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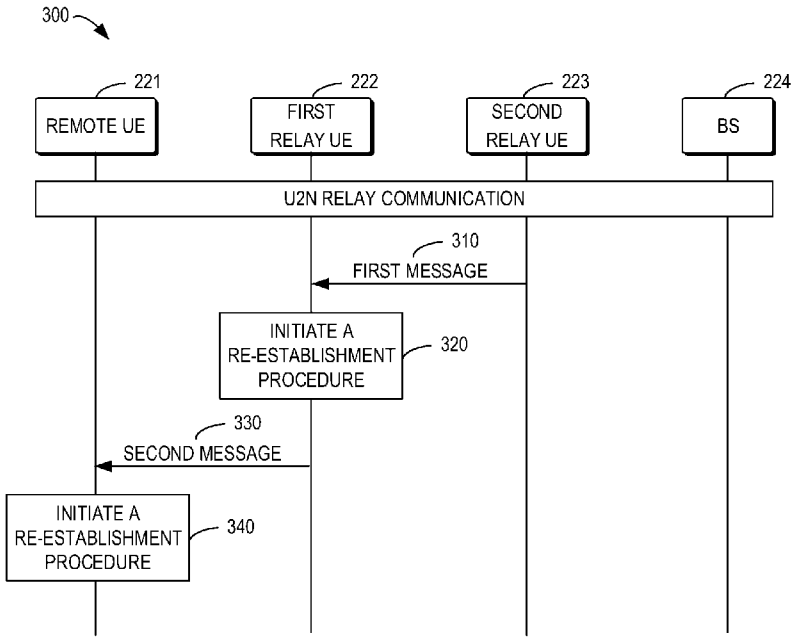


FIG. 3

(57) **Abstract:** Example embodiments of the present disclosure relate to a first relay UE, a second relay UE, a remote UE, methods, apparatuses, processors, and computer readable medium for failure in a relay communication. A first relay UE may determine whether a trigger event is happened, for example the trigger event comprises one of: receiving a first message from a second relay UE, executing a handover towards a candidate cell or a candidate relay UE, detecting a failure between the first relay UE and the second relay UE, or detecting a failure between the first relay UE and the remote UE. In addition, the first relay UE may transmit a second message to the remote UE or a third message to the second relay UE. As such, the proposed solution, in case a failure occurs, other UEs in the communication may be aware of the failure in time, and thus one or more further operations may be performed to maintain the communication.

*[Continued on next page]*

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# FAILURE IN RELAY COMMUNICATION

## TECHNICAL FIELD

**[0001]** The present disclosure relates to wireless communications, and more specifically to user equipment (UE), methods, apparatuses, processors, and computer readable medium for failure in a relay communication.

## 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]** A scenario of UE-to-network (U2N) relay has been discussed in the third generation partner project (3GPP). An indirect path is a type of U2N transmission path, where data is forwarded via at least one U2N relay UE between a U2N remote UE and the network. In case there are two or more relay UEs between the remote UE and the network, a failure may occur and a communication between the remote UE and the network may be affected. Thus, details on the U2N relay with at least two relay UEs are needed to be further studied.

## SUMMARY

**[0004]** The present disclosure relates to a first relay UE, a second relay UE, a remote UE, methods, apparatuses, processors, and computer readable medium for failure in a U2N relay communication. According to the proposed solution, in case a failure occurs, other UEs in

the communication may be aware of the failure in time, and thus one or more further operations may be performed to maintain the communication.

**[0005]** In some implementations, there is provided a first relay UE. The first relay UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the first relay UE to: determine whether a trigger event is happened, wherein the trigger event comprises one of: receiving a first message from a second relay UE which communicates with a base station, executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and the second relay UE, wherein the first relay UE is connected to the base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that the trigger event is happened, transmit, to the remote UE, a second message.

**[0006]** In some implementations, there is provided a first relay UE. The first relay UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the first relay UE to: determine whether a trigger event is happened, wherein the trigger event comprises one of: executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and a remote UE, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that the trigger event is happened, transmit, to the second relay UE, a third message.

**[0007]** In some implementations, there is provided a remote UE. The remote UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the remote UE to: receive, from a first relay UE, a second message indicating a failure, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and initiate a re-establishment procedure based on the second message.

**[0008]** In some implementations, there is provided a second relay UE. The second relay UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the second relay UE to: receive, from a first relay UE, a third message indicating a failure, wherein the first relay UE is connected to a base station

via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and stop forwarding data towards the remote UE via the first relay UE.

**[0009]** In some implementations, there is provided a method performed by the first relay UE. The method comprises: determining whether a trigger event is happened, wherein the trigger event comprises one of: receiving a first message from a second relay UE which communicates with a base station, executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and the second relay UE, wherein the first relay UE is connected to the base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that the trigger event is happened, transmitting, to the remote UE, a second message.

**[0010]** In some implementations, there is provided a method performed by the first relay UE. The method comprises: determining whether a trigger event is happened, wherein the trigger event comprises one of: executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and a remote UE, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that the trigger event is happened, transmitting, to the second relay UE, a third message.

**[0011]** In some implementations, there is provided a method performed by the remote UE. The method comprises: receiving, from a first relay UE, a second message indicating a failure, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and initiating a re-establishment procedure based on the second message.

**[0012]** In some implementations, there is provided a method performed by the second relay UE. The method comprises: receiving, from a first relay UE, a third message indicating a failure, wherein the first relay UE is connected to a base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and stopping forwarding data towards the remote UE via the first relay UE.

**[0013]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and

configured to cause the processor to: determine whether a trigger event is happened, wherein the trigger event comprises one of: receiving a first message from a second relay UE which communicates with a base station, executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and the second relay UE, wherein the first relay UE is connected to the base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that the trigger event is happened, transmit, to the remote UE, a second message.

**[0014]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: determine whether a trigger event is happened, wherein the trigger event comprises one of: executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and a remote UE, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that the trigger event is happened, transmit, to the second relay UE, a third message.

**[0015]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a first relay UE, a second message indicating a failure, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and initiate a re-establishment procedure based on the second message.

**[0016]** In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a first relay UE, a third message indicating a failure, wherein the first relay UE is connected to a base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and stop forwarding data towards the remote UE via the first relay UE.

**[0017]** In some implementations of the methods and the first relay UE described herein, further comprising: receiving, from the second relay UE, the first message being a

notification message or a release message.

**[0018]** In some implementations of the methods and the first relay UE described herein, further comprising: initiating a re-establishment procedure based on receiving the first message.

**[0019]** In some implementations of the methods and the first relay UE described herein, further comprising: determining that an execution condition of the candidate cell for a conditional handover (CHO) is met; or receiving a handover command from a serving base station of the first relay UE.

**[0020]** In some implementations of the methods and the first relay UE described herein, further comprising: initiating a re-establishment procedure based on detecting a radio link failure (RLF) between the first relay UE and the second relay UE.

**[0021]** In some implementations of the methods and the first relay UE described herein, further comprising: detecting an RLF between the first relay UE and the remote UE.

**[0022]** In some implementations of the methods and the remote UE described herein, further comprising: in accordance with a determination that the re-established cell identifier or relay identifier is the same as that of the second relay UE, stopping initiating the re-establishment procedure.

**[0023]** In some implementations of the methods and the remote UE described herein, the second message indicates a failure between the first relay UE and the second relay UE or between the second relay UE and the base station, further comprising: receiving, from the first relay UE, a further notification message indicating that a re-establishment procedure of the first relay UE is successful.

**[0024]** In some implementations of the methods and the remote UE described herein, further comprising: in accordance with a determination that the remote UE is in an idle or inactive state and the link with the first relay UE is to be released, providing indication to an upper layer of the remote UE to release the link with the first relay UE.

**[0025]** In some implementations of the methods and the remote UE described herein, further comprising: in accordance with a determination that the remote UE is in an idle or inactive state and the link with the first relay UE is to be maintained, determining that a cell re-selection occurs.

**[0026]** In some implementations of the methods, the first relay UE, the second relay UE,

and the remote UE described herein, the first message is a notification message or a release message, wherein the notification message comprises a first failure type indicating one of the following: an RLF between the second relay UE and the base station, a handover of the second relay UE, a cell reselection of the second relay UE, a radio resource control (RRC) connection establishment failure of the second relay UE, or an RRC connection resume failure of the second relay UE.

**[0027]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the second message comprises a second failure type indicating one of the following: the RLF between the second relay UE and the base station, the handover of the second relay UE, the cell reselection of the second relay UE, the RRC connection establishment failure of the second relay UE, the RRC connection resume failure of the second relay UE, or a reception of the release message from the second relay UE.

**[0028]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the second message comprises a second failure type indicating that the re-establishment procedure of the first relay UE is failed.

**[0029]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the second message comprises: information indicating that the re-establishment procedure is successful, and a re-established cell identifier or relay identifier selected by the first relay UE for a re-establishment procedure of the first relay UE.

**[0030]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the second message comprises a second failure type indicating the handover of the first relay UE.

**[0031]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the second message comprises a second failure type indicating an RLF between the first relay UE and the second relay UE.

**[0032]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the third message comprises a third failure type indicating the handover of the first relay UE.

**[0033]** In some implementations of the methods, the first relay UE, the second relay UE, and the remote UE described herein, the third message indicates an RLF between the first relay UE and the remote UE, and the third message comprises an identifier of the remote UE.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0034]** FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

**[0035]** FIG. 2A illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

**[0036]** FIG. 2B illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

**[0037]** FIG. 3 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

**[0038]** FIG. 4 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

**[0039]** FIG. 5 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

**[0040]** FIG. 6 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

**[0041]** FIG. 7 illustrates an example of a device that is suitable for implementing embodiments of the present disclosure;

**[0042]** FIG. 8 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

**[0043]** FIG. 9 illustrates a flowchart of an example method implemented at a first relay UE in accordance with aspects of the present disclosure;

**[0044]** FIG. 10 illustrates a flowchart of an example method implemented at a first relay UE in accordance with aspects of the present disclosure;

**[0045]** FIG. 11 illustrates a flowchart of an example method implemented at a remote UE in accordance with aspects of the present disclosure; and

**[0046]** FIG. 12 illustrates a flowchart of an example method implemented at a second relay UE in accordance with aspects of the present disclosure.

