(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 January 2025 (23.01.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/017363 A1

(51) International Patent Classification:
H04W 24/02 (2009.01) *H04W 52/02* (2009.01)

(21) International Application Number:
PCT/IB2023/059254

(22) International Filing Date:
19 September 2023 (19.09.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
23382723.7 14 July 2023 (14.07.2023) EP

(71) Applicant: **TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)** [SE/SE]; SE-164 83, Stockholm (SE).

(72) Inventor: **MUÑOZ DE LA TORRE ALONSO, Miguel Angel**; Padre Claret 6, 8C ESC D, 28002 Madrid (ES).

(74) Agent: **BENNETT, David**; Coats & Bennett, PLLC, 1400 Crescent Green, Suite 300, Cary, North Carolina 27518 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ,

(54) Title: DATA ANALYTICS FOR ENERGY MANAGEMENT

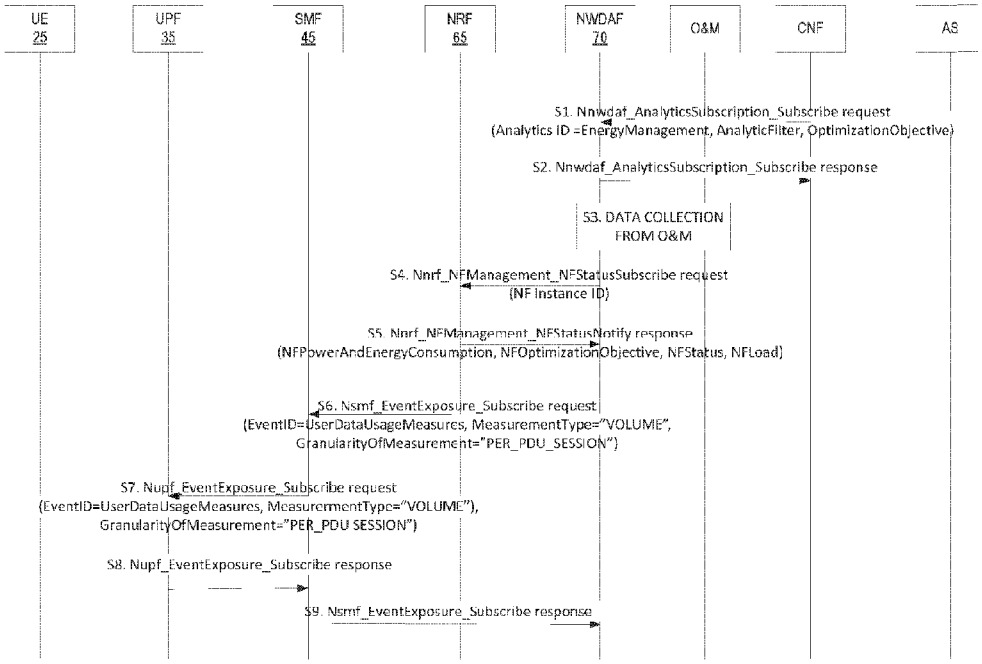

FIG. 3A

(57) Abstract: The definition of a new NWDAF analytic for energy management provides mobile network operator (MNO) with recommendations to reduce energy consumption and/or improve energy efficiency in the core network. The energy management analytics enable the MNO to optimize energy consumption in a simple and efficient way. The MNO can identify energy consumption at various levels of granularity in both loaded and unloaded scenarios. For example, the MNO can obtain energy consumption for all NFs, per NF, per NF set, per NF type, per network slice per DNN, and per Area. The energy management analytics allow the MNO detect potential problems related to energy consumption and take appropriate action to correct identified problems.

WO 2025/017363 A1

[Continued on next page]

RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

DATA ANALYTICS FOR ENERGY MANAGEMENT

TECHNICAL FIELD

The present disclosure relates generally to data analytics for wireless communication networks and, more particularly, to new data analytics for energy management in wireless communication networks.

BACKGROUND

The Fifth Generation (5G) core network (5GC) comprises a number of network functions (NFs) performing various functions. Mobile Network Operators (MNOs) are constantly looking for ways to reduce power consumption of the NFs in the 5GC and lower operational expenses. The 5G standards define a set of Power, Energy and Environmental (PEE) Measurements and Key Performance Indicators (KPIs) related to power consumption by the NFs in the 5GC, which are maintained by the Operations and Management (O&M) system. The KPIs currently defined in 3GPP include the average power, maximum power, minimum power, voltage and current. But there is currently no solution to minimize power consumption or increase energy efficiency in the 5GC while fulfilling performance requirements, such a Quality of Experience (QoE) requirements.

SUMMARY

The present disclosure relates to network analytics for energy management in the wireless communication network. The definition of a new NWDAF analytic for energy management provides mobile network operator (MNO) with recommendations to reduce energy consumption and/or improve energy efficiency in the core network. The energy management analytics enable the MNO to optimize energy consumption in a simple and efficient way. The MNO can identify energy consumption at various levels of granularity in both loaded and unloaded scenarios. For example, the MNO can obtain energy consumption for all NFs, per NF, per NF set, per NF type, per network slice, per data network, and per Area. The energy management analytics allow the MNO detect potential problems related to energy consumption and take appropriate action to correct identified problems.

A first aspect of the disclosure comprises methods of energy management implemented by a data analytics network node in a wireless communication network. The method comprises receiving, from a requesting node, a request for energy management analytics. The request includes a target filter indicating one or more

network functions in the wireless communication network. The method further comprises collecting, from one or more network nodes, energy management data for the one or more network functions in the wireless communication network and traffic data for user plane traffic served by the one or more network functions. The method further comprises generating, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions. The method further comprises sending, to the requesting node responsive to the request, the energy management report containing the energy management recommendation.

A second aspect of the disclosure comprises a data analytics network node configured to provide analytics reports for energy management in the wireless communication network. The network node is configured to receive, from a requesting node, a request for energy management analytics. The request including a target filter indicating one or more network functions in the wireless communication network. The network node is further configured to collect, from one or more network nodes, energy management data for the one or more network functions in the wireless communication network and traffic data for user plane traffic served by the one or more network functions. The network node is further configured to generate, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions. The network node is further configured to send, to the requesting node responsive to the request, the energy management report containing the energy management recommendation.

A third aspect of the disclosure comprises a data analytics network node configured to provide analytics reports for energy management in the wireless communication network. The network node comprises communication circuitry configured for communication with one or more other network nodes and processing circuitry operatively connected to the communication circuitry. The processing circuitry is configured to receive, from a requesting node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network. The processing circuitry is further configured to collect, from one or more network nodes, energy management data for the one or more network functions in the wireless communication network and traffic data for user plane traffic served by the one or more network functions. The processing circuitry is further

configured to generate, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions. The processing circuitry is further configured to send, to the requesting node responsive to the request, the energy management report containing the energy management recommendation.

A fourth aspect of the disclosure comprises a computer program for a data analytics network node. The computer program comprises executable instructions that, when executed by processing circuitry in a network node in a communication network, causes the network node to perform the method according to the first aspect.

A fifth aspect of the disclosure comprises a carrier containing a computer program according to the fourth aspect. The carrier is one of an electronic signal, optical signal, radio signal, or a non-transitory computer readable storage medium.

A sixth aspect of the disclosure comprises methods of energy management implemented by a consumer network node in a wireless communication network. The method comprises sending, to a data analytics network node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network. The method further comprises receiving, from the data analytics network node responsive to the request, an energy management report including at least one energy management recommendation for the one or more network functions. The method further comprises managing energy consumption for the one or more network functions based on the energy management report.

A seventh aspect of the disclosure comprises a consumer network node configured to manage energy consumption in the wireless communication network. The network node is configured to send, to a data analytics network node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network. The network node is further configured to receive, from the data analytics network node responsive to the request, an energy management report including at least one energy management recommendation for the one or more network functions. The network node is further configured to manage energy consumption for the one or more network functions based on the energy management report.

An eighth aspect of the disclosure comprises a consumer network node configured to manage energy consumption in the wireless communication network. The

network node comprises communication circuitry configured for communication with one or more other network nodes and processing circuitry operatively connected to the communication circuitry. The processing circuitry is configured to send, to a data analytics network node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network. The processing circuitry is further configured to receive, from the data analytics network node responsive to the request, an energy management report including at least one energy management recommendation for the one or more network functions. The processing circuitry is further configured to manage energy consumption for the one or more network functions based on the energy management report.

A ninth aspect of the disclosure comprises a computer program for a consumer network node. The computer program comprises executable instructions that, when executed by processing circuitry in a network node in a communication network, causes the network node to perform the method according to the sixth aspect.

A tenth aspect of the disclosure comprises a carrier containing a computer program according to the ninth aspect. The carrier is one of an electronic signal, optical signal, radio signal, or a non-transitory computer readable storage medium.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates logical network functions in a core network of a communication network.

Figure 2 is a schematic diagram illustrating an implementation of energy management analytics in a wireless communication network.

Figures 3A and 3B illustrate an exemplary procedure for providing energy management network analytics to a consumer network function.

Figure 4 illustrates an exemplary method implemented by a data analytics network node in a wireless communication network of providing energy management analytics to a consumer network node.

Figure 5 illustrates an exemplary method of energy management implemented by a consumer network node in a wireless communication network.

Figure 6 illustrates an exemplary data analytics network node configured to provide energy management analytics to a consumer network node.

Figure 7 illustrates an exemplary consumer network node configured for energy management.

Figure 8 illustrates an exemplary network node that can be configured as a data analytics network node in a wireless communication network, or a consumer network node.

DETAILED DESCRIPTION

Referring now to the drawings, an exemplary embodiment of the disclosure will be described in the context of a Fifth Generation (5G) communication network. Those skilled in the art will appreciate that the methods and apparatus herein described are not limited to use in 5G networks but may also be used in communication networks operating according to other standards that use a service-based architecture.

