

AMF ASSISTED DATA COLLECTION FOR LMF

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to an apparatus for performing a location management function (LMF), an apparatus for performing an access and mobility management function (AMF), methods, and a computer readable medium for AMF assisted data collection for LMF.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network communication devices, such as a base station may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] In Rel 19, it will be supported that a location management function (LMF) determines UE location using an artificial intelligence (AI) model operated at LMF side with inputs (e.g., measurements or assisting information) collected from UE or gNB. In some scenarios, LMF may train the LMF-side model by itself and it would require LMF to collect training data (e.g., ground truth UE location and associated measurement/assisting information) from UE or gNB.

SUMMARY

[0004] The present disclosure relates to an apparatus for performing a location management function (LMF), an apparatus for performing an access and mobility management function (AMF), methods, and a computer readable medium for AMF assisted data collection for LMF. According to embodiments of the disclosure, an LMF can determine proper UEs for data collection with assistance of an AMF.

[0005] In a first aspect, there is provided an apparatus of performing a location management function (LMF), the apparatus comprising: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the apparatus to: transmit, to an access and mobility management function (AMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; receive, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria; and transmit, to at least one of the UEs, a third message requesting the at least one UE to report data.

[0006] In a second aspect, there is provided an apparatus for performing an access and mobility management function (AMF), the apparatus comprising, comprising: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the apparatus to: receive, from a location management function (LMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; transmit, to the LMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria to report data to the LMF.

[0007] In a third aspect, there is provided a method of performing a location management function (LMF), the method comprising: transmitting, to an access and mobility management function (AMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; receiving, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria; and transmitting, to at least one of the UEs, a third message requesting the at least one UE to report data.

[0008] In a fourth aspect, there is provided a method of performing an access and mobility management function (AMF), the method comprising: receiving, from a location management function (LMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; transmitting, to the LMF, a

second message comprising information related to a list of UEs that fulfil the one or more criteria to report data to the LMF.

[0009] In a fifth aspect, there is provided a computer readable medium having instructions stored thereon, the instructions, when executed by a processor of an apparatus, causing the apparatus to perform the method according to any of the third and the fourth aspect of the disclosure.

[0010] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the one or more criteria comprise at least one of the following: UE is a positioning reference unit (PRU); UE is capable of UE based positioning methods; UE is capable of LTE positioning protocol (LPP); UE is of a mobility type; or UE is within an area of interest.

[0011] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the information related to a list of UEs comprise at least one of: a UE identity (ID); a serving cell ID of UE; information about whether UE is a PRU; whether UE is capable of UE based positioning method and a corresponding positioning method thereof; whether UE is capable of LPP; or a mobility type of UE.

[0012] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the UE ID is a dedicated ID assigned by the AMF or a subscription permanent identifier (SUPI).

[0013] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the serving cell ID of UE comprises a first serving cell ID of a primary cell in a master random access network (RAN) node, and a second serving cell ID of a primary cell in a secondary RAN node.

[0014] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the apparatus of performing the LMF transmits, to the AMF, a fourth message to request transfer of the third message to the at least one UE.

[0015] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the first message is a

subscription request message to subscribe to information related to UE that fulfills the one or more criteria; and the second message is a notify message comprising the information related to the list of UEs that fulfil the one or more criteria.

[0016] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the first message and the second message are based on a service of the AMF for event exposure.

[0017] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the list of UEs comprises one of: a list of all UEs that fulfil the criteria; a list of new UEs that fulfil the criteria; or a list of old UEs that no longer fulfil the criteria.

[0018] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the first message and the second message are based on a dedicated AMF service in one time request/response manner

[0019] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the third message comprises at least one of the following: configuration related to ground truth determination; reference signal configuration for measurements; indicator on whether UE should report its current serving cell; periodicity of reporting; or an area of interest.

[0020] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the apparatus for performing the AMF receives, from the LMF, a fourth message to request transfer of the third message to the at least one UE.

