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(71) Applicant: NEC LABORATORIES EUROPE GMBH

[DE/DE]; Kurfürsten-Anlage 36, 69115 Heidelberg (DE).

(72) Inventors: FAN, Linghang; c/o NEC Laboratories Europe

GmbH, Kurfürsten-Anlage 36, 69115 Heidelberg (DE).

AL-KANANI, Hassan; c/o NEC Laboratories Europe

GmbH, Kurfürsten-Anlage 36, 69115 Heidelberg (DE).

IANEV, Iskren; c/o NEC Laboratories Europe GmbH,

Kurfürsten-Anlage 36, 69115 Heidelberg (DE).

(74) Agent: SMITH, Jeremy; Mathys & Squire, The Shard, 32

London Bridge Street, London Greater London SE1 9SG (GB).

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(54) Title: DATA ANALYTICS-BASED SLS ASSURANCE SOLUTION UTILISING UE QOE MEASUREMENT

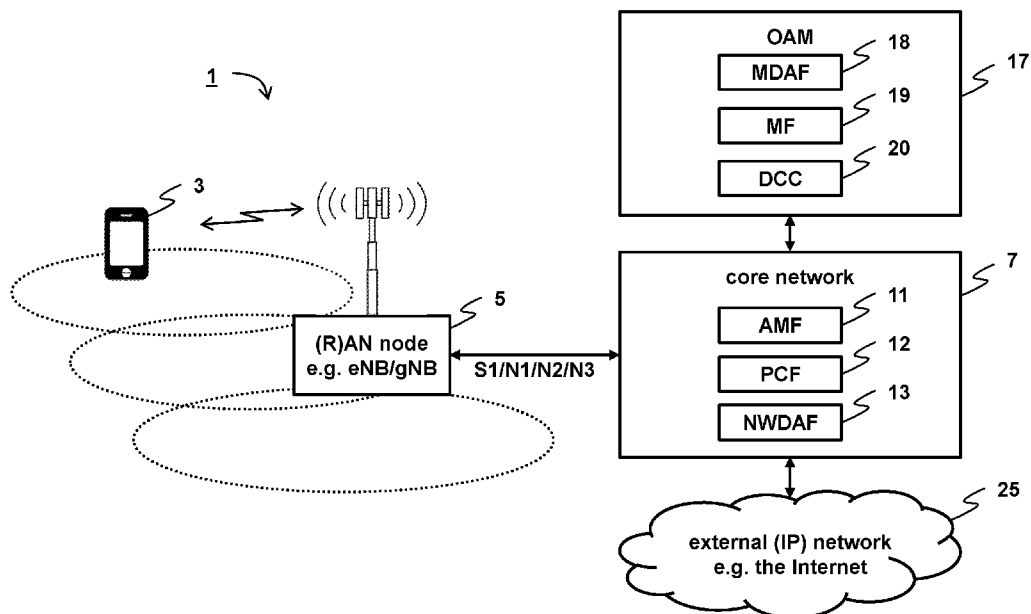


Figure 1

(57) Abstract: A new solution for close-loop SLS assurance, involving UE, RAN, Core network and OAM, is proposed. It allows automatic QoE measurements collection and analysis, and therefore avoids the current inefficient and lengthy procedure to deal with UE's QoE degradation.



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## Data Analytics-based SLS Assurance Solution Utilising UE QoE Measurement

The present invention relates to a communication system. The invention has particular but not exclusive relevance to wireless communication systems and devices thereof operating according to the 3rd Generation Partnership Project (3GPP) standards or  
5 equivalents or derivatives thereof. The invention has particular although not exclusive relevance to service assurance based on data analytics and QoE measurements in the so-called '5G' (or 'Next Generation') systems.

### Background

The 3GPP Working Groups are currently defining the 5G system.

- 10       • The 3GPP TSG SA WG5 (SA5) is specifying the requirements, architecture and solutions for provisioning and management of the network (RAN, CN, IMS) and its services. Within SA5, Quality of Experience (QoE) measurements collection has been defined and documented in a technical specification TS 28.404 V16.0.0 [4] and TS 28.405 V1.0.0 [5].
  
- 15       • The 3GPP TSG SA WG2 is specifying the system architecture and procedures for 5G systems. In order to provide network data analytics in 5G networks, a Network Function (NF) called Network Data Analytics Function (NWDAF) is being specified in the 3GPP TSG SA WG2. QoE measurements are also  
20       important for the core network. TS23.288 v16.1.0 [8] states that "QoE measurements from the applications are based on outcome of the ongoing SA5 Rel-16 WID "Management of QoE measurement collection" which addresses  
30       how to collect the QoE measurements from the applications in the UE".

Recently, a new work item "Closed loop SLS Assurance" has been proposed in SA5 to specify a closed loop assurance solution that helps an operator to continuously deliver  
25       the expected level of communication service quality.

### Problem Description

Since Service Level Specification (SLS) assurance is always a challenging task for operators, as pointed out in the SA5 work item, there is a need to create a closed loop management service that automatically adjusts and optimizes the NG-RAN and 5GC  
30       configurations based on the various performance management and QoE measurements

input, and the state of the 5G network, using data analytics techniques such as ML and AI.

The QoE measurements collection is an important mean for 5GC and the OAM to improve end user's experience. However, there are several problems in the existing QoE measurement collection procedure, which is an integral part of SLS assurance solution.

5 Firstly, the existing QoE measurements collection procedure cannot perform automatically. This procedure is triggered when there is a customer complaint. In this procedure, operator's request is transferred to the UE via the OAM and 5GC, and then the UE collects the requested information and sends it to the specified collection centre.

10 This is an inefficient and lengthy process, and cannot adjust the system configurations in timely manner to guarantee SLS.

Secondly, according to current specifications, the UE reports QoE measurements only on two service types to the network based on the network's requests: streaming services and Multimedia Telephony Service for IMS (MTSI). It does not cover other service types,

15 such as gaming, whose QoE needs to be measured and reported to the network to ensure end users' quality of experience.

According to current specifications, UE's QoE measurements are sent to a specified collection centre, which doesn't have any data analytics capability. This leads to the OAM makes its decision purely based on the QoE measurements directly collected from the

20 UE, which may not be very reliable.

Clearly there is a need to define a new solution which can automate the service assurance and maintain SLS.

Accordingly, preferred embodiments of the present invention aim to provide methods and apparatus which address or at least partially deal with one or more of the above

25 issues.

Although for efficiency of understanding for those of skill in the art, the invention will be described in detail in the context of a 3GPP system (NR), the principles of the invention can be applied to other systems in which communication devices or User Equipment (UE) access a core network using a radio access technology.

In one aspect, the invention provides a method performed by an operations, administration and maintenance (OAM) function for service level specification (SLS) assurance, the method comprising: determining at least one policy for SLS assurance for a user equipment (UE) to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and transmitting said at least one policy towards said UE.

In one aspect, the invention provides a method performed by a user equipment (UE) for service level specification (SLS) assurance, the method comprising: receiving, from an operations, administration and maintenance (OAM) function, at least one policy for SLS assurance to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and performing QoE measurement reporting based on said at least one policy.

In one aspect, the invention provides a method performed by a user equipment (UE) for service level specification (SLS) assurance, the method comprising: reporting results of a QoE measurement to a data collection centre, based on an associated criterion, when at least one of the following is met: the UE determines a QoE degradation associated with a service type; and the UE determines that at least one QoE metric of a service type is below an associated threshold.

In one aspect, the invention provides an operations, administration and maintenance (OAM) function for service level specification (SLS) assurance, the OAM function comprising: means for determining at least one policy for SLS assurance for a user equipment (UE) to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and means for transmitting said at least one policy towards said UE.

In one aspect, the invention provides a user equipment (UE) for service level specification (SLS) assurance, the UE comprising: means for receiving, from an operations, administration and maintenance (OAM) function, at least one policy for SLS assurance to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and

a reporting format; and means for performing QoE measurement reporting based on said at least one policy.

In one aspect, the invention provides a user equipment (UE) for service level specification (SLS) assurance, the UE comprising: means for reporting results of a QoE measurement to a data collection centre, based on an associated criterion, when at least one of the following is met: the UE determines a QoE degradation associated with a service type; and the UE determines that at least one QoE metric of a service type is below an associated threshold.

In another aspect, the invention provides an operations, administration and maintenance (OAM) function for service level specification (SLS) assurance, the OAM function comprising a transceiver and a controller, wherein the controller is configured to: determine at least one policy for SLS assurance for a user equipment (UE) to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and control the transceiver to transmit said at least one policy towards said UE.

In another aspect, the invention provides a user equipment (UE) for service level specification (SLS) assurance, the UE comprising a transceiver and a controller, wherein the controller is configured to: control the transceiver to receive, from an operations, administration and maintenance (OAM) function, at least one policy for SLS assurance to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and perform QoE measurement reporting based on said at least one policy.

In another aspect, the invention provides a user equipment (UE) for service level specification (SLS) assurance, the UE comprising a transceiver and a controller, wherein the controller is configured to: report results of a QoE measurement to a data collection centre, based on an associated criterion, when at least one of the following is met: the UE determines a QoE degradation associated with a service type; and the UE determines that at least one QoE metric of a service type is below an associated threshold.

Aspects of the invention extend to corresponding systems, apparatus, and computer program products such as computer readable storage media having instructions stored thereon which are operable to program a programmable processor to carry out a method

as described in the aspects and possibilities set out above or recited in the claims and/or to program a suitably adapted computer to provide the apparatus recited in any of the claims.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of (or in combination with) any other disclosed and/or illustrated features. In particular but without limitation the features of any of the claims dependent from a particular independent claim may be introduced into that independent claim in any combination or individually.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 illustrates schematically a mobile (cellular or wireless) telecommunication system to which embodiments of the invention may be applied;

Figure 2 is a block diagram of a User Equipment (UE) forming part of the system shown in Figure 1;

Figure 3 is a block diagram of a base station forming part of the system shown in Figure 1;

Figure 4 is a block diagram of a core network node entity forming part of the system shown in Figure 1; and

Figures 5a to 5c and 6a to 6c are schematic signalling (timing) diagrams illustrating exemplary ways in which service assurance based on data analytics and QoE measurements may be performed in the system shown in Figure 1.