Figure 1 illustrates a wireless communication network 10 according to one exemplary embodiment. The wireless communication network 10 comprises a 5G radio access network (RAN) 20 and a 5G core network (5GC) 30 employing a service-based architecture. The RAN 20 comprises one or more base stations 25 providing radio access to UEs 15 operating in the communication network 10. The base stations 25 are also referred to in applicable standards as gNodeBs (gNBs). The UEs 15 may comprise cellular phones, smart phones, tablets, laptop computers, or other electronic devices with communication capabilities. The 5GC 30 provides a connection between the RAN 20 and other packet data networks, such as the Internet Protocol (IP) Multimedia Subsystem (IMS) or the Internet. Those skilled in the art will appreciate that other types of RANs in addition to the 5G RAN 25 can connect to the 5GC 30. For example, an Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access (EUTRA) base station in an Evolved UMTS Terrestrial Radio Access Network (EUTRAN) may also connect to the 5GC 30.

The 5GC 30 comprises a number of Network Function (NFs). These NFs include a User Plane Function (UPF) 35, Access and Mobility Management Function (AMF) 40, Session Management Function (SMF) 45, a Policy Control Function (PCF) 50, a Unified Data Repository (UDR) 55, a Network Exposure Function (NEF) 60, a Network Repository Function (NRF) 65, a Network Data Analytics Function (NWDAF) 70, and a Charging Function (CHF) 75. Some embodiments may further include a Analytics Data Repository Function (ADRF) 80 to store historical data analytics for the NWDAF 70.

One or more Application Functions (AFs) 90 providing application services may be located in the core network 30 or be external to the core network 30.

The NFs shown in Figure 1 comprise logical entities that may be implemented by one or more processors, hardware, firmware, or a combination thereof. In cloud-based networks, the NFs are typically implemented as virtual machines (VMs), or as containers (e.g., Kubernetes). The network 10 may include multiple instances of each NF type. The NFs can also be implemented in stand-alone servers or specialized servers.

In conventional communication network, the various NFs (e.g., UPF 35, SMF 45, AMF 40, PCF 50, etc.) in the 5GC 30 communicate with one another over predefined interfaces. In the service-based architectures shown in Figure 1, the 5GC 30 uses a services model in which the NFs query a Network Repository Function (NRF) 65 or other NF discovery node to discover other NFs and communicate with each other over web-based Application Programming Interfaces (APIs). In some deployments, the UPF 35 uses a pre-defined interface called the N4 interface to communicate with the SMF 45. The NFs can subscribe to receive notification 10 services and data from other NFs. In this context, the NF providing the service or data is referred to as a service producer and the NF receiving the data and reports is referred to as a service consumer.

The most relevant NFs for purposes of this disclosure are the UPF 35, SMF 45, UDR 55, and NWDAF 70.

The UPF 35 supports handling of user plane traffic, including packet inspection, packet routing and forwarding, traffic usage reporting, and QoS handling. The UPF 35 connects with external IP networks and serves as an IP anchor point for UEs 14 served by the UPF 35 so that the UE 15 is reachable even when moving around in the network 10. The UPF 35 processes data being forwarded. Such processing may include packet inspection, classification, and QoS marking of forwarded packets. The UPF 35 generates traffic usage reports, which the SMF 45 incudes in charging reports, and is involved in policy enforcement.

The SMF 45 manages Packet Data Unit (PDU) sessions for the UEs 15, which includes the establishment, modification, and release of PDU sessions. The SMF 45 selects the UPF 35 to handle a PDU session and controls the UPF 35. The SMF 45 receives Policy and Charging Control (PCC) Rules from the PCF 50 and configures the UPF 35 for various data flow tasks, such as shaping, policing to provide bandwidth, and charging functions.

The UDR 55 is a data repository where data of various types is stored. The stored data can include subscription data, policy data, structured data for exposure, and application data. The UDR 55 offers data storage and access as a service to other NFs in the 5GC 30.

The NWDAF 70 collects various types of network data and subscriber data, performs an analysis of the data, and provides analytics reports to other NFs. The NWDAF 70 may store historical analytic reports and data in the ADRF 80. Consumer NFs within the 5GC 30 use the Nnwdaf interface to send subscription requests for analytics reports to the NWDAF 70. The requests may specify a target (e.g., group of UEs 15 or a group of NFs) for which data is requested. The NWDAF 70 collects event data from other NFs, such as the AMF 40, SMF 45, and PCF 50, using the event exposure services offered by these NFs. The NWDAF 70 may also retrieve data from the O&M system 85 (Figure 2) and data related to various NFs from the NRF 65. Subscriber-related data is retrieved from the UDR 55 via the Unified Data Management (UDM) function (not shown). Following data collection, the NWDAF 70 generates analytics reports for the targets identified in the request and sends the analytics reports to the subscribing NF. The analytic reports can be sent periodically or responsive to a triggering event.

One aspect of the present disclosure is to provide data analytics for energy management in the 5GC 30. MNOs are constantly looking for ways to reduce power consumption in the 5GC 30 and lower operational expenses. The 5G standards define a set of Performance Measurements and Key Performance Indicators (KPIs) related to energy consumption and energy efficiency, but there is currently no solution to minimize energy consumption in various NFs in the 5GC 30 while fulfilling performance requirements, such a Quality of Experience (QoE) requirements.

Figure 2 is a schematic diagram illustrating an implementation of energy management analytics in a wireless communication network 10. A consumer NF (CNF) subscribes to a new energy management analytic identified, for example, by the Analytic ID = EnergyManagement (1). The subscription is triggered by sending an analytics subscription request to the NWDAF 70. The analytics subscription request includes the Analytic ID = EnergyManagement and an analytic filter identifying the NFs targeted by the request. The targeted NFs can, for example, be a list of specific NF instances, a NF set ID, or a NF type (e.g., SMF). When a NF type is provided, the analytic report covers all NFs of the specified type. The analytics filter may also specify a Data Network Name

(DNN), a network slice, and/or an Area. For example, the analytic filter may target all SMFs 45 that are part of a particular DNN.

In some embodiments, the analytic subscription may further include an optimization objective. The optimization objective may be, for example, to minimize energy consumption, to maximize energy efficiency, or to provide a threshold for a control parameter (e.g., number of PDU sessions, load, etc.). The threshold may, for example, comprise a maximum target energy consumption, which may vary over time. If the analytic subscription request does not include an optimization objective, the NWDAF 70 may apply a default objective or a locally configured optimization objective. In some embodiments, the optimization objective can be locally configured in the NF so that the optimization objective may be different for different NF instances.

Based on the analytic subscription from the CNF, NWDAF 70 triggers collection of energy management data from the O&M 85 and NRF 65 (2). Relevant information available from the O&M 85 includes Power, Energy and Environmental (PEE) Measurements as defined in 3GPP TS 28.552, section 5.1.1.19, NF resource usage, and NF resource configuration. The 5GC PEE Measurements include:

- Average Power (kW)
- Minimum Power (kW)
- Maximum Power (kW)
- Energy Consumption (kWh)
- Voltage (V)
- Current (A)

The NF usage information indicates usage of assigned virtual resources currently in use for the targeted NF instance(s), such as the mean usage of virtual compute and memory resources (e.g., Central Processing Unit (CPU), memory, disk) as defined in 3GPP TS 28.552, section 5.7. The NF configuration information indicates the life cycle changes of specific NF resources (e.g., NF operational or interrupted during virtual/physical resources reconfiguration) as defined in 3GPP TS 28.552, section 5.2.

The NRF 65 stores relevant information in NF profiles as defined in 3GPP TS 29.510. In some embodiments, the NF profile is extended to include information about the NF power and energy consumption and/or an optimization objective. For example, the NF Profile can be extended to include static information (e.g., nominal power in kW) and dynamic information (e.g., energy consumption in kWh). In some embodiments, the optimization objective is stored per NF in the NF Profile. As previously indicated, the

optimization objective may be to minimize energy consumption, to maximize energy efficiency, or to provide a threshold for a control parameter. The NFProfile as defined in TS 29.510, Table 6.1.6.2.2-1 can, for example, be extended to include the following new attributes:

Attribute	Data Type	P	Card.	Description
power	float	O	0..1	Static power information (in kW)
energyConsumption	float	O	0..1	Dynamic energy information, indicates the energy consumption (in kWh) of the NF.
energyTimeStamp	DateTime	O	0..1	It indicates the point in time in which the latest energy consumption information (sent by the NF in the "energyConsumption" attribute of the NF Profile) was generated at the NF Instance. If the NF did not provide a timestamp, the NRF 65 should set it to the instant when the NRF 65 received the message where the NF provided the latest energy consumption information.
nfOptimizationObjective	array(string)	O	0..1	It indicates the NF optimization objective in terms of energy (e.g. minimize energy consumption).

Table 1: New NFProfile Attributes

Additional information stored in the NF Profile defined in 3GPP TS 29.510, Table 6.1.6.2.2-1 includes the NF status and NF load. The profile element NFStatus indicates the status of one or more specific NF instances (registered, suspended, undiscoverable) and the profile element NFLoad indicates the load of one or more specific NF instances.

The NWDAF 70 also triggers collection of traffic data from the UPF 35 handling the user traffic for the targeted NFs (3). The UPF 35 supports event subscription for the UserDataUsageMeasures event. This event provides usage information per PDU Session. It can be used for UPF data collection by the NWDAF 70 for analytics as described in 3GPP TS 23.288, section 4.15.4.5. The event notification may contain following information:

- Volume Measurement: measures of data volume exchanged (UL, DL and/or overall) and/or number of packets exchanged (UL, DL and/or overall) with or without application granularity. This measurement can also include number of packets transmitted for applications where that is possible to differentiate.
- Throughput Measurement: measures of data throughput (UL and DL) measures aggregated for the PDU Session or per application.
- Application related Information: URL/s and/or Domain name/s detected in the PDU Session for the target traffic.