[0021] In some implementations of the methods, the apparatus for performing the LMF, and the apparatus for performing the AMF described herein, the apparatus for performing the AMF triggers network (NW) triggered service request to the list of UEs that are in a radio resource control (RRC) idle state.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented.

[0023] FIG. 2 illustrates an example of a process flow in which an LMF requests data from UE with assistance of an AMF in accordance with some example embodiments of the present disclosure.

[0024] FIG. 3 illustrates an example of a process flow in which an LMF requests data from UE with assistance of an AMF via subscription/notify method in accordance with some example embodiments of the present disclosure.

[0025] FIG. 4 illustrates an example of a process flow in which an LMF requests data from UE with assistance of an AMF via one time request/response method in accordance with some example embodiments of the present disclosure.

[0026] FIG. 5 illustrates an example of a device that is suitable for implementing some embodiments of the present disclosure.

[0027] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure.

[0028] FIG. 7 illustrates a flowchart of a method of performing an LMF in accordance with aspects of the present disclosure.

[0029] FIG. 8 illustrates a flowchart of a method of performing an AMF in accordance with aspects of the present disclosure.

[0030] Throughout the drawings, the same or similar reference numerals represent the same or similar elements.

DETAILED DESCRIPTION

[0031] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below. In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0032] References in the present disclosure to “one embodiment,” “an example embodiment,” “an embodiment,” “some embodiments,” and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0033] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as “best,” “lowest,” “highest,” “minimum,” “maximum,” or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0034] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “has,” “having,” “includes” and/or “including,” when used herein, specify the presence of stated features, elements, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term “includes” and its variants are to be read as open terms that mean “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of

an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0035] In Rel-19, it will be supported that LMF determines the UE location using an AI model operated at the LMF side with inputs (e.g., measurement or assisting information) collected from UE or gNB. In one scenario, LMF may train an LMF-side model by itself and it would require the LMF to collect training data (e.g., ground truth UE location and associated measurement/assisting information) from UE or gNB.

[0036] However, in legacy procedures for location service, an LMF does not autonomously initiate location service and related LTE positioning protocol (LPP) session procedure, instead it will follow the instruction/request based on AMF. For example, in a mobile terminating-location request (MT-LR) case, an AMF receives a location service request from a location service (LCS) client for concerned UE(s), then the AMF sends a Nlmf_Location_DetermineLocation message to the LMF asking for UE location determination wherein the UE is identified by an LCS correlation identifier; in a mobile originated-location request (MO-LR) case, AMF receives a MO-LR request from a UE, then the AMF sends a Nlmf_Location_DetermineLocation message to the LMF asking for UE location determination wherein the UE is identified by an LCS correlation identifier. In other words, the LMF does not know in advance which UEs are out there e.g., in the interested area, and does not know towards which UE the LMF should initiate LPP session and starts data collection. In addition, the LMF does not know the detailed information about the UE (e.g., subscription permanent identifier (SUPI), which cell UE is connected to, etc.), the LMF distinguishes different UEs only based on the LCS correlation identifier, which is used only for correlation as the name indicates. Therefore, methods are required for an AMF to assist an LMF to select proper UEs to establish LPP session(s) and start data collection for AI operation.

[0037] In view of this, embodiments of the present disclosure provide solutions for AMF assisted data collection for LMF. In an example aspect, an LMF may transmit a request to an AMF for information about UE that fulfils certain criteria. Upon receipt of the request, the AMF may find out UE that fulfils the criteria and transmit information about the UEs to the LMF. The LMF may select at least one of the UEs identified by AMF and request the selected UE to report data. Aspects of the present disclosure are described in the context of a wireless communications system.

[0038] In an example scenario, when the LMF wants to train/monitor an LMF-side artificial intelligence/machine learning (AI/ML) model that is capable of UE location estimation under certain applicability conditions, it would initiate LPP procedures towards target UEs and collect data for AI/ML model training/monitoring (e.g., ground truth UE location and relevant measurement result). In order to do that, the LMF may need the assistance from an AMF to know which UEs exist out there and fulfill the applicability conditions of the AI/ML model. Then the LMF could initiate LPP procedure towards those particular UEs for data collection. It is worth noting that embodiments of the disclosure are also applicable to scenarios different from AI/ML model data collection.