### **Overview**

Figure 1 schematically illustrates a mobile (cellular or wireless) telecommunication system 1 to which the above embodiments are applicable.

In this network, users of mobile devices 3 (UEs) can communicate with each other and other users via respective base stations 5 and a core network 7 using an appropriate 3GPP radio access technology (RAT), for example, an E-UTRA and/or 5G RAT. It will be appreciated that a number of base stations 5 form a (radio) access network or (R)AN. As those skilled in the art will appreciate, whilst one mobile device 3 and one base station 5 are shown in Figure 1 for illustration purposes, the system, when implemented, will typically include other base stations and mobile devices (UEs).

Each base station 5 controls one or more associated cells (either directly or via other nodes such as home base stations, relays, remote radio heads, distributed units, and/or the like). A base station 5 that supports E-UTRA/4G protocols may be referred to as an 'eNB' and a base station 5 that supports Next Generation/5G protocols may be referred to as a 'gNBs'. It will be appreciated that some base stations 5 may be configured to support both 4G and 5G, and/or any other 3GPP or non-3GPP communication protocols.

The mobile device 3 and its serving base station 5 are connected via an appropriate air interface (for example the so-called 'Uu' interface and/or the like). Neighbouring base stations 5 are connected to each other via an appropriate base station to base station interface (such as the so-called 'X2' interface, 'Xn' interface and/or the like). The base station 5 is also connected to the core network nodes via an appropriate interface (such as the so-called 'S1', 'N1', 'N2', 'N3' interface, and/or the like).

The core network 7 typically includes logical nodes (or 'functions') for supporting communication in the telecommunication system 1. Typically, for example, the core network 7 of a 'Next Generation' / 5G system will include, amongst other functions, control plane functions (CPFs) and user plane functions (UPFs). It will be appreciated that the core network 7 may also include, amongst others: an Access and Mobility Management Function (AMF) 11; a Policy Control Function (PCF) 12, and a Network Data Analytics Function (NWDAF) 13.

Operations, Administration and Maintenance (OAM) 17 functionality may also be provided via one or more nodes/functions coupled to the core network 7 (as shown in Figure 1). Such OAM functionality includes for example a Management Data Analytics Function (MDAF) 18, a Management Function (MF) 19, and a Data Collection Centre (DCC) 20.

From the core network 7, connection to an external IP network / data network 25 (such as the Internet) is also provided.

The components of this system 1 are configured to perform data analytics based on QoE measurements reporting. Specifically, the OAM (e.g. the MDAF 18) decides policies with QoE measurement reporting criteria and reporting format for the UE 3. The UE 3 reports (automatically) its QoE measurement according to the policies, and a data analytics function (e.g. the MDAF 18 or the NWDAF 13) performs data analytics based on the QoE measurements report.



### User equipment (UE)

Figure 2 is a block diagram illustrating the main components of the UE (mobile device 3) shown in Figure 1. As shown, the UE includes a transceiver circuit 31 which is operable to transmit signals to and to receive signals from the connected node(s) via one or more antenna 33. Although not necessarily shown in Figure 2, the UE will of course have all the usual functionality of a conventional mobile device (such as a user interface 35) and this may be provided by any one or any combination of hardware, software and firmware, as appropriate. A controller 37 controls the operation of the UE in accordance with software stored in a memory 39. The software may be pre-installed in the memory 39 and/or may be downloaded via the telecommunication network 1 or from a removable data storage device (RMD), for example. The software includes, among other things, an operating system 41 and a communications control module 43. The communications control module 43 is responsible for handling (generating/ sending/receiving) signalling messages and uplink/downlink data packets between the UE 3 and other nodes, including (R)AN nodes 5, core network nodes, and OAM functions. Such signaling includes appropriately formatted requests and responses relating to data analytics based on QoE measurement report.

### (R)AN node

Figure 3 is a block diagram illustrating the main components of an exemplary (R)AN node 5 (base station) shown in Figure 1. As shown, the (R)AN node 5 includes a transceiver circuit 51 which is operable to transmit signals to and to receive signals from connected UE(s) 3 via one or more antenna 53 and to transmit signals to and to receive signals from other network nodes (either directly or indirectly) via a network interface 55. The network interface 55 typically includes an appropriate base station – base station interface (such as X2/Xn) and an appropriate base station – core network interface (such as S1/N1/N2/N3). A controller 57 controls the operation of the (R)AN node 5 in accordance with software stored in a memory 59. The software may be pre-installed in the memory 59 and/or may be downloaded via the telecommunication network 1 or from a removable data storage device (RMD), for example. The software includes, among other things, an operating system 61 and a communications control module 63. The communications control module 63 is responsible for handling (generating/sending/receiving) signalling between the (R)AN node 5 and other nodes, such as the UE 3 and the core network / OAM nodes. Such signaling includes appropriately formatted requests and responses relating to data analytics based on QoE measurement report.

### Core network / OAM node

Figure 4 is a block diagram illustrating the main components of a generic core network node (or function) shown in Figure 1, for example, the AMF 11, the PCF 12, and the NWDAF 14. It will be appreciated that the same block diagram may be applicable to the OAM 17 as well, for example, the MDAF 18, the MF 19, and the Data Collection Centre 20. As shown, the core network / OAM node includes a transceiver circuit 71 which is operable to transmit signals to and to receive signals from other nodes (including the UE 3 and the (R)AN node 5) via a network interface 75. A controller 77 controls the operation of the core network / OAM node in accordance with software stored in a memory 79. The software may be pre-installed in the memory 79 and/or may be downloaded via the telecommunication network 1 or from a removable data storage device (RMD), for example. The software includes, among other things, an operating system 81 and at least a communications control module 83. The communications control module 83 is responsible for handling (generating/sending/ receiving) signaling between the core network / OAM node and other nodes, such as the UE 3, (R)AN node 5, and other core network / OAM nodes. Such signaling includes appropriately formatted requests and responses relating to data analytics based on QoE measurement report.

### Detailed description

In order to address the aforementioned problems, the inventors propose a data analytics-based SLS assurance solution. The main idea of this solution is that it is a close-loop SLS assurance solution, which involves the UE 3, the RAN 5, the core network 7 and the OAM 17. This solution has a new trigger to enable automatic reporting of the QoE degradation on certain service type, by conducting data analytics on the collected QoE measurement, and adjusting the network configuration based on UE's QoE measurements report and analytics result in an end-to-end close-loop design.

The following is a detailed description of two exemplary embodiments:

- Embodiment 1 MDAF performs data analytics based on QoE measurements report in the close loop SLS assurance solution
- Embodiment 2 NWDAF performs data analytics based on QoE measurements report in the close loop SLS assurance solution

**Embodiment 1 – MDAF performs data analytics based on QoE measurements report in the close loop SLS assurance solution**

In this Embodiment, the Management Data Analytics service producer within the OAM system 17, e.g., the Management Data Analytics Function (MDAF) 18, or any other relevant entity, function or service dedicated for the purpose in the OAM 17 performs the data analytics and produces relevant analytics service (analytics results) based on the QoE measurements report collected and reported by the UE 3. The analytic service or report can be consumed (i.e., reported to or subscribed to) by the relevant consumer, function or service within the OAM system 17 and/or network, e.g., by a Management Function (MF) 19 within the OAM 17 and/or within the network e.g. by the NWDAF 13.

Figures 5a to 5c demonstrate schematically an exemplary procedure for the OAM analytics service producer, e.g., an MDAF 18 (or any other relevant service, function or entity dedicated for the purpose) that performs data analytics based on the QoE measurement report (collected and reported by the UE 3) as part of the close loop SLS assurance solution.

Step 1: The MDAF 18 or any other relevant entity, function or service in the OAM 17 invokes the event exposure service procedure or any other procedure adopted for the purpose or sends the Data Collection Centre 20, e.g., a Trace Collection Entity (TCE) or any other relevant entity or service dedicated for the purpose in the OAM 17 to subscribe to the collection of QoE measurements data from the Data Collection Centre 20 in the OAM 17. Besides the data obtained from the Data Collection Centre 20 in the OAM 17, the MDAF 18 may also subscribe for other network data from network entities, functions or services and management data from management functions entities or services (i.e., Management Service “MnS”) on the purpose of performing its data analytics. The MF subscribes into the MDAF’s services to obtain analytics results from the MDAF 18. The Data Collection Centre 20 in the OAM 17 subscribes into core network/RAN/UE’s services on data reporting to obtain the required data from core network/RAN/UE. The data collection center (e.g., TCE) may obtain data via file-based or non-file based mechanisms (e.g., via streaming).

Step 2: The MF or any other relevant entity or service in the OAM 17 decides the QoE measurement collection and reporting policy based on the SLS and operators’ policies, and sends these policies to the PCF 12, which then transfers the policies to the RAN 5.

Step 3: The RAN 5 invokes the QoE measurement configuration procedure or any other procedure or sends the UE 3 an RRC connection reconfiguration message or any other message with the information on the measurement configuration to configure the UE 3 on QoE measurement(s) and collection reporting-criterion and reporting-format. The QoE measurements configuration criterion and reporting format include parameters, at least one of the type of reporting, the service type, the event that triggers the QoE measurement reporting, and thresholds that triggers the start of QoE measurement reporting. The types of reporting can be either scheduled or event-based reporting. The service type includes the type of service for QoE measurement reporting, at least one of streaming services, MTSI services, Network Controlled Interactive Service, VR Based Interactive Service, Cloud Rendering for Games, and IoE based social networking services. The event that triggers the QoE measurement reporting includes the event(s), at least one of QoE metrics of a certain service type is below a threshold. Thresholds that trigger the QoE measurement reporting include the threshold(s) of QoE metrics of a certain service type, at least one of Representation Switch Events, Average Throughput, Initial Playout Delay, Buffer Level, Play List, MPD Information, Playout Delay for Media Start-up and Device information.

Step 4: If the QoE measurement on a certain service type drops below certain, pre-defined threshold, the UE 3 records the QoE measurement on the specific service type, the QoE metrics, location and time in a QoE measurement collection report.

When the QoE measurements are triggered the UE 3 may also trigger the start and report of other lower layer measurements including coverage quality, signal strength, packet loss, and other related measurements.

