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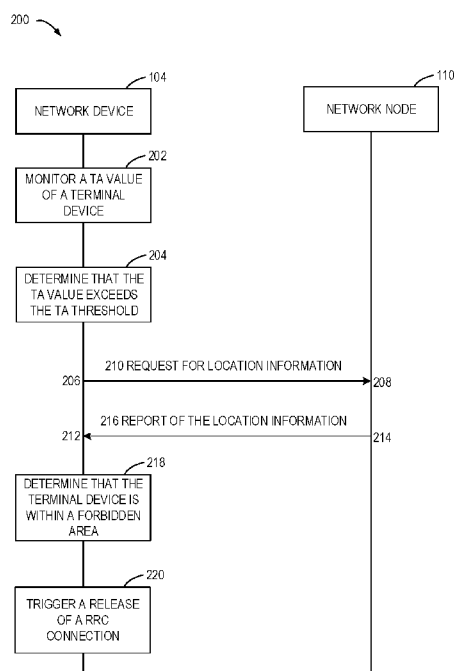


Fig. 2

(57) Abstract: Embodiments of the present disclosure relate to a network device, a method and a medium for triggering a release of a radio resource control connection. A network device monitors a timing advance (TA) value of a terminal device to determine whether the TA value exceeds a TA threshold. Based on determining that the TA value exceeds the TA threshold, the network device requests a network node to report location information of the terminal device. Based on determining that the terminal device is within a forbidden area based on the reported location information, the network device triggers a release of a radio resource control connection of the terminal device with the network device. With the embodiments in the present disclosure, the retainability key performance indicator impact can be reduced, and the influence on other users who may be in the area defined by a TA value can also be reduced.

TRIGGERING RELEASE OF RADIO RESOURCE CONTROL CONNECTION

FIELD

- 5 [0001] Various example embodiments generally relate to the field of communication, and in particular, to a network device, a method, an apparatus and a computer readable storage medium for triggering a release of a radio resource control connection.

BACKGROUND

- 10 [0002] In the fifth generation (5G) New Radio (NR) systems, timing advance (TA) enables a terminal device to adjust its uplink transmission timing to fit a common reception timing reference used at a network device. This kind of uplink transmission timing adjustment may apply to physical uplink shared channel (PUSCH) transmission, physical uplink control channel (PUCCH) transmission, sounding reference signal (SRS) transmission, etc. The
15 terminal device anticipates its uplink transmission with respect to its downlink reception timing by a TA value equal to the round trip delay between the terminal device and the network device. The TA value to be used by a terminal device is determined by the network device, and is thus indicative of the distance between the terminal device and the network device.

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SUMMARY

- [0003] In general, example embodiments of the present disclosure provide a solution for triggering a release of a radio resource control connection when users are located inside a forbidden area, for instance beyond a national border.
- 25 [0004] In a first aspect, there is provided a network device. The network device may comprise at least one processor; and at least one memory storing instructions that, when executed by the at least one processor, cause the network device at least to: monitor a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; based on determining that the TA value exceeds the TA threshold, request a network node to report
30 location information of the terminal device; and based on determining that the terminal device is within a forbidden area based on the reported location information, trigger a release of a RRC connection of the terminal device with the network device.

[0005] In a second aspect, there is provided a method. The method may comprise: monitoring, at a network device, a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; based on determining that the TA value exceeds the TA threshold, requesting a network node to report location information of the terminal device; and based on determining that the terminal device is within a forbidden area based on the reported location information, triggering a release of a RRC connection of the terminal device with the network device.

[0006] In a third aspect, there is provided an apparatus. The apparatus may comprise: means for monitoring, at a network device, a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; means for requesting a network node to report location information of the terminal device based on determining that the TA value exceeds the TA threshold; and means for triggering a release of a RRC connection of the terminal device with the network device based on determining that the terminal device is within a forbidden area based on the reported location information.

[0007] In a fourth aspect, a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform a method comprising: monitoring, at a network device, a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; based on determining that the TA value exceeds the TA threshold, requesting a network node to report location information of the terminal device; and based on determining that the terminal device is within a forbidden area based on the reported location information, triggering a release of a RRC connection of the terminal device with the network device.

[0008] In a fifth aspect, there is provided a computer program comprising instructions, which, when executed by an apparatus, cause the apparatus at least to: monitor, at a network device, a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; based on determining that the TA value exceeds the TA threshold, request a network node to report location information of the terminal device; and based on determining that the terminal device is within a forbidden area based on the reported location information, trigger a release of a RRC connection of the terminal device with the network device.

[0009] In a sixth aspect, there is provided a network device. The network device may comprise a monitoring circuitry configured to monitor a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; and a requesting circuitry configured

to request a network node to report location information of the terminal device based on determining that the TA value exceeds the TA threshold; and a triggering circuitry configured to trigger a release of a RRC connection of the terminal device with the network device based on determining that the terminal device is within a forbidden area based on the reported location information.

[0010] It is to be understood that the summary section is not intended to identify key or essential features of embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Some example embodiments will now be described with reference to the accompanying drawings, in which:

[0012] FIG. 1A illustrates an example network environment in which example embodiments of the present disclosure may be implemented;

[0013] FIG. 1B illustrates an example TA boundary in accordance with some example embodiments of the present disclosure;

[0014] FIG. 2 illustrates an example signaling process for triggering a release of a radio resource control connection in accordance with some example embodiments of the present disclosure;

[0015] FIG. 3 illustrates an example high level information flow of a distributed unit (DU) based solution in accordance with some example embodiments of the present disclosure;

[0016] FIG. 4 illustrates an example high level information flow of a centralized unit (CU) based solution in accordance with some example embodiments of the present disclosure;

[0017] FIG. 5 illustrates an example flowchart of a location aware geo-fence enforcement in accordance with some example embodiments of the present disclosure;

[0018] FIG. 6 illustrates an example illustration of a successful location aware geo-fence enforcement in accordance with some example embodiments of the present disclosure;

[0019] FIG. 7 illustrates an example illustration of a location aware geo-fence abort in accordance with some example embodiments of the present disclosure;

[0020] FIG. 8 illustrates an example signaling process for a location aware DU for geo-fence enforcement in accordance with some example embodiments of the present disclosure;

[0021] FIG. 9 illustrates an example signaling process for a location aware CU for geo-fence enforcement in accordance with some example embodiments of the present disclosure;

5 [0022] FIG. 10 illustrates an example flowchart of a method implemented at a network device in accordance with some example embodiments of the present disclosure;

[0023] FIG. 11 illustrates an example simplified block diagram of a device that is suitable for implementing embodiments of the present disclosure; and

10 [0024] FIG. 12 illustrates an example block diagram of an example computer readable medium in accordance with some embodiments of the present disclosure.

[0025] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

15 [0026] Principles of the present disclosure will now be described with reference to some example 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 may be implemented in various manners other than the ones
20 described below.

[0027] 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 the present disclosure belongs.

25 [0028] References in the present disclosure to “one embodiment,” “an embodiment,” “an example embodiment,” and the like indicate that the embodiment 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 are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is
30 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.

[0029] It may be understood that although the terms “first” and “second” etc. 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. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms.

[0030] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example 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, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. As used herein, “at least one of the following: <a list of two or more elements>” and “at least one of <a list of two or more elements>” and similar wording, where the list of two or more elements are joined by “and” or “or”, mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements.

[0031] As used in this application, the term “circuitry” may refer to one or more or all of the following:

(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and

(b) combinations of hardware circuits and software, such as (as applicable):

(i) a combination of analog and/or digital hardware circuit(s) with software/firmware and

(ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

(c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s) that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.

[0032] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

[0033] As used herein, the term “communication network” refers to a network following any suitable communication standards, such as long term evolution (LTE), LTE-advanced (LTE-A), wideband code division multiple access (WCDMA), high-speed packet access (HSPA), narrow band Internet of things (NB-IoT) and so on. Furthermore, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, and/or beyond. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will of course also be future type communication technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0034] As used herein, the term “network device” refers to a node in a communication network via which a terminal device accesses the network and receives services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a remote radio unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node such as a femto, a pico, and so forth, depending on the applied terminology and technology.

[0035] The term “terminal device” refers to any end device that may be capable of wireless communication. By way of example rather than limitation, a terminal device may also be referred to as a communication device, user equipment (UE), a subscriber station (SS), a portable subscriber station, a mobile station (MS), or an access terminal (AT). The terminal device may include, but not limited to, a mobile phone, a cellular phone, a smart phone, voice over IP (VoIP) phones, wireless local loop phones, a tablet, a wearable terminal device, a

personal digital assistant (PDA), portable computers, desktop computer, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, vehicle-mounted wireless terminal devices, wireless endpoints, mobile stations, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), USB
5 dongles, smart devices, wireless customer-premises equipment (CPE), an Internet of things (IoT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial,
10 a relay node, an integrated access and backhaul (IAB) node, and/or industrial wireless networks, and the like. In the following description, the terms “terminal device”, “communication device”, “terminal”, “user equipment” and “UE” may be used interchangeably.

[0036] As used herein, the term “resource”, “transmission resource”, “resource block”,
15 “physical resource block” (PRB), “uplink (UL) resource” or “downlink (DL) resource” may refer to any resource for performing a communication, for example, a communication between a terminal device and a network device, such as a resource in time domain, a resource in frequency domain, a resource in space domain, a resource in code domain, a resource in a combination of more than one domain or any other resource enabling a
20 communication, and the like. In the following, a resource in time domain (such as, a subframe) will be used as an example of a transmission resource for describing some example embodiments of the present disclosure. It is noted that example embodiments of the present disclosure are equally applicable to other resources in other domains.

[0037] As discussed above, the TA value is taken as a measure of the distance of the terminal
25 device from the network device. TA value is used as a means to release the terminal device when applicable (such as national borders). However, this is not robust since this approach causes impact to other users and hence impacts the overall retainability key performance indicator (KPI).

[0038] For example, there are several aspects that may be considered as several issues may
30 need to be solved. One aspect is that there is a recurring requirement. For cells that are in a nations border, to block any UE which is outside the national border even though it's within the cell coverage. Another aspect is that with the traditional solution, it's not possible to target only the user that is inside the geographical region defined by the national border. Yet another

aspect is that the traditional solution affects other users who may be inside the national border.

[0039] Therefore, example embodiments of the present disclosure provide a mechanism to reduce the retainability KPI impact. According to the example embodiments for triggering a release of a radio resource control connection of a terminal device with a network device as provided in the present disclosure, the TA value can be used as a means to release the terminal device when applicable, for example, when the terminal device is outside the national border. The retainability KPI impact can be reduced, and the influence on other users who may be in the area defined by a TA value (based on some configured threshold) can also be reduced.

[0040] For illustrative purposes, principle and example embodiments of the present disclosure for determining resource blocks for transmissions will be described below with reference to FIG. 1A- FIG. 12. However, it is to be noted that these embodiments are given to enable the skilled in the art to understand inventive concepts of the present disclosure and implement the solution as proposed herein, and not intended to limit scope of the present application in any way.