[0039] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0040] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired

connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface. In a 3GPP non-terrestrial network (NTN), a network entity 102 in form of a satellite can directly communicate to UE 104 using NR/LTE Uu interface. The satellite may be a transparent satellite or a regenerative satellite. For NTN with a transparent satellite, a base station on earth may communicate with a UE via the satellite. For NTN with a regenerative satellite, the base station may be on board and directly communicate with the UE.

[0041] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0042] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system

100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0043] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0044] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0045] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs). In some implementations, the network entity 102 may include an entity for performing a location management function (LMF).

[0046] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0047] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0048] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0049] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0050] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-c, F1-u), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0051] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a server 117 for performing a location management function (LMF), a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)), and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106. The LMF may be defined in the core network 106 and/or the network entity 102 to provide positioning functionality by means to determine the geographic position of a UE 104 based on downlink and uplink location measuring radio signals. The packet data network 108 may include an application server 118.

[0052] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0053] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0054] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A

fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0055] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0056] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0057] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz –

52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0058] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0059] FIG. 2 illustrates an example of a process flow 200 in which an LMF requests data from UE with assistance of an AMF in accordance with some example embodiments of the present disclosure. The process flow 200 may involve an LMF 201, an AMF 202, and UE 204. For brevity, a network entity (for example, a base station or gNB) is omitted in FIG. 2.

[0060] The process flow 200 may be applied to the wireless communications system 100 with reference to FIG. 1, for example, the UE 204 may be any of UEs 104. The LMF 201 may be or deployed at the server 117 in the core network 106, or at the any of the network entities 102. The LMF 201 may be deployed at the server 117 in the core network 106, or at the any of the network entities 102. The AMF 202 may be deployed at the server 117 in the core network 106. It would be appreciated that the process flow 200 may be applied to other communication scenarios, which will not be described in detail.

[0061] At 210, the LMF 201 transmits, to the AMF 202, a first message 215 requesting for information related to UE that fulfils one or more criteria. Accordingly, at 220, the AMF 202 receives the first message 215 from the LMF 201.

[0062] The first message may indicate the AMF 202 of the criteria that UE should satisfy, such that the AMF may identify UE(s) for data collection for the LMF 201. In some embodiments, the criteria may comprise one or more of the following criteria: UE is positioning reference unit (PRU), UE is capable of UE based positioning methods such as global navigation satellite system (GNSS), global positioning system (GPS), network-assisted GNSS, NR enhanced Cell-ID (NR E-CID), downlink-angle of departure (DL-AoD), downlink-time difference of arrival (DL-TDOA) and others, UE is capable of LTE positioning protocol (LPP), UE is of a mobility type (e.g. static, mobile, or highly mobile), or UE is within an area of interest (for example, represented by a list of cell IDs, or area ID).

[0063] At 230, the AMF 202 transmits a second message 235 comprising information related to a list of UEs to the LMF 201. Accordingly, at 240, the LMF 201 receives the second message from the AMF 202. In some embodiments, the AMF 202 may identify a list of UEs that fulfill the criteria indicated via the first message 215 and provide relevant UE information via the second message 235. In some embodiments, the UE information may include at least one of the following: a UE identity (ID); a serving cell ID of UE; information about whether UE is a PRU; whether UE is capable of UE based positioning method and a corresponding positioning method thereof; whether UE is capable of LPP; or a mobility type of UE. In some embodiments, the AMF 202 may trigger network (NW) triggered service request to those UEs that are identified and that are in RRC idle state.

[0064] After receiving the information of UEs that fulfil the criteria via the second message 235, at 250, the LMF 201 transmits a third message 255 to at least one of the UEs, requesting the at least one UE to report data. Accordingly, at 260, the UE 204 receives the third message 255 from the LMF 201. In some embodiments, before transmission of the third message, the LMF 201 may perform a LPP session procedure with the UE 204. In the LPP session procedure, the LMF 201 may transmit a fourth message to request transfer of the third message to the UE 204, where the LPP message may be conveyed in, for example, a `Namf_Communication_N1N2MessageTransfer` message.