Based on the data collected from the O&M 85, NRF 65, and UPF 35, the NWDAF 70 runs analytic processes and generates the analytic result (4). The data analytics processing comprises essentially two steps. First, the NWDAF 70 performs an analysis of the collected data and generates one or more energy usage metrics. The NWDAF 70 can analyze energy consumption at various levels of granularity in both loaded and unloaded scenarios. For example, the MNO can obtain energy consumption for all NFs, per NF, per NF set, per NF type, per network slice per DNN, and per Area. Second, based on the analysis, the NWDAF 70 generates an analytic result including one or more energy management recommendations.

In one embodiment, the NWDAF 70 calculates an energy efficiency KPI for one or more of the target NFs. The NWDAF calculates an energy efficiency KPI by aggregating the total uplink (UL) and downlink (DL) data volumes for the targeted NFs and dividing the accumlated data volumes by the sum of the power consumption of the targeted NFs for the same period as follows:

$$EnergyEfficincyKPI = \frac{AccumulatedDataVolume}{TotalPowerConsumption}$$

The *EnergyEfficicincyKPI* is proportional to energy efficiency so that increasing KPI value corresponds to increasing energy efficiency, i.e., a greater KPI value indicates higher energy efficiency.

In the case where all of the targeted NFs belong the same DNN (or the same network slice or the same Area), the energy efficiency can be computed for all target NFs. In this case, the *AccumulatedDataVolume* is the total data volume for all targeted NFs in the DNN, network slice, or Area, and the *TotalPowerConsumption* is the total power consumed by all targeted NFs. *AccumulatedDataVolume* is computed based on data volumes reported by all UPFs. *TotalPowerConsumption* is computed based on reported power consumption of all targeted NFs. The power consumption of the targeted NFs is obtained from NFProfile for the targeted NFs.

In some embodiments, *EnergyEfficicincyKPI* may, alternatively or in addition, be computed per NF. For example, in the case where NFType = SMF, *EnergyEfficicincyKPI* can be computed by aggregating the data volume for all sessions handled by each SMF 45 and dividing the accumulated data volume by the SMF power consumption for the same period.

In some embodiments, *EnergyEfficicincyKPI* can be computed for a plurality of different time intervals, e.g., for a plurality of consecutive time periods. The computed

EnergyEfficicincyKPI for different time period can be compared to reveal how *EnergyEfficicincyKPI* evolves over time.

Another energy usage metric useful for energy management analytics is energy consumption versus number of active sessions. For example, a graph or plot can be generated showing the relation between total power consumption of the targeted NFs and the number of active sessions being handled by the same targeted NFs. The number of active PDU sessions can be obtained from the UserDataUsageMeasures events, which are per PDU session. This comparison, considered alone or together with *EnergyEfficicincyKPI*, may show a non-linear relationship between power consumption and number of active PDU sessions. For example, the graph or plot of the power consumption versus number of active PDU sessions may show that, beyond some point, the rate of power consumption increases non-linearly with the number of active PDU sessions. This information can be useful, for example, to determine a maximum threshold for the number of active PDU sessions. The MNO or CNF can then take appropriate action based on the number of active PDU sessions, such as scaling the number of active NFs depending on the number of active PDU sessions, or changing admission control policies to keep the number of active sessions below the threshold. As one example, the MNO of CNF can scale the active NFs depending on the threshold. When the number of active PDU sessions reaches the threshold, additional NFs can be instantiated. When the number of active sessions drops below the threshold, unneeded NFs can be removed. The threshold may be computed for all target NFs collectively and/or per NF.

Yet another energy usage metric useful for energy management analytics is energy consumption versus NF load. For example, a graph or plot can be generated showing the relation between the total power consumption of the targeted NFs and the number of active sessions being handled by the same targeted NFs. In one embodiment, the NF load equals *AccumulatedDataVolume*. This comparison, considered alone or together with *EnergyEfficicincyKPI*, may show a non-linear relationship between power consumption and the NF load. For example, the graph or plot of the power consumption versus NF load may show that, beyond some point, the rate of power consumption increases non-linearly with the NF load. This information can be useful, for example, to determine a maximum threshold for the NF load. The MNO or CNF can then take appropriate action based on the NF load, such as scaling the number of active NFs depending on the NF load, or changing admission control policies to keep

the NF load below the threshold. As one example, the MNO of CNF can scale the active NFs depending on the threshold. When the NF load reaches the threshold, additional NFs can be instantiated. When the NF load drops below the threshold, unneeded NFs can be removed. The threshold may be computed for all target NFs collectively and/or per NF.

Based on the data analytics, the NWDAF 70 generates the analytic result including one or more energy management recommendations. The energy management recommendation(s) indicate(s) one or more specific actions that the MNO or CNF could take to meet the optimization objective. For example, the analytics report may recommend moving a certain number of PDU sessions to optimize energy consumption or to achieve a certain energy consumption target. In addition to recommendations, the analytics reports may also provide "findings", which are basically hint(s) to the MNO or CNF that something might need to be addressed by the MNO. As one example, the analytics report may indicate which specific NF instances contribute most to energy consumption, or if there is a load threshold where energy consumption increases significantly. In the later case, the MNO or CNF may want to maintain the load of a specific NF should below the threshold for high energy consumption. These examples illustrate some of the possibilities and are not intended to be limiting.

In addition to the energy management recommendation, the analytics result may include one or more of the following:

- Resource (e.g. NF Type, NF Instance ID, S-NSSAI, DNN or Area)
- Energy Efficiency value
- Energy consumption
- Number of active PDU sessions
- Load information

The NWDAF 70 returns the analytic result to the requesting CNF (5). Based on the analytic-result returned by the NWDAF 70, the CNF (e.g., PCF 50) may take an energy management action to manage energy consumption in the network (6). As previously noted, the energy management action may be an action recommended by the NWDAF 70, or an action determined independently by the MNO based on the "findings.".

Figures 3A and 3B illustrate an exemplary signaling flow for providing energy management analytics to a CNF. A CNF subscribes to NWDAF 70 to receive energy management analytics (Analytic-ID= EnergyManagement) by sending an analytics subscription request message (*Nnwdaf_AnalyticsSubscription_Subscribe*) to the

NWDAF 70 (S1). The analytics subscription request may include AnalyticsID=Energy Management attribute, an analytic filter (e.g., *AnalyticFilter* attribute) identifying the NFs targeted by the request, and, optionally, an optimization objective (e.g., *OptimizationObjective* attribute). The targeted NFs can be a list of specific NF instances, a NF set ID, or a NF type (e.g., SMF). When a NF type is provided, the analytic report covers all NFs of the specified type. The analytics filter may also specify a Data Network Name (DNN), a network slice, and/or an Area. For example, the analytic filter may target all SMFs that are part of a particular DNN. The NWDAF 70 answers the request message with a response message accepting the subscription or indicating success (S2).

After accepting the subscription request from the CNF, the NWDAF 70 initiates data collection (S3 – S9). The NWDAF 70 retrieves 5GC PEE Measurements from the O&M 85 using procedures defined in the standards (S3). The NWDAF 70 triggers data collection from the NRF 65 by sending a status subscription request (*Nnrf_NFManagement_NFStatusSubscribe*) to the NRF 65 including a list of NF instances for which the information is needed and requested event attributes (S4). The NRF 65 answers the request with a notification message (*Nnrf_NFManagement_NFStatusNotify*) including the new power and energy consumption attributes as defined in Table 1 above, NFLoad, and NFStatus (S5). In some embodiments, the notification message may further include a NFOptimizationObjective attribute indicating the optimization objective per NF.

The NWDAF 70 also triggers data collection from the UPF 35 to obtain traffic information by sending an event exposure subscription request (*Nsmf_EventExposure_Subscription*) to the SMF 45 to obtain traffic-related information for user plane traffic (S6). The event exposure subscription request includes the following attributes:

EventID = UserDataMeasures,
MeasurementType = “VOLUME”, and
GranularityOfMeasurement = “PER_PDU_SESSION”

The SMF 45 in turn sends an event exposure subscription request (*Nupf_EventExposure_Subscribe*) to the UDF 35 with the same attributes (S7). The UPF 35 answers the subscription request from the SMF 45 with a response accepting the subscription or indicating success (S8). The SMF 45 then answers the subscription

request from the NWDAF 70 with a response accepting the subscription or indicating success (S9).

After accepting the subscription to event reporting, the UPF 35 begins data collection. Figure 3B illustrates data collection for a single PDU session with the understanding that a similar process is performed for each PDU session. An application on the UE 15 sends application traffic towards the application server (S10). The UPF 35 detects the application traffic, accumulates the traffic volume of the application traffic, and forwards the application data to the application server (S11, S12) After passage of the predetermined period of time, or responsive to a predetermined event, the UPF 35 reports data for Event ID = UserDataUsageMeasures to the NWDAF 70 by sending a notification message (*Nupf_EventExposure_Notify*) to the NWDAF 70 (S13). The notification message includes the volume measurements per PDU session collected by the UPF 35 as previously described. The NWDAF 70 answers the notification message with a response indicating successful receipt of the notification message (S14).

Based on the data collected from the O&M 85, NRF 65, and UPF 35, the NWDAF 70 runs analytic processes and generates an analytic result as described above (S15). The NWDAF 70 sends the analytic result to the CNF in a notification message (*Nnwdaf_AnalyticsSubscription_Notify*) (S16). The CNF answers the notification message with a response indicated successful receipt of the notification message (S17).