Step 5: The UE 3 invokes the measurement reporting procedure or any other procedure or sends the RAN 5 a measReportAppLayer message or any other relevant message with the QoE measurement report to report to the RAN 5 the QoE measurement(s). The QoE measurements report may include parameters, at least one of a UE ID, a service type, and the measurement on the QoE metrics, location and time.

Other measurements, such as signal strength and packet loss, can also be included in the QoE measurement reports.

Step 6: The RAN 5 sends UE's QoE measurement report to the Data Collection Centre (e.g, TCE) or any other relevant entity or service consumer/producer in the OAM.

Step 7: The Data collection Centre 20 (e.g., TCE) or any other relevant entity or service consumer/producer in the OAM 17 notifies the MDAF 18 or any other relevant entity or service consumer the UE QoE measurement report.

5 Step 8: The MDAF 18 or any other relevant entity or service consumer/producer performs data analytics on QoE measurements, related network data from the core network 7 and management data from the OAM 17.

10 Step 9: The MDAF 18 or any other relevant entity or service consumer/producer reports QoE analytics results to the management function or any other relevant function or service. The QoE analytics results are based on data analytics on QoE measurements, related network data and management data.

Step 10: The Management Function (MF) or any other relevant entity or service consumer /producer in the OAM 17 makes its decision and applies the new configurations to the network and the RAN 5 if it is necessary.

15 Step 11: In order to ensure UE's QoE is satisfied after the network reconfiguration, the Management Function (MF) or any other relevant entity or service consumer /producer in the OAM 17 invokes the QoE measurement reporting procedure or any other procedure to request the UE 3 to report its QoE measurement. This step is not needed if the UE 3 is scheduled to report to the network its measurements.

20 Step 12: The UE 3 records the QoE measurement on the QoE metrics, the service type, location and time in a QoE measurement report. Step 13: The UE 3 sends the RAN 5 a measReportAppLayer message or any other message with the QoE measurement(s) report to inform the RAN 5 the QoE measurement. The QoE measurement report may include parameters, at least one of a UE ID, a service type, and the measurement on the QoE metrics, location and time.

25 Step 14: The RAN 5 sends UE's QoE measurement report to the Data Collection Centre 20 in the OAM 17.

Step 15: The Data Collection Centre 20 in the OAM 17 notifies the MDAF 18 or any other relevant entity or service consumer /producer in the OAM 17 the UE's QoE measurement report.

Step 16: The MDAF 18 or any other relevant entity or service consumer/producer in the OAM 17 performs data analytics on QoE measurements and related network and management data.

5 Step 17: The MDAF 18 or any other relevant entity or service consumer/producer in the OAM 17 reports QoE analytics results to the Management Function (MF) or any other relevant entity or service consumer/producer. The QoE analytics results are based on data analytics on QoE measurements, related network data and management data.

10 Step 18: The Management Function (MF) or any other relevant entity or service consumer /producer in the OAM 17 make its decision and applies the new configuration to the network and the RAN 5 if it is necessary.

Repeat Step 11 to 18 until UE's QoE is satisfied (i.e. SLS is guaranteed).

### **Embodiment 2 – NWDAF performs data analytics based on QoE measurement report in the close loop SLS assurance solution**

15 In this Embodiment, an NWDAF 13 in the core network 7 performs data analytics based on the QoE measurement report collected from the UE 3, and notifies the Management Function (MF) 19 or any other relevant entity or service its analytics results.

Figures 6a to 6c demonstrate schematically an exemplary procedure for an NWDAF 13 that performs data analytics based on QoE measurement report in the close loop SLS assurance solution.

20 Step 1: The MDAF 18 or any other entity or service consumer /producer in the OAM 17 subscribes to NWDAF's service by sending Nnwdaf\_Events\_Subscription\_Subscribe message or any other service procedure or message for the purpose of subscribing to analytics and/or statistics information from the NWDAF 13. Besides the analytics information from the NWDAF 13, the MDAF 18 subscribes other network data from  
25 network entities and management data from other management functions or service producers/consumers on the purpose of performing its data analytics. The MF subscribes to the MDAF's services to obtain analytics results from the MDAF 18. The NWDAF 13 invokes the event exposure service procedure or any other procedure or sends the Data Collection Centre 20 or any other relevant entity or service consumer  
30 /producer in the network or the OAM 17 an Nnf\_EventExposure\_Subscribe message to subscribe the collection of QoE measurement data from the Data Collection Centre 20 in or any other relevant entity or service consumer/producer in the network or the OAM

17. Besides the data from the Data Collection Centre 20 in the OAM 17, the NWDAF 13 subscribes other network data from network entities and management data from management functions on the purpose of performing its data analytics. The Data Collection Centre 20 in the OAM 17 subscribes core network/RAN/UE's services on data reporting to obtain the required data from core network/RAN/UE.

Step 2: The MF or any other relevant entity or service consumer /producer in the OAM 17 decides the QoE measurement collection and reporting policy based on the SLS and operators' policies, and sends these policies to the PCF 12, who transfers the policies to the RAN 5.

Step 3: The RAN 5 invokes the QoE measurement configuration procedure or any other procedure or sends the UE 3 an RRC connection reconfiguration message or any other message with the information on the measurement configuration to configure the UE 3 on QoE measurement and collection reporting criterion and reporting format. The QoE measurement configuration criterion and reporting format include parameters, at least one of the type of reporting, the service type, the event that triggers the QoE measurement reporting, and thresholds that triggers the QoE measurement reporting. The types of reporting can be either scheduled or event-based reporting. The service type includes the type of service for QoE measurement reporting, at least one of streaming services, MTSI services, Network Controlled Interactive Service, VR Based Interactive Service, Cloud Rendering for Games, and IoE based social networking services. The event that triggers the QoE measurement reporting includes the event(s), at least one of QoE metrics of a certain service type is below a threshold. Thresholds that trigger the QoE measurement reporting include the threshold(s) of QoE metrics of a certain service type, at least one of Representation Switch Events, Average Throughput, Initial Playout Delay, Buffer Level, Play List, MPD Information, Playout Delay for Media Start-up and Device information.

Step 4: If the QoE measurement on a certain service type drops below certain threshold, the UE 3 records the QoE measurement(s) on the service type, the QoE metrics, location and time in a QoE measurement collection report. Other measurements, such as signal strength and packet loss, can also be included in the QoE measurement reports.

Step 5: The UE 3 invokes the measurement reporting procedure or any other procedure or sends the RAN 5 a measReportAppLayer message or any other message with the QoE measurement report to report the RAN 5 the QoE measurement. The QoE

measurement report may include parameters, at least one of a UE ID, a service type, and the measurement on the QoE metrics, location and time.

Other measurements, such as signal strength and packet loss, can also be included in the QoE measurement reports.

5 Step 6: The RAN 5 sends UE's QoE measurement report to the Data Collection Centre 20 or any other relevant entity or service consumer /producer in the network or the in the OAM 17.

Step 7: The Data Collection Centre 20 or any other relevant entity or service consumer /producer in the network or the in the OAM 17 notifies the NWDAF 13 the UE QoE  
10 measurement report.

Step 8: The NWDAF 13 performs data analytics on QoE measurements, and related network data. Management data also can be used in the data analytics if it is needed.

Step 9: The NWDAF 13 notifies the MDAF 18 its QoE analytics results. The QoE analytics results are based on data analytics on QoE measurements and related network  
15 data/management data.

Step 10: The MDAF 18 or any other relevant entity or service consumer/producer in the OAM 17 performs further data analytics on QoE analytics results provided by the NWDAF 13 and other network and management data, and notifies the Management Function or any other entity or service consumer/producer in the OAM 17 its analytics  
20 results.

Step 11: The Management Function or any other relevant entity or service consumer/producer in the OAM 17 make its decision and applies the new configurations to the network and to the RAN 5 if it is necessary.

Step 12: In order to ensure UE's QoE is satisfied after the network reconfiguration, the  
25 Management Function or any other relevant entity or service consumer/producer in the OAM 17 invokes the QoE measurement reporting procedure or any other procedure to request the UE 3 to report its QoE measurement. This step is not needed if the UE 3 is scheduled to report to the network its measurements.

Step 13: The UE 3 records the QoE measurement on the QoE metrics, the service type,  
30 location and time in a QoE measurement report.



Step 14: The UE 3 sends the RAN 5 a measReportAppLayer message or any other message with the QoE measurement report to inform the RAN 5 the QoE measurement. The QoE measurement report may include parameters, at least one of a UE ID, a service type, and the measurement on the QoE metrics, location and time.

5 Step 15: The RAN 5 sends UE's QoE measurement report to the Data Collection Centre or any other relevant entity or service consumer/producer in the network or in the OAM 17.

Step 16: The Data Collection Centre 20 or any other relevant entity or service consumer/producer in the network or in the OAM 17 notifies the NWDAF 13 the UE QoE  
10 measurement report.

Step 17: The NWDAF 13 performs data analytics on QoE measurements and related network data. Management data also can be used in the data analytics if it is needed.

Step 18 The NWDAF 13 notifies the MDAF 18 or any other relevant entity or service consumer/producer in the OAM 17 the QoE analytics results. The QoE analytics results  
15 are based on data analytics on QoE measurements and related network data/management data.

Step 19: The MDAF 18 or any other relevant entity or service consumer/producer in the OAM 17 performs data analytics on QoE analytics results and other related network and management data and notifies the Management Function or any other relevant entity or  
20 service consumer/producer its analytics results.

Step 20: The Management Function or any other relevant entity or service consumer/producer in the OAM 17 makes its decision and applies the new configurations to the network and to the RAN 5 if it is necessary.

Repeat Step 12 to 20 until UE's QoE is satisfied (i.e. SLS is guaranteed).

25 In this solution, the SLS assurance procedure has been automated. As its result, it allows the network to react quickly and efficiently to QoE degradation and therefore enhance user's experience efficiently and in a timely manner.

### Summary

Beneficially, the above described embodiments include, although they are not limited to,  
30 one or more of the following functionalities:

- 1) This is a close-loop SLS assurance solution, which involves the UE 3, the RAN 5, the core network 7, and the OAM 17. This solution has a new trigger to automatically report the QoE degradation on a certain service type, using data analytics on the collected QoE measurement, and adjusting the network configuration based on UE's QoE measurement and analytics result in an end-to-end close-loop design
- 2) QoE measurement is sent to the NWDAF 13 / MDAF 18 for data analytics. OAM's decision based on the analytics results is more reliable than that of based purely on QoE measurement directly collected from the UE 3. The analytics results are based on QoE measurement, other network data and management data.

