like NWDAF(i) 230 within NRF 210, in addition to the set of analytics IDs to be supported by NWDAF(i) 230 and the area of interest to covered by NWDAF(i) 230, the AP ID is also configured equivalent to one of NWDAF(j)s 220 already registered as aggregation points.

The mapping between NWDAF(j)s 220 and NWDAF(i)s 230 in AP IDs can take into account multiple factors including the level of load per NWDAF, analytics IDs supported per NWDAF, area of interest supported per NWDAF, any predefined hierarchy for mapping or other KPIs set by the network operator. NWDAF information maintained in NRF 210 or any other designated Data Repository structures may hold this mapping between NWDAFs based on AP IDs. In case B, both NRF 210 and NWDAF service consumer 200 become aware of the mapping between central and distributed NWDAFs based on AP IDs.

Figure 3 illustrates a scenario where there is a consumer NF 200, NRF 210, NWDAF(j) 220 and NWDAF(i) 230 forming at least part of a system. The details of each step shown in Figure 3 are as follows:

1. Similar to step 1 of case A shown in Figure 2 (distributed deployment), except the NRF 210 response may include both distributed NWDAF(i)s and central NWDAF(j)s. The NRF 210 response also includes the AP ID per NWDAF(i) 230 instance indicating possible aggregation point(s) NWDAF(j) 220 for different values of (j) i.e. the mapping between central and distributed NWDAFs. NWDAF service consumer 200 determines central aggregation points based on the mapping received from NRF 210 as AP IDs.

2. NWDAF service consumer 200 sends a subscription request to NWDAF(j) 220 (to designate it as an aggregation point) including AnalyticsIDs(i), TAI(i) (as analytics filter) for NWDAF(i) 230. NWDAF(j) 220 identifies its designation as aggregation point being the addressee of service consumer request. Alternatively, another explicit flag or parameter can be set as an input parameter by NWDAF service consumer 200 to explicitly designate an aggregation point, NWDAF(j) 220.

3. NWDAF(j) 220 subscribes to all NWDAF(i)s 230 in a similar procedure as case A (single instance subscription procedure). All NWDAF(i)s notify with analytics specific parameters per analytics ID in the set of AnalyticsIDs(i).

4. NWDAF(j) 220 may aggregate the target of analytics reporting across different NWDAF(i)s 230 for AnalyticsIDs(i) for corresponding area of interest, TAI(i).

5. NWDAF(j) 220 notifies with analytics specific parameters per analytics ID for all aggregated analytics IDs per NWDAF(i) 230.

Case C: (Semi-) Centralised Data Collection Model without AP ID

In an alternative embodiment of the invention, similar to case B, step 1 is exactly similar to case A (distributed deployment) where the data kept in NRF 210 or any other data repository structure stays agnostic to deployment information (i.e. aggregation point identifiers). As a result, the NWDAF consumer 200 decides on aggregation point(s) without any other assistance information.

In another case of centralised aggregation (termed here as case C), no mapping is indicated between central and distributed NWDAFs at NRF 210. In this case, no AP ID is configured for NWDAFs and only aggregation points are differentiated when registering in NRF 210 either implicitly (refer to case D, which follows) or explicitly e.g. by configuring an identifier. In case C, NRF 210 becomes agnostic to the mapping between central and distributed NWDAFs.

The details of each step are as follows:

1. Similar to step 1 of case A shown in Figure 2, except NRF 210 response may include both distributed NWDAF (i)s 230 and NWDAF (j)s 220 identified as aggregation points. NWDAF service consumer 200 determines central aggregation point(s) based on its configuration or implemented selection criteria.

2-5. are as above described for case B.

Case D: (Semi-) Centralised Data Collection Model, pre-negotiated

In an alternative embodiment of the invention similar to case B, step 1 is similar to case A (distributed deployment) except in respect of the data kept within NRF 210 or any other data repository structure, the analyticsIDs(j) advertised by NWDAF(j) 220 is an extended set of analytics IDs from different NWDAF(i)s 230 that can be pre-negotiated for instance j, e.g. based on some configurations or a pre-defined hierarchy when each NWDAF registers within NRF 210. As a result, no explicit identifier is defined per NWDAF within NRF 210, unlike case B and no mapping is indicated between central and distributed NWDAFs at NRF 210.

The extended set of analytics IDs supported can be differentiated from analytics IDs directly supported per NWDAF. Some central NWDAFs may only aggregate analytics so the extended list may not have directly supported analytics in such a situation. Consequently, the NWDAF service consumer 200 may utilise this information in addition to its implemented selection criteria to decide on how multiple NWDAFs collaborate (e.g. the NWDAF(s) supporting more analytics IDs directly can be preferred to extend their list to avoid extra signalling overhead or network latency).

The details of each step are as follows:

1. Similar to step 1 of case A shown in Figure 2, except NRF 210 response may include both distributed NWDAF (i)s 230 and NWDAF (j)s 220 identified as aggregation points. NWDAF service consumer 200 determines central aggregation point based on its implemented selection criteria.