[0065] The third message may be a LPP message. In some embodiments, the third message 255 may comprise information on reporting configurations, for example,

configuration related to ground truth determination, reference signal configuration for measurements; indicator on whether UE should report its current serving cell; periodicity of reporting; or an area of interest. Afterwards, the UE 204 may report data to the LMF 201 based on the information in the third message 255. In some embodiments, the reported data from the UE 204 to the LMF 201 may include ground truth UE location, which is either known by the UE 204 (if it is a PRU) or determined by other UE positioning methods (e.g., GPS, GNS, and others). Additionally or alternatively, the reported data may include measurement result of relevant reference signals such as SSB, PRS, CSI-RS, and others. In addition, the reported data may include serving cell information and time information (e.g., represented by a UTC timestamp, or by SFN/slot/symbol information).

[0066] FIG. 3 illustrates an example of a process flow in which an LMF requests data from UE with assistance of an AMF via subscription/notify method in accordance with some example embodiments of the present disclosure. The process flow 300 is an example implementation of the process flow 200 shown in FIG. 2.

[0067] In FIG. 3, the LMF 201 requests the AMF 202 to continuously provide or update UE list information that fulfils certain criteria, as such the LMF 201 may collect required AIML training/monitoring data from those UEs. In some embodiments, the LMF 201 may request the UE list information from the AMF 202 via a subscription request message, and may receive the UE list information or an update of the UE list information via a notify message. The subscription request and the notify message may be based on a service of the AMF for event exposure.

[0068] At steps 1 and 2, the LMF 201 transmits a subscription request message (e.g., Namf_EventExposure_Subscribe Request) to the AMF 202 to subscribe to any UE information that fulfill the criteria. The subscription request message may indicate the criteria to the AMF 202, including any of the following: UE is PRU UE, UE is capable of regular UE based positioning methods, such as GNSS, GPS, network-assisted GNSS, NR E-CID, DL-AoD, DL-TDOA, UE is LPP capable, mobility type (e.g., static, mobile, highly mobile), UE is within an area of interest, represented by a list of cell IDs, or area ID(s).

[0069] In this case, the AMF 202 should notify the LMF 201 about updates of the UE list that fulfills the requested criteria in the subsequent procedures using e.g.,

Namf_EventExposure_Notify service operation. The subscription as such may be defined as a new event ID for the Namf_EventExposure service of the AMF 202. Note that in the subscription request message, the LMF 201 does not include any information related to UE ID (e.g., SUPI), since the LMF 202 does not know this. The following Table 1 shows an example of the criteria indicated in the subscription request, with an Event ID of “UE of interest for data collection”.

Table 1

Event ID	Event Filter (List of Parameter Values to Match)
Location Report	<Parameter Type = LocationFilter, Value = TA1>
...	...
Number of UEs present in a geographical area	<Parameter Type = UE Type, Value = Aerial UE> <Parameter Type = PDU session status, Value = PDU session established for DNN subject to aerial services>
UE of interest for data collection	<Parameter Type = UE Type, Value = PRU> <Parameter Type = UE Mobility Type, Value = Static> <Parameter Type = AOI, Value = Cell ID> <Parameter Type = Protocol, Value = LPP> ...

[0070] At step 3, after receiving the subscription request message, the AMF 202 may identify UEs that fulfill the criteria, and provide the UE information to the LMF 201 using Namf_EventExposure_Notify service operation. The UE information may include UE ID(s), which can be a dedicated ID that is assigned by AMF itself (e.g. correlation ID used for correlation only) or SUPI. Additionally, the UE information may include, for each UE ID, a first serving cell identity of the primary cell in the master RAN node and a second serving cell identity of the primary cell in the secondary RAN node when available based on dual connectivity scenarios. Additionally, the UE information may include information about if UE is capable of UE based positioning methods and which, such as GNSS, GPS, network-assisted GNSS, NR E-CID, DL-AoD,

DL-TDOA. Additionally, the UE information may include information about if UE is LPP capable. Additionally, the UE information may include a mobility type of UE. Optionally, the AMF 202 may autonomously trigger NW triggered service request to all possible UEs that are identified and that are in RRC idle state.