[0041] Reference is made to FIG. 1A, which illustrates an example of a communication network 100 in which some example embodiments of the present disclosure may be implemented. As illustrated in FIG. 1A, the communication network 100 includes a terminal device (which may also be referred to as user equipment or UE) 102 and a network devices (which may also be referred to as a gNB or base station), such as the network device 104. Although the terminal device 102 and the network device 104 are shown in FIG. 1A, the numbers of the network devices and the terminal devices are not limited. In other words, there may be one or more network devices 104 and one or more terminal devices 102 in the communication network 100.

[0042] The network device 104 can provide services to the terminal device 102, and the network device 104 and the terminal device 102 may communicate data and control information with each other. In some example embodiments, the network device 104 and the terminal device 102 may communicate with direct links/channels.

[0043] In the communication system 100, the network device 104 provides a serving cell 106 (which may also be referred to as a service area), and the terminal device 102 camps on the serving cell 106. In some embodiments, the network device 104 can provide multiple serving cells and the terminal device 102 may switch from a source cell to a target cell

between the serving cells during its mobility. It is to be understood that the number of serving cell(s) shown in FIG. 1A is for illustrative purposes without suggesting any limitation.

[0044] Communications in the network environment 100 may be implemented according to any proper communication protocol(s), comprising, but not limited to, cellular communication protocols of the fourth generation (4G) and the fifth generation (5G) and on the like, wireless local network communication protocols such as institute for electrical and electronics engineers (IEEE) 802.11 and the like, and/or any other protocols currently known or to be developed in the future. Moreover, the communication may utilize any proper wireless communication technology, comprising but not limited to: code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), frequency division duplex (FDD), time division duplex (TDD), multiple-input multiple-output (MIMO), orthogonal frequency division multiple (OFDM), discrete Fourier transform spread OFDM (DFT-s-OFDM), and/or any other technologies currently known or to be developed in the future.

[0045] In the serving cell 106, there may be a forbidden area 108 (which may be also referred to as a geo-fence or geo-slice). Services provided by the network device 104 may be barred within the forbidden area 108. The forbidden area 108 may be geographical region defined by certain rules, such as a national border, a geo-fence or geographical coordinates. The communication system 100 may comprise a network node 110. The network node 110 may act as a location management function (LMF) or may provide LMF service.

[0046] It is to be understood that the number of devices and their connection relationships and types shown in FIG. 1A are for illustrative purposes without suggesting any limitation. The communication system 100 may comprise any suitable number of devices adapted for implementing embodiments of the present disclosure.

[0047] Reference is made to FIG. 1B, which illustrates an example TA boundary in accordance with some example embodiments of the present disclosure. The TA boundary 112 may be determined based on a TA threshold. It is to be understood that if the distance of the terminal device 102 from the network device 104 is beyond the TA threshold, the terminal device 102 is outside the TA boundary 112. If the distance of the terminal device 102 from the network device 104 is below the TA threshold, the terminal device 102 is inside the TA boundary 112.

[0048] In the case that the terminal device 102 is outside the TA boundary 112 meanwhile within the serving cell 106, the terminal device 102 may be inside the forbidden area 108. Thus, in this case, the service should be barred and a release of a RRC connection of the terminal device 102 with the network device 104 should be triggered.

5 **[0049]** Reference is made to FIG. 2, which illustrates an example signaling process 200 for triggering a release of a radio resource control connection in accordance with some example embodiments of the present disclosure. As shown in FIG. 2, the network device 104 monitors (202) a TA value of the terminal device 102. The network device 104 determines (204) whether the TA value exceeds a TA threshold. If the network device 104 determines that the
10 TA value exceeds a TA threshold, it means that the terminal device 102 is outside the TA boundary. Thus, the location information will be required to determine whether the terminal device is inside or outside the forbidden area.

[0050] In case that the TA value exceeds the TA threshold, the terminal device 102 transmits (206) request 210 to report location information of the terminal device 102 to the network
15 node 110. The network node 110 receives (208) the request 210 from the network device 104. The network node 110 transmits (214) a report 216 of the location information to the network device 104. The network device 104 receives (212) the report 216 from the network node 110.

[0051] Based on the reported location information 210, the network device 104 determines
20 (218) whether the terminal device 102 is within the forbidden area. In case that the terminal device 102 is within the forbidden area, the network device 104 triggers (220) a release of a RRC connection of the terminal device 102 with the network device 104.

[0052] By implementing embodiments of FIG. 2, the retainability key performance indicator (KPI) impact can be reduced, and the influence on other users who may be in the
25 area defined by a TA value (based on some configured threshold) can also be reduced.

[0053] In some example embodiments, the network device 104 may comprise a DU and a CU. The determination that the TA value exceeds the TA threshold and the determination that the terminal device is within the forbidden area may be performed by the DU, and the triggering of the release of the RRC connection may be performed by the CU upon trigger
30 from the DU. This approach is referred to as a DU based solution and will be described with FIG. 3.

[0054] Reference is made to FIG. 3, which illustrates an example high level information flow 300 of a DU based solution in accordance with some example embodiments of the present disclosure. Generally, this approach makes the gNB-DU UE location aware. In this approach, the gNB-DU may be configured with one or more geo-slices with co-ordinates of the edges along with the TA threshold value. If the UE location is within that geo-slice, the UE will be released.

[0055] As an example, a gNB-DU-operation administration and management (OAM) 302 may configure a gNB-DU 306 with a TA configuration and a geo-fence configuration. The gNB-DU 302 may request the reporting of UE location when the appropriate conditions are met (e.g., TA Threshold exceeded). A gNB-CU 308 may send the UE location information (based on any methods related to global navigation satellite system (GNSS) or NR positioning protocol A (NRPPa)).

[0056] As an example, the gNB-DU 306 may transmit the UE location request via F1 application protocol (F1AP) message 310 to the gNB-CU 308. The gNB-CU 308 may transmit the UE location response via F1AP message 312 to the gNB-DU 306. The gNB-DU 306 may transmit the UE context release request via F1AP message 314 to the gNB-CU 308.

[0057] In some example embodiments, the gNB-CU 308 may transmit, to an access and mobility management function (AMF) device, a next generation application protocol (NGAP) message for requesting the location information of the terminal device 102. The AMF device may in turn sent a message to the LMF for requesting the location information of the terminal device 102.

[0058] In some example embodiments, the gNB-CU 308 may receive, from the AMF, a NGAP message including the location information of the terminal device 102. For example, the location information may be obtained by the AMF device from the LMF, and then included into the NGAP message sent to the gNB-CU 308.

[0059] This DU based solution can enable gNB-DU 306 to perform an additional geo-fence checking, for example, whether the reported UE location is in within the geo-fence. If it's the case (e.g., UE has crossed national border), gNB-DU 306 may trigger the UE release.

[0060] Referring back to FIG.2, in some example embodiments, the determination that the TA value exceeds the TA threshold may be performed by the DU, and the determination that the terminal device is within the forbidden area and the triggering of the release of the RRC

connection may be performed by the CU. This approach is referred to as a CU based solution and will be described with FIG. 4.

[0061] Reference is made to FIG. 4, which illustrates an example high level information flow 400 of a CU based solution in accordance with some example embodiments of the present disclosure. Generally speaking, this approach introduces a new cause value indicating the “TA exceeded or resolved” condition from a gNB-DU 406 to a gNB-CU 408. This new cause value can be indicated in the F1AP message. Thus, UE context modification may be required. The gNB-CU 408 may trigger the UE location tracking and when condition is met, triggers a UE release.

[0062] As an example, the gNB-DU-OAM 402 may configure gNB-DU 406 with a TA configuration. The gNB-CU-OAM 404 may configure the gNB-CU 408 with a geo-fence configuration. The gNB-DU 406 may monitor the TA value. If the TA value exceeds the TA threshold, the gNB-DU 406 may transmit the new cause value via F1AP message 410 to the gNB-CU 408. The gNB-CU 408 may monitor the location of the UE. Based on that the condition is met, the gNB-CU 408 may decide to release the UE. The gNB-CU 408 may transmit UE context release command via F1AP message 412 to the gNB-DU 406.

[0063] In some example embodiments, the gNB-CU 408 may transmit, to an AMF device, a NGAP message for requesting the location information of the terminal device 102. The gNB-CU 408 may receive, from the AMF device, a NGAP message including the location information of the terminal device 102. In some example embodiments, the network device 104 may be caused to trigger the release of the RRC connection by transmitting a RRC release message to the terminal device 102.

[0064] Referring back to FIG.2, in some example embodiments, if the network device 104 determines that the TA value falls below the TA threshold, the network device 104 may disable the reporting of the location information of the terminal device 102.

[0065] In some example embodiments, if the network device 104 determines that the terminal device 102 is outside the forbidden area 108 based on the reported location information, the network device 104 determines whether a distance between the terminal device 102 and the forbidden area 108 is below a distance threshold. In some example embodiments, if the network device 104 determines the distance is below the distance threshold, the network device 104 may trigger periodic reporting of the location information of the terminal device.

[0066] In some example embodiments, if the network device 104 determines that a speed of the terminal device 102 is below a first speed threshold, the network device 104 may increase a periodicity of the reporting. In some example embodiments, if the network device 104 determines that the speed of the terminal device is above a second speed threshold, the network device 104 may reduce the periodicity of the reporting.

[0067] In some example embodiments, the reporting of the location information may either be a periodic or a one-shot reporting for the location information exchange. Periodic reports may be useful since they enable the RAN node to continuously monitor if the terminal device 102 is within the geo-fence or not and trigger the appropriate action immediately once it enters the geo-fence.

[0068] In some example embodiments, the one-shot report may be used to first check whether the terminal device 102 is near the geo-fence region or not before triggering a periodic report. Also, the RAN node may dynamically adjust the periodicity of the periodic reporting for different terminal devices depending on some criteria (such as their respective speed). For example, the RAN node can increase the periodicity for low speed terminal devices, while it can reduce the periodicity for high speed terminal devices.

[0069] This CU based solution can distribute functional responsibilities between gNB-CU and gNB-DU. The gNB-DU may handle the TA evaluation and gNB-CU may get the location information from the user and evaluate it against the geo-fence.

[0070] Reference is made to FIG. 5, which illustrates an example flowchart of a process 500 of a location aware geo-fence enforcement in accordance with some example embodiments of the present disclosure. FIG. 5 describes the high level logical flow of the DU based solution. At 502, configuration for a TA threshold and edges of the geo-fence may be configured to the gNB-CU. At 504, accumulated TA may be set to an initial TA. The initial TA may be equal to initial TA value from a random access channel (RACH) access. At 506, accumulated TA may be updated by adding the TA evaluated during connected mode transmission.

[0071] At 508, if the accumulated TA is greater than the TA threshold, the process 500 may continue to 510. If the accumulated TA is lower than the TA threshold, the process 500 may go back to 506. At 510, the process 500 may configure measurement to get location of the UE. The process 500 may use the location in the measurement reports sent by the UE.

[0072] At 512, the process 500 may check if the UE location is inside the configured geo slice (which may be used interchangeably with geo fence). If the UE location is inside the configured geo slice, the process 500 may continue to 514. If the UE location is outside the configured geo slice, the process 500 may continue back to 506. At 514, the process 500 may initiate a release of a RRC connection of the UE with the gNB. At 516, the process 500 may check if the location reporting measurement is configured for the UE. If yes, the process 500 may continue to 518. If not, the process 500 may go back to 506. At 518, the process 500 may remove the location reporting measurement configuration.