Based on the recommendation or analytic result, the CNF or MNO performs an energy management action to reduce energy consumption or improve energy efficiency (S18). Examples of energy management actions include moving PDU session from one UPF to another, scaling a number of NFs in or out, or limiting loads handled by the NFs based on identified thresholds impacting energy efficiency and energy consumption. More generally, the energy management action may be any action that impacts energy consumption of the NFs and/or energy efficiency.

Figure 4 illustrates an exemplary method 100 implemented by NWDAF 70 or other data analytics network node in a wireless communication network of providing energy management analytics to a consumer network node. The method 100 comprises receiving, from a requesting node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network (block 110). The method 100 further comprises collecting, from one or more network nodes, energy management data for the one or more network functions in the wireless communication network and traffic data for user plane traffic

served by the one or more network functions (block 120). The method 100 further comprises generating, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions (block 130). The method 100 further comprises sending, to the requesting node responsive to the request, the energy management report containing the energy management recommendation (block 140).

In some embodiments of method 100, the request includes a desired optimization objective.

In some embodiments of method 100, the optimization objective comprises one or more of minimizing power consumption and maximizing energy efficiency.

In some embodiments of method 100, the target filer comprises one or more of a specific network function, a list of network functions, a data network name, a network slice, and an area within the network.

In some embodiments of method 100, the energy management data comprises one or more of average power, minimum power, maximum power, energy consumption, voltage, number of active PDU sessions, load information, and status information.

In some embodiments of method 100, the traffic data comprises one or more of volume measurements, throughput measurements, application-related information, and session-related information.

In some embodiments of the method 100, generating an analytics report including at least one energy management recommendation for the one or more network functions comprises computing one or more energy usage metrics, and generating the energy management recommendation based on the energy usage metrics.

In some embodiments of method 100, computing one or more energy usage metrics comprises computing an aggregate energy efficiency metric for the one or more network functions.

In some embodiments of method 100, computing one or more energy usage metrics comprises computing an aggregate energy consumption metric for the one or more network functions.

In some embodiments of method 100, computing one or more energy usage metrics comprises computing a relation between energy consumption and a number of active sessions.

In some embodiments of method 100, computing one or more energy usage metrics comprises computing a relation between energy consumption and a load.

In some embodiments of method 100, the relation between energy consumption and a number of active sessions, or the relation between energy consumption and a load is computed in the aggregate for the one or more network functions.

In some embodiments of method 100, the relation between energy consumption and a number of active sessions, or the relation between energy consumption and a load is computed per network function for one or more of the network functions.

In some embodiments of method 100, generating the energy management recommendation comprises generating a recommendation to do one or more of the following scale a network function, move one or more active sessions between network functions, provide a threshold for a number of active sessions and/or load for one or more of the network functions.

Figure 5 illustrates an exemplary method 200 of energy management implemented by a consumer network node in a wireless communication network. The method 200 comprises sending, to a data analytics network node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network (block 210). The method 200 further comprises receiving, from the data analytics network node responsive to the request, an energy management report including at least one energy management recommendation for the one or more network functions (block 220). The method 200 further comprises managing energy consumption for the one or more network functions based on the energy management report (block 230).

In some embodiments of method 200, the request includes a desired optimization objective.

In some embodiments of method 200, the optimization objective comprises one or more of minimizing power consumption, and maximizing energy efficiency.

In some embodiments of method 200, the target filer comprises one or more of a specific network function, a list of network functions, a data network name, a network slice, and an area within the network.

In some embodiments of method 200, the energy management recommendation comprises one or more of scaling a network function, moving one or more active sessions between network functions, providing a threshold for a number of active sessions and/or load for one or more of the network functions.

An apparatus can perform any of the methods herein described by implementing any functional means, modules, units, or circuitry. In one embodiment, for example, the

apparatuses comprise respective circuits or circuitry configured to perform the steps shown in the method figures. The circuits or circuitry in this regard may comprise circuits dedicated to performing certain functional processing and/or one or more microprocessors in conjunction with memory. For instance, the circuitry may include one or more microprocessor or microcontrollers, as well as other digital hardware, which may include Digital Signal Processors (DSPs), special-purpose digital logic, and the like. The processing circuitry may be configured to execute program code stored in memory, which may include one or several types of memory such as read-only memory (ROM), random-access memory, cache memory, flash memory devices, optical storage devices, etc. Program code stored in memory may include program instructions for executing one or more telecommunications and/or data communications protocols as well as instructions for carrying out one or more of the techniques described herein, in several embodiments. In embodiments that employ memory, the memory stores program code that, when executed by the one or more processors, carries out the techniques described herein.

Figure 6 illustrates an exemplary data analytics network node 300 configured to perform the method 100 shown in Figure 4. The data analytics network node 300 comprises a receiving unit 310, a data collecting unit 320, a generating unit 330, and a reporting unit 340. The various units 310 - 340 can be implemented by hardware and/or by software code that is executed by a processor or processing circuit. The receiving unit 310 is configured to receive, from a requesting node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network. The data collecting unit 320 is configured to collect, from one or more network nodes, energy management data for the one or more network functions in the wireless communication network and traffic data for user plane traffic served by the one or more network functions. The generating unit 330 is configured to generate, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions. The reporting unit 340 is configured to send, to the requesting node responsive to the request, the energy management report containing the energy management recommendation.

Figure 7 illustrates an exemplary consumer network node 400 configured to perform the method 200 shown in Figure 5. The consumer network node 400 comprises a sending unit 410, a receiving unit 420, and a management unit 430. The various units

410 - 430 can be implemented by hardware and/or by software code that is executed by a processor or processing circuit. The sending unit 410, is configured to send, to a data analytics network node, a request for energy management analytics. The request includes a target filter indicating one or more network functions in the wireless communication network. The receiving unit 420 is configured to receive, from the data analytics network node, a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network. The management unit 430 is configured to manage energy consumption for the one or more network functions based on the energy management report.

Figure 8 illustrates the main functional components of another exemplary network node 500 that can be configured to perform any one of the methods shown in Figures 3 – 5. The network node 500 comprises communication circuitry 510, processing circuitry 520, and memory 530.

The communication circuitry 510 comprises network interface circuitry for communicating with other core network nodes over a communication network, such as an Internet Protocol (IP) network.

Processing circuitry 520 controls the overall operation of the network node 500 and is configured to perform one or more of the methods 100 and 200 shown in Figures 4 and 5 respectively. The processing circuitry 520 may comprise one or more microprocessors, hardware, firmware, or a combination thereof. The processing circuitry can be configured by software to perform the methods 100 and 200 shown in Figures 4 and 5 respectively.

Memory 530 comprises both volatile and non-volatile memory for storing computer program code and data needed by the processing circuitry 520 for operation. Memory 530 may comprise any tangible, non-transitory computer-readable storage medium for storing data including electronic, magnetic, optical, electromagnetic, or semiconductor data storage. Memory 530 stores a computer program 540 comprising executable instructions that configure the processing circuitry 520 to implement one or more of the methods 100 and 200 shown in Figures 4 and 5 respectively. A computer program in this regard may comprise one or more code modules corresponding to the means or units described above. In general, computer program instructions and configuration information are stored in a non-volatile memory, such as a ROM, erasable programmable read only memory (EPROM) or flash memory. Temporary data

generated during operation may be stored in a volatile memory, such as a random access memory (RAM). In some embodiments, computer program 540 for configuring the processing circuitry 520 as herein described may be stored in a removable memory, such as a portable compact disc, portable digital video disc, or other removable media. The computer program 540 may also be embodied in a carrier such as an electronic signal, optical signal, radio signal, or computer readable storage medium.

Those skilled in the art will also appreciate that embodiments herein further include corresponding computer programs. A computer program comprises instructions which, when executed on at least one processor of an apparatus, cause the apparatus to carry out any of the respective processing described above. A computer program in this regard may comprise one or more code modules corresponding to the means or units described above.

Embodiments further include a carrier containing such a computer program. This carrier may comprise one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

In this regard, embodiments herein also include a computer program product stored on a non-transitory computer readable (storage or recording) medium and comprising instructions that, when executed by a processor of an apparatus, cause the apparatus to perform as described above.

Embodiments further include a computer program product comprising program code portions for performing the steps of any of the embodiments herein when the computer program product is executed by a computing device. This computer program product may be stored on a computer readable recording medium.

CLAIMS

What is claimed is:

1. A method (100) implemented by a network node in a wireless communication network of managing energy consumption in a wireless communication network, the method (100) comprising:

receiving (110), from a requesting node, a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network;

collecting (120), from one or more network nodes:

energy management data for the one or more network functions in the wireless communication network;

traffic data for user plane traffic served by the one or more network functions;

generating (130), based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions; and

sending (140), to the requesting node responsive to the request, the energy management report containing the energy management recommendation.

2. The method (100) of claim 1, wherein the request includes a desired optimization objective.

3. The method (100) of claim 2, wherein the optimization objective comprises one or more of:

minimizing power consumption; and

maximizing energy efficiency.

4. The method (100) of any one of claims 1 - 3, wherein the target filer comprises one or more of:

a specific network function;

a list of network functions;

a data network name;

a network slice; and

an area within the network.

5. The method (100) of any one of claims 1 - 4, wherein the energy management data comprises one or more of:

average power;
minimum power;
maximum power;
energy consumption;
voltage;
number of active packet data unit (PDU) sessions;
load information; and
status information.

6. The method (100) of any one of claims 1 - 5, wherein the traffic data comprises one or more of:

volume measurements;
throughput measurements;
application-related information; and
session-related information.

7. The method (100) of any one of claims 1- 6, wherein generating an analytics report including at least one energy management recommendation for the one or more network functions comprises:

computing one or more energy usage metrics; and
generating the energy management recommendation based on the energy usage metrics.