In order to provide these functionalities, the above aspects describe exemplary methods comprising (at least some of) the following steps:

- 1) A new closed-loop QoE-based data analytics solution is proposed:
- The network configures the UE 3 with the policies with the QoE related reporting criteria to automatically report.
  - The UE 3 reports its QoE measurement to the network (e.g. NWDAF/MDAF) when reporting criteria is met. The NWDAF 13 / MDAF 18 reports analytics results to the Management Function. The analytics results are based on data analytics on QoE measurements and related network data/management data.
  - The Management Function make its decision and applies the new configuration to the network.
  - The UE 3 reports QoE measurement based on the network's request or defined policies
  - The OAM 17 adjusts its network configuration based on QoE analytics result with other network data until the UE's SLS can be guaranteed.
- 2) The QoE measurement configuration criterion and reporting format include parameters, at least one of the type of reporting, the service type, the event that triggers the QoE measurement reporting, and thresholds that triggers the QoE measurement reporting.
- The types of reporting can be either scheduled or event-based reporting.
  - The service type includes the type of service for QoE measurement reporting, at least one of streaming services, MTSI services, Network

Controlled Interactive Service, VR Based Interactive Service, Cloud Rendering for Games, and IoE based social networking services.

- The event that triggers the QoE measurement reporting includes the event(s), at least one of QoE metrics of a certain service type is below a threshold. Thresholds that trigger the QoE measurement reporting include the threshold(s) of QoE metrics of a certain service type, at least one of Representation Switch Events, Average Throughput, Initial Playout Delay, Buffer Level, Play List, MPD Information, Playout Delay for Media Start-up and Device information.

5

## 10 **Benefits**

A new close-loop SLS assurance solution, which is among UE, RAN, the core network and OAM, is proposed. It allows automatic QoE measurement collection, and therefore avoids the current inefficient and lengthy procedure to deal with UE's QoE degradation.

## **Modifications and Alternatives**

15 Detailed embodiments have been described above. As those skilled in the art will appreciate, a number of modifications and alternatives can be made to the above embodiments whilst still benefiting from the inventions embodied therein. By way of illustration only a number of these alternatives and modifications will now be described.

In the above description, the UE, the (R)AN node, and the core network / OAM node are described for ease of understanding as having a number of discrete modules (such as the communication control modules). Whilst these modules may be provided in this way for certain applications, for example where an existing system has been modified to implement the invention, in other applications, for example in systems designed with the inventive features in mind from the outset, these modules may be built into the overall operating system or code and so these modules may not be discernible as discrete entities. These modules may also be implemented in software, hardware, firmware or a mix of these.

25

Each controller may comprise any suitable form of processing circuitry including (but not limited to), for example: one or more hardware implemented computer processors; microprocessors; central processing units (CPUs); arithmetic logic units (ALUs); input/output (IO) circuits; internal memories / caches (program and/or data); processing registers; communication buses (e.g. control, data and/or address buses); direct memory

30

access (DMA) functions; hardware or software implemented counters, pointers and/or timers; and/or the like.

In the above embodiments, a number of software modules were described. As those skilled in the art will appreciate, the software modules may be provided in compiled or un-compiled form and may be supplied to the UE, the (R)AN node, and the core network / OAM node as a signal over a computer network, or on a recording medium. Further, the functionality performed by part or all of this software may be performed using one or more dedicated hardware circuits. However, the use of software modules is preferred as it facilitates the updating of the UE, the (R)AN node, and the core network / OAM node in order to update their functionalities.

The above embodiments are also applicable to 'non-mobile' or generally stationary user equipment.

The method performed by the OAM function may further comprise obtaining QoE analytics results from a data analytics function and adjusting a network configuration based on said results in order to meet the SLS.

The method performed by the OAM function may further comprise determining at least one new or updated policy for SLS assurance for said UE, obtaining QoE analytics results from a data analytics function and adjusting a network configuration determining, based on said results, until said SLS is met at least one new or updated policy for SLS assurance for said UE.

The method performed by the UE may further comprise reporting, to a data collection centre, a result of a QoE measurement when the UE determines at least one of the following: a QoE degradation associated with a service type based on an associated criterion; and at least one QoE metric of a service type being below an associated threshold based on an associated criterion.

The method performed by the UE may comprise receiving said at least one policy from the OAM function via a policy control function (PCF) and a radio access network (RAN).

The method performed by the UE may comprise receiving said at least one policy via a QoE measurement configuration procedure (e.g. using at least one radio resource control (RRC) connection reconfiguration message).

The at least one policy may be based on an SLS and at least one operator policy applicable to the UE.

The QoE measurement reporting criteria may comprise a criterion for automatic QoE measurement reporting by the UE to a data collection centre of the OAM.

- 5 The QoE measurement reporting criteria may comprise at least one of: a criterion for QoE measurement reporting when the UE determines a QoE degradation associated with a service type; and a criterion for QoE measurement reporting when the UE determines that at least one QoE metric of a service type is below an associated threshold.
- 10 The OAM function may comprise a management data analytics function (MDAF).

Various other modifications will be apparent to those skilled in the art and will not be described in further detail here.

### Abbreviations and Terminology

	3GPP	3rd Generation Partnership Project
15	5GC	5G Core Network
	5GS	5G System
	5G-AN	5G Access Network
	AF	Application Function
	AI	Artificial Intelligence
20	AMF	Access and Mobility Management Function
	AN	Access Network
	CM-CONNECTED	Connection Management - CONNECTED State
	CM-IDLE	Connection Management - IDLE State
	D2D	Device to device
25	DNN	Data Network Name
	GFBR	Guaranteed Flow Bit Rate
	IoE	Internet of Everything
	MDAF	Management Data Analytics Function
	MDAS	Management Data Analytics Service
30	MF	Management Function
	MnS	Management Service
	ML	Machine Learning

	MM	Mobility Management
	MTSI	Multimedia Telephony Service for IMS
	N1	Reference point between the UE and the Access and Mobility Management Function
5	N2	Reference point between the (R)AN and the Access and Mobility Management Function
	NAS	Non-Access-Stratum
	NF	Network Function
	NG	Next Generation
10	NG-RAN	Next Generation-Radio Access Network
	NWDAF	Network Data Analytics Function
	OAM	Operations, Administration and Maintenance
	OTT	Over the Top
	PCC	Policy and Charging Control
15	PCF	Policy Control Function
	PDB	Packet Delay Budget
	PDU	Protocol Data Unit
	PER	Packet Error Rate
	ProSe	Proximity-based Service
20	QFI	QoS Flow Identifier
	QoE	Quality of Experience
	RAN	Radio Access Network
	RRC	Radio Resource Control
	SBA	Service-based Architecture
25	SLA	Service-level Agreement
	SLS	Service Level Specification
	SM	Session Management
	SMF	Session Management Function
	TCE	Trace Collection Entity
30	UE	User Equipment
	UPF	User Plane Function
	Uu	The reference point between the UE and the radio access network
	V2X	Vehicle-to-everything
	VR	Virtual Reality

**List of references**

[1] 3GPP TS 23.501 V16.2.0

[2] 3GPP TS 23.502 V16.2.0

[3] 3GPP TS 23.503 V16.2.0

5 [4] 3GPP TS 28.404 V16.0.0

[5] 3GPP TS 28.405 V1.0.0

[6] 3GPP TS 36.331 V15.6.0

[7] 3GPP TS 23.288 V16.1.0

[8] 3GPP TS32.422 V15.2.0

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## CLAIMS

1. A method performed by an operations, administration and maintenance (OAM) function for service level specification (SLS) assurance, the method comprising:

5 determining at least one policy for SLS assurance for a user equipment (UE) to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and

transmitting said at least one policy towards said UE.

10 2. The method according to claim 1, wherein said QoE measurement reporting criteria comprises a criterion for automatic QoE measurement reporting by the UE to a data collection centre of the OAM.

3. The method according to claim 1 or 2, wherein said QoE measurement reporting criteria comprises at least one of:

15 a criterion for QoE measurement reporting when the UE determines a QoE degradation associated with a service type; and

a criterion for QoE measurement reporting when the UE determines that at least one QoE metric of a service type is below an associated threshold.

20 4. The method according to any of claims 1 to 3, wherein the at least one policy is based on an SLS and at least one operator policy applicable to the UE.

5. The method according to any of claims 1 to 4, further comprising obtaining QoE analytics results from a data analytics function and adjusting a network configuration based on said results in order to meet said SLS.

25 6. The method according to any of claims 1 to 5, further comprising determining at least one new or updated policy for SLS assurance for said UE; obtaining QoE analytics results from a data analytics function; and adjusting a network configuration, based on said results, until said SLS is met.

7. The method according to any of claims 1 to 6, wherein the OAM function comprises a management data analytics function (MDAF).



8. A method performed by a user equipment (UE) for service level specification (SLS) assurance, the method comprising:

receiving, from an operations, administration and maintenance (OAM) function, at least one policy for SLS assurance to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and

performing QoE measurement reporting based on said at least one policy.

9. The method according to claim 8, wherein the method further comprises reporting, to a data collection centre, a result of a QoE measurement when the UE determines at least one of the following:

a QoE degradation associated with a service type based on an associated criterion; and

at least one QoE metric of a service type being below an associated threshold based on an associated criterion.

10. The method according to claim 8 or 9, comprising receiving said at least one policy from the OAM function via a policy control function (PCF) and a radio access network (RAN).

11. The method according to any of claims 8 to 10, comprising receiving said at least one policy via a QoE measurement configuration procedure (e.g. using at least one radio resource control (RRC) connection reconfiguration message).

12. A method performed by a user equipment (UE) for service level specification (SLS) assurance, the method comprising:

reporting results of a QoE measurement to a data collection centre, based on an associated criterion, when at least one of the following is met:

the UE determines a QoE degradation associated with a service type; and

the UE determines that at least one QoE metric of a service type is below an associated threshold.

13. An operations, administration and maintenance (OAM) function for service level specification (SLS) assurance, the OAM function comprising:

means for determining at least one policy for SLS assurance for a user equipment (UE) to be used in automatic quality of experience (QoE) measurement reporting, the at  
5 least one policy including an associated QoE measurement reporting criterion and a reporting format; and

means for transmitting said at least one policy towards said UE.