[0073] Reference is made to FIG. 6, which illustrates an example illustration 600 of a successful location aware geo-fence enforcement in accordance with some example embodiments of the present disclosure. At 600A, the UE is in position A which is inside the TA boundary 602 of the cell 604. At 600B, the UE moves to position-B which is outside the TA boundary 602. At this point, it may enable location reporting measurement through measurement configuration. UE will start reporting measurements.

[0074] At 600C, the UE moves to position-C. Since position-C is outside the configured geo slice 606, the UE is not released. At 600D, the UE moves to position-D which is inside the configured geo slice 606 (e.g., outside the national border). It may initiate a RRC release of the UE.

[0075] Reference is made to FIG. 7, which illustrates an example illustration 700 of a location aware geo-fence abort in accordance with some example embodiments of the present disclosure. At 700A, the UE is in position A which is inside the TA boundary 702 of the cell 704. At 700B, the UE moves to position-B which is outside the TA boundary 702. At this point, it may enable location reporting measurement through measurement configuration. UE will start reporting measurements. At 700C, UE moves to position-C which is inside the TA boundary 702. It may disable the location reporting measurement configuration.

[0076] Reference is made to FIG. 8, which illustrates an example signaling process 800 for a location aware DU for geo-fence enforcement in accordance with some example embodiments of the present disclosure. With reference to FIG. 1A, a UE 802 may be an example of the terminal device 102. A DU 804, a CU 806 and an OAM 808 may be comprised in the network device 104. An LMF 812 may be hosted by the network node 110.

[0077] At high level, there are six steps in FIG. 8. Each step may have one or more signaling. At step-1, the OAM 808 may configure the DU 804 with the TA threshold and the “geo-fence”

configuration. For example, the OAM 808 may transmit (814B) configuration 816 to the DU 804. The configuration 816 may comprise the TA threshold and edges of the geo-fence. The DU 804 may receive (814A) the configuration 816 from the OAM 808.

[0078] At step-2, for every UE, the DU may evaluate the TA value against the TA threshold.

5 Once the TA value crosses the threshold, step-2a or step-2b may be performed. At step-2a, DU 804 may request CU 806 to enable location information. This may be done via a new F1AP message F1AP: UE Location Request. At step-2b: the gNB may request the AMF 810 to trigger location service request towards the LMF 812 via a new NGAP: Location Service Request message.

10 **[0079]** For example, the DU 804 may evaluate the TA value of the UE 802 against the TA threshold. Once the TA value crosses the TA threshold, the DU 804 may decide (818) to enable location reporting. The DU 804 may transmit (820A) a F1AP message 822 comprising UE location request to the CU 806. The CU 806 may receive (820B) the F1AP message 822. The CU 806 may transmit (824A) a location service request 826 via a NGAP message to an
15 AMF 810. The AMF 810 may receive (824B) the location service request 826.

[0080] At step-3, the LMF 812 may receive a location service request from the AMF 810, and may initiate the gNB to report measurements for the UE 802. The gNB may configure measurement to the UE to report location information via RRC Reconfiguration.

[0081] For example, the AMF 810 may transmit (828A) a location service request 830 to
20 the LMF 812. The LMF 812 may receive (828B) the location service request 830. The LMF 812 may transmit (832B) an E-CID measurement initiation request 834 via an NRPPa message to the CU 806. The CU 806 may receive (832A) the E-CID measurement initiation request 834. The CU 806 may transmit (836B) a F1AP message 838 called DL RRC message transfer to the DU 804 via a F1AP message. The DU 804 may receive (836A) the F1AP
25 message 838. The DU 804 may transmit (840B) a RRC reconfiguration message 842 to the UE 802. The UE 802 may receive (840A) the RRC reconfiguration message 842. The UE 802 may transmit (844A) a reconfiguration complete message 846 to the DU 804. The DU 804 may receive (844B) the reconfiguration complete message 846.

[0082] The DU 804 may transmit (848A) a F1AP message 850 called of a UL RRC message
30 transfer to the CU 806 via a F1AP message. The CU 806 may receive (848B) the F1AP message 850. The CU 806 may transmit (852A) an E-CID measurement initiation response

854 via an NRPPa message to the LMF 812. The LMF 812 may receive (852B) the E-CID measurement initiation response 854.

[0083] At step-4, UE 802 may start to report the measurement via RRC Measurement report, and the gNB may report it to the LMF 812. The LMF 812 may derive the UE location based on the measurement reports and may share it with the AMF 810 via a location service response.

[0084] For example, the UE 802 may transmit (856A) a measurement report 858 to the DU 804. The DU 804 may receive (856B) the measurement report 858. The DU 804 may transmit (860A) a F1AP message 862 called a UL RRC message via a F1AP message. The CU 806 may receive (860B) the F1AP message 862. The CU 806 may transmit (864A) an E-CID measurement report 866 to the LMF 812 via an NRPPa message. The LMF 812 may receive (864B) the E-CID measurement report 866. The LMF 812 may transmit (868B) a location service response 870 to the AMF 810. The AMF 810 may receive (868A) the location service response 870.

[0085] At step-5, the AMF 810 may provide the location information via a new NGAP: Location Service Response message. CU 806 may update the same to gNB-DU via a new F1AP Message F1AP: UE Location Info Notification. Based on the information, DU 804 may decide if the user has to be released or not.

[0086] For example, the AMF 810 may transmit (872B) a location service response 874 via a NGAP message to the CU 806. The CU 806 may receive (872A) the location service response 874. The CU 806 may transmit (876B) a UE location information notification 878 via a F1AP message. The DU 804 may receive (876A) the UE location information notification 878. The DU 804 may decide (880) to release the UE 802.

[0087] At step-6, once the DU 804 decides to release the user, it may initiate the UE release. For example, the DU 804 may initiate (882) a procedure for releasing the UE 802.

[0088] Reference is made to FIG. 9, which illustrates an example signaling process 900 for a location aware CU for geo-fence enforcement in accordance with some example embodiments of the present disclosure. With reference to FIG. 1A, a UE 902 may be an example of the terminal device 102. ADU 904, a CU 906 and an OAM 908 may be comprised in the network device 104. An LMF 912 may be hosted by the network node 110.

[0089] Similar to FIG. 8, at high level, there are six steps in FIG. 9. Each step may have one or more signaling. At step-1, the OAM 908 may configure the DU 904 with the TA

threshold. The OAM 908 may configure the CU 906 with geo-fence configuration. For example, the OAM 908 may transmit (914B) configuration 916 to the CU 906. The configuration 916 may comprise edges of the geo-fence. The CU 906 may receive (914A) the configuration 916 from the OAM 908. The OAM 908 may transmit (918B) configuration 5 920 to the DU 904. The configuration 920 may comprise the TA threshold. The DU 904 may receive (918A) the configuration 920 from the OAM 908.

[0090] At step-2, the DU 904 may evaluate the TA value of the user. If the TA value is above the TA threshold, the DU 904 may initiate geo-location evaluation for the user at the CU 906. This is done via F1AP: UE Context Modification required message, where a new cause value 10 is added, such as TA threshold exceeded or alike.

[0091] For example, the DU 904 may evaluate the TA value of the UE 902 against the TA threshold. Once the TA value crosses the TA threshold, the DU 904 may decide (922) to enable location reporting. The DU 904 may transmit (924A) the cause value 926 via a F1AP message. The CU 906 may receive (924B) the cause value 926.

15 [0092] For step-3, once CU 906 sees the new cause value, it may request the AMF 910 for location information and it may configure location reporting to the user via measurement configuration. The details of the signaling will be referred to steps 2 and 3 of FIG. 8. For step-4, the UE 906 may start to report location via Measurement Report. The details of the signaling will be referred to step 4 of FIG. 8. For brevity, step 3 and step 4 of FIG. 9 will not 20 be described herein.

[0093] For step-5, the LMF 912 may share the location service response to AMF 910 and the same may be shared with gNB via a new NGAP message: Location Service Response. For example, the AMF 910 may transmit (974B) a location service response 976 via a NGAP message to the CU 906. The CU may receive (974A) the location service response 976. The 25 CU 906 may decide (928) to release the UE 902 based on the location of the UE 902 being inside the geo-fence. For step-6, if the UE location is within the geo-fence configured at the CU 906, then the CU 906 may initiate (984) release of the user.

[0094] Through the use of the new F1AP procedures to enable UE Location exchange between gNB-DU and gNB-CU, it can increase abilities to restrict user service to given 30 allowed regions by an entity.

[0095] Reference is made to FIG. 10, which illustrates an example flowchart of a method 1000 implemented at a network device in accordance with some example embodiments of the present disclosure. FIG. 10 will be described with reference to FIG. 1A.

[0096] At 1002, the network device 104 monitors a TA value of a terminal device 102 to determine whether the TA value exceeds a TA threshold. At 1004, the network device 104 requests a network node to report location information of the terminal device 102 based on determining that the TA value exceeds the TA threshold. At 1006, the network device 104 triggers a release of a RRC connection of the terminal device 102 with the network device 104 based on determining that the terminal device 102 is within a forbidden area based on the reported location information.

[0097] In some example embodiments, the network device 104 may comprise a DU and a CU. In some example embodiments, the DU may obtain, from an OAM device, the TA threshold and information indicative of the forbidden area.

[0098] In some example embodiments, the network device 104 may request the network node 110 to report the location information of the terminal device 102 by: transmitting, by the DU to the CU, a first F1AP message for requesting the location information of the terminal device; and transmitting, by the CU to an AMF device, a first NGAP message for requesting the location information of the terminal device 102.

[0099] In some example embodiments, the CU may receive, from the AMF device, a second NGAP message including the location information of the terminal device 102; and the CU may transmit, to the DU, a second F1AP message including the location information of the terminal device 102.

[00100] In some example embodiments, the determination that the TA value exceeds the TA threshold and the determination that the terminal device 102 is within the forbidden area may be performed by the DU. In some example embodiments, the triggering of the release of the RRC connection may be performed by the CU upon trigger from the DU.

[00101] In some example embodiments, the DU may obtain, from an OAM device, information indicative of the forbidden area; and the DU may obtain, from the OAM device, the TA threshold.

[00102] In some example embodiments, the network device 104 may request the network node 110 to report location information of the terminal device 102 by: transmitting, by the DU to the CU, a third F1AP message including a cause value indicating that the TA value

exceeds the TA threshold; and transmitting, by the CU to an AMF device, a third NGAP message for requesting the location information of the terminal device 102.

[00103] In some example embodiments, the CU may receive, from the AMF device, a fourth NGAP message including the location information of the terminal device 102. In some example embodiments, the determination that the TA value exceeds the TA threshold may be performed by the DU. In some example embodiments, the determination that the terminal device 102 is within the forbidden area and the triggering of the release of the RRC connection may be performed by the CU.