8. The method (100) of claim 7, wherein computing one or more energy usage metrics comprises computing an aggregate energy efficiency metric for the one or more network functions.

9. The method (100) of claim 7 or 8, wherein computing one or more energy usage metrics comprises computing an aggregate energy consumption metric for the one or more network functions.

10. The method (100) of any one of claims 7 - 9, wherein computing one or more energy usage metrics comprises computing a relation between energy consumption and a number of active sessions.

11. The method (100) of any one of claims 7 - 10, wherein computing one or more energy usage metrics comprises computing a relation between energy consumption and a load.

12. The method (100) of claim 10 or 11 wherein the relation between energy consumption and a number of active sessions, or the relation between energy consumption and a load is computed in the aggregate for the one or more network functions.

13. The method (100) of claim 10 or 11 wherein the relation between energy consumption and a number of active sessions, or the relation between energy consumption and a load is computed per network function for one or more of the network functions.

14. The method (100) of any one of claims 7 - 13, generating the energy management recommendation comprises generating a recommendation to do one or more of the following:

scale a network function;

move one or more active sessions between network functions;

provide a threshold for a number of active sessions and/or load for one or more of the network functions.

15. A method (200) implemented by a network node in a wireless communication network of managing energy consumption in a wireless communication network, the method (200) comprising:

sending (210), to a data analytics network node, a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network;

receiving (220), from a data analytics network node responsive to the request, an energy management report including at least one energy management recommendation for the one or more network functions; and

managing energy consumption (230) for the one or more network functions based on the energy management report.

16. The method (200) of claim 15, wherein the request includes a desired optimization objective.

17. The method (200) of claim 16, wherein the optimization objective comprises one or more of:

minimizing power consumption; and

maximizing energy efficiency.

18. The method (200) of any one of claims 15 - 17, wherein the target filer comprises one or more of:

a specific network function;

a list of network functions;

a data network name;

a network slice; and

an area within the network.

19. The method (200) of any one of claims 15 - 18, wherein the energy management recommendation comprises one or more of:

scaling a network function;

moving one or more active sessions between network functions;

providing a threshold for a number of active sessions and/or load for one or more of the network functions.

20. A network node (300, 500) operative to manage energy consumption in a wireless communication network, the network node being configured to:

receive, from a requesting node (400, 500), a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network;

collect , from one or more network nodes:
energy management data for the one or more network functions in the wireless communication network;
traffic data for user plane traffic served by the one or more network functions;
generate, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions; and
send, to the requesting node (300, 500) responsive to the request, the energy management report containing the energy management recommendation.

21. The network node (300, 500) of claim 20, wherein the network node is further configured to perform the method of any one of claims 2 - 14.

22. A network node (500) operative to manage energy consumption in a wireless communication network, the network node comprising:
communication circuitry (510) configured for communication with one or more other network nodes;
processing circuitry (520) operatively connected to the communication circuitry and configured to:
receive, from a requesting node, a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network;
collect, from one or more network nodes:
energy management data for the one or more network functions in the wireless communication network;
traffic data for user plane traffic served by the one or more network functions;
generate, based on the energy management data and traffic data, an energy management report including at least one energy management recommendation for the one or more network functions; and

send, to the requesting node responsive to the request, the energy management report containing the energy management recommendation.

23. A computer program (540) comprising executable instructions that, when executed by a processing circuit in a network node (300, 500) in a wireless communication network, causes the network node to perform the method of any one of claims 1 - 14.

24. A carrier containing a computer program (540) of claim 23, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

25. A non-transitory computer-readable storage medium (530) containing a computer program (540) comprising executable instructions that, when executed by a processing circuit in a network node (300, 500) in a wireless communication network causes the network node to perform the method of any one of claims 1 - 14.

26. A network node (400, 500) operative to manage energy consumption in a wireless communication network, the network node being configured to:

send, to a data analytics network node (300, 500), a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network;

receive, from the data analytics network node (300, 500), a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network; and

manage energy consumption for the one or more network functions based on the energy management report.

27. The network node (400, 500) of claim 26, wherein the network node is further configured to perform the method of any one of claims 16 - 19.

28. A network node (500) in a wireless communication network (10) operative to manage energy consumption in a wireless communication network, the network node comprising:

communication circuitry (510) configured for communication with one or more other network nodes;

processing circuitry (520) operatively connected to the communication circuitry and configured to:

send, to a data analytics network node, a request for energy management analytics, the request including a target filter indicating one or more network functions in the wireless communication network;

receive, from a data analytics network node responsive to the request, an energy management report including at least one energy management recommendation for the one or more network functions; and

manage energy consumption for the one or more network functions based on the energy management report.

29. The network node of claim 28, wherein the processing circuitry is further configured to perform the method of any one of claims 16 - 19.

30. A computer program (540) comprising executable instructions that, when executed by a processing circuit in a network node in a wireless communication network, causes the network node to perform the method of any one of claims 15 -19.

31. A carrier containing a computer program of claim 29, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

32. A non-transitory computer-readable storage medium (530) containing a computer program comprising executable instructions that, when executed by a processing circuit in a network node in a wireless communication network causes the network node to perform the method of any one of claims 15- 19.

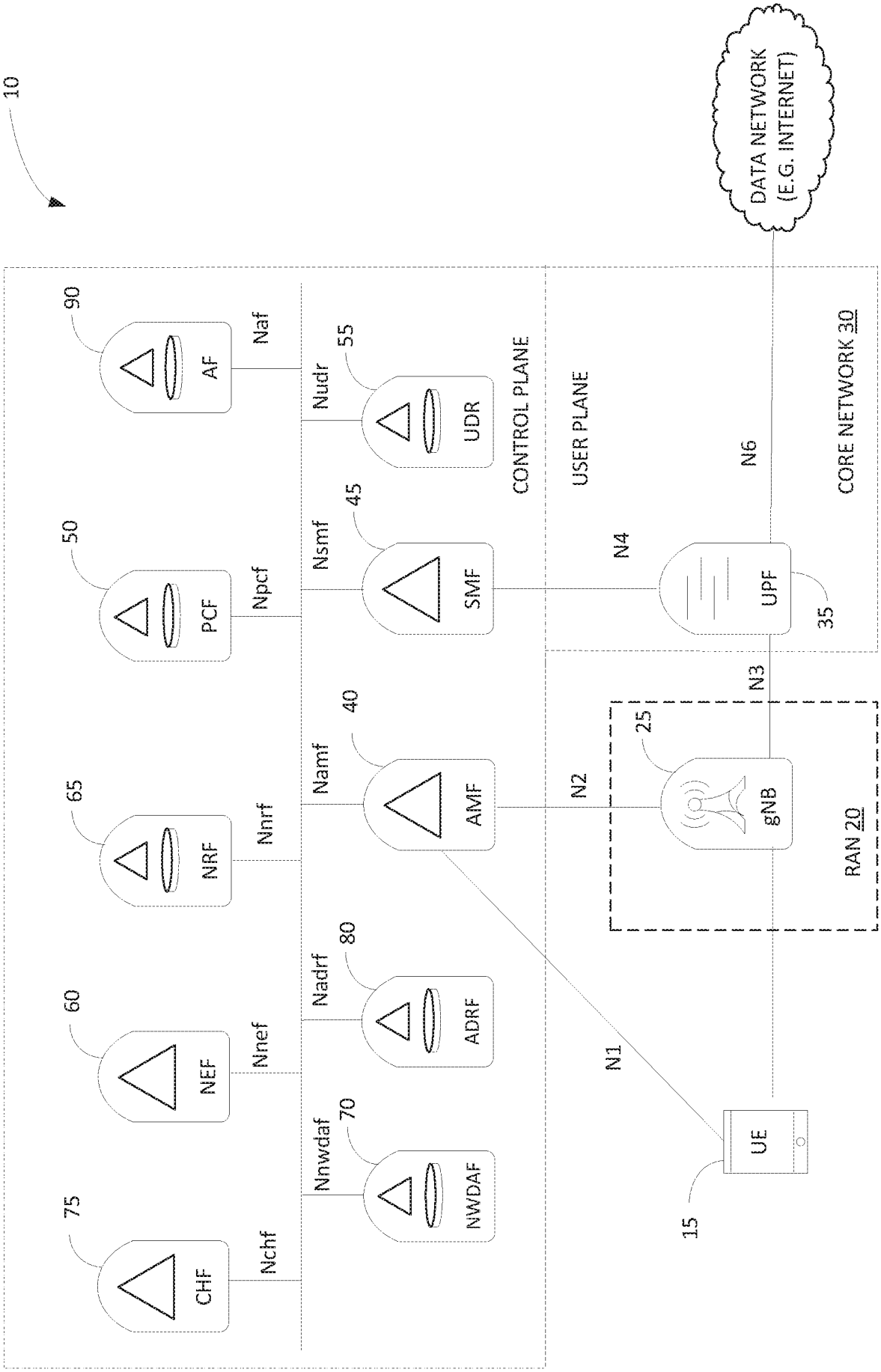
10
DATA NETWORK (E.G. INTERNET)
CONTROL PLANE
USER PLANE
CORE NETWORK 30
RAN 20
AF
90
Naf
Nudr
55
UDR
PCF
50
Npcf
Nsmf
45
SMF
N4
UPF
35
N6
NRF
65
Nnrf
Namf
40
AMF
N2
gNB
25
N3
NEF
60
Nnef
Nadrf
80
ADRF
N1
CHF
75
Nchf
Nnwdaf
70
NWDAF
UE
15