**[0047]** Throughout the drawings, the same or similar reference numerals represent the same or similar element.

## DETAILED DESCRIPTION

**[0048]** 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.

**[0049]** 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.

**[0050]** 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.

**[0051]** 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.

**[0052]** 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 (CN) 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 a long term evolution (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 a new radio (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.

**[0053]** 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.

**[0054]** 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, message, 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.

**[0055]** 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.

**[0056]** 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 CN 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.

**[0057]** 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 (SL). For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

**[0058]** A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, 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 CN 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).

**[0059]** 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.

**[0060]** 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)).

**[0061]** 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 adaption 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.

**[0062]** 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).

**[0063]** 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.

**[0064]** The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include 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 CN 106.

**[0065]** The CN 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, 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 CN 106 via a network entity 102. The CN 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 CN 106 (e.g., one or more network functions of the CN 106).

**[0066]** 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.

**[0067]** 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., μ=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., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=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., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

**[0068]** 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.

**[0069]** 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., μ=0, μ=1, μ=2, μ=3, μ=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., μ=0)

associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

**[0070]** 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.

**[0071]** 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.

**[0072]** In the context of the present disclosure, the term "proximity communication 5 (PC5) link" may be used interchangeably with PC5 interface, sidelink (SL), PC5 unicast link, SL unicast link, device-to-device (D2D) link, user-to-user link, UE-to-UE (U2U) link, or the like. The term "relay UE" may be used interchangeably with U2N relay UE, U2U relay UE, layer 2 (L2) relay UE, L2 U2N relay UE, L2 U2U relay UE, or the like. The term "relay UE ID" may be used interchangeably with link ID, path ID, L2 relay UE ID, or the like.

**[0073]** In the present disclosure, a failure type may also be used interchangeably with a failure cause, a cause value, a cause type, etc., the present disclosure does not limit this aspect.

**[0074]** A wireless communications system may include one or more devices, such as one or more base stations and/or one or more UEs. In some implementations, two different UEs

may communicate with each other via a PC5 link (PC5 interface), two different base stations may communicate with each other via an Xn link (Xn interface), and a UE and a base station may communicate with each via a Uu link (Uu interface).

**[0075]** FIG. 2A illustrates a schematic diagram of an example communication network 210 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2A, a UE 211 may communicate with a base station via a relay UE. The base station may be a gNB 212 or an NG-eNB 213, and the relay UE may be a relay UE 214 or a relay UE 215. For example, the NG-eNB 213 may be an evolved long term evolution (eLTE) base station that supports an NG interface. In some embodiments, the sidelink transmission and reception over the PC5 link are supported when the UE 211 is inside Next Generation Radio Access Network (NG-RAN) coverage, irrespective of which RRC state the UE is in, and also supported when the UE 211 is outside NG-RAN coverage.

**[0076]** Sidelink relay is introduced to support 5G ProSe UE-to-Network (U2N) Relay function to provide connectivity to the network for U2N Remote UE. A U2N Relay UE shall be in RRC_CONNECTED to perform relaying of unicast data. For L2 U2N Relay operation, the following RRC state combinations are supported:

- Both L2 U2N Relay UE and L2 U2N Remote UE shall be in RRC_CONNECTED to perform transmission/reception of relayed unicast data; and

- The L2 U2N Relay UE can be in RRC_IDLE, RRC_INACTIVE or RRC_CONNECTED as long as all the L2 U2N Remote UE(s) that are connected to the L2 U2N Relay UE are either in RRC_INACTIVE or in RRC_IDLE.

**[0077]** A single unicast link is established between one L2 U2N Relay UE and one L2 U2N Remote UE. The traffic of L2 U2N Remote UE via a given L2 U2N Relay UE and the traffic of the L2 U2N Relay UE shall be separated in different Uu Relay RLC channels.

**[0078]** In some cases, more than one relay UE is needed for a communication of the U2N remote UE.

**[0079]** FIG. 2B illustrates a schematic diagram of an example communication network 220 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2B, the communication network 220 includes a remote UE 221-1 which is connected to the base station 224 via a relay UE 222-1 and a relay UE 223. The communication network 220 also include a remote UE 221-2 which is connected to the base station 224 via a relay UE 222-2 and a relay UE 223.

**[0080]** As shown in FIG. 2B, the relay UE 222-2 and the relay UE 223 are located in coverage of the base station 224, while the remote UE 221-1, the remote UE 221-2, and the relay UE 222-1 are outside the coverage of the base station 224.

**[0081]** For ease of description, the remote UE 221-1 and the remote UE 221-2 can be collectively or separately referred to as a remote UE 221, and the relay UE 222-1 and the relay UE 222-2 can be collectively or separately referred to as a first relay UE 222.

**[0082]** In the present disclosure, a remote UE 221 accesses the base station 224 via two relay UEs including a first relay UE and a second relay UE, and the first relay UE accesses (e.g. connects) the base station 224 via the second relay UE. For ease of description, the second relay UE may also be called as a parent relay UE, a first hop relay UE, a top relay UE, etc. For ease of description, the first relay UE may also be called as a child relay UE, a second hop relay UE, etc. With reference to FIG. 2B, the relay UE 222 may be the child relay UE or the first relay UE; and the relay UE 223 may be the parent relay UE or the second relay UE.

**[0083]** It is to be understood that the number of devices in FIG. 2B is given for the purpose of illustration without suggesting any limitations to the present disclosure. For example, there may be more relay UEs between the remote UE 221 and the base station 224.

**[0084]** In the scenario of a communication between the remote UE 221 and the base station 224 via the first relay UE 222 and the second relay UE 223, there may three links involved: a link between the second relay UE 223 and the base station 224, a link between the first relay UE 222 and the second relay UE 223, and a link between the remote UE 221 and the first relay UE 222. However, when the communication is disabled, a notification mechanism or a release mechanism needs to be discussed.

**[0085]** Reference is further made to FIG. 3, which illustrates a signalling chart illustrating communication process 300 in accordance with some example embodiments of the present disclosure. The process 300 may involve the remote UE 221, the first relay UE 222, the second relay UE 223, and the base station 224 as shown in FIG. 2B. It is to be understood that the process 300 may also be applied to another scenario different from that shown in FIG. 2B, the present disclosure does not limit this aspect.

**[0086]** The remote UE 221 is connected to the BS 224 via the first relay UE 222 and the second relay UE 223, where the second relay UE 223 connects to the BS 224 via a Uu interface, and the first relay UE 222 connects to the BS 224 via the second relay UE. In

some examples, the first relay UE 222 will access the BS 224 (i.e. serving gNB) via an L2 U2N relay UE (such as the second relay UE 223) before the remote UE 221 accesses the BS 224 via the two relay UEs 222 and 223.

**[0087]** In some examples, if the remote UE 221 is in an RRC connected (RRC_CONNECTED) state, an end-to-end RRC connection between the remote UE 221 and the BS 224 is established.

**[0088]** In the process 300, the second relay UE 223 transmits a first message to the first relay UE 222 at 310. In some implementations, the first message may be a notification message or a release message. The notification message is a PC5 RRC message. The release message could be a PC5-S message. The PC5-S layer is a layer above an access stratum (AS) layer. In some other implementations, the first message may be another type of message and the present disclosure does not limit this aspect.

**[0089]** In some implementations, when one of the following cases occurs, the second relay UE 223 may transmit the first message: Uu RLF of the second relay UE 223, a handover of the second relay UE 223, a cell reselection of the second relay UE 223, an RRC connection establishment failure of the second relay UE 223, or an RRC connection resume failure of the second relay UE 223. In some examples, the first message may be a notification message which includes a first failure type, for example, the first failure type may indicate one of the following: Uu RLF of the second relay UE 223, a handover of the second relay UE 223, a cell reselection of the second relay UE 223, an RRC connection establishment failure of the second relay UE 223, or an RRC connection resume failure of the second relay UE 223. In some other example, the first message may be a release message. For example, there is no failure type included in the release message.

**[0090]** In the process 300, the first relay UE 222 initiates a re-establishment procedure at 320 after receiving the first message. The first relay UE 222 transmits a second message to the remote UE 221 at 330 after receiving the first message. For example, the second message may be transmitted over a PC5 RRC link or a PC5-S link between the first relay UE 222 and the remote UE 221.

**[0091]** In some implementations, the operations 320 and 330 may be performed independently. In some examples, the second message may be a notification message or a release message which is transmitted over a PC5 RRC link between the first relay UE 222 and the remote UE 221.

**[0092]** In some examples, the second message is a notification message which include a second failure type. For example, the second failure type may be determined based on the received first message, for example, the second failure type may indicate one of: Uu RLF of the second relay UE 223, a handover of the second relay UE 223, a cell reselection of the second relay UE 223, an RRC connection establishment failure of the second relay UE 223, an RRC connection resume failure of the second relay UE 223, or a reception of a release message from the second relay UE 223 (e.g. the first message is a release message). In some examples, the second message may be a notification message which further includes information about whether the first relay UE 222 decides to keep the current PC5 link or not.

**[0093]** In some embodiments, whether the second message is a notification message or a release message may be determined based on a predefined principle. For example, the predefined principle may be one of principle 1, principle 2, principle 3, or principle 4 below.

**[0094]** Principle 1: if the first relay UE 222 receives a notification message (i.e. the first message is a notification message) from the second relay UE 223, then either a notification message or a release message may be used as the second message transmitted to the remote UE 221.