2. NWDAF service consumer sends subscription request to NWDAF(j) 220 (to designate as aggregation point) including all Analytics IDs, TAIs needed without indicating any mapping per NWDAF (i)s 230.

3. NWDAF (j) 220 based on extended set of supporting analytics IDs and also configuration, implementation or queries to NRF 210, decides on mapping to specific distributed NWDAFs to aggregate analytics from and subscribes to them.

4. NWDAF(j) 220 may aggregate the target of analytics reporting across different NWDAF(i)s 230 for Analytics IDs(i) for corresponding area of interest.

5. NWDAF (j) 220 notifies with analytics specific parameters per analytics ID for all aggregated analytics IDs without indicating any mapping per NWDAF(i)s 230.

Case D1: (Semi-) Centralised Data Collection Model, mapping at central NWDAFs

In another case of centralised aggregation (referred to here as case D1, as a sub-case of Case D), no mapping is indicated between central and distributed NWDAFs at NRF 210 similar to D. In this option also, no AP ID configured and only aggregation points are differentiated when registering in NRF 210 either implicitly (again similar to case D) or explicitly e.g. by configuring an identifier. Furthermore, in addition to NRF 210, NWDAF service consumer 200 also becomes agnostic to the mapping between central and distributed NWDAFs. Instead, each central NWDAF 220 based on configuration, implementation or queries to NRF 210 or a pre-defined hierarchy (when registers to NRF) decides on mapping to specific distributed NWDAFs.

The details of each step are as follows:

1. Similar to step 1 of case A shown in Figure 2, except NRF 210 response may include both distributed NWDAF (i)s 230 and NWDAF (j)s 220 identified as aggregation points. NWDAF service consumer 200 chooses central aggregation points.

2. NWDAF service consumer sends subscription request to NWDAF(j) 220 (to designate as aggregation point) including all Analytics IDs, TAIs needed without indicating any mapping of analytics IDs or TAIs per NWDAF (i) 230.

3. NWDAF (j) 220 based on configuration, implementation or queries to NRF 210 decides on mapping to specific distributed NWDAFs 230 to aggregate analytics from and accordingly subscribes to them.

4. NWDAF(j) 220 may aggregate the target of analytics reporting across different NWDAF(i)s 230 for Analytics IDs(i) for corresponding areas of interest.

5. NWDAF (j) 220 notifies with analytics specific parameters per analytics ID for all aggregated analytics IDs without indicating any mapping of analytics IDs or TAIs per NWDAF (i) 230.

Case E: Mixed mode Data Collection Model

In third embodiment of the invention, a mixture of distributed and (semi-)centralised modes of deployment can be used.

Figure 4 illustrates a scenario where there is a consumer NF 300, NRF 310, NWDAF(k) 320, NWDAF(j) 330 and NWDAF(i) 340 forming at least part of a system.

The details of each step shown in Figure 4 are as follows:

1. NWDAF service consumer 300 sends NF discovery request (1a) to NRF 310 including all required Analytics ID(s) and the area of interest (e.g. in form of TAIs). The request may also include extra information, e.g. Network Slice Selection Assistance Information (i.e. Single-NSSAI or S-NSSAI). NRF response may include (1b) a (set of) NWDAF instance ID(s), i.e. NWDAF(k) 320, deployed in distributed manner. NRF 310 response may also include (1c) a (set of) NWDAF instance ID(s) (i.e. NWDAF(i) 340) to be aggregated in a (set of) NWDAF instance IDs (i.e. NWDAF(j) 330).

2. NWDAF service consumer 300 subscribes to all NWDAF(k)s 320 similar to the distributed deployment procedure in case A and receives individual notifications.

3. NWDAF service consumer 300 also subscribes to NWDAF(j) 330. NWDAF(j) 330 subscribes to all relevant NWDAF(i)s 340 to be aggregated similar to the (semi-)centralised deployment procedure in cases B or C or D or D1 and provides aggregate notification to the NWDAF service consumer 300.

4. The NWDAF service consumer 300 aggregates analytics data from both distributed and (semi-) centralised NWDAF instances.

At least some of the example embodiments described herein may be constructed, partially or wholly, using dedicated special-purpose hardware. Terms such as 'component', 'module' or 'unit' used herein may include, but are not limited to, a hardware device, such as circuitry in the form of discrete or integrated components, a Field Programmable Gate Array (FPGA) or Application Specific Integrated Circuit (ASIC), which performs certain tasks or provides the associated functionality. In some embodiments, the described elements may be configured to reside on a tangible, persistent, addressable storage medium and may be configured to execute on one or more processors. These functional elements may in some embodiments include, by way of example, components, such as software components, object-oriented software components, class components and task components, processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables. Although the example embodiments have been described with reference to the components, modules and units discussed herein, such functional elements may be combined into fewer elements or separated into additional

elements. Various combinations of optional features have been described herein, and it will be appreciated that described features may be combined in any suitable combination. In particular, the features of any one example embodiment may be combined with features of any other embodiment, as appropriate, except where such combinations are mutually exclusive. Throughout this specification, the term "comprising" or "comprises" means including the component(s) specified but not to the exclusion of the presence of others.

Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A method of managing analytics data in a telecommunication network, wherein a consumer Network Function, NF, determines on the basis of the aggregation capability of at least one of a plurality of Network Data Analytics Functions, NWDAFs, how analytics data from a plurality of individual sources is collected and analysed in one of:

a) a distributed manner from the plurality of NWDAFs;
b) a centralised manner by aggregating analytics data from the plurality of NWDAFs, before analysing it at an Aggregator NWDAF; or
c) a mixture of a) and b) above.

2. The method of claim 1 wherein the aggregation capability enables combining analytics from a plurality of areas of interest or plurality of target users, within an aggregator NWDAF.

3. The method of claim 2 wherein aggregation capability is registered and stored in a Network Repository Function, NRF.

4. The method of any preceding claim wherein a consumer Network Function, NF, determines one or more NWDAFs from which to collect data, based on NWDAF aggregation capability information as part of its implemented internal selection criteria.

5. The method of claim 4 wherein implemented selection criteria comprises one or more of newly registered capabilities in NRF, determined based on the level of load per NWDAF, number of analytics IDs directly supported per NWDAF and other Key Performance Indicators (KPIs) pre-configured by the network Operator.

6. The method of any preceding claim wherein an identifier, such as aggregation point identifier, AP ID, is defined per Aggregator NWDAF, as an assistance information registered in NRF wherein the identifier indicates which amongst NWDAFs are able to act as an aggregation point.

7. The method of any of claims 4 to 6, wherein the consumer NF autonomously determines how a plurality of NWDAFs operate together.

8. The method of claim 7 wherein the determination is based on selection criteria, whereby the consumer NF considers all NWDAFs identified by the NRF and based on the implemented selection criteria decides how to collect data from a combination of them.

9. The method of any one of claims 3 to 8 wherein each of the plurality of NWDAFs pre-negotiates with one or more other Aggregator NWDAFs how many analytics IDs it supports and the Aggregator NWDAF advertises such extended set of supported analytics IDs within the NRF.

10. The method of claim 1 comprising the steps of:

a network function service consumer sends a discovery request to a Network Repository Function, NRF, including all required Analytics ID(s) and an area of interest;

the NRF responding with one or more distributed NWDAF instance IDs, each covering a set of Analytics ID(s), and at least part of the area of interest supported;

the network function service consumer sends a subscription request to each distributed NWDAF;

each distributed NWDAF responds with analytics specific parameters per analytics ID; and

per analytics ID, the network function service consumer itself aggregates the target of analytics reporting across distributed NWDAFs for corresponding areas of interest.

11. The method of claim 1 comprising the steps of:

a network function service consumer sends a discovery request to a Network Repository Function, NRF, including all required Analytics ID(s) and an area of interest;

the NRF responding with one or more of: a set of NWDAF instance IDs, each covering a set of Analytics ID(s), and at least part of the area of interest supported and AP ID, or other identifier, per Aggregator NWDAF instance(s) indicating possible aggregation point(s);

the network function service consumer, based on its internal selection criteria, considering registered NWDAF capabilities and information from NRF, selects at least one NWDAF as Aggregator NWDAF;

the network function service consumer sends a subscription request to Aggregator NWDAF to designate as an aggregation point, including Analytics IDs and area of interest per NWDAF to aggregate from; and either:

a) Aggregator NWDAF identifies its designation as aggregation point; or

b) Aggregator NWDAF based on configuration, implementation or queries to NRF decides on mapping to specific NWDAFs to aggregate analytics;

Aggregator NWDAF subscribes to all NWDAFs ;

NWDAFs notify with analytics specific parameters per analytics ID in the set of Analytics IDs;

Per analytics ID, Aggregator NWDAF aggregates the target of analytics reporting across different NWDAFs for corresponding area of interest; and

Aggregator NWDAF notifies to the network function service consumer with analytics specific parameters per analytics ID for all aggregated analytics IDs per NWDAF.

12. The method of claim 1 comprising the steps of:

a network function service consumer sends a discovery request to a Network Repository Function, NRF, including all required Analytics ID(s) and an area of interest;

the NRF responding with one or more of: at least one NWDAF instance ID; at least one NWDAF instance ID to be aggregated into at least one Aggregator NWDAF instance ID as registered in NRF;

the network function service consumer subscribing to all NWDAFs, including aggregation points acting as central NWDAFs and receiving individual notifications; and

per analytics ID, the network function service consumer aggregating analytics data from both distributed and (semi-) centralised NWDAF instances for corresponding points of interest.

13. A telecommunication network operable to perform the method of any preceding claim.