14. A user equipment (UE) for service level specification (SLS) assurance, the UE comprising:

10 means for receiving, from an operations, administration and maintenance (OAM) function, at least one policy for SLS assurance to be used in automatic quality of experience (QoE) measurement reporting, the at least one policy including an associated QoE measurement reporting criterion and a reporting format; and

15 means for performing QoE measurement reporting based on said at least one policy.

15. A user equipment (UE) for service level specification (SLS) assurance, the UE comprising:

means for reporting results of a QoE measurement to a data collection centre, based on an associated criterion, when at least one of the following is met:

20 the UE determines a QoE degradation associated with a service type; and

the UE determines that at least one QoE metric of a service type is below an associated threshold.

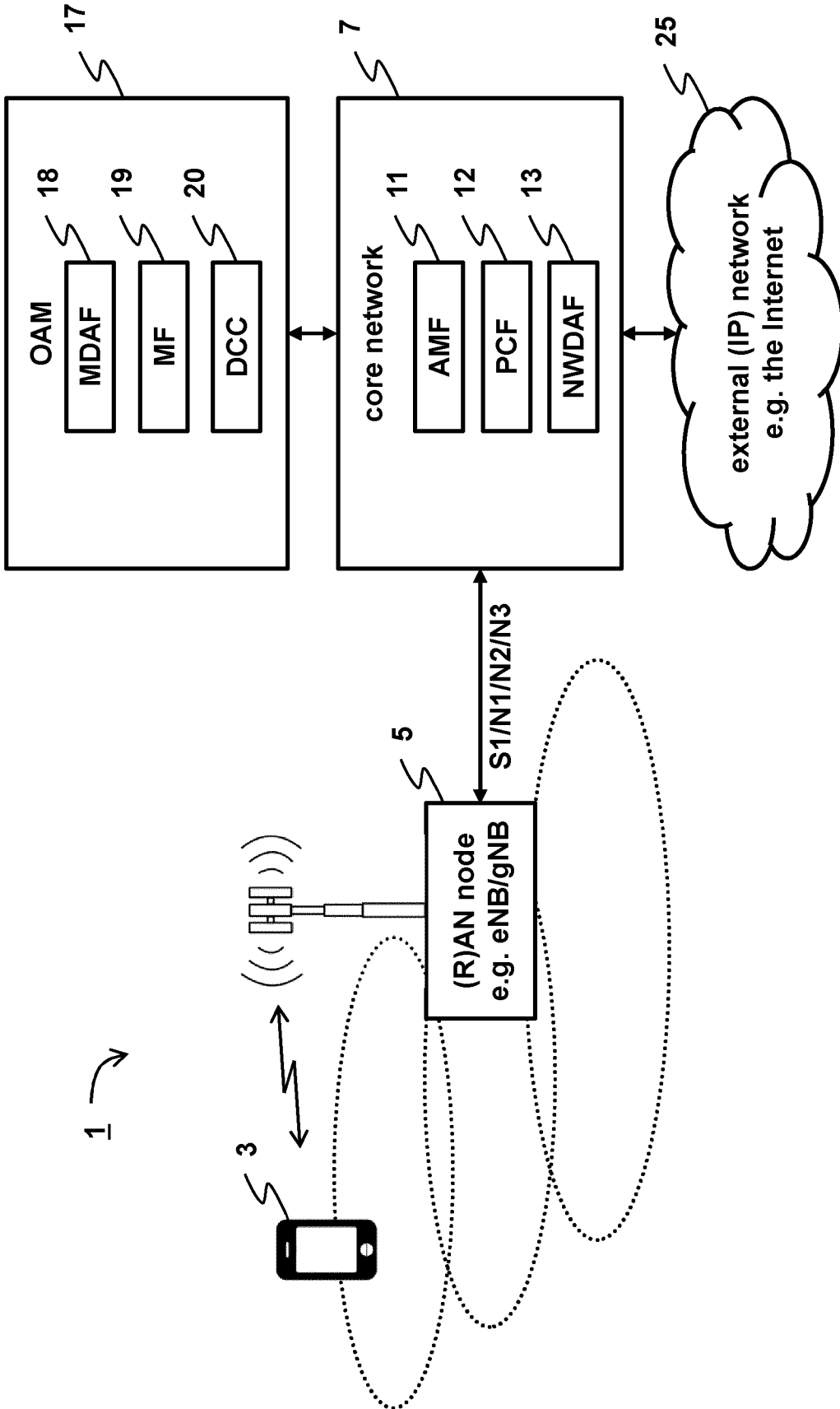
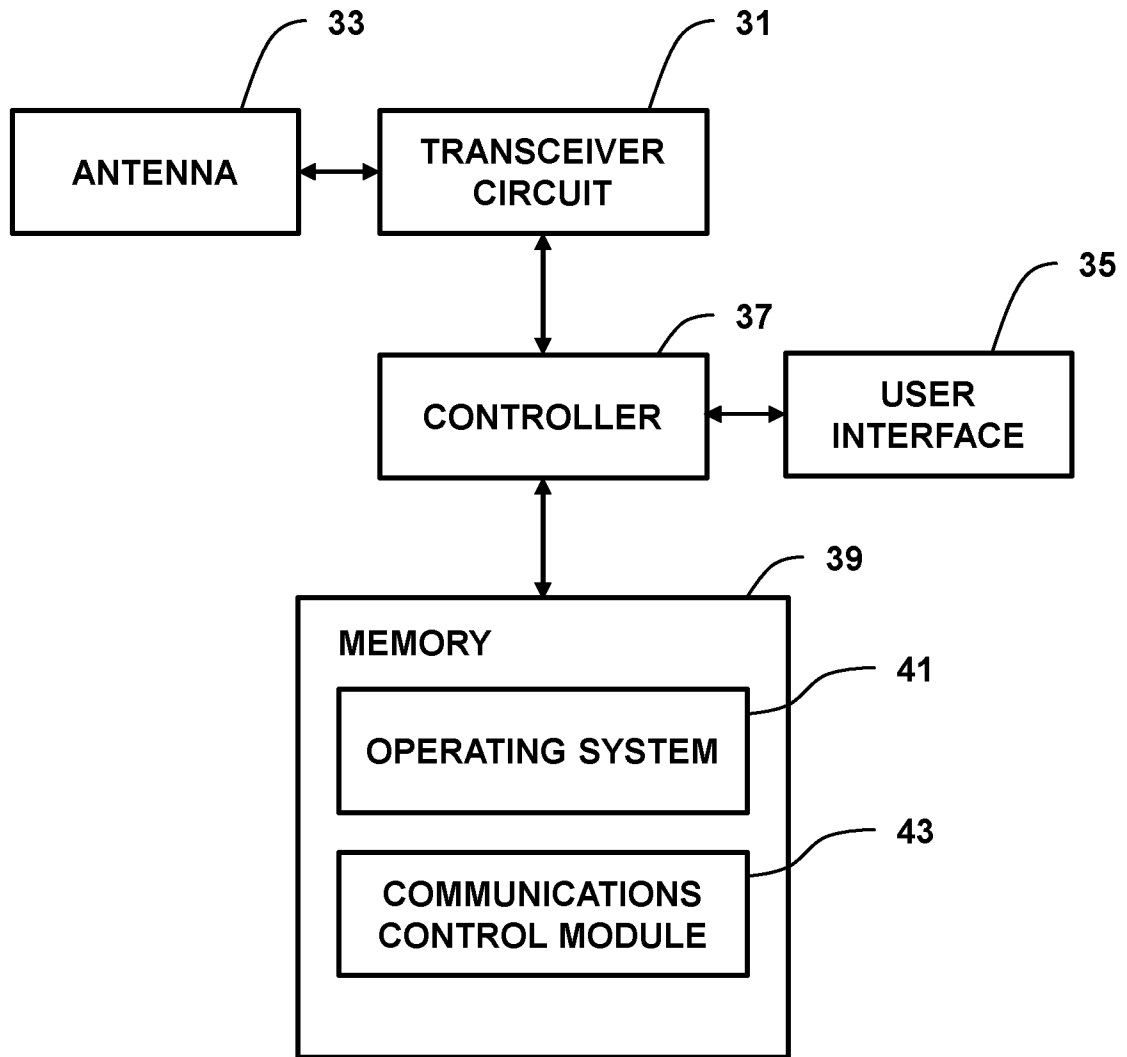
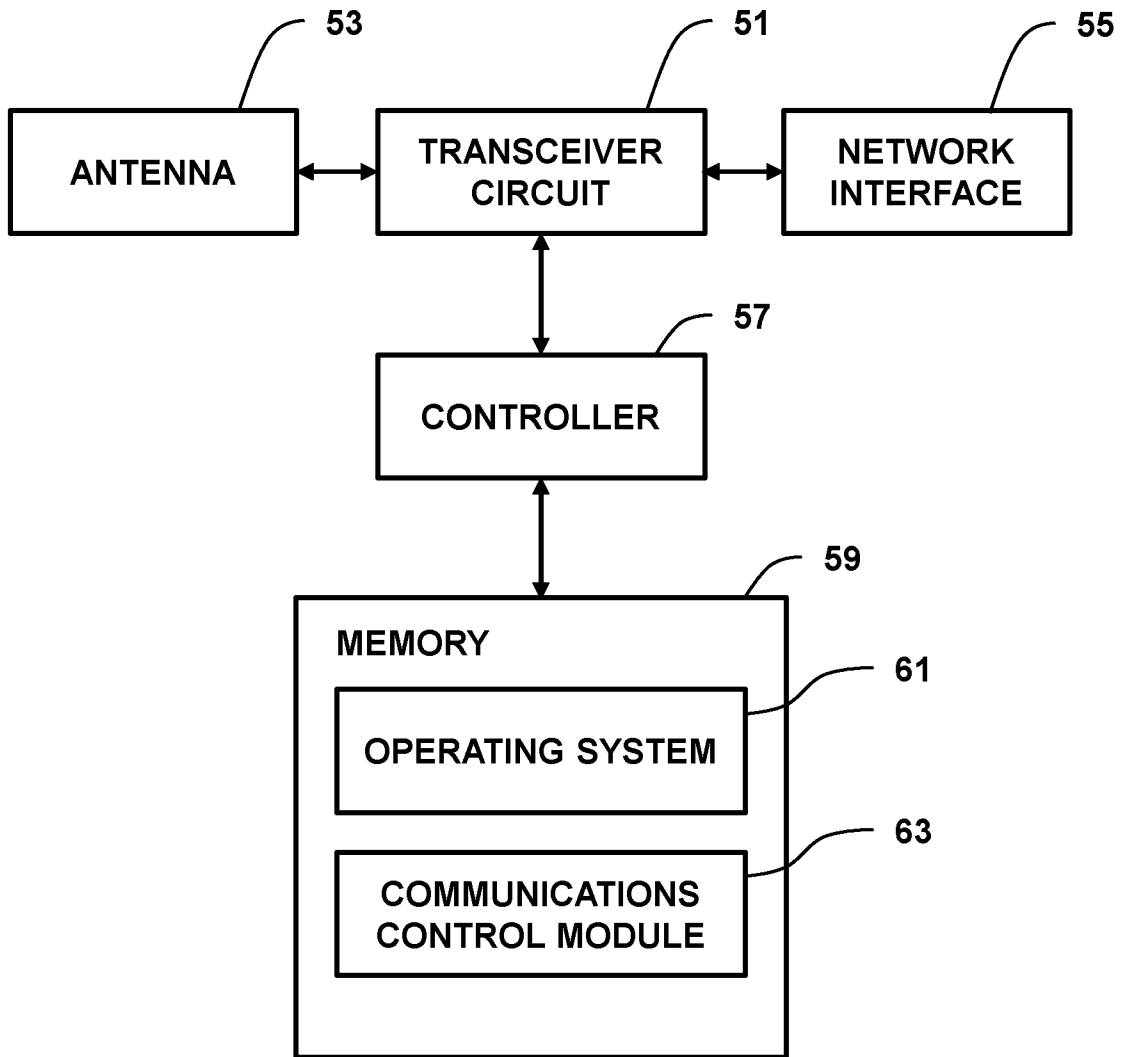