**[0095]** Principle 2: if the first relay UE 222 receives a notification message (i.e. the first message is a notification message) from the second relay UE 223, then only a notification message may be used as the second message transmitted to the remote UE 221.

**[0096]** Principle 3: if the first relay UE 222 receives a release message (i.e. the first message is a release message) from the second relay UE 223, then only a release message may be used as the second message transmitted to the remote UE 221.

**[0097]** Principle 4: if the first relay UE 222 receives a release message (i.e. the first message is a release message) from the second relay UE 223, then a notification message may be used as the second message transmitted to the remote UE 221. For example, the second message which is a notification message, may include a second failure type indicating a reception of the release message from the second relay UE 223.

**[0098]** In some other implementations, the second message at 330 may depend on a result of the re-establishment procedure of the first relay UE 222.

**[0099]** In some examples, the second message is transmitted after the re-establishment procedure of the first relay UE 222 is finished, for example, the re-establishment procedure of the first relay UE 222 may be successful or may be failed.

**[00100]** In some embodiments, the re-establishment procedure of the first relay UE 222 at 320 is successful, for example, the first relay UE 222 successfully completes its re-establishment procedure, then the second message may indicate that the re-establishment procedure of the first relay UE 222 is successful. In some examples, the second message may include a re-established cell ID or relay ID.

**[00101]** Alternatively, if the re-establishment procedure of the first relay UE 222 at 320 is successful and the same relay UE (the second relay UE 223) is selected, the second message may be omitted, that is, the first relay UE 222 may not transmit the second message to the remote UE 221.

**[00102]** In some other embodiments, the re-establishment procedure of the first relay UE 222 at 320 is failed, for example, the first relay UE 222 fails to complete its re-establishment procedure, then the second message may be a notification message which indicates that the re-establishment procedure of the first relay UE 222 is failed or may be a release message.

**[00103]** In the process 300, the remote UE 221 initiates a re-establishment procedure at 340 after receiving the second message.

**[00104]** In some implementations, the second message may indicate that a re-establishment procedure of the first relay UE 222 is successful, and the second message may include a re-established cell ID or relay ID, in this case, the remote UE 221 may determine whether the re-established cell ID or relay ID is the same as that of the second relay UE 223. In some examples, if the re-established cell ID or relay ID is the same as that of the second relay UE 223, the remote UE 221 may do nothing, for example, no re-establishment procedure is needed.

**[00105]** In some examples, if the re-established cell ID or relay ID is different from that of the second relay UE 223, the remote UE 221 may initiate the re-establishment procedure via the same relay UE (i.e. the first relay UE 222). For example, the remote UE 221 may perform a relay selection or a cell selection, and the same relay UE (i.e. the first relay UE 222) will be selected.

**[00106]** In some implementations, the second message may be a notification message which include a second failure type as described above, or the second message may be a release message, or the second message may indicate that a re-establishment procedure of the first relay UE 222 is failed, in this case, the remote UE 221 may initiate the re-establishment procedure. For example, the remote UE 221 may perform a relay reselection or a cell

reselection, for example, the same relay UE (i.e. the first relay UE 222) will not be selected, that is, the remote UE 221 will avoid selecting the same relay UE.

**[00107]** According to embodiments with reference to FIG. 3, the first relay UE 222 may transmit a second message to the remote UE 221 in case a first message is received from the second relay UE 223, therefore a re-establishment procedure may be initiated. However, it is to be appreciated that the operations shown in FIG. 3 are only for illustration without any limitation. For example, the second message at 330 may be omitted in case a re-establishment procedure is successful and the second relay UE 223 is still used. For example, the re-establishment procedure at 340 may be omitted in case the second message indicates a successful re-establishment procedure of the first relay UE 222 and the second relay UE 223 is still used.

**[00108]** In some other implementations, a further notification may be transmitted from the first relay UE 222 to the remote UE 221. In some examples, when the re-establishment procedure is initiated at 320, the first relay UE 222 may transmit the second message which may be a notification message indicating a failure. In some examples, the remote UE 221 may not initiate a re-establishment procedure after receiving the second message. In some examples, the PC5 link towards the second relay UE 223 may be suspended or continue being kept. In some examples, the first relay UE 222 may transmit the further notification message to the remote UE 221 after a completion of the re-establishment procedure (e.g. successful or failed).

**[00109]** FIG. 4 illustrates a signalling chart illustrating communication process 400 in accordance with some example embodiments of the present disclosure. The process 400 may involve the remote UE 221, the first relay UE 222, the second relay UE 223, and the base station 224 as shown in FIG. 2B. It is to be understood that the process 400 may also be applied to another scenario different from that shown in FIG. 2B, the present disclosure does not limit this aspect.

**[00110]** The remote UE 221 is connected to the BS 224 via the first relay UE 222 and the second relay UE 223, where the second relay UE 223 connects to the BS 224 via a Uu interface, and the first relay UE 222 connects to the BS 224 via the second relay UE. In some examples, the first relay UE 222 will access the BS 224 (i.e. serving gNB) via an L2 U2N relay UE (such as the second relay UE 223) before the remote UE 221 accesses the BS 224 via the two relay UEs 222 and 223.

**[00111]** In some examples, if the remote UE 221 is in an RRC connected (RRC_CONNECTED) state, an end-to-end RRC connection between the remote UE 221 and the BS 224 is established.

**[00112]** In the process 400, the first relay UE 222 executes a handover towards a candidate cell or a candidate relay UE at 410. For example, the candidate cell is provided by another base station different from the BS 224. For example, the candidate relay UE is different from the second relay UE 223.

**[00113]** In some implementations, the first relay UE 222 may be configured with a CHO configuration, in some examples, the first relay UE 222 may determine that an execution condition of the CHO candidate cell is met. In some other implementations, the first relay UE 222 may receive a handover command from its serving gNB (such as the BS 224).

**[00114]** In the process 400, the first relay UE 222 transmits a second message to the remote UE 221 at 420 and transmits a third message to the second relay UE 223 at 430.

**[00115]** In some implementations, the second and third messages may be triggered after the first relay UE 222 executes the handover towards the candidate cell or the candidate relay UE.

**[00116]** In some examples, the second message transmitted to the remote UE 221 may be a notification message or a release message. For example, the notification message may include a second failure type indicating a handover of the first relay UE 222. For example, the second failure type may be a newly defined value or an existing value associated with a handover.

**[00117]** In some examples, the third message transmitted to the second relay UE 223 may be a notification message or a release message or a newly defined PC5 message. For example, the third message may include a failure type indicating a handover of the first relay UE 222.

**[00118]** In addition or alternatively, the remote UE 221 may initiate a re-establishment procedure at 440. The second relay UE 223 may stop forwarding data towards the remote UE 221 at 450.

**[00119]** According to embodiments with reference to FIG. 4, in case a handover of the first relay UE 222 occurs, it may notify the remote UE 221 and the second relay UE 223 of the handover, in this case, the remote UE 221 and the second relay UE 223 may be aware of the handover, and thus one or more necessary operations may be performed. For example, a

re-establishment procedure may be initiated by the remote UE 221, to make sure that a communication between the remote UE 221 and the BS 224 is performed. For example, the forwarding of data towards the remote UE 221 may be stopped by the second relay UE 223, therefore, the transmission resource may be used for other communications.

**[00120]** FIG. 5 illustrates a signalling chart illustrating communication process 500 in accordance with some example embodiments of the present disclosure. The process 500 may involve the remote UE 221, the first relay UE 222, the second relay UE 223, and the base station 224 as shown in FIG. 2B. It is to be understood that the process 500 may also be applied to another scenario different from that shown in FIG. 2B, the present disclosure does not limit this aspect.

**[00121]** The remote UE 221 is connected to the BS 224 via the first relay UE 222 and the second relay UE 223, where the second relay UE 223 connects to the BS 224 via a Uu interface, and the first relay UE 222 connects to the BS 224 via the second relay UE. In some examples, the first relay UE 222 will access the BS 224 (i.e. serving gNB) via an L2 U2N relay UE (such as the second relay UE 223) before the remote UE 221 accesses the BS 224 via the two relay UEs 222 and 223.

**[00122]** In some examples, if the remote UE 221 is in an RRC connected (RRC_CONNECTED) state, an end-to-end RRC connection between the remote UE 221 and the BS 224 is established.

**[00123]** In the process 500, the first relay UE 222 detects an RLF between the first relay UE 222 and the second relay UE 223 at 510. In some implementations, the first relay UE 222 may detect whether the sidelink between the first relay UE 222 and the second relay UE 223 is failed.

**[00124]** In the process 500, the first relay UE 222 initiates a re-establishment procedure at 520 after detecting the RLF between the first relay UE 222 and the second relay UE 223. The first relay UE 222 transmits a second message to the remote UE 221 at 530 after detecting the RLF between the first relay UE 222 and the second relay UE 223. For example, the second message may be transmitted over a PC5 RRC link or a PC5-S link between the first relay UE 222 and the remote UE 221.

**[00125]** In some implementations, the second message at 530 may be a notification message which includes a second failure type. In some examples, the second failure type may indicate the RLF between the first relay UE 222 and the second relay UE 223.

**[00126]** In the process 500, the remote UE 221 initiates a re-establishment procedure at 540 after receiving the second message.

**[00127]** In some implementations, if the remote UE 221 is in an idle or inactive state and the PC5-RRC connection with the first relay UE 222 is determined to be released, then an upper layer of the remote UE 221 may be instructed to trigger the PC5 unicast link release. For example, an RRC layer of the remote UE 221 may provide an indication to the PC5-S layer of the remote UE 221.

**[00128]** In some implementations, if the remote UE 221 is in an idle or inactive state and the remote UE 221 decides to maintain the PC5 RRC connection with the first relay UE 222, then the remote UE 221 may consider that a cell re-selection occurs.