[0071] At steps 4 and 5, after receiving the UE information that fulfills the criteria, the LMF 201 may further determine towards which of them the LMF 201 shall collect required AI/ML model training/monitoring data from. Towards those UEs, the LMF 201 may trigger a LPP session setup, e.g., by invoking the Namf_Communication_N1N2MessageTransfer service operation towards the AMF 202 to request the transfer of a LPP message to the UE 204. In some embodiments, the Namf_Communication_N1N2MessageTransfer message may use the UE ID that has been provided at step 3 to identify the associated UE 204. Optionally, the AMF 202 may trigger NW triggered service request to those selected UEs that are in RRC idle state.

[0072] At step 6, the LMF 201 transmits a LPP message towards the UE 204 which contains information related to the data collection, requesting the UE 204 to report data to the LMF 201. The LPP message may comprise configurations related to the ground truth determination, e.g., if it is determined by any of the UE based positioning methods and which, such as GNSS, GPS, network-assisted GNSS, NR E-CID, DL-AoD, DL-TDOA. Additionally or alternatively, the LPP message may comprise reference signal (RS) configurations (e.g., positioning reference signal (PRS), synchronization signal and PBCH block (SSB), channel state information-RS (CSI-RS)) that UE should measure. Additionally or alternatively, the LPP message may comprise information about if UE should report its current serving cell that UE is connected to. Additionally or alternatively, the LPP message may comprise periodicity of reporting. Additionally or alternatively, the LPP message may comprise information about area of interest (e.g., list of cells) that UE shall collect and report data when UE is in the concerned area.

[0073] At steps 7 and 8, UE 204 may indicate to the gNB 203 about an on-going data collection session, and the gNB 203 may configure the UE 204 with a dedicated radio bearer (e.g., with low priority than other regular radio bearers). Then any subsequent LPP message reporting required data from the UE 204 to the LMF 201 is transmitted by this dedicated radio bearer. At step 9, UE 204 may report the required data to the LMF 201 as configured at step 6. In some embodiments, the reported data

from the UE 204 to the LMF 201 may include ground truth UE location, which is either known by the UE 204 (if it is a PRU) or determined by other UE positioning methods (e.g., GPS, GNS, and others). Additionally or alternatively, the reported data may include measurement result of relevant reference signals such as SSB, PRS, CSI-RS, and others. In addition, the reported data may include serving cell information and time information (e.g., represented by a UTC timestamp, or by SFN/slot/symbol information).

[0074] At step 10, in case of any change of the UE list information that fulfills the criteria, e.g., any UE that does not meet the criteria anymore or any new UE that meets the criteria, the AMF 202 may transmit send an updated UE list and relevant information as described in step 3. In some embodiments, the updated UE list may be a list of all UEs that fulfil the criteria, a list of new UEs that fulfil the criteria, or a list of a list of old UEs that no longer fulfil the criteria. Based on the updated UE list information, the LMF 201 may determine to initiate LPP sessions for data collection from new UEs, and terminate the LPP session for data collection from old UEs. It should be understood that subscription request message (e.g., Namf_EventExposure_Subscribe Request) in step 1 can be regarded as the first message in Fig.2, and the notify message (e.g. Namf_EventExposure_Notify service operation) in step 3 can be regarded as the second message in Fig.2.

[0075] FIG. 4 illustrates an example of a process flow in which an LMF requests data from UE with assistance of an AMF via one time request/response method in accordance with some example embodiments of the present disclosure. The process flow 400 is an example implementation of the process flow shown in FIG. 2.

[0076] For UEs which are either PRUs or of a static mobility type, the LMF 201 may request the UE list information from the AMF 202 in one time request/response manner as the UE list information is not expected to change in short time period. In some embodiments, a new dedicated AMF service may be defined (e.g., namely, a Namf_UEInformation service), or an existing AMF service could be enhanced to serve the purpose. In FIG. 4, most details are similar as in FIG. 3 except that the steps 1 and 2 are based on a dedicated AMF service in one time request/response manner and there is no update step, i.e. step 10 of FIG.3.