Figure 1



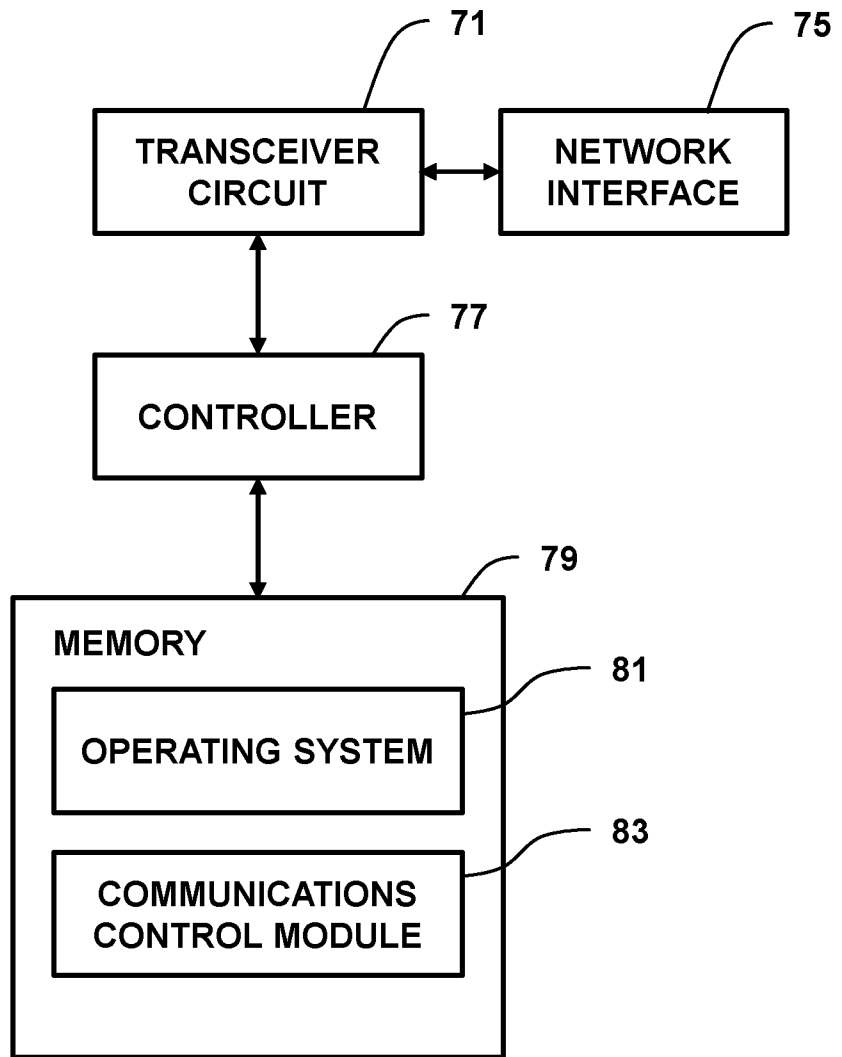
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Figure 2