**[00129]** According to embodiments with reference to FIG. 5, in case an RLF between the first relay UE 222 and the second relay UE 223 occurs, the second message may be transmitted to the remote UE 221, in this case, the remote UE 221 may be aware of the RLF between the first relay UE 222 and the second relay UE 223, and thus one or more necessary operations may be performed. For example, the PC5 RRC connection may be released or be maintained by the remote UE 221.

**[00130]** FIG. 6 illustrates a signalling chart illustrating communication process 600 in accordance with some example embodiments of the present disclosure. The process 600 may involve the remote UE 221, the first relay UE 222, the second relay UE 223, and the base station 224 as shown in FIG. 2B. It is to be understood that the process 600 may also be applied to another scenario different from that shown in FIG. 2B, the present disclosure does not limit this aspect.

**[00131]** The remote UE 221 is connected to the BS 224 via the first relay UE 222 and the second relay UE 223, where the second relay UE 223 connects to the BS 224 via a Uu interface, and the first relay UE 222 connects to the BS 224 via the second relay UE. In some examples, the first relay UE 222 will access the BS 224 (i.e. serving gNB) via an L2 U2N relay UE (such as the second relay UE 223) before the remote UE 221 accesses the BS 224 via the two relay UEs 222 and 223.

**[00132]** In some examples, if the remote UE 221 is in an RRC connected (RRC_CONNECTED) state, an end-to-end RRC connection between the remote UE 221 and the BS 224 is established.

**[00133]** In the process 600, the first relay UE 222 detects an RLF between the first relay UE

222 and the remote UE 221. In some implementations, the first relay UE 222 may detect whether the sidelink between the first relay UE 222 and the remote UE 221 is failed.

**[00134]** In the process 600, the first relay UE 222 transmits a third message to the second relay UE 223 at 620 after detecting the RLF between the first relay UE 222 and the remote UE 221. For example, the third message may be transmitted over a PC5 RRC link or a PC5-S link between the first relay UE 222 and the second relay UE 223.

**[00135]** In some implementations, the third message at 620 may include an ID of the remote UE 221, such as a local UE ID for the remote UE 221.

**[00136]** In the process 600, the second relay UE 223 stops forwarding data towards the remote UE 221.

**[00137]** According to embodiments with reference to FIG. 6, in case an RLF between the first relay UE 222 and the remote UE 221 occurs, the third message may be transmitted to the second relay UE 223, in this case, the second relay UE 223 may be aware of the RLF between the first relay UE 222 and the remote UE 221, and thus one or more necessary operations may be performed. For example, the forwarding of data towards the remote UE 221 may be stopped by the second relay UE 223, therefore, the transmission resource may be used for other communications.

**[00138]** According to embodiments shown in FIGS. 3-6, an issue of how to handle failure in U2N relay with two relay UEs is solved, therefore, the UE behavior for the relay UEs and the remote UE are defined and a U2N communication is guaranteed.

**[00139]** FIG. 7 illustrates an example of a device 700 that is suitable for implementing embodiments of the present disclosure. The device 700 may be an example of a RAN node as described herein. The device 700 may support wireless communication with the remote UE 221, the first relay UE 222, the second relay UE 223, or any combination thereof. The device 700 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 702, a memory 704, a transceiver 706, and, optionally, an I/O controller 708. 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).

**[00140]** The processor 702, the memory 704, the transceiver 706, 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 702, the memory 704, the transceiver 706, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

**[00141]** In some implementations, the processor 702, the memory 704, the transceiver 706, 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 702 and the memory 704 coupled with the processor 702 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 702, instructions stored in the memory 704).

**[00142]** For example, the processor 702 may support wireless communication at the device 700 in accordance with examples as disclosed herein. The processor 702 may be configured to operable to support a means for actions discussed above.

**[00143]** The processor 702 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 702 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 702. The processor 702 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 704) to cause the device 700 to perform various functions of the present disclosure.

**[00144]** The memory 704 may include random access memory (RAM) and read-only memory (ROM). The memory 704 may store computer-readable, computer-executable code including instructions that, when executed by the processor 702 cause the device 700 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 702 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In

some implementations, the memory 704 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.

**[00145]** The I/O controller 708 may manage input and output signals for the device 700. The I/O controller 708 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 708 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 708 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 708 may be implemented as part of a processor, such as the processor 706. In some implementations, a user may interact with the device 700 via the I/O controller 708 or via hardware components controlled by the I/O controller 708.

**[00146]** In some implementations, the device 700 may include a single antenna 710. However, in some other implementations, the device 700 may have more than one antenna 710 (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 706 may communicate bi-directionally, via the one or more antennas 710, wired, or wireless links as described herein. For example, the transceiver 706 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 706 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 710 for transmission, and to demodulate packets received from the one or more antennas 710. The transceiver 706 may include one or more transmit chains, one or more receive chains, or a combination thereof.

**[00147]** 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 710 for transmitting the amplified signal into the air or wireless medium.

**[00148]** 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 710 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.

**[00149]** FIG. 8 illustrates an example of a processor 800 that is suitable for implementing some embodiments of the present disclosure. The processor 800 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 800 may include a controller 802 configured to perform various operations in accordance with examples as described herein. The processor 800 may optionally include at least one memory 804, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 800 may optionally include one or more arithmetic-logic units (ALUs) 806. 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).

**[00150]** The processor 800 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 800) 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).

**[00151]** The controller 802 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 800 to cause the processor 800 to support various operations in accordance with examples as described herein.

For example, the controller 802 may operate as a control unit of the processor 800, generating control signals that manage the operation of various components of the processor 800. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

**[00152]** The controller 802 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 804 and determine subsequent instruction(s) to be executed to cause the processor 800 to support various operations in accordance with examples as described herein. The controller 802 may be configured to track memory address of instructions associated with the memory 804. The controller 802 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 802 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 800 to cause the processor 800 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 802 may be configured to manage flow of data within the processor 800. The controller 802 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 800.

**[00153]** The memory 804 may include one or more caches (e.g., memory local to or included in the processor 800 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 804 may reside within or on a processor chipset (e.g., local to the processor 800). In some other implementations, the memory 804 may reside external to the processor chipset (e.g., remote to the processor 800).

**[00154]** The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 800, cause the processor 800 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 802 and/or the processor 800 may be configured to execute computer-readable instructions stored in the memory 804 to cause the processor 800 to perform various functions. For example, the processor 800 and/or the controller 802 may be coupled with or to the memory 804, the processor 800, the controller 802, and the memory 804 may be configured to perform various functions described herein. In some examples, the processor 800 may include multiple processors and the memory 804 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.

**[00155]** The one or more ALUs 806 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 806 may reside within or on a processor chipset (e.g., the processor 800). In some other implementations, the one or more ALUs 806 may reside external to the processor chipset (e.g., the processor 800). One or more ALUs 806 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 806 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 806 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 806 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 806 to handle conditional operations, comparisons, and bitwise operations.

**[00156]** The processor 800 may support wireless communication in accordance with examples as disclosed herein. The processor 800 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

**[00157]** FIG. 9 illustrates a flowchart of a method 900 performed by a first relay UE in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by the first relay UE 222 in FIG. 2B. 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.

**[00158]** At 910, the method may include receiving a first message from a second relay UE which communicates with a base station, executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and the second relay UE, wherein the first relay UE is connected to the base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 910 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by the first relay UE 222 as described with reference to FIG. 2B.

**[00159]** At 920, the method may include in accordance with a determination that the trigger event is happened, transmitting, to the remote UE, a second message. The operations of 920 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 920 may be performed by the first relay UE 222 as described with reference to FIG. 2B.

**[00160]** FIG. 10 illustrates a flowchart of a method 1000 performed by a first relay UE in accordance with aspects of the present disclosure. The operations of the method 1000 may be implemented by a device or its components as described herein. For example, the operations of the method 1000 may be performed by the first relay UE 222 in FIG. 2B. 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.

**[00161]** At 1010, the method may include determining whether a trigger event is happened, wherein the trigger event comprises one of: executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and a remote UE, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 1010 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1010 may be performed by the first relay UE 222 as described with reference to FIG. 2B.

**[00162]** At 1020, the method may include in accordance with a determination that the trigger event is happened, transmitting, to the second relay UE, a third message. The operations of 1020 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1020 may be performed by the first relay UE 222 as described with reference to FIG. 2B.

**[00163]** FIG. 11 illustrates a flowchart of a method 1100 performed by a remote UE in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by the remote UE 221 in FIG. 2B. 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.

**[00164]** At 1110, the method may include receiving, from a first relay UE, a second message indicating a failure, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by the remote UE 221 as described with reference to FIG. 2B.

**[00165]** At 1120, the method may include initiating a re-establishment procedure based on the second message. The operations of 1120 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1120 may be performed by the remote UE 221 as described with reference to FIG. 2B.

**[00166]** FIG. 12 illustrates a flowchart of a method 1200 performed by a second rely UE in accordance with aspects of the present disclosure. The operations of the method 1200 may be implemented by a device or its components as described herein. For example, the operations of the method 1200 may be performed by the second relay UE 223 in FIG. 2B. 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.

**[00167]** At 1210, the method may include receiving, from a first relay UE, a third message indicating a failure, wherein the first relay UE is connected to a base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by the second relay UE 223 as described with reference to FIG. 2B.

**[00168]** At 1220, the method may include stopping forwarding data towards the remote UE via the first relay UE. The operations of 1220 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1220 may be performed by the second relay UE 223 as described with reference to FIG. 2B.

**[00169]** 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.

**[00170]** 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.

**[00171]** 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.

**[00172]** 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.

**[00173]** 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.

**[00174]** 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

What is claimed is:

1. A first relay user equipment (UE) comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the first relay UE to:

determine whether a trigger event is happened, wherein the trigger event comprises one of: receiving a first message from a second relay UE which communicates with a base station, executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and the second relay UE, wherein the first relay UE is connected to the base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and

in accordance with a determination that the trigger event is happened, transmit, to the remote UE, a second message.