[0077] According to some embodiments discussed with reference to FIGS. 2 to 4, procedures are proposed to enable an LMF to collect, with assistance of an AMF, data from proper UEs which fulfils certain criteria.

[0078] FIG. 5 illustrates an example of a device that is suitable for implementing some embodiments of the present disclosure. The device 500 may be an example of an LMF or an AMF as described herein. The device 500 may support wireless or wired communication with one or more network entities 102, UEs 104, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0079] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0080] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[0081] For example, the processor 502 may support wireless or wired communication at the device 500 in accordance with examples as disclosed herein. The

device 500 may be implemented for performing an LMF. The processor 502 may be configured to operable to support means for transmitting, to an AMF, a first message requesting for information related to UE that fulfils one or more criteria; means for receiving, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria, and means for transmitting, to at least one of the list of UEs, a third message requesting the at least one UE to report data.

[0082] The device 500 may be implemented for performing an AMF. The processor 502 may be configured to operable to support means for receiving, from a location management function (LMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; and means for transmitting, to the LMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria to report data to the LMF.

[0083] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

[0084] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0085] The I/O controller 508 may manage input and output signals for the device 500. The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 508 may be implemented as part of a processor, such as the processor 502. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[0086] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[0087] A transmit chain may be configured to generate and transmit signals (e.g., control information, data, packets). The transmit chain may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting the amplified signal into the air or wireless medium.

[0088] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receive chain may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receive chain may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0089] FIG. 6 illustrates an example of a processor 600 is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0090] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0091] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the

processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0092] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[0093] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[0094] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions (e.g., functions or tasks supporting transmit power

prioritization). For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0095] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[0096] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be implemented for performing an LMF. The processor 600 may be configured to or operable to support means for transmitting, to an AMF, a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; means for receiving, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria; and means for transmitting, to at least one of the list of UEs, a third message requesting the at least one UE to report data.

[0097] The processor 600 may be implemented for performing an AMF. The processor 600 may be configured to or operable to support means receiving, from a location management function (LMF), a first message requesting for information related

to user equipment (UE) that fulfils one or more criteria; and means for transmitting, to the LMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria to report data to the LMF.

[0098] FIG. 7 illustrates a flowchart of a method 700 of performing an LMF in accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by a server in a core network or a network entity as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0099] At 710, the method may include transmitting, to an access and mobility management function (AMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by a server 117 implemented in the core network 106 or a network entity 102 as described with reference to FIG. 1.

[0100] At 720, the method may include receiving, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by a server 117 implemented in the core network 106 or a network entity 102 as described with reference to FIG. 1.

[0101] At 730, the method may include transmitting, to at least one of the list of UEs, a third message requesting the at least one UE to report data. The operations of 730 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 730 may be performed by a server 117 implemented in the core network 106 or a network entity 102 as described with reference to FIG. 1.

[0102] FIG. 8 illustrates a flowchart of a method 1000 of performing an AMF in accordance with aspects of the present disclosure. The operations of the method 800

may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by a server in a core network as described herein. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0103] At 810, the method may include receiving, from a location management function (LMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by a server 117 implemented in the core network 106 as described with reference to FIG. 1.

[0104] At 820, the method may include transmitting, to the LMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria to report data to the LMF. The operations of 820 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by a server 117 implemented in the core network 106 as described with reference to FIG. 1.

[0105] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0106] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0107] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0108] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[0109] As used herein, including in the claims, an article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in

part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[0110] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

1. An apparatus for performing a location management function (LMF), the apparatus comprising, comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the apparatus to:

transmit, to an access and mobility management function (AMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria;

receive, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria; and

transmit, to at least one of the list of UEs, a third message requesting the at least one UE to report data.