[00104] In some example embodiments, the network device 104 may trigger the release of the RRC connection by transmitting a RRC Release message to the terminal device 102. In some example embodiments, the network device 104 may disable the reporting of the location information of the terminal device 102 based on determining that the TA value falls below the TA threshold.

[00105] In some example embodiments, the network device 104 may determine whether a distance between the terminal device 102 and the forbidden area is below a distance threshold based on determining that the terminal device 102 is outside the forbidden area based on the reported location information. The network device 104 may trigger periodic reporting of the location information of the terminal device 102 based on determining that the distance is below the distance threshold.

[00106] In some example embodiments, the reporting may be periodic. In some example embodiments, the network device 104 may increase a periodicity of the reporting based on determining that a speed of the terminal device 102 is below a first speed threshold. In some example embodiments, the network device 104 may reduce the periodicity of the reporting based on determining that the speed of the terminal device 102 is above a second speed threshold.

[00107] In some example embodiments, the network node may host a location management function (LMF).

[00108] By implementing the method 1000, the retainability key performance indicator (KPI) impact can be reduced, and the influence on other users who may be in the area defined by a TA value (based on some configured threshold) can also be reduced.

[00109] In some example embodiments, an apparatus capable of performing the method 1000 may comprise means for performing the respective steps of the method 1000. The

means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[00110] In some example embodiments, the apparatus may comprise means for monitoring, at a network device, a TA value of a terminal device to determine whether the TA value exceeds a TA threshold; means for requesting a network node to report location information of the terminal device based on determining that the TA value exceeds the TA threshold; and means for triggering a release of a RRC connection of the terminal device with the network device based on determining that the terminal device is within a forbidden area based on the reported location information.

[00111] In some example embodiments, the apparatus may further comprise a DU and a CU. In some example embodiments, the apparatus may further comprise means for obtaining, by the DU from an OAM device, the TA threshold and information indicative of the forbidden area.

[00112] In some example embodiments, the means for requesting a network node to report location information of the terminal device may comprise means for transmitting, by the DU to the CU, a first F1 F1AP message for requesting the location information of the terminal device; and means for transmitting, by the CU to an AMF device, a first NGAP message for requesting the location information of the terminal device.

[00113] In some example embodiments, the apparatus may comprise means for receiving, by the CU from the AMF device, a second NGAP message including the location information of the terminal device; and means for transmitting, by the CU to the DU, a second F1AP message including the location information of the terminal device.

[00114] In some example embodiments, the determination that the TA value exceeds the TA threshold and the determination that the terminal device is within the forbidden area may be performed by the DU. In some example embodiments, the triggering of the release of the RRC connection may be performed by the CU upon trigger from the DU.

[00115] In some example embodiments, the apparatus may comprise means for obtaining, by the CU from an OAM device, information indicative of the forbidden area; and means for obtaining, by the DU from the OAM device, the TA threshold.

[00116] In some example embodiments, the means for requesting a network node to report location information of the terminal device may comprise means for transmitting, by the DU to the CU, a third F1AP message including a cause value indicating that the TA value exceeds

the TA threshold; and means for transmitting, by the CU to an AMF device, a third NGAP message for requesting the location information of the terminal device.

[00117] In some example embodiments, the apparatus may comprise means for receiving, by the CU from the AMF device, a fourth NGAP message including the location information of the terminal device.

[00118] In some example embodiments, the determination that the TA value exceeds the TA threshold may be performed by the DU. In some example embodiments, the determination that the terminal device is within the forbidden area and the triggering of the release of the RRC connection may be performed by the CU.

[00119] In some example embodiments, the apparatus may comprise means for triggering the release of the RRC connection may comprise means for transmitting a RRC Release message to the terminal device.

[00120] In some example embodiments, the apparatus may comprise means for disabling the reporting of the location information of the terminal device based on determining that the TA value falls below the TA threshold.

[00121] In some example embodiments, the apparatus may comprise means for determining whether a distance between the terminal device and the forbidden area is below a distance threshold based on determining that the terminal device is outside the forbidden area based on the reported location information; and means for triggering periodic reporting of the location information of the terminal device based on determining that the distance is below the distance threshold.

[00122] In some example embodiments, the reporting may be periodic. In some example embodiments, the apparatus may comprise means for increasing a periodicity of the reporting based on determining that a speed of the terminal device is below a first speed threshold; and means for reducing the periodicity of the reporting based on determining that the speed of the terminal device is above a second speed threshold.

[00123] In some example embodiments, the network node may host a location management function (LMF).

[00124] In some example embodiments, the apparatus may further comprise means for performing other steps in some embodiments of the method 1000. In some example embodiments, the means comprises at least one processor and at least one memory including

computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[00125] Reference is made to FIG. 11, which illustrates an example simplified block diagram of a device that is suitable for implementing embodiments of the present disclosure. The device 1100 may be provided to implement the communication device, for example the network device 104 as shown in FIG. 1A. As shown, the device 1100 includes one or more processors 1110, one or more memories 1120 may couple to the processor 1110, and one or more communication modules 1140 may couple to the processor 1110.

[00126] The communication module 1140 is for bidirectional communications. The communication module 1140 has at least one antenna to facilitate communication. The communication interface may represent any interface that is necessary for communication with other network elements, for example the communication interface may be wireless or wireline to other network elements, or software based interface for communication.

[00127] The processor 1110 may be of any type suitable to the local technical network and may include one or more of the following: general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 1100 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[00128] The memory 1120 may include one or more non-volatile memories and one or more volatile memories. Examples of the non-volatile memories include, but are not limited to, a read only memory (ROM) 1124, an electrically programmable read only memory (EPROM), a flash memory, a hard disk, a compact disc (CD), a digital video disk (DVD), and other magnetic storage and/or optical storage. Examples of the volatile memories include, but are not limited to, a random access memory (RAM) 1122 and other volatile memories that will not last in the power-down duration.

[00129] A computer program 1130 includes computer executable instructions that are executed by the associated processor 1110. The program 1130 may be stored in the ROM 1124. The processor 1110 may perform any suitable actions and processing by loading the program 1130 into the RAM 1122.

[00130] The embodiments of the present disclosure may be implemented by means of the program so that the device 1100 may perform any process of the disclosure as discussed with

reference to FIG. 10. The embodiments of the present disclosure may also be implemented by hardware or by a combination of software and hardware.

[00131] In some embodiments, the program 1130 may be tangibly contained in a computer readable medium which may be included in the device 1100 (such as in the memory 1120) or other storage devices that are accessible by the device 1100. The device 1100 may load the program 1130 from the computer readable medium to the RAM 1122 for execution. The computer readable medium may include any types of tangible non-volatile storage, such as ROM, EPROM, a flash memory, a hard disk, CD, DVD, and the like. FIG. 12 shows an example of the computer readable medium 1200 in form of CD or DVD. The computer readable medium has the program 1130 stored thereon.

[00132] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it is to be understood that the block, apparatus, system, technique or method described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00133] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the method 1000 as described above with reference to FIG. 10. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[00134] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when
5 executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[00135] In the context of the present disclosure, the computer program codes or related data
10 may be carried by any suitable carrier to enable the device, apparatus or processor to perform various processes and operations as described above. Examples of the carrier include a signal, computer readable medium, and the like.

[00136] The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable medium may include but not
15 limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory
20 (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. The term “non-transitory,” as used herein, is a limitation of the medium itself (i.e., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM).

[00137] Further, while operations are depicted in a particular order, this should not be
25 understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above
30 discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features

that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

5 **[00138]** Although the present disclosure has been described in languages specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

WHAT IS CLAIMED IS:

1. A network device comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one

5 processor, cause the network device at least to:

monitor a timing advance (TA) value of a terminal device to determine whether the TA value exceeds a TA threshold;

based on determining that the TA value exceeds the TA threshold, request a network node to report location information of the terminal device; and

10 based on determining that the terminal device is within a forbidden area based on the reported location information, trigger a release of a radio resource control (RRC) connection of the terminal device with the network device.

2. The network device of claim 1, wherein the network device comprises a distributed
15 unit (DU) and a centralized unit (CU), and wherein the network device is further caused to:

obtain, by the DU from an operation administration and management (OAM) device, the TA threshold and information indicative of the forbidden area.

3. The network device of claim 2, wherein the network device is caused to request the
20 network node to report the location information of the terminal device by:

transmitting, by the DU to the CU, a first F1 application protocol (F1AP) message for requesting the location information of the terminal device; and

transmitting, by the CU to an access and mobility management function (AMF)
device, a first next generation application protocol (NGAP) message for requesting the
25 location information of the terminal device.

4. The network device of claim 3, wherein the network device is further caused to:

receive, by the CU from the AMF device, a second NGAP message including the location information of the terminal device; and

30 transmit, by the CU to the DU, a second F1AP message including the location information of the terminal device.

5. The network device of any of claims 2-4, wherein the determination that the TA value exceeds the TA threshold and the determination that the terminal device is within the forbidden area are performed by the DU, and wherein the triggering of the release of the RRC connection is performed by the CU upon trigger from the DU.

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6. The network device of claim 1, wherein the network device comprises a DU and a CU, and wherein the network device is further caused to:

obtain, by the CU from an OAM device, information indicative of the forbidden area;

and

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obtain, by the DU from the OAM device, the TA threshold.

7. The network device of claim 6, wherein the network device is caused to request the network node to report the location information of the terminal device by:

transmitting, by the DU to the CU, a third F1AP message including a cause value

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indicating that the TA value exceeds the TA threshold; and

transmitting, by the CU to an AMF device, a third NGAP message for requesting the location information of the terminal device.

8. The network device of claim 7, wherein the network device is further caused to:

20

receive, by the CU from the AMF device, a fourth NGAP message including the location information of the terminal device.

9. The network device of any of claims 6-8, wherein the determination that the TA value exceeds the TA threshold is performed by the DU, and wherein the determination that the terminal device is within the forbidden area and the triggering of the release of the RRC connection are performed by the CU.

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10. The network device of any of claims 1-9, wherein the network device is caused to trigger the release of the RRC connection by transmitting a RRC Release message to the terminal device.

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11. The network device of any of claims 1-10, wherein the network device is further caused to:

based on determining that the TA value falls below the TA threshold, disable the reporting of the location information of the terminal device.

12. The network device of any of claims 1-11, wherein the network device is further caused to:

based on determining that the terminal device is outside the forbidden area based on the reported location information, determine whether a distance between the terminal device and the forbidden area is below a distance threshold; and

based on determining that the distance is below the distance threshold, trigger periodic reporting of the location information of the terminal device.

13. The network device of any of claims 1-12, wherein the reporting is periodic, and the network device is further caused to:

based on determining that a speed of the terminal device is below a first speed threshold, increase a periodicity of the reporting; and

based on determining that the speed of the terminal device is above a second speed threshold, reduce the periodicity of the reporting.

14. The network device of any of claims 1-13, wherein the network node hosts a location management function (LMF).

15. A method comprising:

monitoring, at a network device, a timing advance (TA) value of a terminal device to determine whether the TA value exceeds a TA threshold;

based on determining that the TA value exceeds the TA threshold, requesting a network node to report location information of the terminal device; and

based on determining that the terminal device is within a forbidden area based on the reported location information, triggering a release of a radio resource control (RRC) connection of the terminal device with the network device.