2. The first relay UE of claim 1, wherein the first message is a notification message or a release message, and wherein the notification message comprises a first failure type indicating one of the following:

a radio link failure (RLF) between the second relay UE and the base station,

a handover of the second relay UE,

a cell reselection of the second relay UE,

a radio resource control (RRC) connection establishment failure of the second relay UE, or

an RRC connection resume failure of the second relay UE.

3. The first relay UE of claim 2, wherein the second message comprises a second failure type indicating one of the following:

the RLF between the second relay UE and the base station,

the handover of the second relay UE,

the cell reselection of the second relay UE,

the RRC connection establishment failure of the second relay UE,

the RRC connection resume failure of the second relay UE, or

a reception of the release message from the second relay UE.

4. The first relay UE of claim 2, wherein the at least one processor is further configured to cause the first relay UE to:

initiate a re-establishment procedure based on receiving the first message.

5. The first relay UE of claim 4, wherein the second message comprises a second failure type indicating that the re-establishment procedure of the first relay UE is failed.

6. The first relay UE of claim 4, wherein the second message comprises:

information indicating that the re-establishment procedure is successful, and

a re-established cell identifier or relay identifier selected by the first relay UE for the re-establishment procedure.

7. The first relay UE of claim 1, wherein the at least one processor is further configured to cause the first relay UE to:

determine that an execution condition of the candidate cell for a conditional handover (CHO) is met; or

receive a handover command from a serving base station of the first relay UE.

8. The first relay UE of claim 7, wherein the second message comprises a second failure type indicating the handover of the first relay UE.

9. The first relay UE of claim 1, wherein the at least one processor is further configured to cause the first relay UE to:

initiate a re-establishment procedure based on detecting an RLF between the first relay UE and the second relay UE, and

wherein the second message comprises a second failure type indicating the RLF between the first relay UE and the second relay UE.

10. A first relay user equipment (UE) comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the first relay UE to:

determine whether a trigger event is happened, wherein the trigger event

comprises one of: executing a handover towards a candidate cell or a candidate relay UE, or detecting a failure between the first relay UE and a remote UE, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and

in accordance with a determination that the trigger event is happened, transmit, to the second relay UE, a third message.

11. The first relay UE of claim 10, wherein the at least one processor is further configured to cause the first relay UE to:

determine that an execution condition of the candidate cell for a conditional handover (CHO) is met; or

receive a handover command from a serving base station of the first relay UE.

12. The first relay UE of claim 11, wherein the third message comprises a third failure type indicating the handover of the first relay UE.

13. The first relay UE of claim 10, wherein the at least one processor is further configured to cause the first relay UE to:

detect a radio link failure (RLF) between the first relay UE and the remote UE, and

wherein the third message indicates the RLF between the first relay UE and the remote UE, and the third message comprises an identifier of the remote UE.

14. A remote user equipment (UE) comprising:

at least one memory; and

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

receive, from a first relay UE, a second message indicating a failure, wherein the first relay UE is connected to a base station via a second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and

initiate a re-establishment procedure based on the second message.

15. The remote UE of claim 14, wherein the second message comprises a second failure type indicating one of the following:

a radio link failure (RLF) between the second relay UE and the base station,

a handover of the second relay UE,

a cell reselection of the second relay UE,

a radio resource control (RRC) connection establishment failure of the second relay UE,

an RRC connection resume failure of the second relay UE, or

a reception of a release message from the second relay UE.

16. The remote UE of claim 14, wherein the second message comprises a second failure type indicating that a re-establishment procedure of the first relay UE is failed.

17. The remote UE of claim 14, wherein the second message comprises:

information indicating that the re-establishment procedure is successful, and

a re-established cell identifier or relay identifier selected by the first relay UE for a re-establishment procedure of the first relay UE.

18. A second relay user equipment (UE) comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the second relay UE to:

receive, from a first relay UE, a third message indicating a failure, wherein the first relay UE is connected to a base station via the second relay UE, and wherein a remote UE is connected to the base station via the first relay UE and the second relay UE; and

stop forwarding data towards the remote UE via the first relay UE.

19. The second relay UE of claim 18, wherein the third message comprises a third failure type indicating a handover of the first relay UE.

20. The second relay UE of claim 18, wherein the third message indicates a radio link failure (RLF) between the first relay UE and the remote UE, and the third message comprises an identifier of the remote UE.

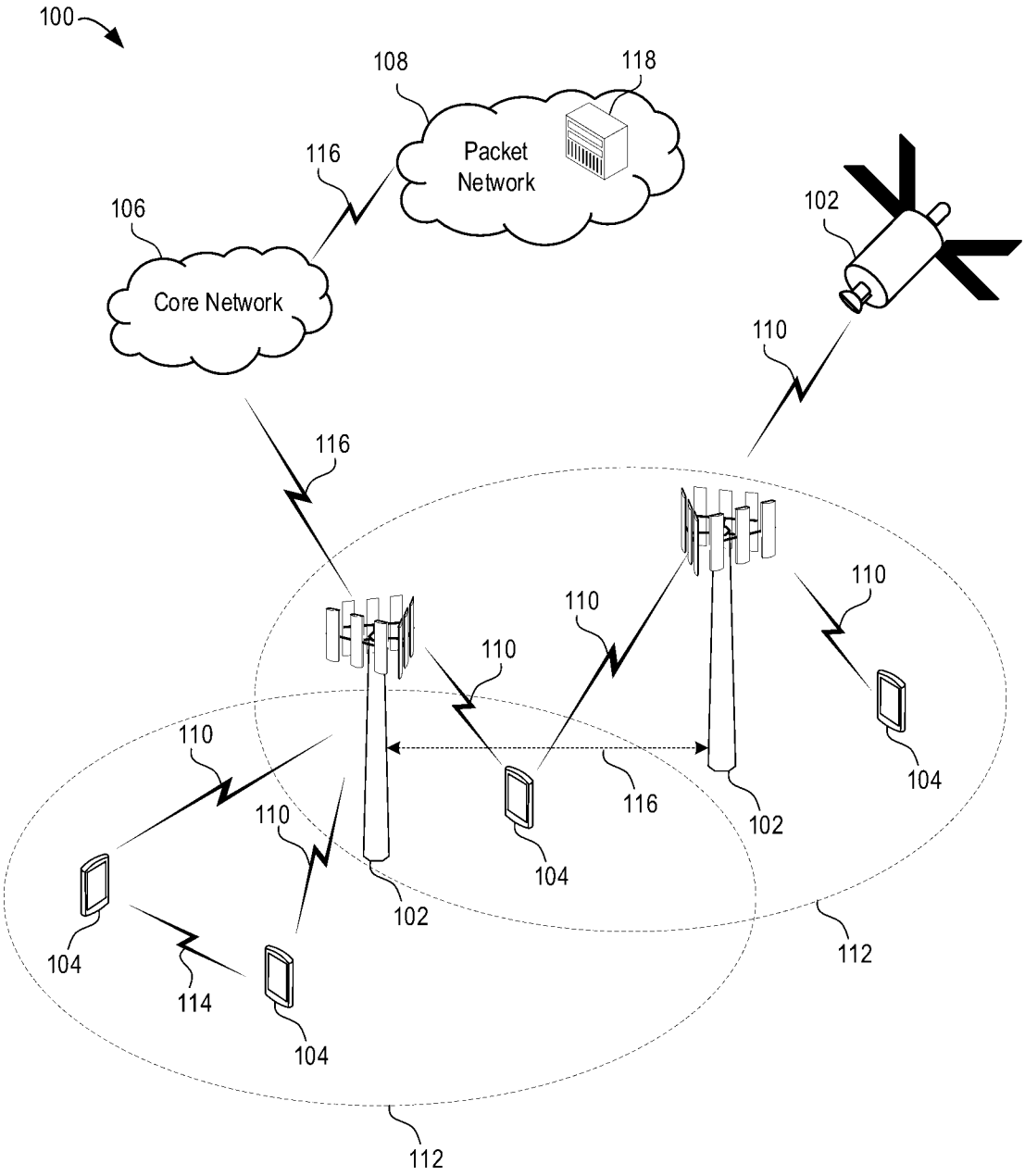
100
108
118
Packet Network
116
106
Core Network
102
110
116
110
110
110
110
104
116
102
110
110
104
102
104
114
104
112
112