2. The apparatus of claim 1, wherein the one or more criteria comprise at least one of the following :

UE is a positioning reference unit (PRU);

UE is capable of UE based positioning methods;

UE is capable of LTE positioning protocol (LPP);

UE is of a mobility type; or

UE is within an area of interest.

3. The apparatus of claim 1, wherein the information related to a list of UEs comprise at least one of:

a UE identity (ID);

a serving cell ID of UE;

information about whether UE is a PRU;

whether UE is capable of UE based positioning method and a corresponding positioning method thereof;

whether UE is capable of LPP; or

a mobility type of UE.

4. The apparatus of claim 3, wherein the UE ID is a dedicated ID assigned by the AMF or a subscription permanent identifier (SUPI).

5. The apparatus of claim 3, wherein the serving cell ID of UE comprises a first serving cell ID of a primary cell in a master random access network (RAN) node, and a second serving cell ID of a primary cell in a secondary RAN node.

6. The apparatus of claim 1, wherein the apparatus is further cause to:
transmit, to the AMF, a fourth message to request transfer of the third message to the at least one UE.

7. The apparatus of claim 1, wherein
the first message is a subscription request message to subscribe to information related to UE that fulfills the one or more criteria; and
the second message is a notify message comprising the information related to the list of UEs that fulfil the one or more criteria.

8. The apparatus of claim 7, wherein the first message and the second message are based on a service of the AMF for event exposure.

9. The apparatus of claim 1, wherein the list of UEs comprises one of:
a list of all UEs that fulfil the criteria;
a list of new UEs that fulfil the criteria; or
a list of old UEs that no longer fulfil the criteria.

10. The apparatus of claim 1, wherein the first message and the second message are based on a dedicated AMF service in one time request/response manner.

11. The apparatus of claim 1, the third message comprises at least one of the following:

configuration related to ground truth determination;
reference signal configuration for measurements;
indicator on whether UE should report its current serving cell;

periodicity of reporting; or
an area of interest.

12. An apparatus for performing an access and mobility management function (AMF), the apparatus comprising, comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the apparatus to:

receive, from a location management function (LMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; and

transmit, to the LMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria to report data to the LMF.

13. The apparatus of claim 12, wherein the one or more criteria comprise at least one of the following:

UE is a positioning reference unit (PRU);

UE is capable of UE based positioning methods;

UE is capable of LTE positioning protocol (LPP);

UE is of a mobility type; or

UE is within an area of interest.

14. The apparatus of claim 12, wherein the information related to a list of UEs comprise at least one of:

a UE identity (ID);

a serving cell ID of UE;

information about whether UE is a PRU;

whether UE is capable of UE based positioning method and a corresponding method thereof;

whether UE is capable of LPP; or

a mobility type of UE.

15. The apparatus of claim 14, wherein the UE ID is a dedicated ID assigned

by the AMF or a subscription permanent identifier (SUPI).

16. The apparatus of claim 14, wherein the serving cell ID of UE comprises a first serving cell ID of a primary cell in a master random access network (RAN) node and a second serving cell ID of a primary cell in a secondary RAN node.

17. The apparatus of claim 12, wherein
the first message is a subscription request message to subscribe to information related to UE that fulfills the one or more criteria, and
the second message is a notify message comprising the information related to the list of UEs that fulfil the one or more criteria.

18. The apparatus of claim 12, wherein the list of UEs comprises one of:
a list of all UEs that fulfil the criteria;
a list of new UEs that fulfil the criteria; or
a list of old UEs that no longer fulfil the criteria.

19. A method of performing a location management function (LMF), the method comprising:

transmitting, to an access and mobility management function (AMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria;

receiving, from the AMF, a second message comprising information related to a list of UEs that fulfil the one or more criteria; and

transmitting, to at least one of the list of UEs, a third message requesting the at least one UE to report data.

20. A method of performing an access and mobility management function (AMF), the method comprising:

receiving, from a location management function (LMF), a first message requesting for information related to user equipment (UE) that fulfils one or more criteria; and

transmitting, to the LMF, a second message comprising information related to a

list of UEs that fulfil the one or more criteria to report data to the LMF.