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Figure 3



11-20

Figure 4

### MDAF performs data analytics based on QoE measurement report in the close loop SLS assurance solution (1/3)

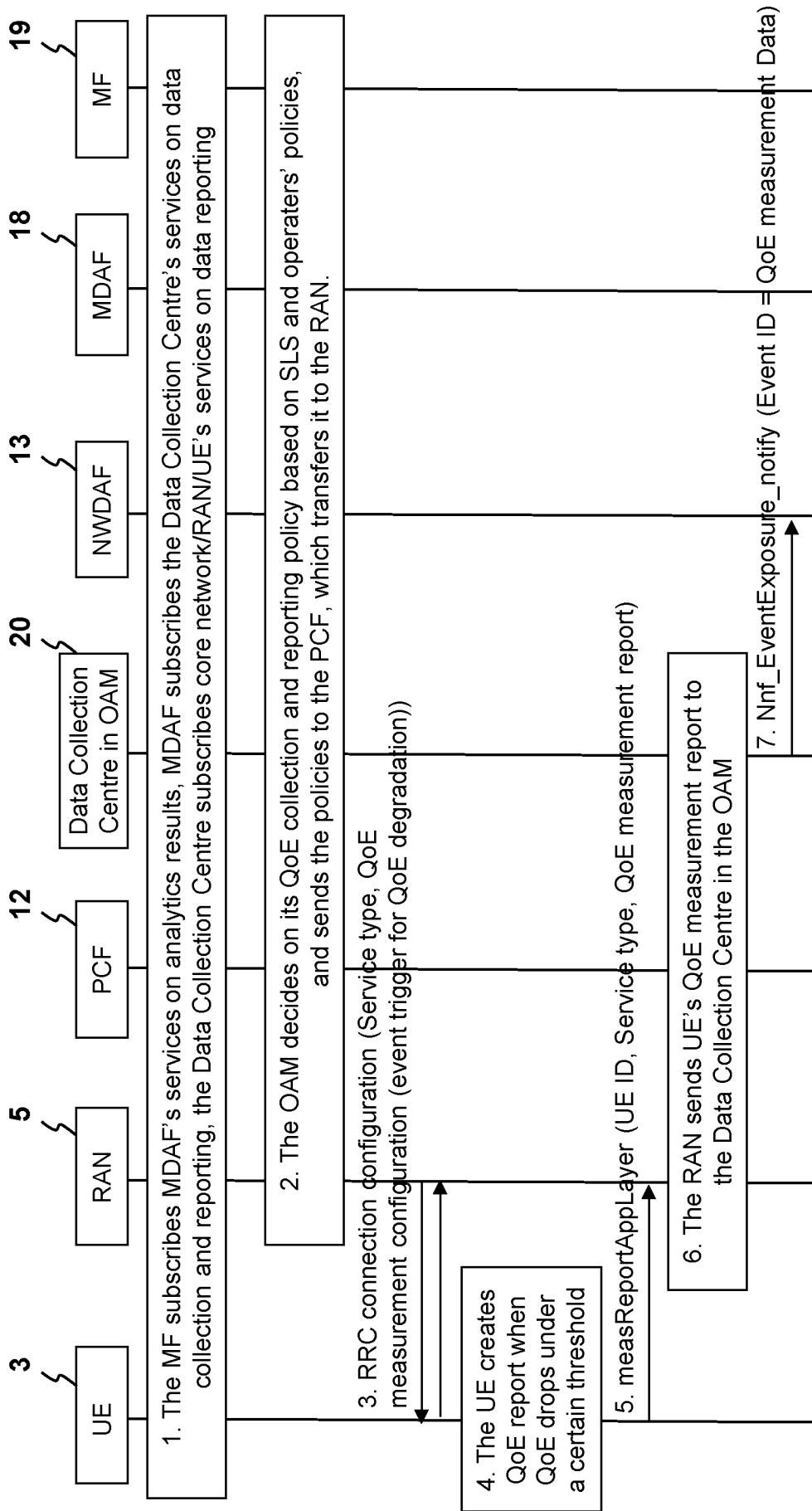


Figure 5a

### MDAF performs data analytics based on QoE measurement report in the close loop SLS assurance solution (2/3)

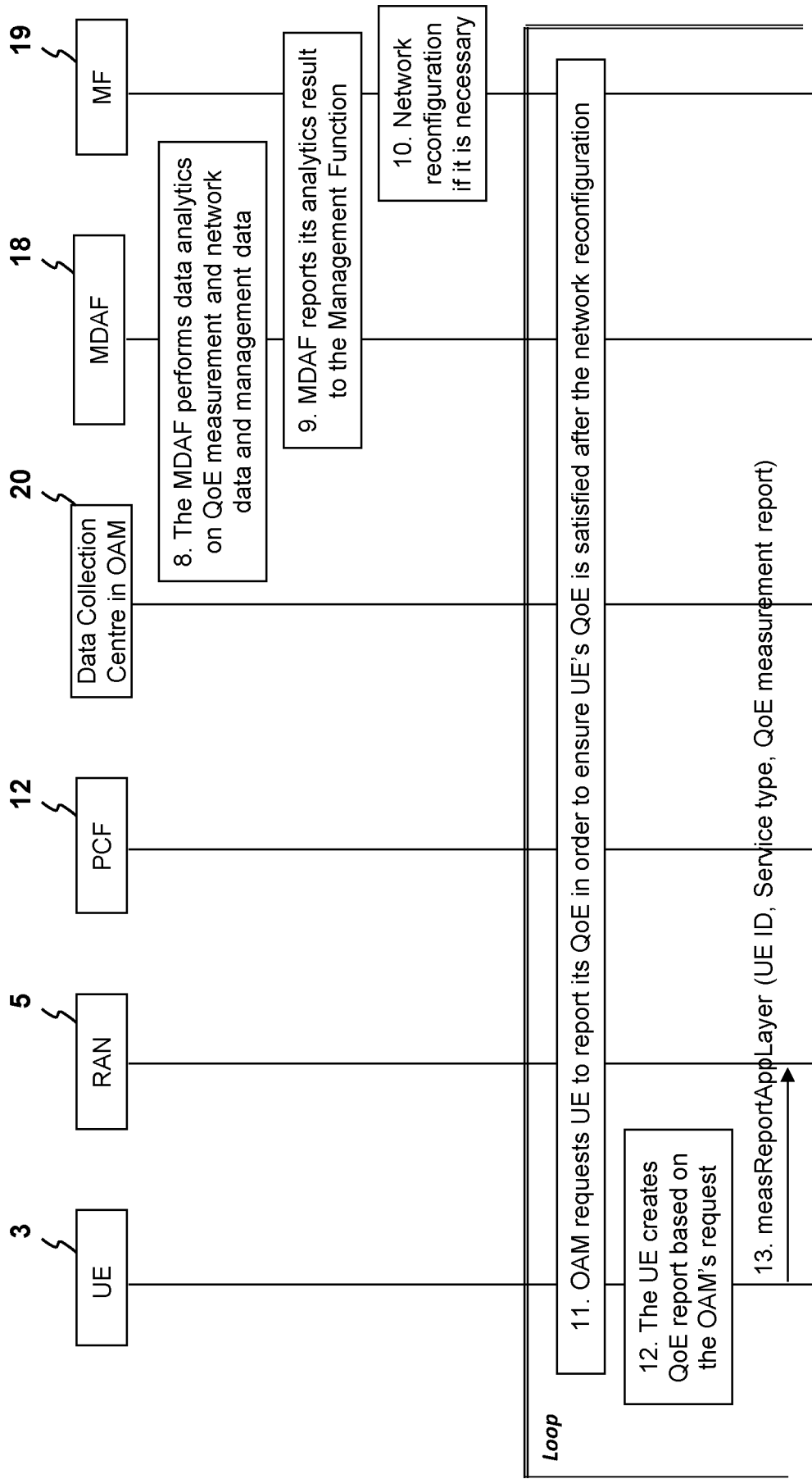
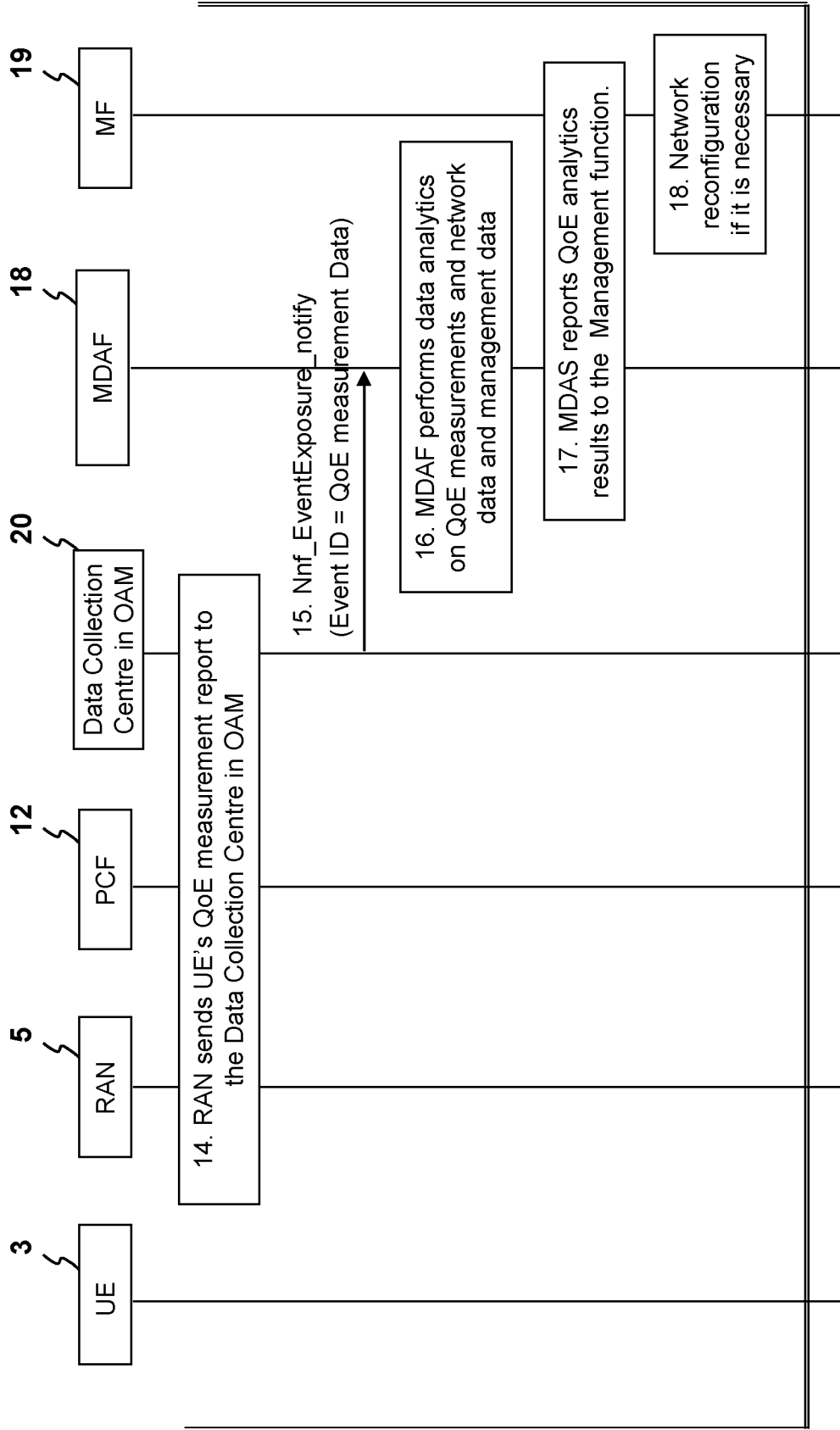