FIG. 1

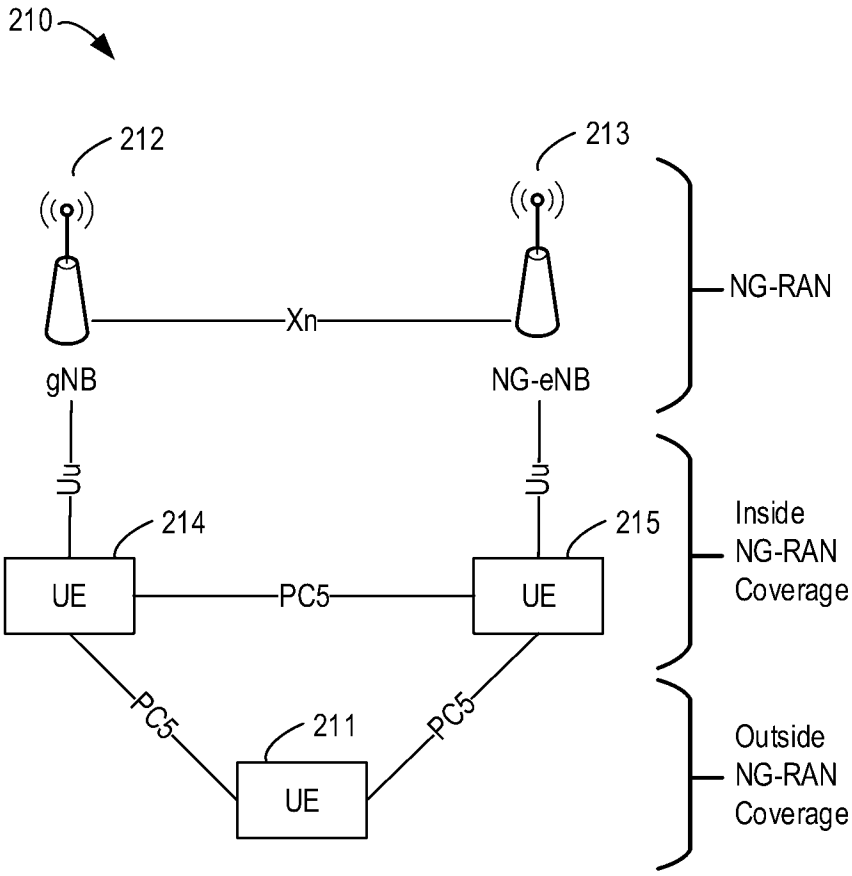
210
212
213
Xn
NG-RAN
gNB
NG-eNB
Uu
Uu
214
215
UE
PC5
UE
Inside
NG-RAN
Coverage
PC5
PC5
211
UE
Outside
NG-RAN
Coverage

FIG. 2A

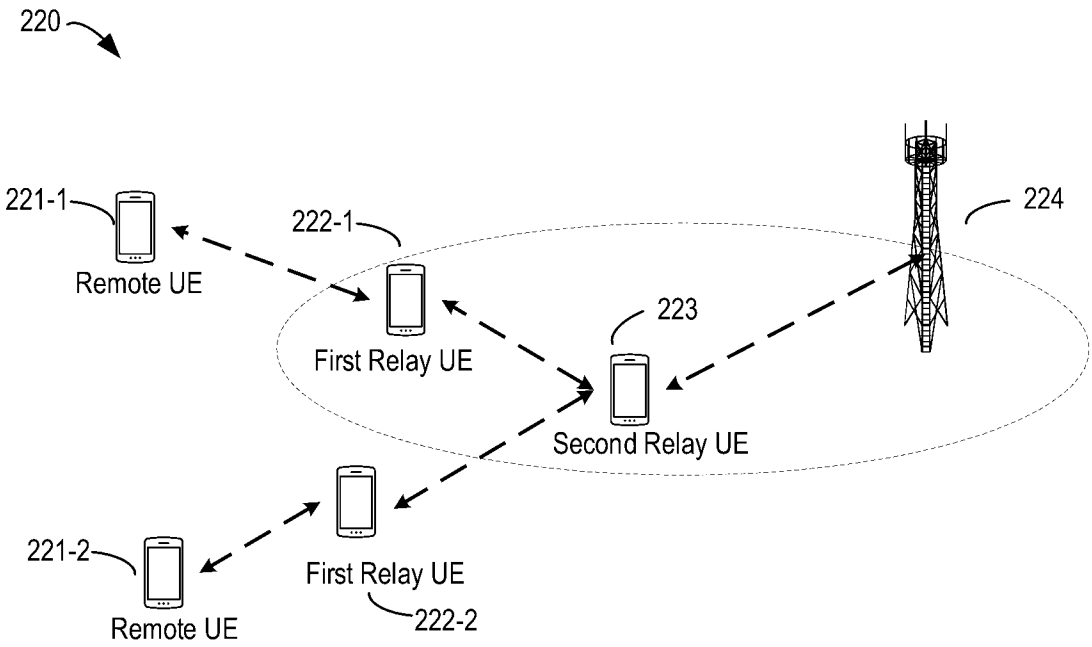
220
221-1
Remote UE
222-1
First Relay UE
223
Second Relay UE
224
221-2
Remote UE
First Relay UE
222-2

FIG. 2B

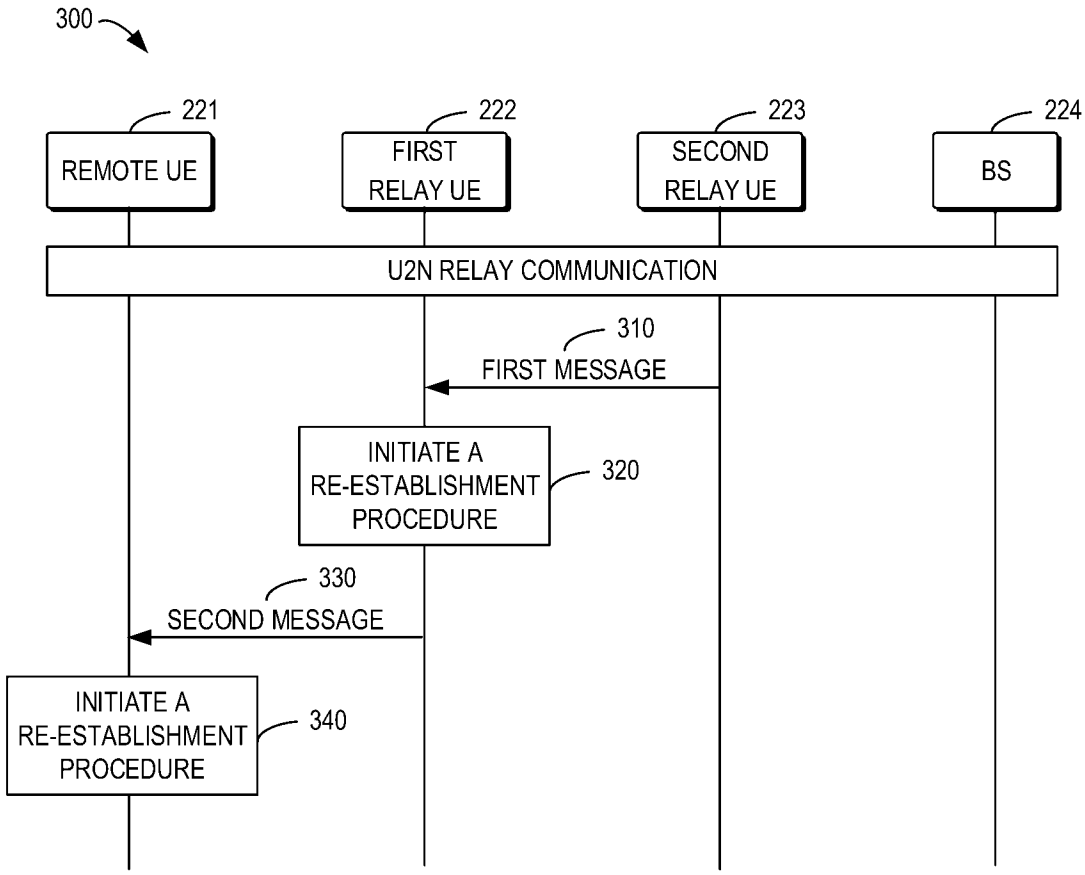
300
221
REMOTE UE
222
FIRST RELAY UE
223
SECOND RELAY UE
224
BS
U2N RELAY COMMUNICATION
310
FIRST MESSAGE
INITIATE A RE-ESTABLISHMENT PROCEDURE
320
330
SECOND MESSAGE
INITIATE A RE-ESTABLISHMENT PROCEDURE
340

**FIG. 3**

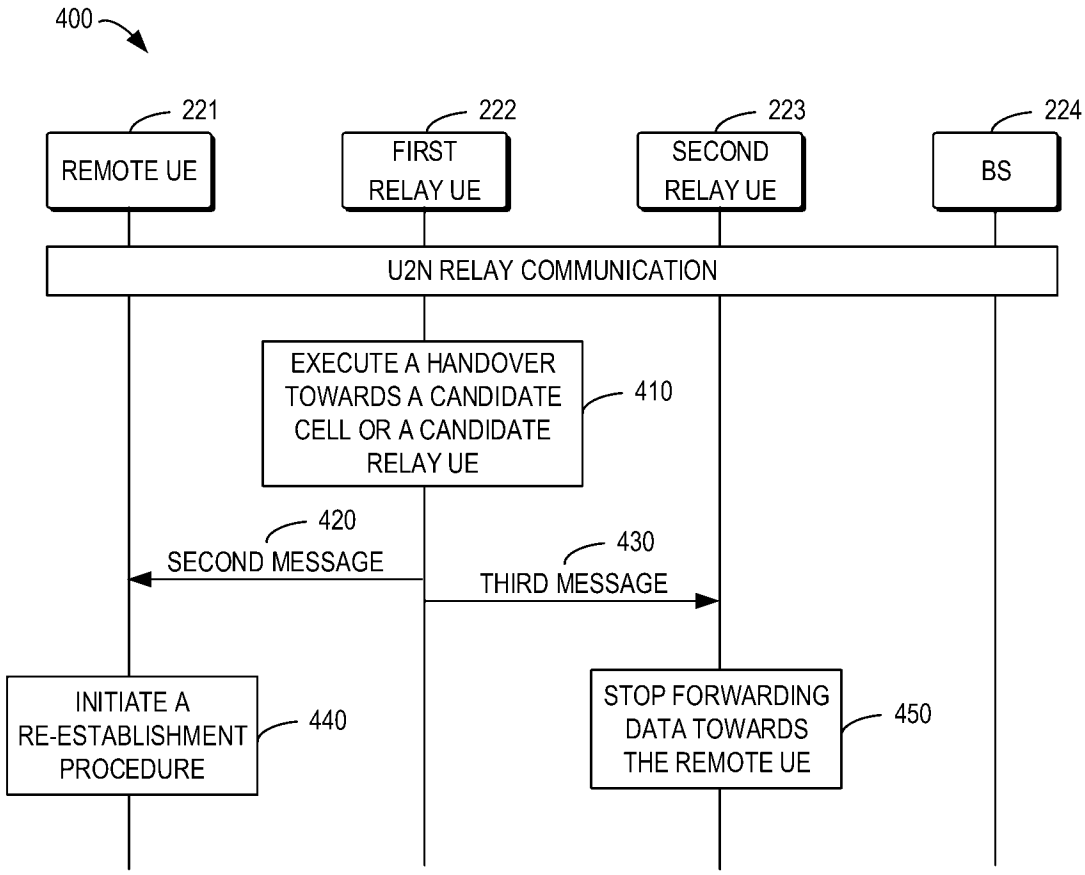
400
221
REMOTE UE
222
FIRST RELAY UE
223
SECOND RELAY UE
224
BS
U2N RELAY COMMUNICATION
EXECUTE A HANDOVER TOWARDS A CANDIDATE CELL OR A CANDIDATE RELAY UE
410
420
SECOND MESSAGE
430
THIRD MESSAGE
INITIATE A RE-ESTABLISHMENT PROCEDURE
440
STOP FORWARDING DATA TOWARDS THE REMOTE UE
450