16. An apparatus comprising:

means for monitoring, at a network device, a timing advance (TA) value of a terminal device to determine whether the TA value exceeds a TA threshold;

means for, based on determining that the TA value exceeds the TA threshold, requesting a network node to report location information of the terminal device; and

means for, based on determining that the terminal device is within a forbidden area based on the reported location information, triggering a release of a radio resource control (RRC) connection of the terminal device with the network device.

17. A non-transitory computer readable medium comprising program instructions for causing an apparatus to perform a method comprising:

monitoring, at a network device, a timing advance (TA) value of a terminal device to determine whether the TA value reaches or exceeds a TA threshold;

based on determining that the TA value exceeds the TA threshold, requesting a network node to report location information of the terminal device; and

based on determining that the terminal device is within a forbidden area based on the location information, triggering a release of a radio resource control (RRC) connection of the terminal device with the network device.

DRAWINGS

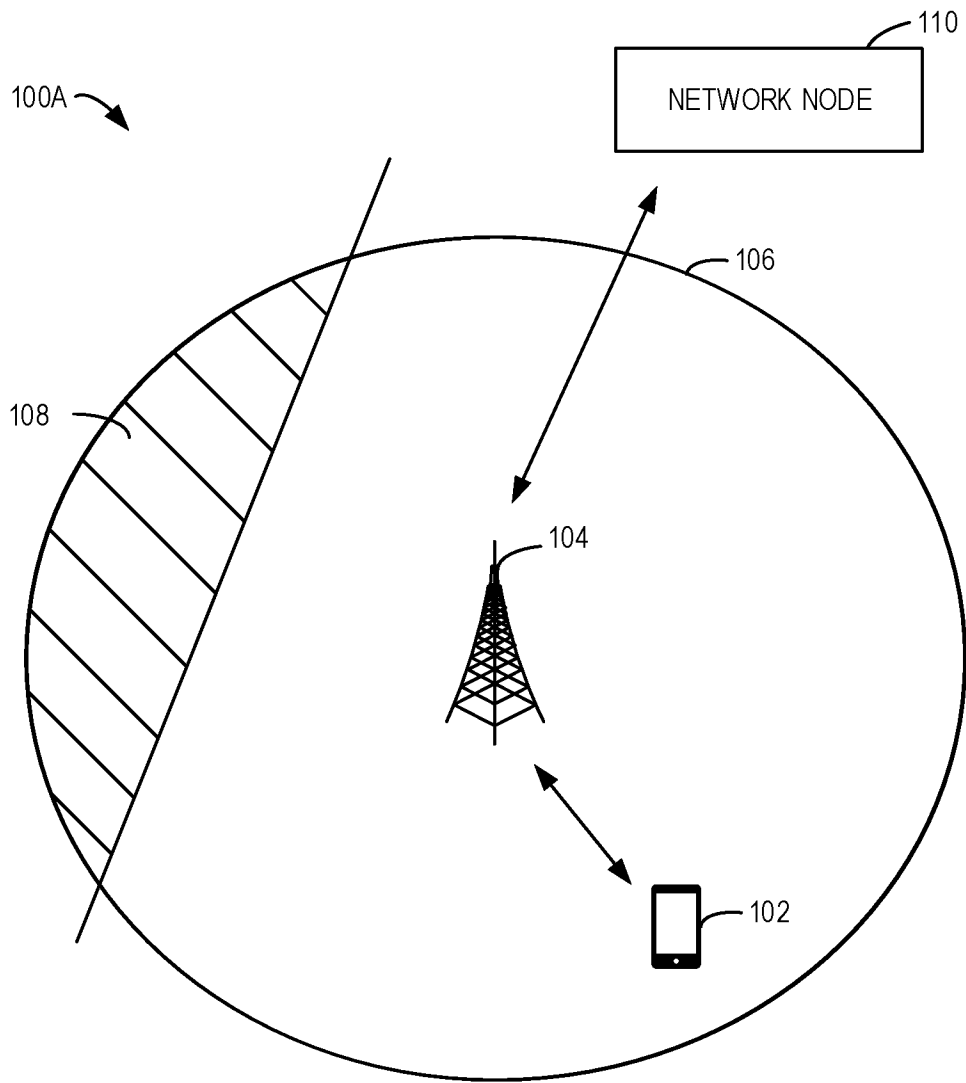


Fig. 1A

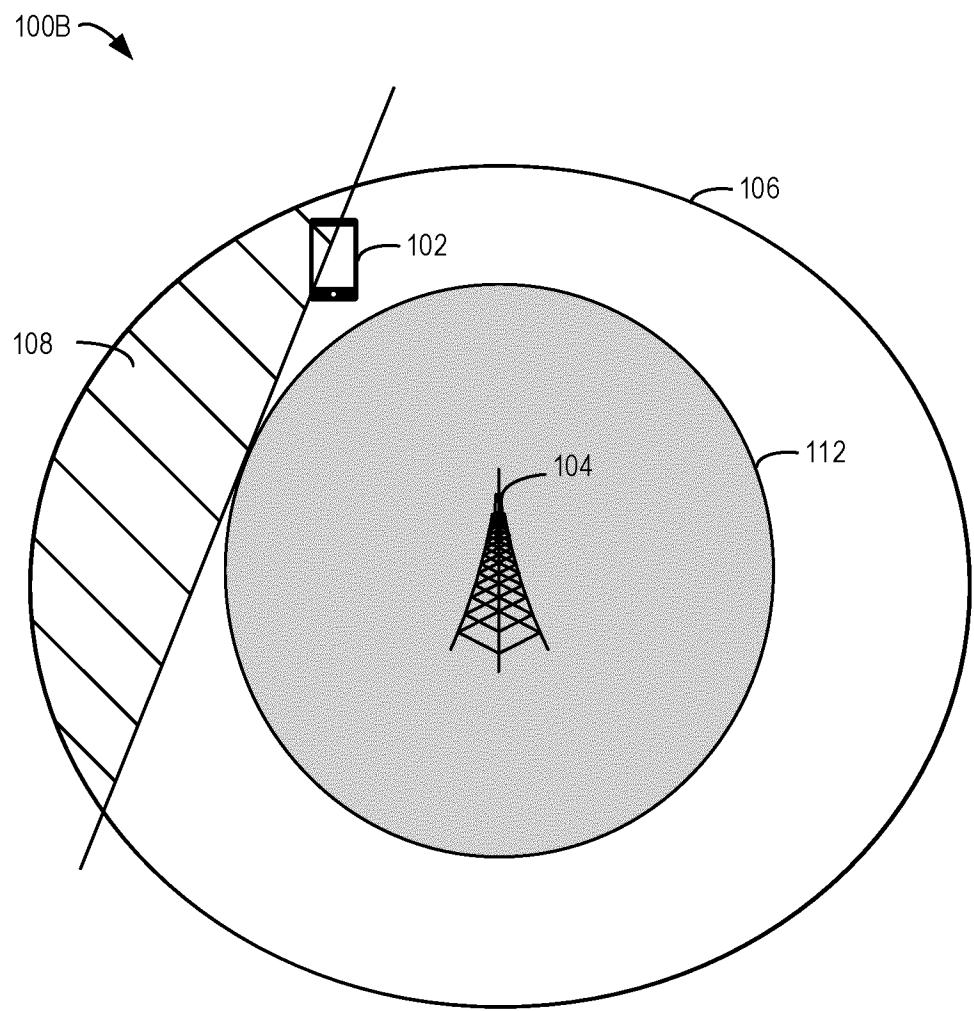


Fig. 1B

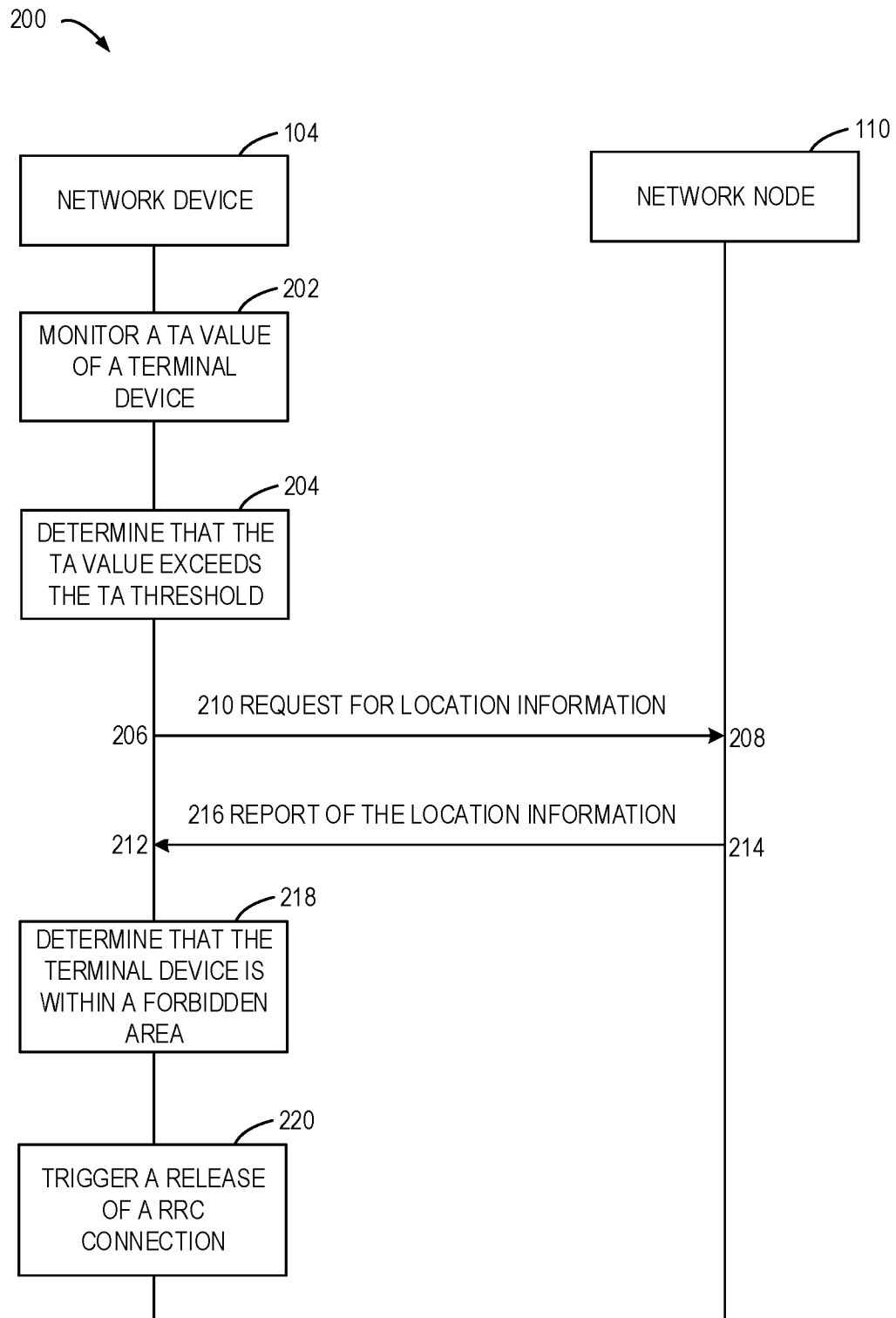