Figure 5b



**MDAF performs data analytics based on QoE measurement report in the close loop SLS assurance solution (3/3)**



**Figure 5c**

### NWDAF performs data analytics based on QoE measurement report in the close loop SLS assurance solution (1/3)

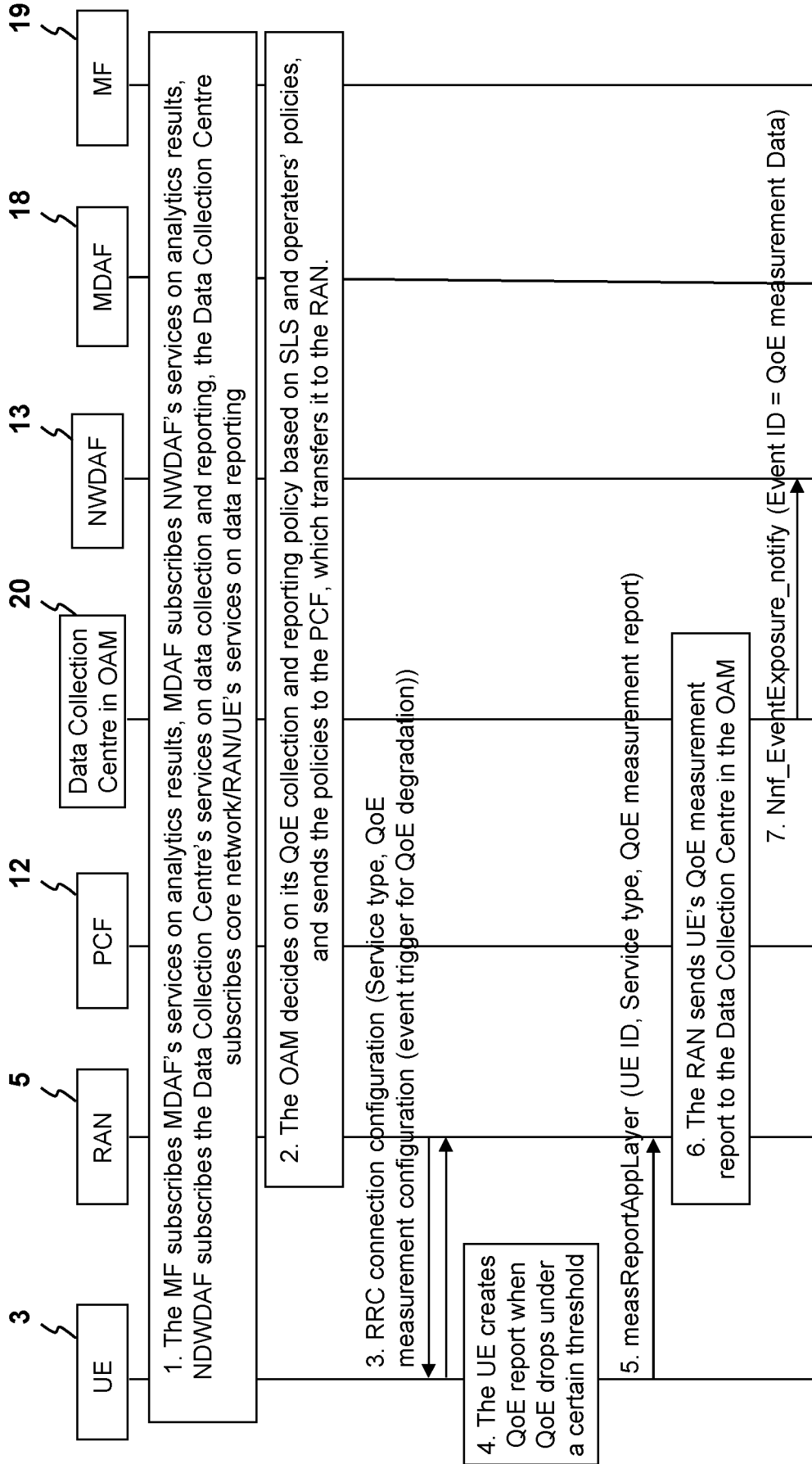
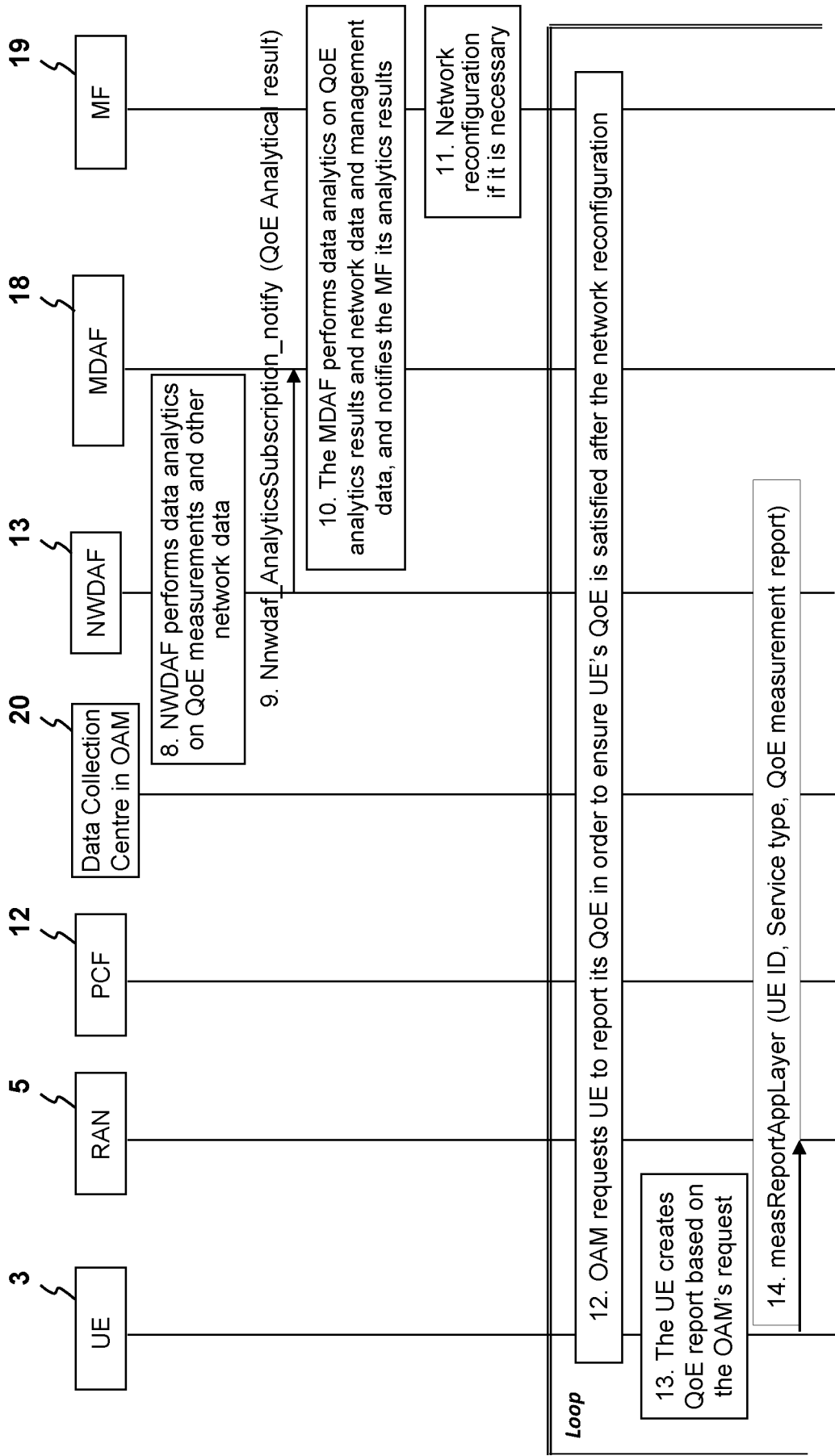


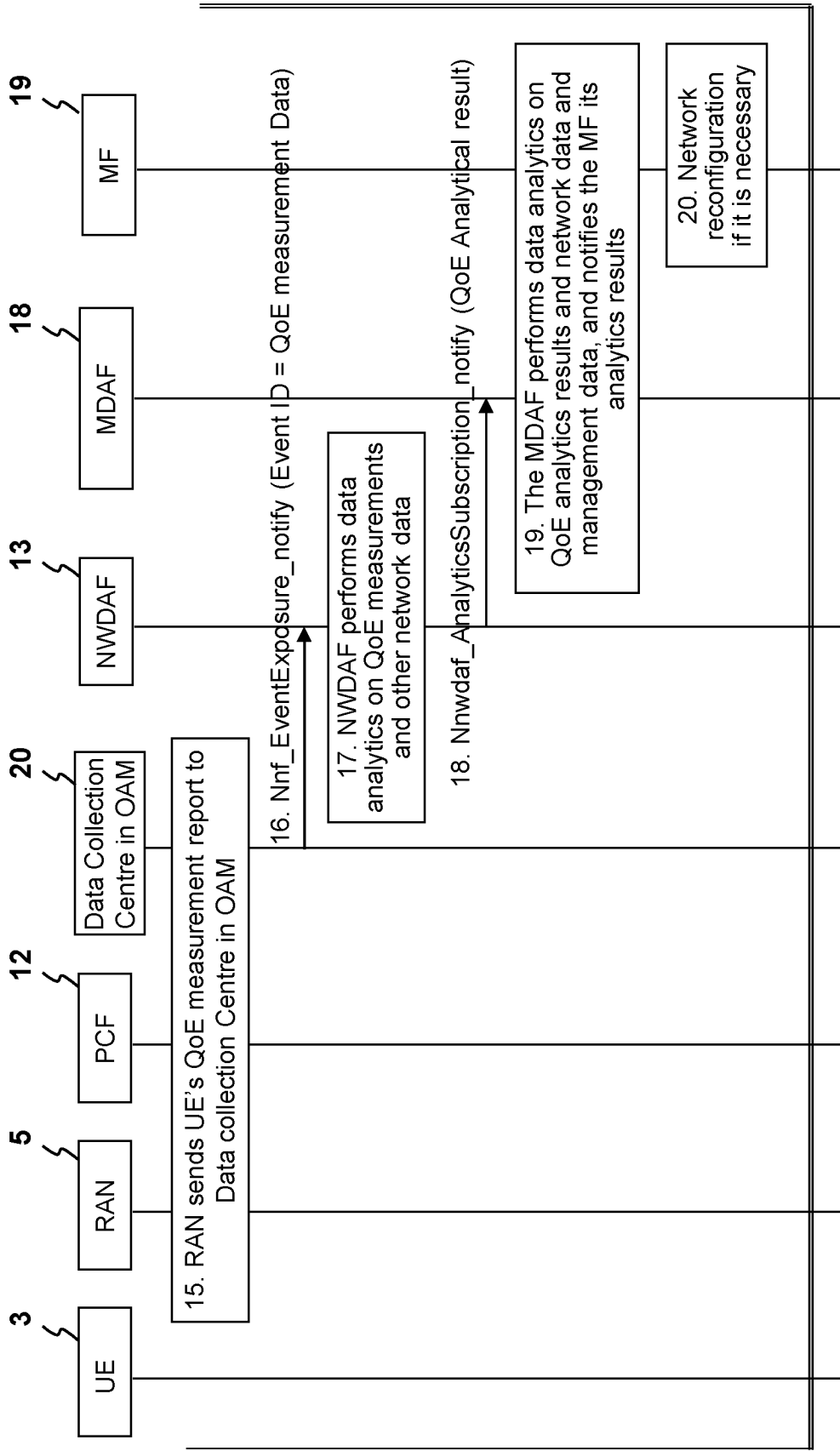
Figure 6a

**NWDAF performs data analytics based on QoE measurement report in the close loop SLS assurance solution (2/3)**



**Figure 6b**

**NWDAF performs data analytics based on QoE measurement report  
in the close loop SLS assurance solution (3/3)**



**Figure 6c**

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2020/077890

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04L12/24 H04W24/00 H04W28/24  
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)  
H04L 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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2019/010606 A1 (NOKIA TECHNOLOGIES OY [FI]; NOKIA TECH BEIJING CO LTD [CN]) 17 January 2019 (2019-01-17)	1-4,8-15
Y	abstract; figures 7-9 paragraph [0002] - paragraph [0017] paragraph [0048] - paragraph [0115] ----- -/--	5-7

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search  3 December 2020	Date of mailing of the international search report  11/12/2020
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Plata-Andres, Isabel
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2020/077890

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Study on management aspects of communication services (Release 16)", 3GPP STANDARD; TECHNICAL REPORT; 3GPP TR 28.805, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, no. V16.0.0 25 September 2019 (2019-09-25), pages 1-42, XP051784815, Retrieved from the Internet: URL:ftp://ftp.3gpp.org/Specs/archive/28_series/28.805/28805-g00.zip 28805-g00.doc [retrieved on 2019-09-25]</p>	1-4,8-15
Y	<p>Sections 4.6, 4.7, 5.1, 5.2 -----</p>	5-7
A	<p>"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study of Enablers for Network Automation for 5G (Release 16)", 3GPP DRAFT; 23791-120, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, 5 December 2018 (2018-12-05), XP051846052, Retrieved from the Internet: URL:https://ftp.3gpp.org/Email_Discussions/SA2/Archive/2018-11-12/23791-120.zip draft23791-120_clean.doc [retrieved on 2018-12-05] Sections 5-8 -----</p>	1-15
A	<p>WO 2019/065617 A1 (NEC CORP [JP]) 4 April 2019 (2019-04-04) abstract; figure 8 paragraph [0028] - paragraph [0102] -----</p>	1-15
A	<p>WO 2019/106055 A1 (ERICSSON TELEFON AB L M [SE]) 6 June 2019 (2019-06-06) the whole document -----</p>	1-15

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Information on patent family members

International application No PCT/EP2020/077890
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