**FIG. 4**

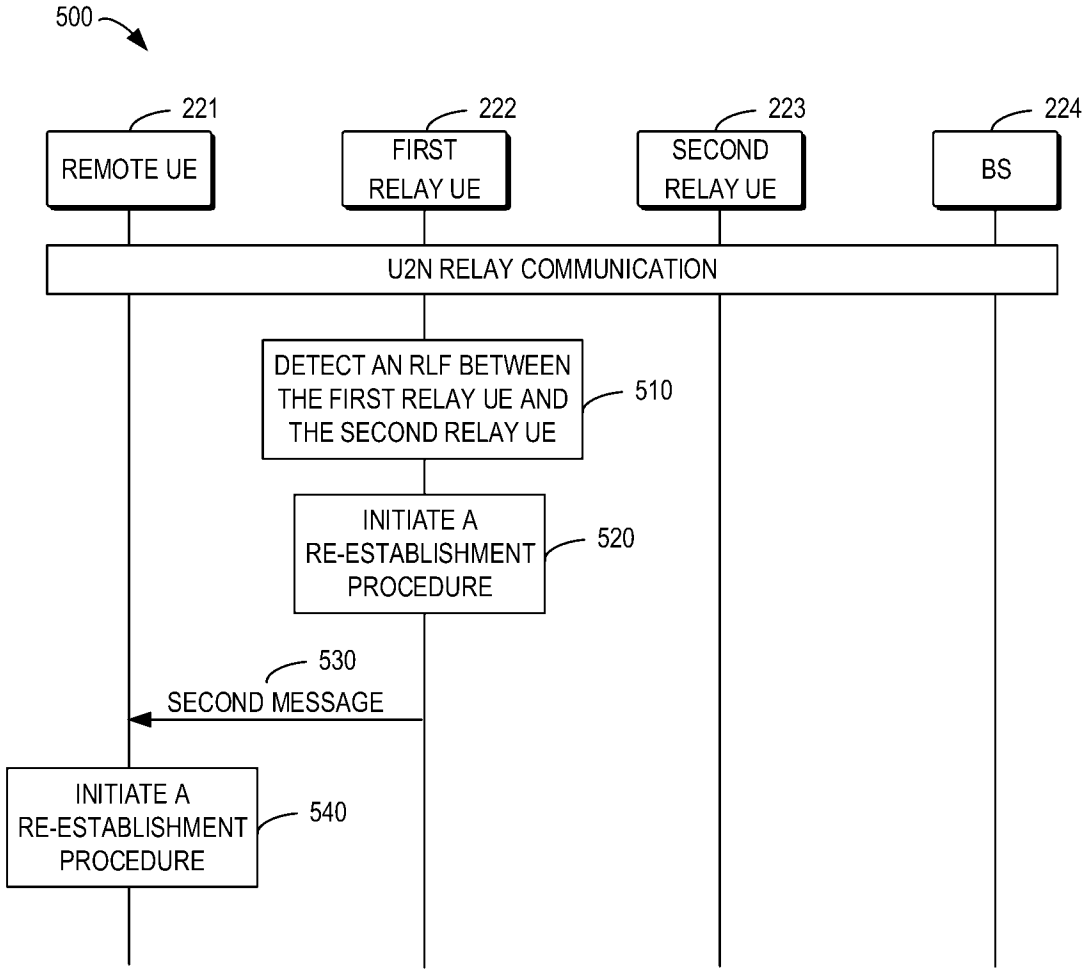
500
221
REMOTE UE
222
FIRST RELAY UE
223
SECOND RELAY UE
224
BS
U2N RELAY COMMUNICATION
DETECT AN RLF BETWEEN THE FIRST RELAY UE AND THE SECOND RELAY UE
510
INITIATE A RE-ESTABLISHMENT PROCEDURE
520
530
SECOND MESSAGE
INITIATE A RE-ESTABLISHMENT PROCEDURE
540

**FIG. 5**

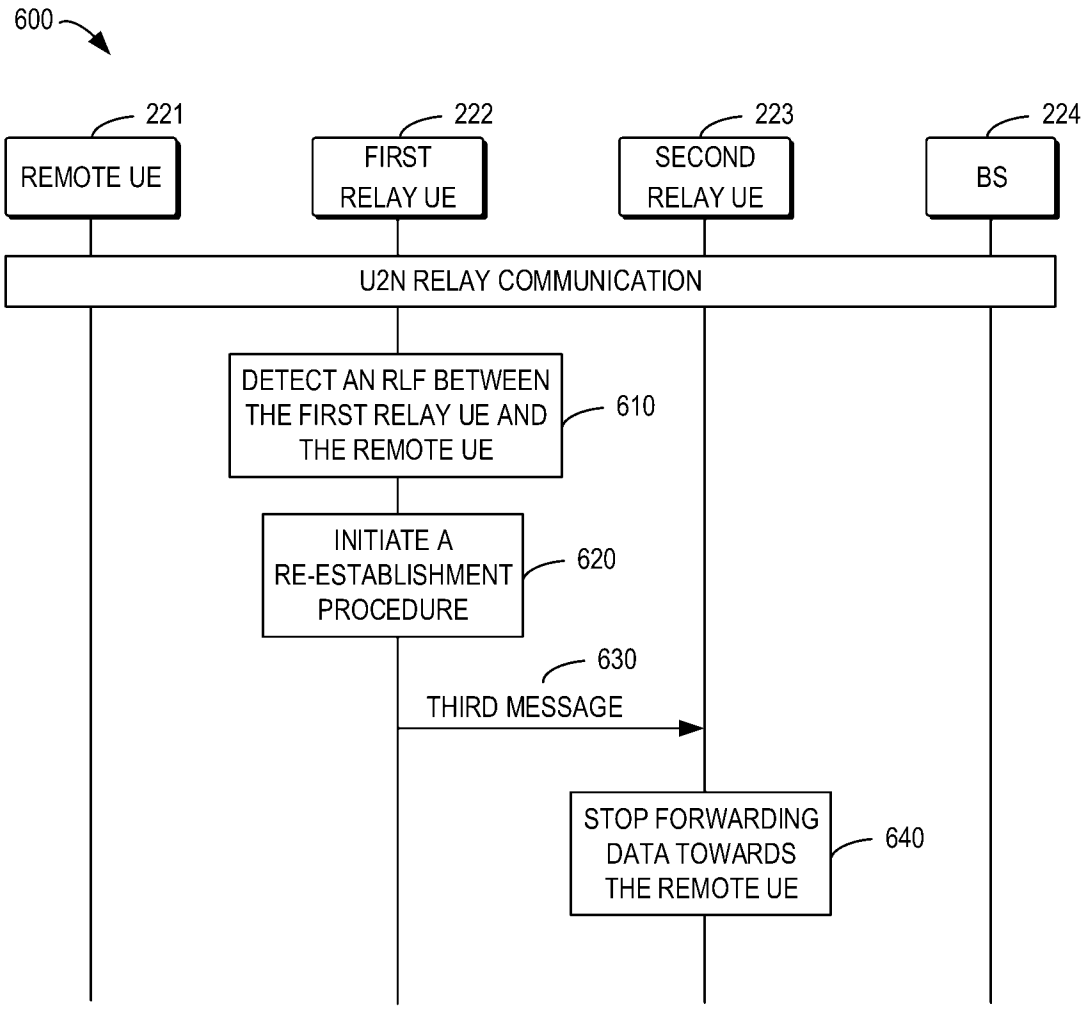
600
221
REMOTE UE
222
FIRST RELAY UE
223
SECOND RELAY UE
224
BS
U2N RELAY COMMUNICATION
DETECT AN RLF BETWEEN THE FIRST RELAY UE AND THE REMOTE UE
610
INITIATE A RE-ESTABLISHMENT PROCEDURE
620
630
THIRD MESSAGE
STOP FORWARDING DATA TOWARDS THE REMOTE UE
640