FIG. 1

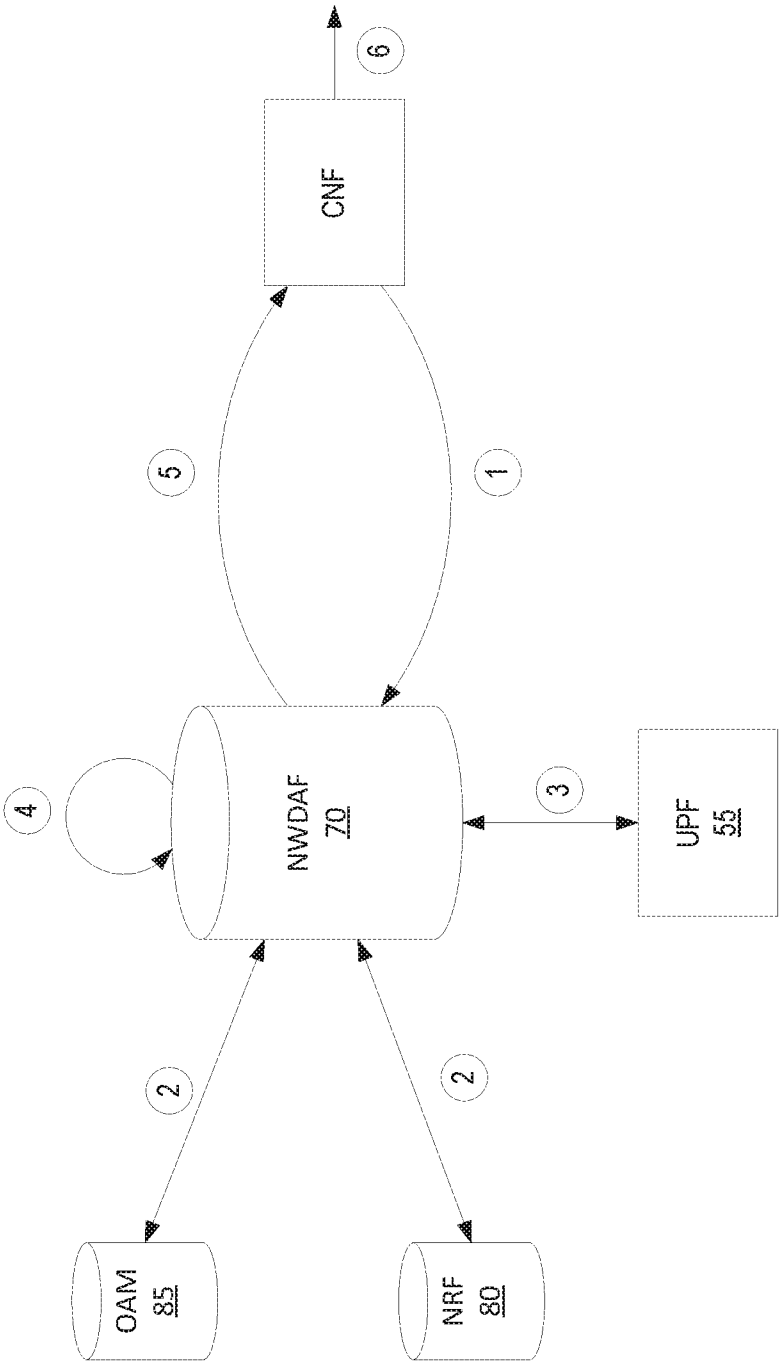

FIG. 2

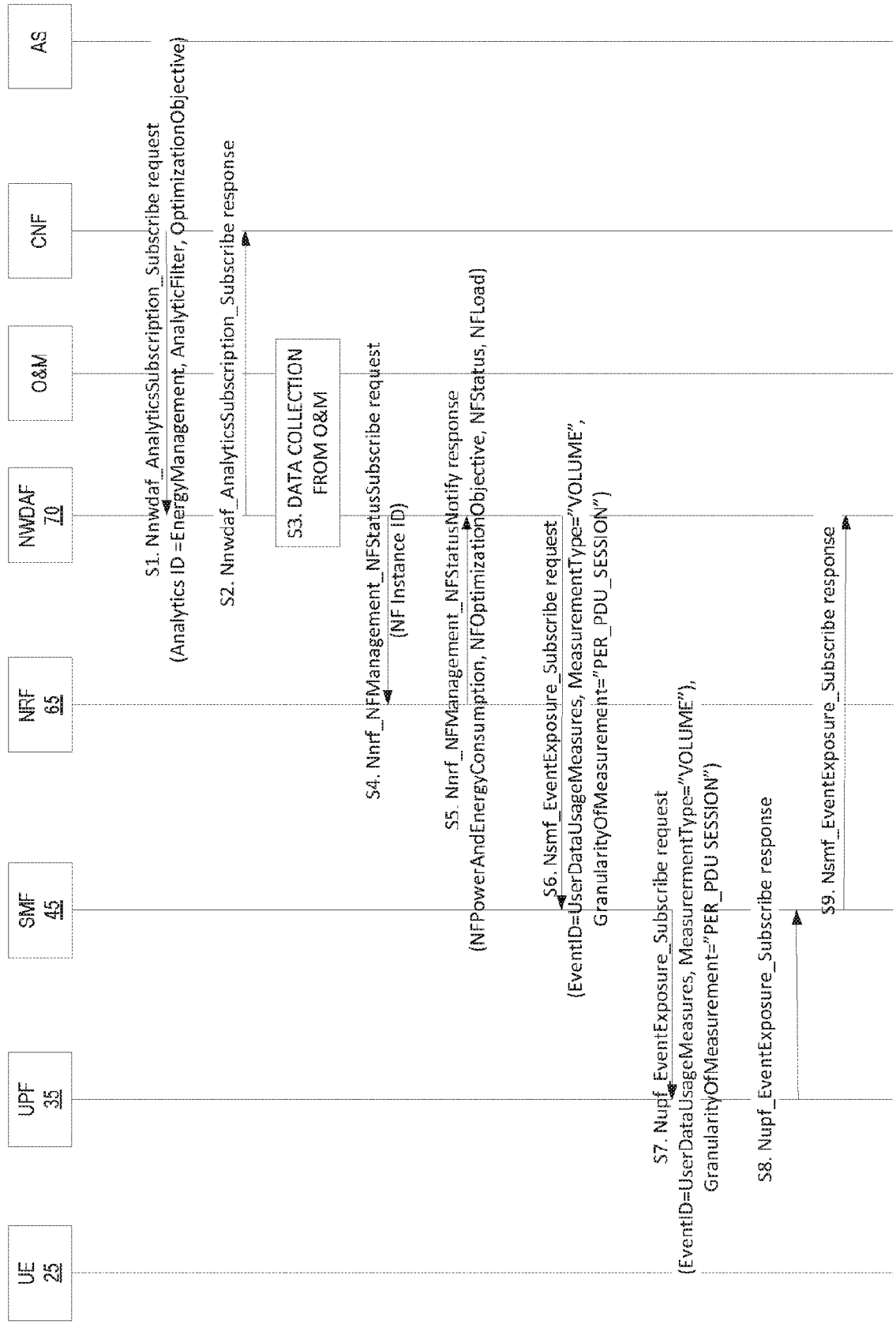
UE 25
UPF 35
SMF 45
NRF 65
NWDAF 70
O&M
CNF
AS
S1. Nnwdaf_AnalyticsSubscription_Subscribe request
(Analytics ID =EnergyManagement, AnalyticFilter, OptimizationObjective)
S2. Nnwdaf_AnalyticsSubscription_Subscribe response
S3. DATA COLLECTION FROM O&M
S4. Nnrf_NFManagement_NFStatusSubscribe request
(NF Instance ID)
S5. Nnrf_NFManagement_NFStatusNotify response
(NFPowerAndEnergyConsumption, NFOptimizationObjective, NFStatus, NFLoad)
S6. Nsmf_EventExposure_Subscribe request
(EventID=UserDataUsageMeasures, MeasurementType="VOLUME",
GranularityOfMeasurement="PER_PDU_SESSION")
S7. Nupf_EventExposure_Subscribe request
(EventID=UserDataUsageMeasures, MeasurementType="VOLUME"),
GranularityOfMeasurement="PER_PDU SESSION")
S8. Nupf_EventExposure_Subscribe response
S9. Nsmf_EventExposure_Subscribe response