Fig. 2

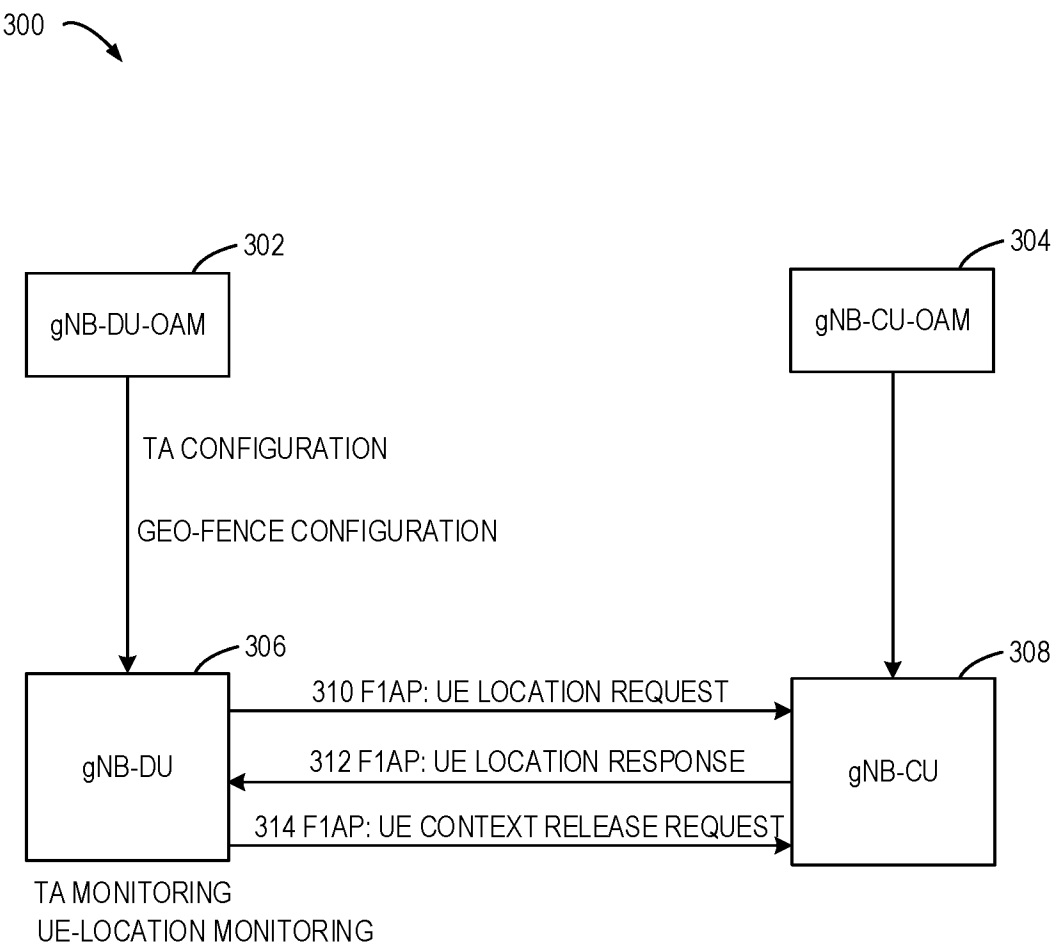


Fig. 3

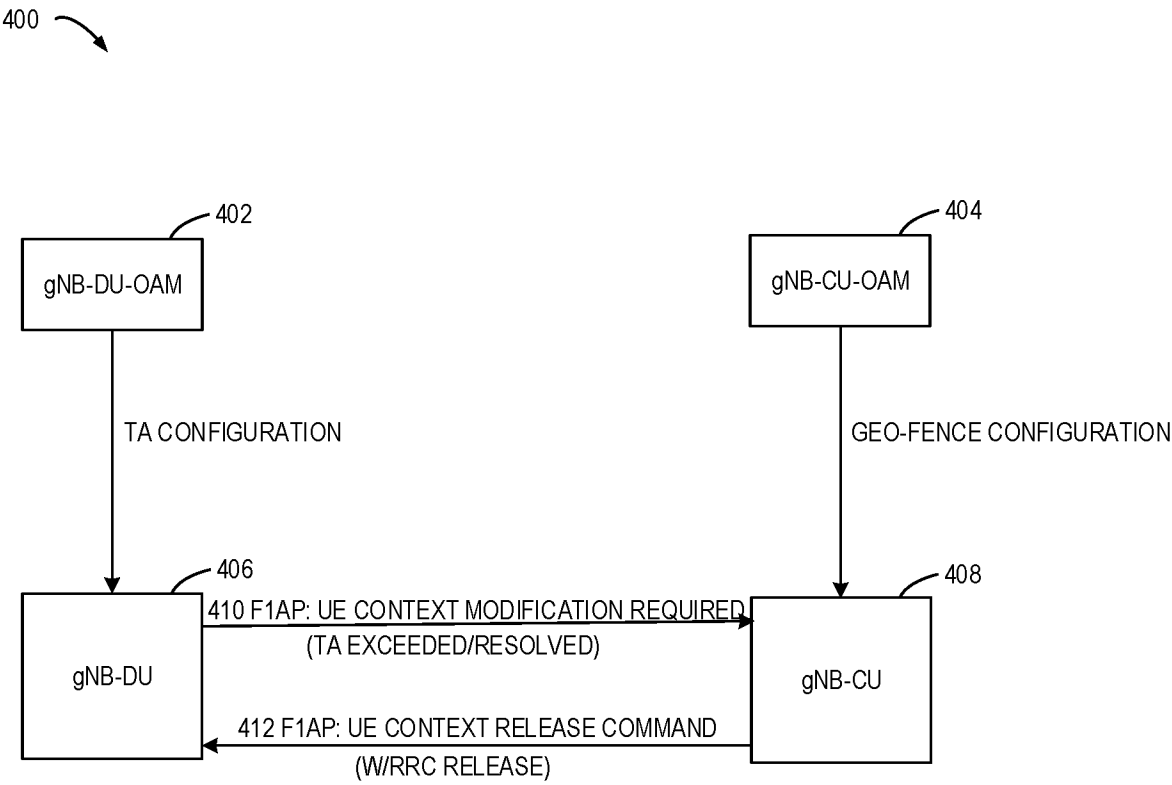


Fig. 4

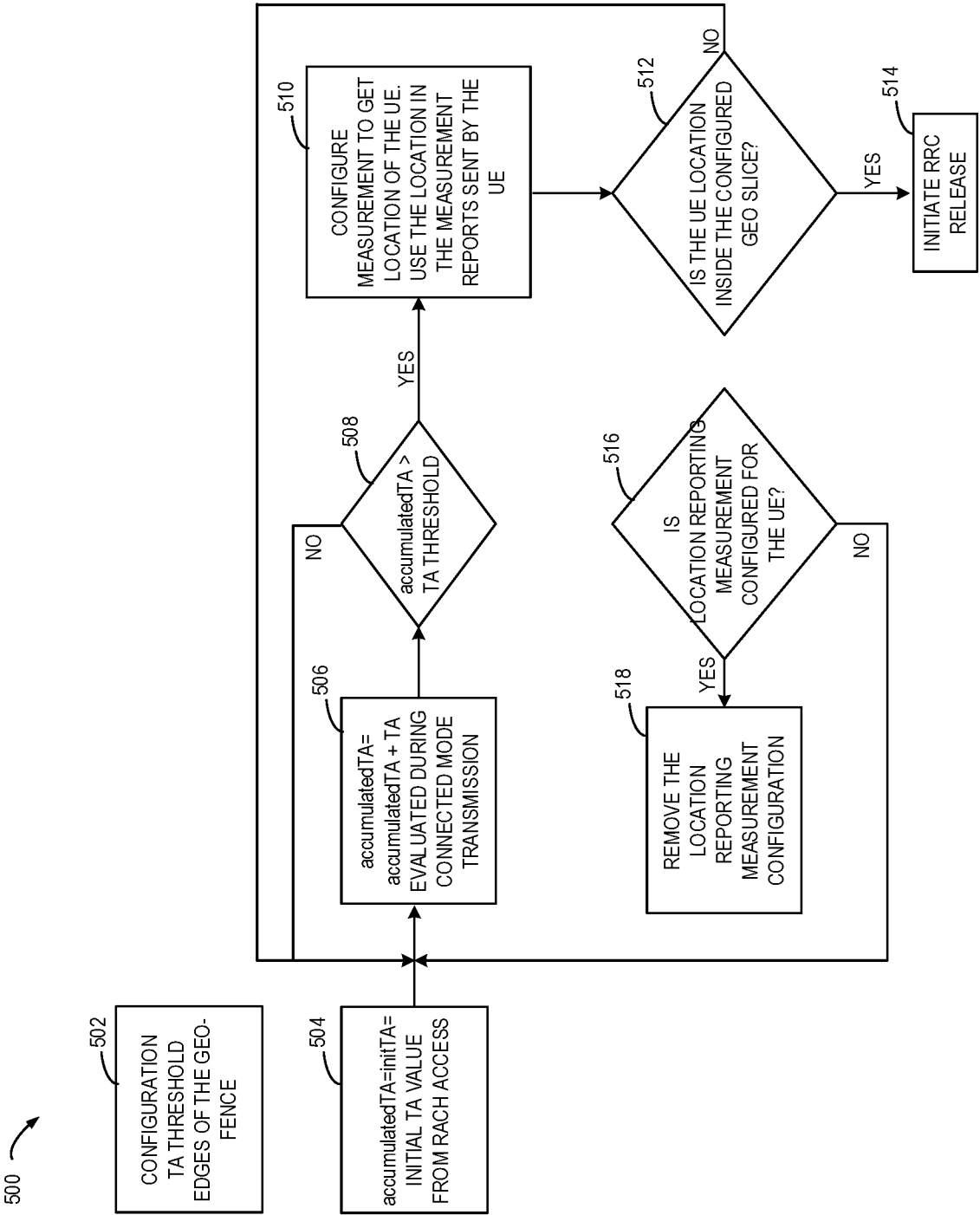


Fig. 5

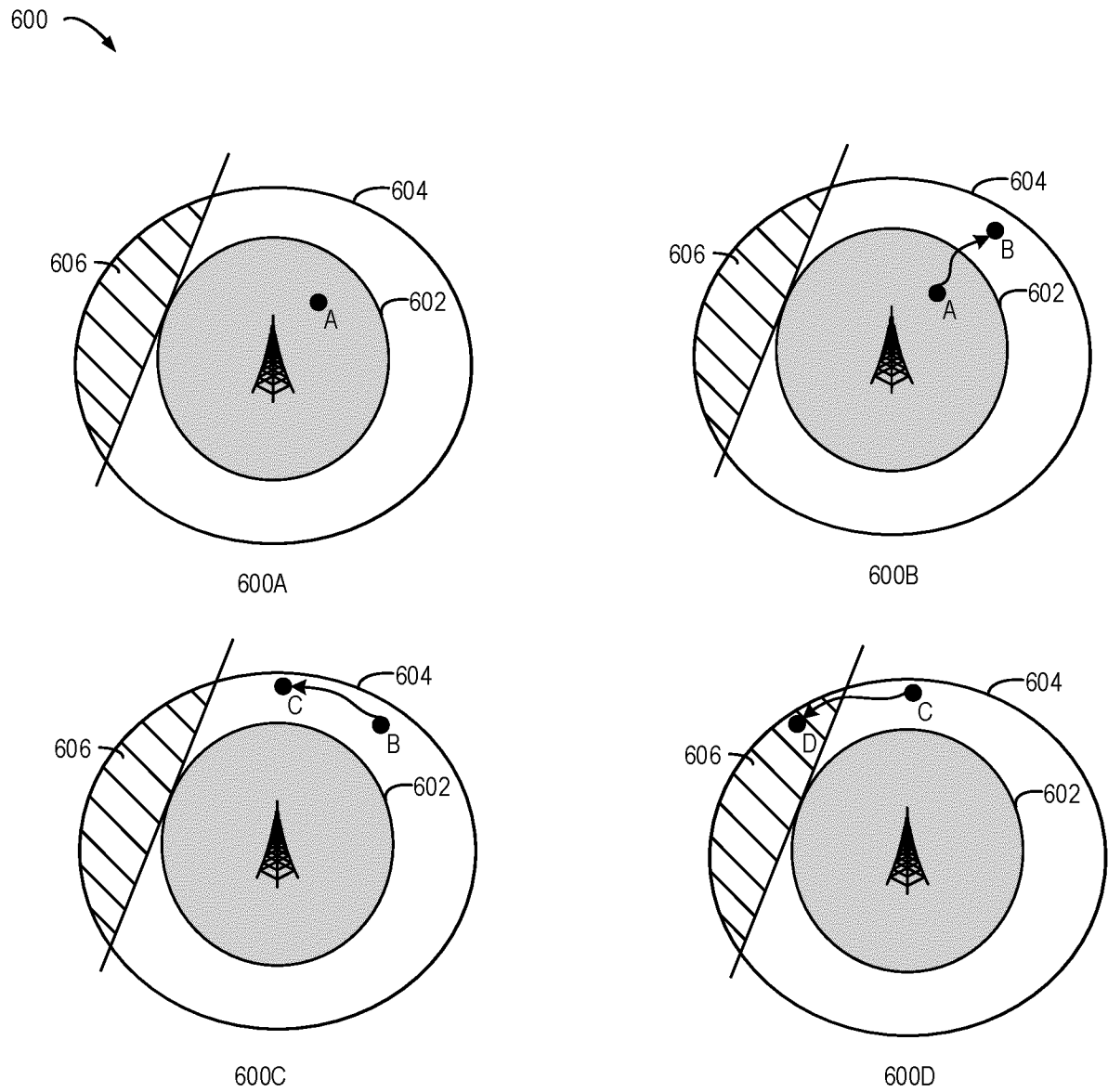


Fig. 6

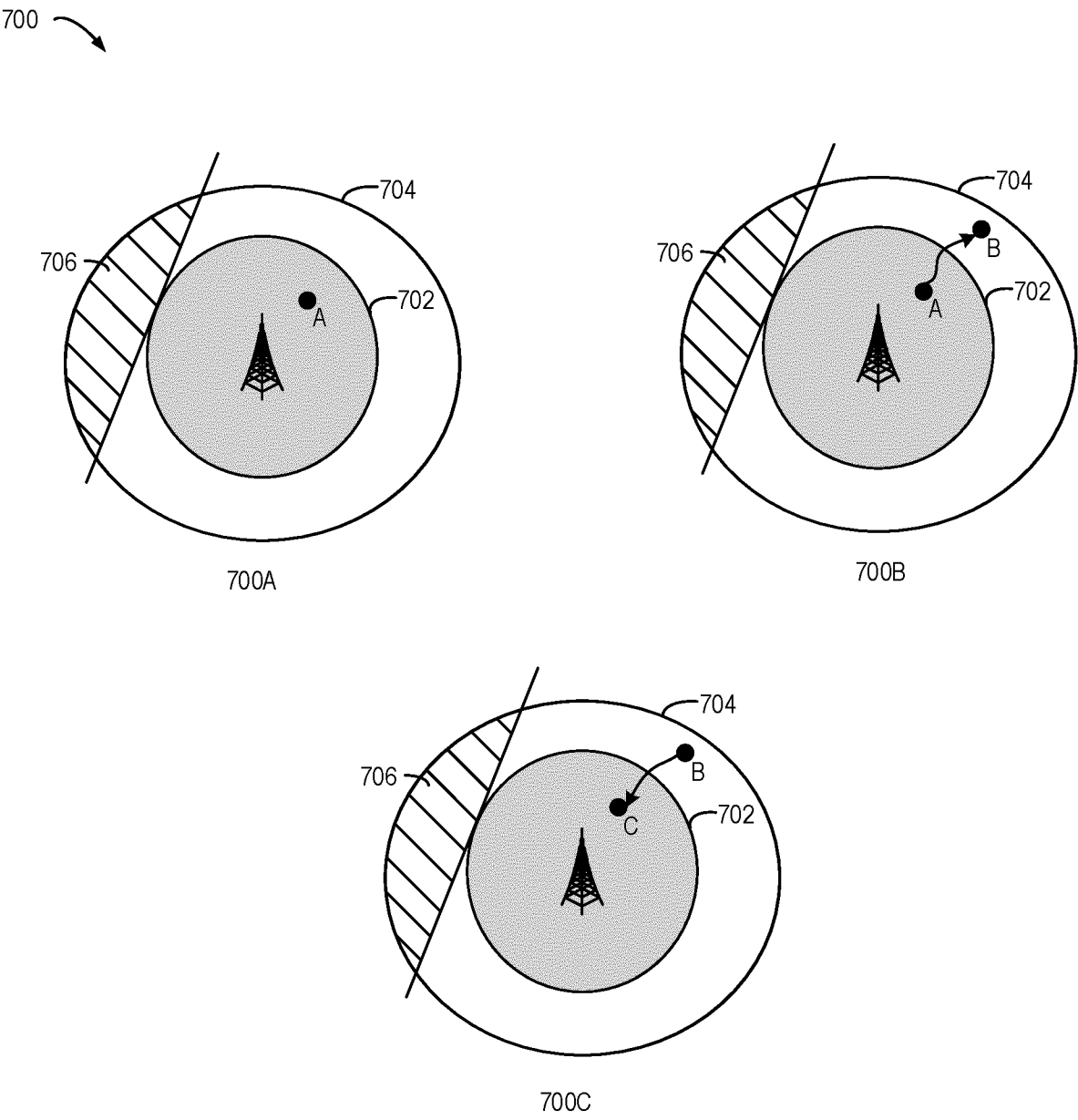


Fig. 7

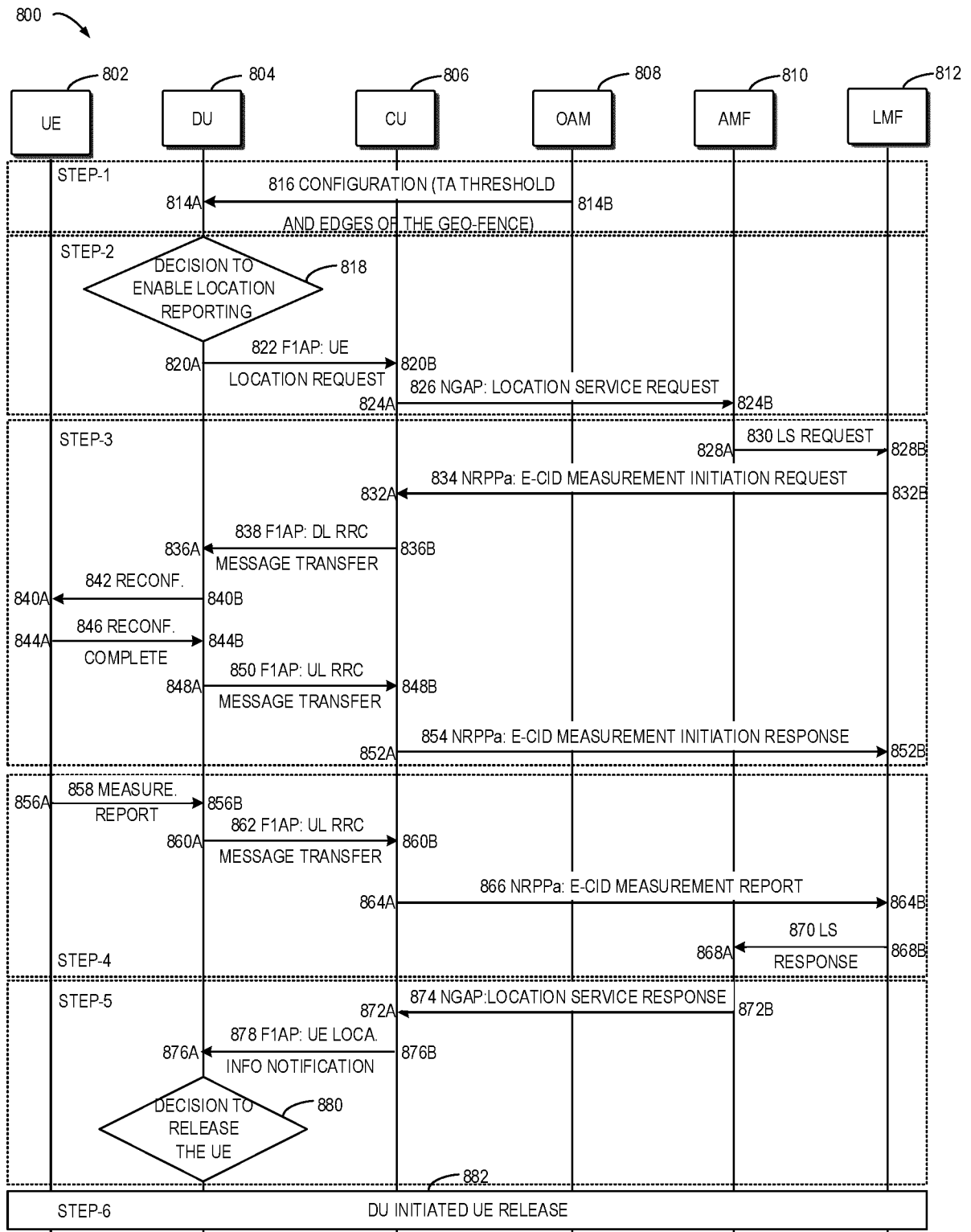


Fig. 8

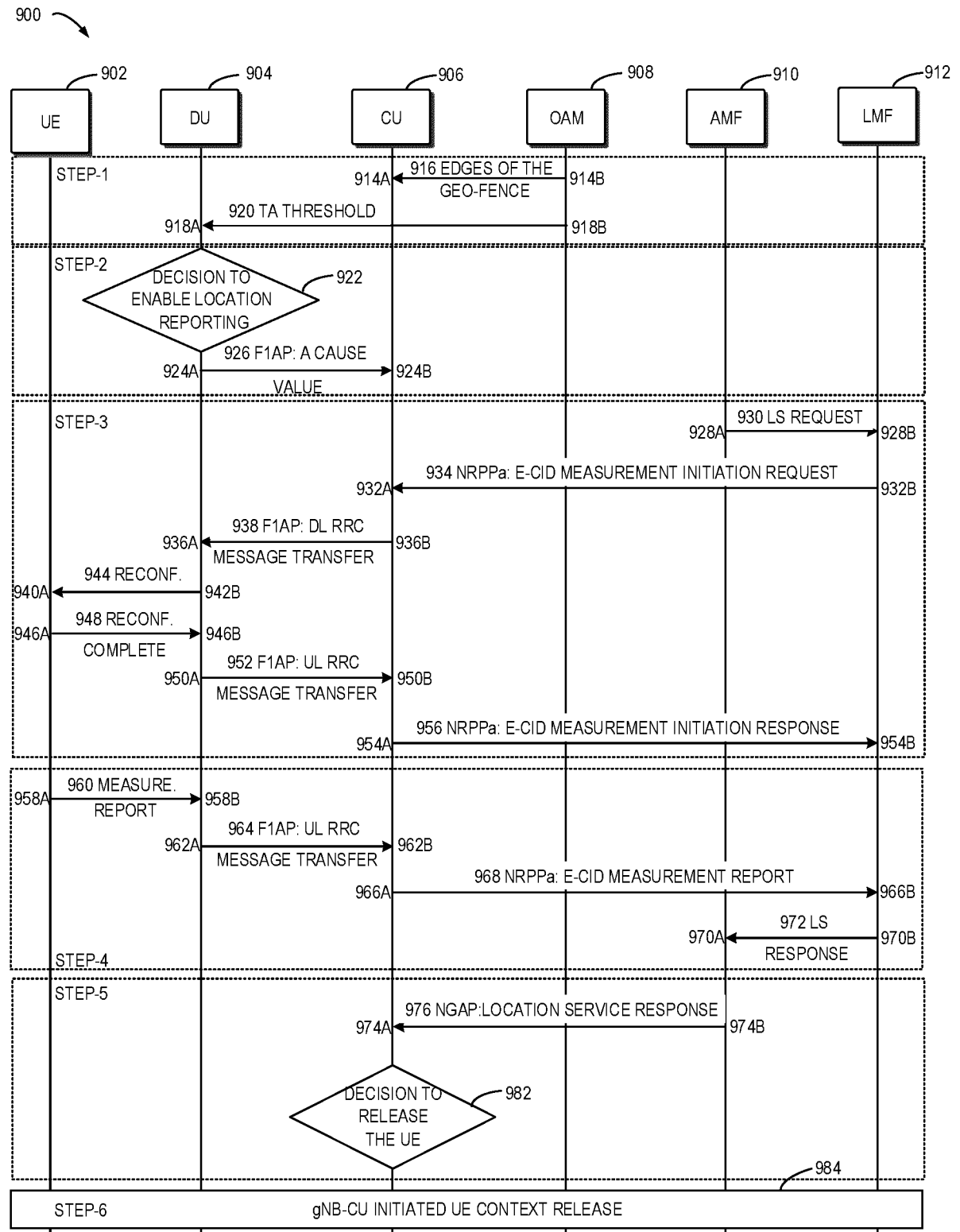


Fig. 9

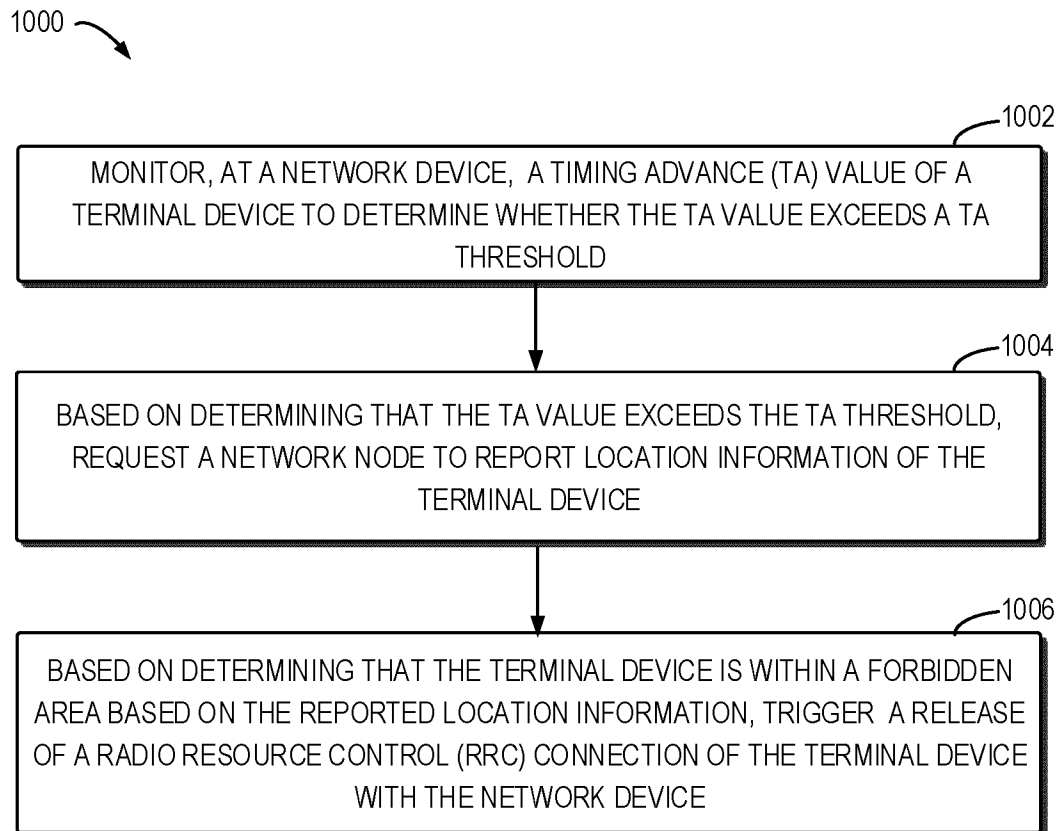


Fig. 10

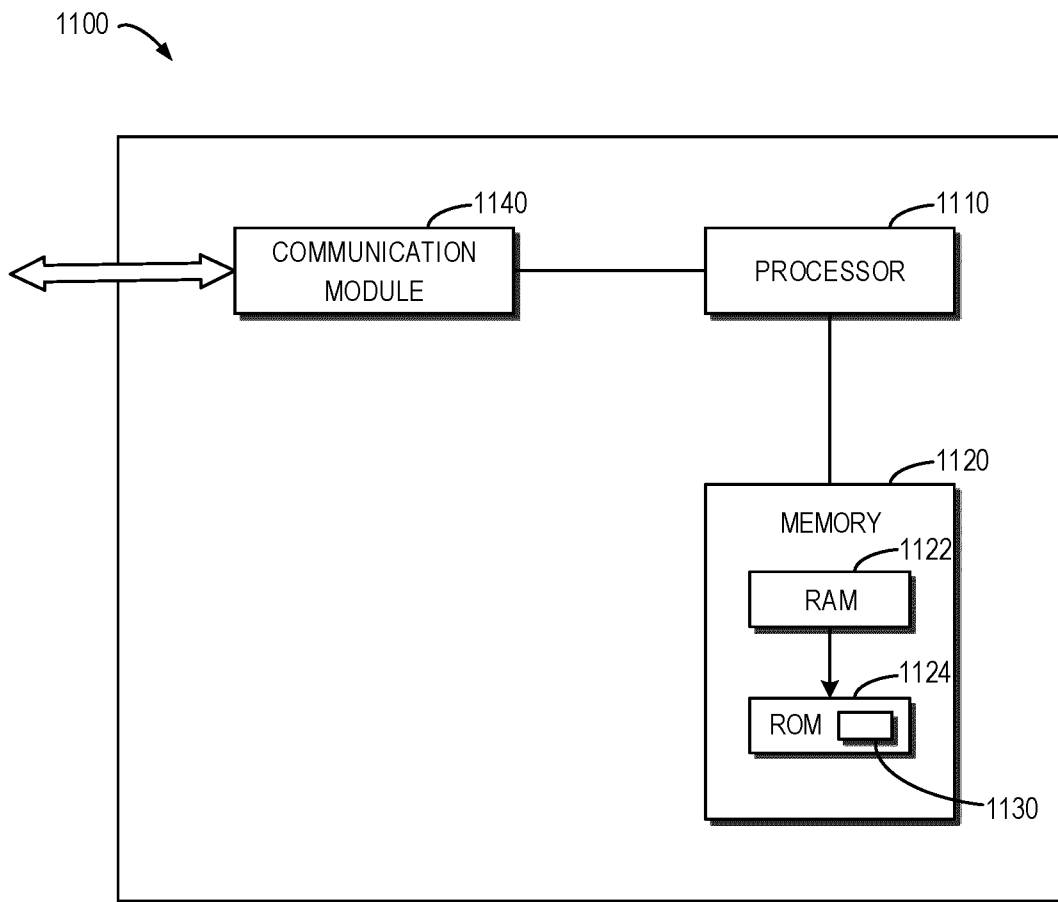


Fig. 11

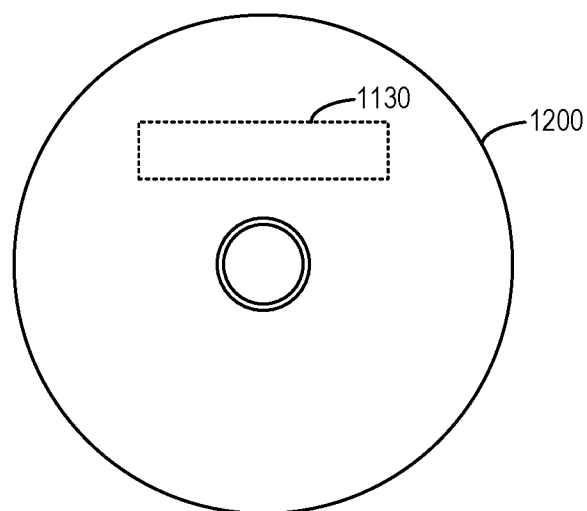


Fig. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/060672

A. CLASSIFICATION OF SUBJECT MATTER INV. H04W56/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) H04W		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8 463 297 B2 (BULL JEFFREY F [US]; WARD MATTHEW L [US]; TRUEPOSITION INC [US]) 11 June 2013 (2013-06-11) the whole document -----	1 - 17
A	EP 2 816 842 B1 (DATANG MOBILE COMMUNICATIONS EQUIPMENT CO LTD [CN]) 17 July 2019 (2019-07-17) figures 1-8 -----	1 - 17
A	EP 1 889 497 B1 (TRUEPOSITION INC [US]) 25 August 2010 (2010-08-25) figures 1-8 -----	1 - 17
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 9 July 2024		Date of mailing of the international search report 26/07/2024
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 Bohnhoff, Peter

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2024/060672

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