FIG. 3A

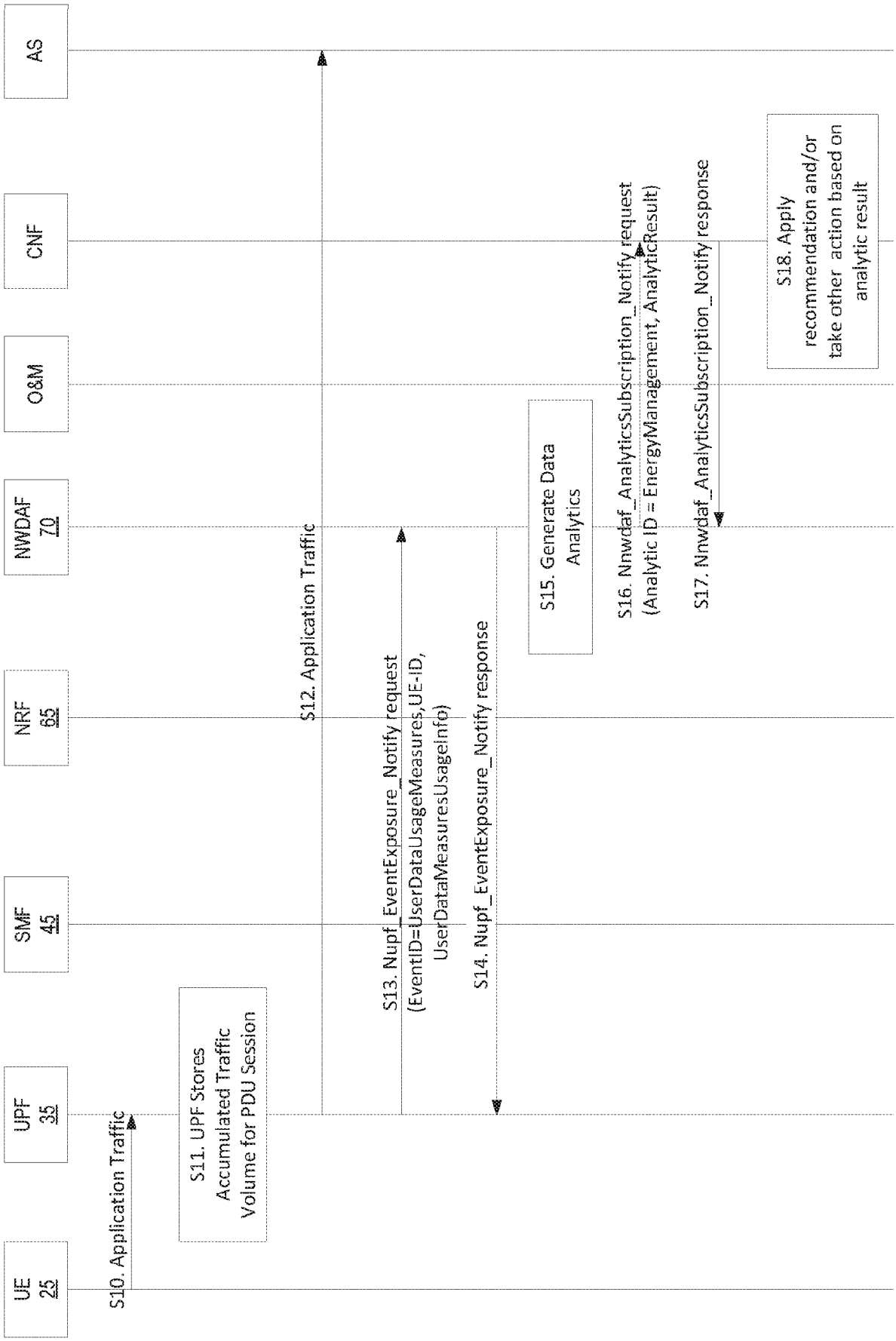
UE 25
UPF 35
SMF 45
NRF 65
NWDAF 70
O&M
CNF
AS
S10. Application Traffic
S11. UPF Stores Accumulated Traffic Volume for PDU Session
S12. Application Traffic
S13. Nupf_EventExposure_Notify request (EventID=UserDataUsageMeasures,UE-ID, UserDataMeasuresUsageInfo)
S14. Nupf_EventExposure_Notify response
S15. Generate Data Analytics
S16. Nnwdaf_AnalyticsSubscription_Notify request (Analytic ID = EnergyManagement, AnalyticResult)
S17. Nnwdaf_AnalyticsSubscription_Notify response
S18. Apply recommendation and/or take other action based on analytic result

FIG. 3B

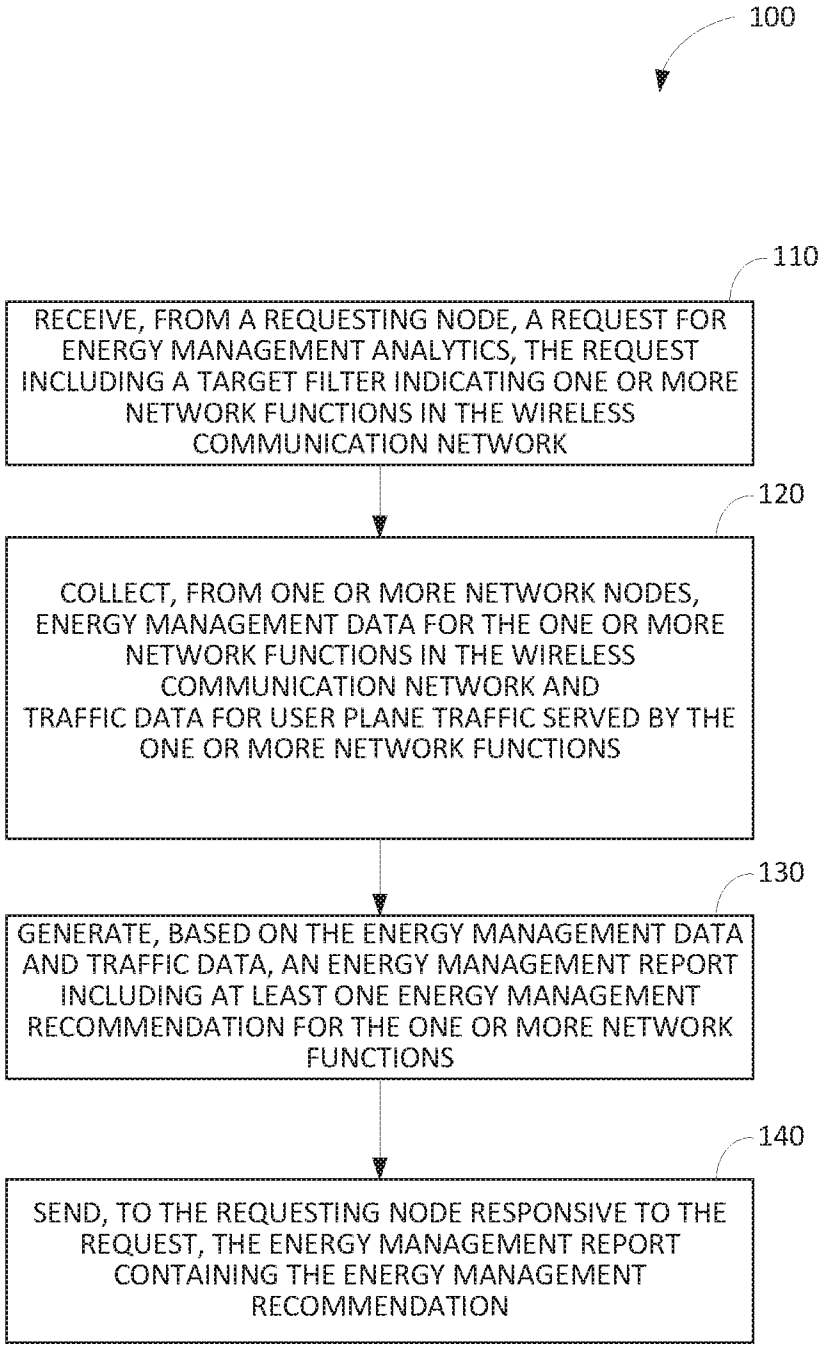
100
110
RECEIVE, FROM A REQUESTING NODE, A REQUEST FOR ENERGY MANAGEMENT ANALYTICS, THE REQUEST INCLUDING A TARGET FILTER INDICATING ONE OR MORE NETWORK FUNCTIONS IN THE WIRELESS COMMUNICATION NETWORK
120
COLLECT, FROM ONE OR MORE NETWORK NODES, ENERGY MANAGEMENT DATA FOR THE ONE OR MORE NETWORK FUNCTIONS IN THE WIRELESS COMMUNICATION NETWORK AND TRAFFIC DATA FOR USER PLANE TRAFFIC SERVED BY THE ONE OR MORE NETWORK FUNCTIONS
130
GENERATE, BASED ON THE ENERGY MANAGEMENT DATA AND TRAFFIC DATA, AN ENERGY MANAGEMENT REPORT INCLUDING AT LEAST ONE ENERGY MANAGEMENT RECOMMENDATION FOR THE ONE OR MORE NETWORK FUNCTIONS
140
SEND, TO THE REQUESTING NODE RESPONSIVE TO THE REQUEST, THE ENERGY MANAGEMENT REPORT CONTAINING THE ENERGY MANAGEMENT RECOMMENDATION

FIG. 4

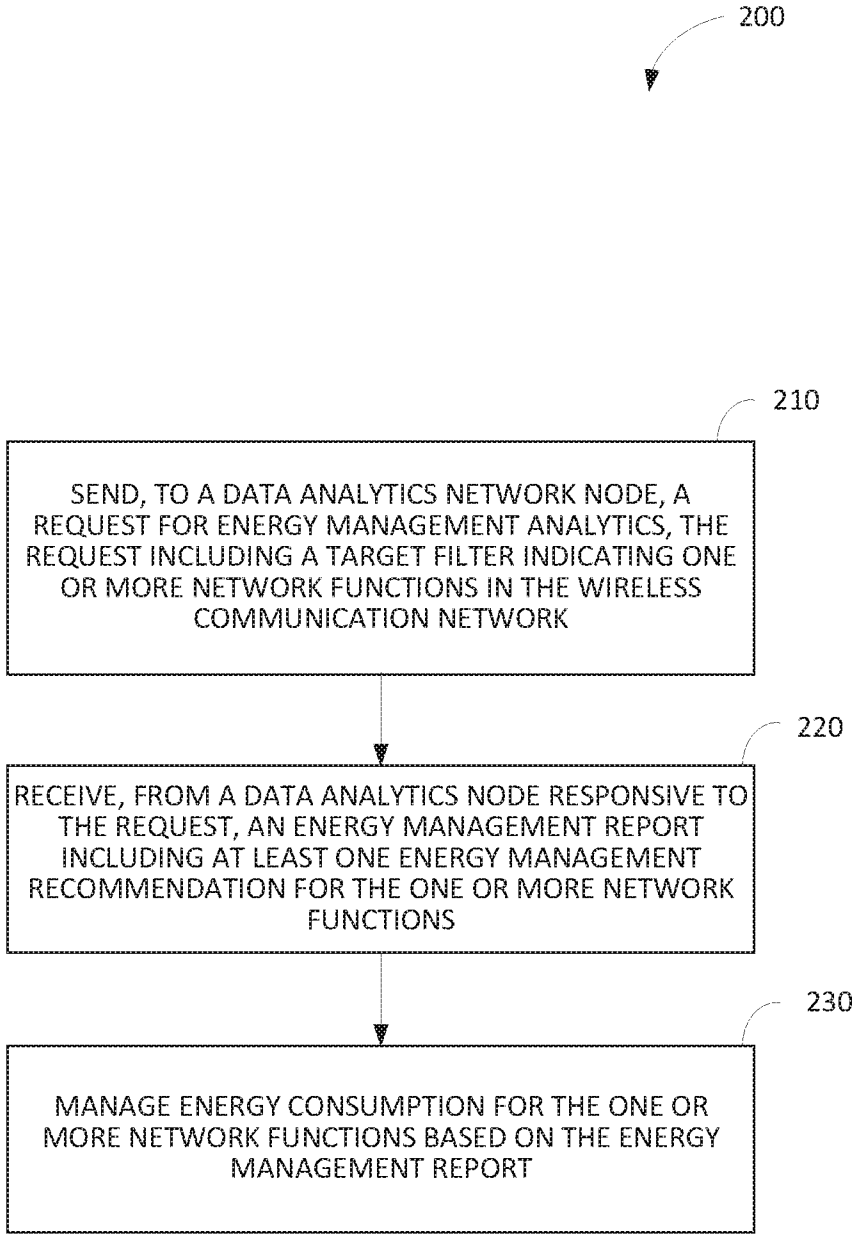
200
210
SEND, TO A DATA ANALYTICS NETWORK NODE, A REQUEST FOR ENERGY MANAGEMENT ANALYTICS, THE REQUEST INCLUDING A TARGET FILTER INDICATING ONE OR MORE NETWORK FUNCTIONS IN THE WIRELESS COMMUNICATION NETWORK
220
RECEIVE, FROM A DATA ANALYTICS NODE RESPONSIVE TO THE REQUEST, AN ENERGY MANAGEMENT REPORT INCLUDING AT LEAST ONE ENERGY MANAGEMENT RECOMMENDATION FOR THE ONE OR MORE NETWORK FUNCTIONS
230
MANAGE ENERGY CONSUMPTION FOR THE ONE OR MORE NETWORK FUNCTIONS BASED ON THE ENERGY MANAGEMENT REPORT

FIG. 5

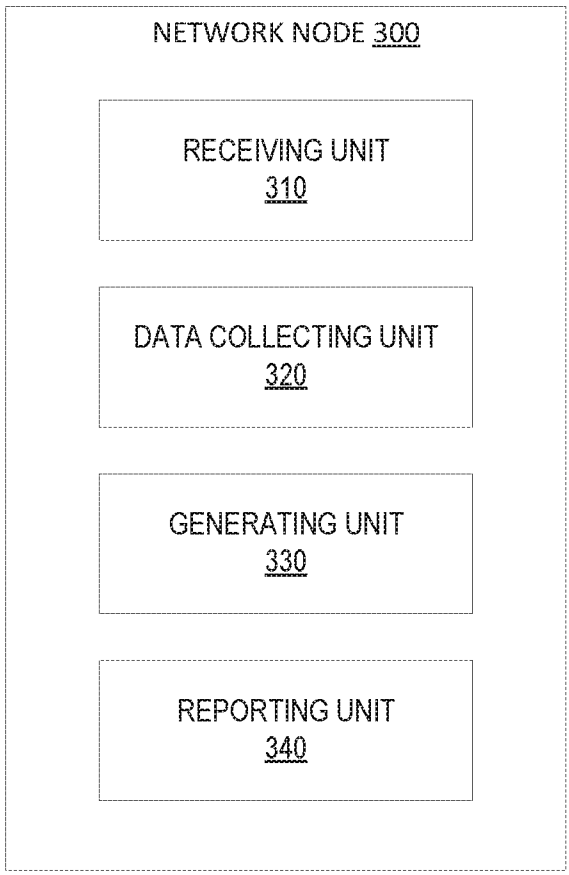
NETWORK NODE 300
RECEIVING UNIT
310
DATA COLLECTING UNIT
320
GENERATING UNIT
330
REPORTING UNIT
340

FIG. 6

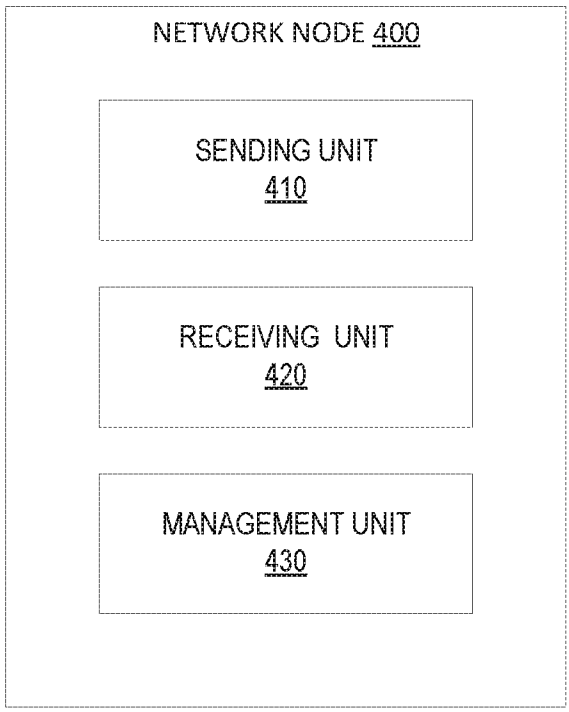
NETWORK NODE 400
SENDING UNIT
410
RECEIVING UNIT
420
MANAGEMENT UNIT
430

FIG. 7

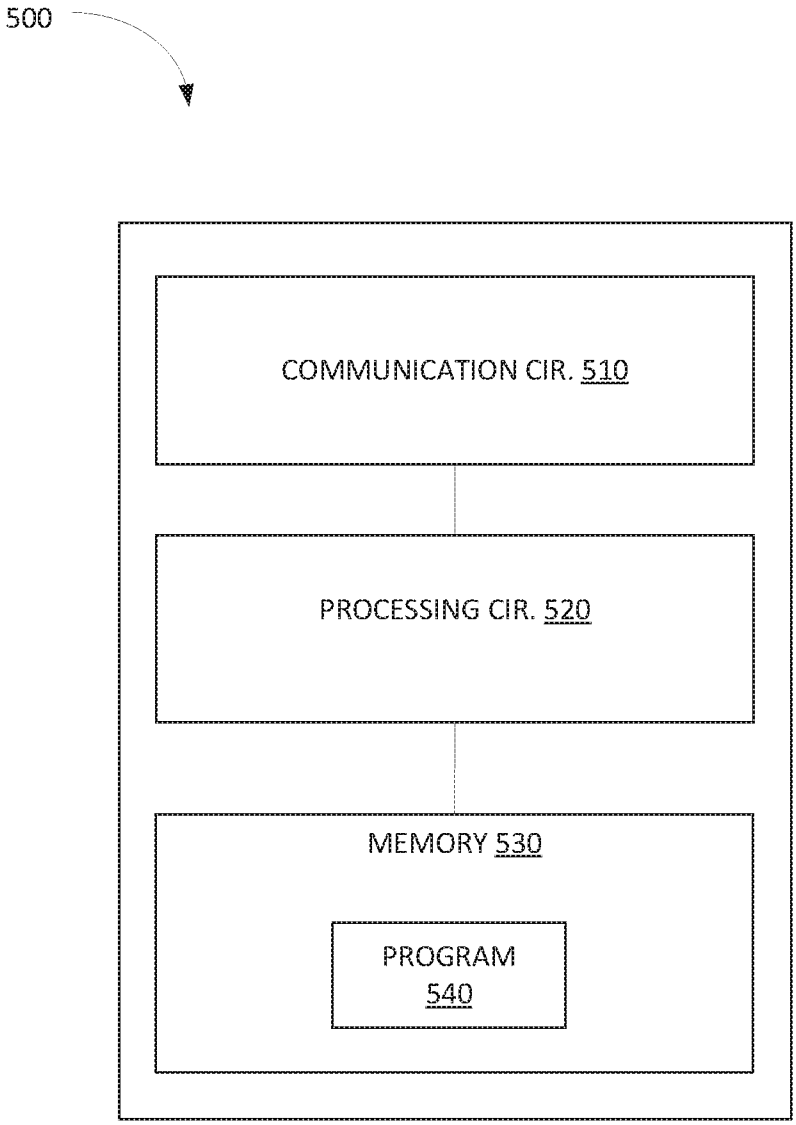
500
COMMUNICATION CIR. 510
PROCESSING CIR. 520
MEMORY 530
PROGRAM
540

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/059254

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W24/02 H04W52/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2023/006228 A1 (NOKIA SOLUTIONS & NETWORKS OY [FI]) 2 February 2023 (2023-02-02) paragraph [0168] - paragraph [0178]; figure 8 paragraph [0151] ----- -/--	1,4-6, 12-15, 18-32

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 March 2024	11/04/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tessier, Serge

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/059254

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JOEY CHOU ET AL: "Input to draft CR Rel-18 28.104 Revise energy saving analysis use case", 3GPP DRAFT; S5-232714; TYPE OTHER; EMDAS_PH2, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. 3GPP SA 5, no. Athens, GR; 20230227 - 20230303 17 February 2023 (2023-02-17), XP052239728, Retrieved from the Internet: URL:https://www.3gpp.org/ftp/TSG_SA/WG5_TM/TSGS5_147/Docs/S5-232714.zip S5-232714 Rel-18 draft CR 28.104 UC energy consumption.docx [retrieved on 2023-02-17] page 3 - page 4 -----	1-3, 6-11, 15-17, 20,22, 23,25, 26,28, 30,32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2023/059254

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2023006228 A1	02-02-2023	NONE	