**FIG. 6**

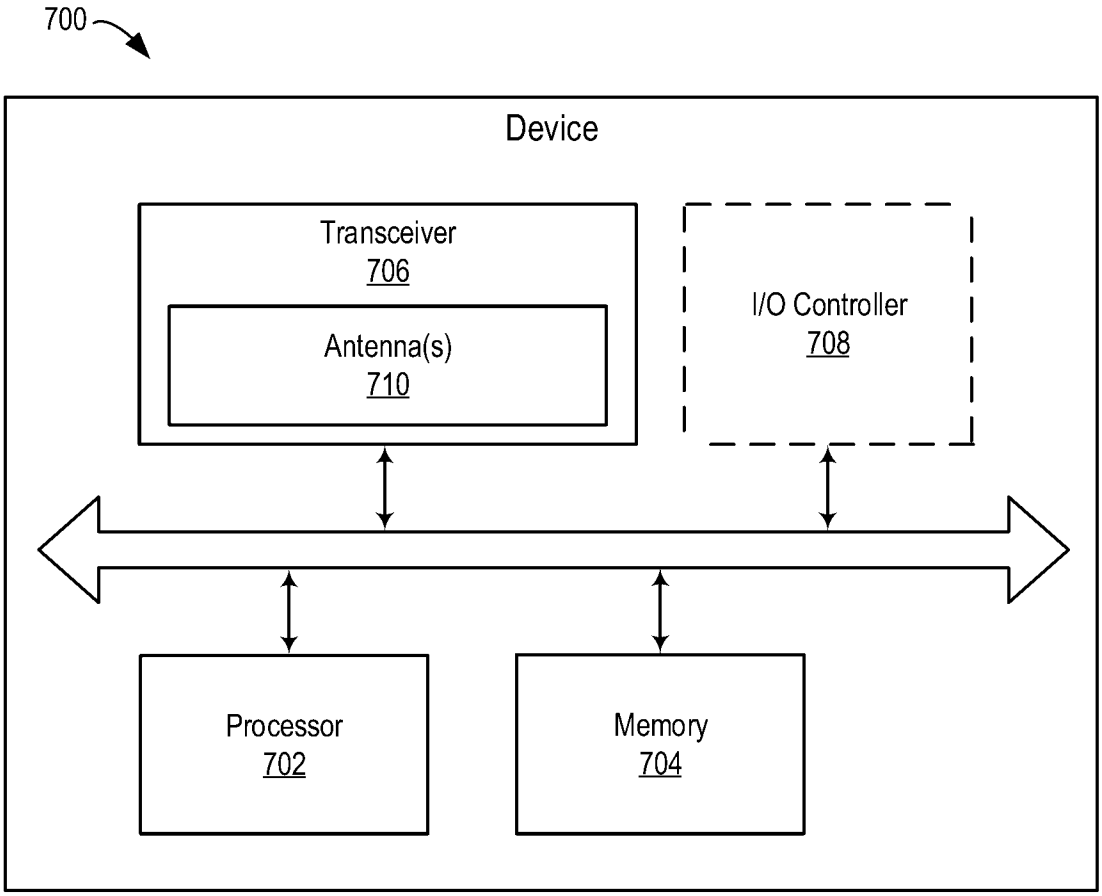
700
Device
Transceiver
706
Antenna(s)
710
I/O Controller
708
Processor
702
Memory
704

FIG. 7

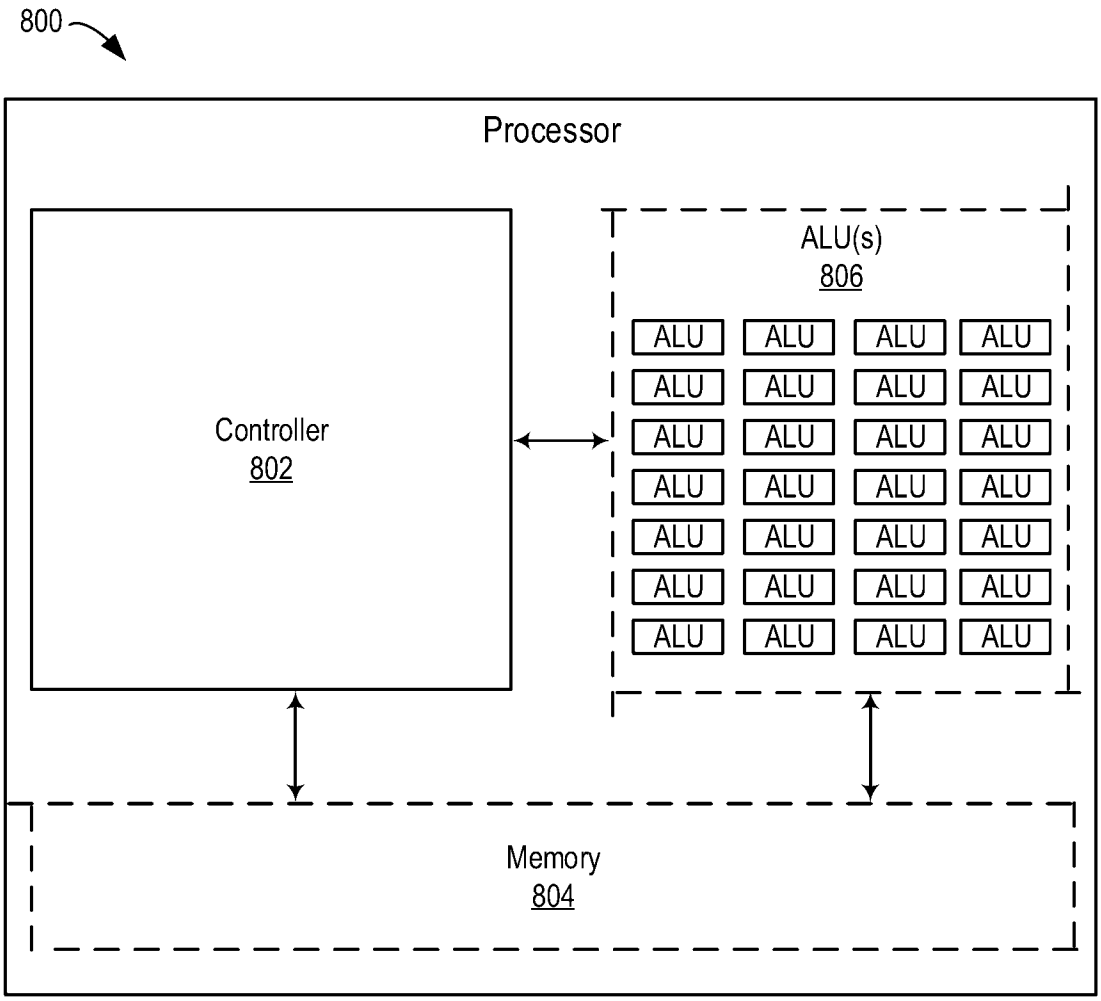


FIG. 8

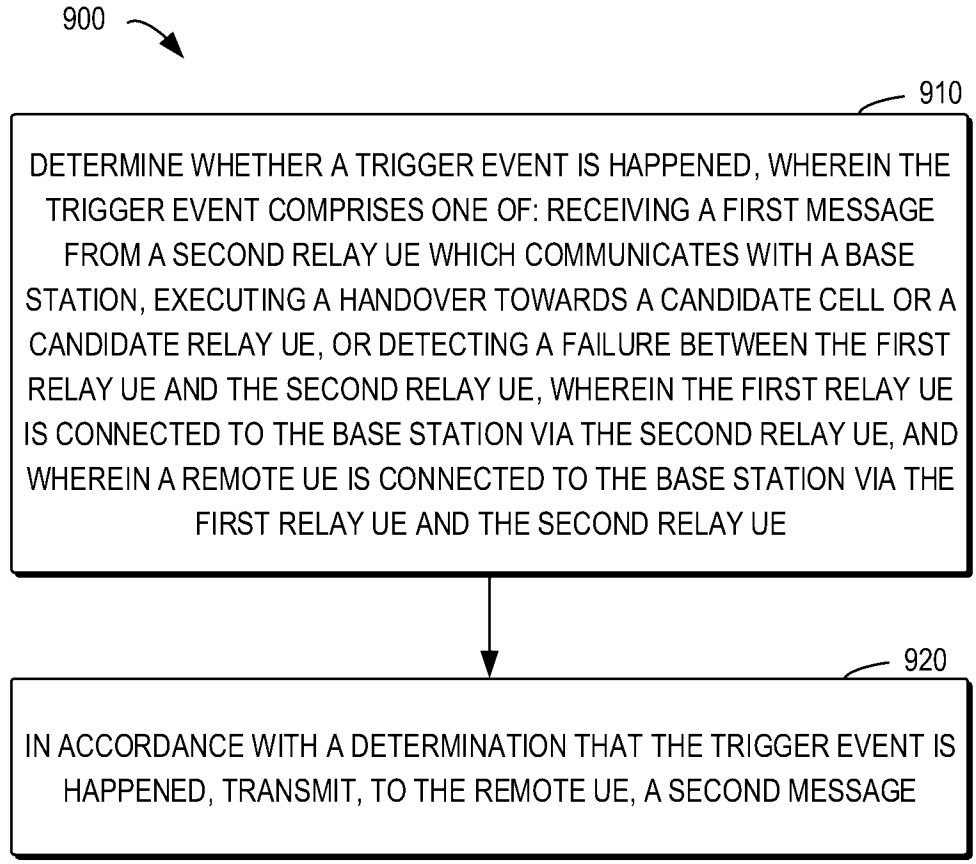
900
910
DETERMINE WHETHER A TRIGGER EVENT IS HAPPENED, WHEREIN THE TRIGGER EVENT COMPRISES ONE OF: RECEIVING A FIRST MESSAGE FROM A SECOND RELAY UE WHICH COMMUNICATES WITH A BASE STATION, EXECUTING A HANDOVER TOWARDS A CANDIDATE CELL OR A CANDIDATE RELAY UE, OR DETECTING A FAILURE BETWEEN THE FIRST RELAY UE AND THE SECOND RELAY UE, WHEREIN THE FIRST RELAY UE IS CONNECTED TO THE BASE STATION VIA THE SECOND RELAY UE, AND WHEREIN A REMOTE UE IS CONNECTED TO THE BASE STATION VIA THE FIRST RELAY UE AND THE SECOND RELAY UE
920
IN ACCORDANCE WITH A DETERMINATION THAT THE TRIGGER EVENT IS HAPPENED, TRANSMIT, TO THE REMOTE UE, A SECOND MESSAGE

**FIG. 9**

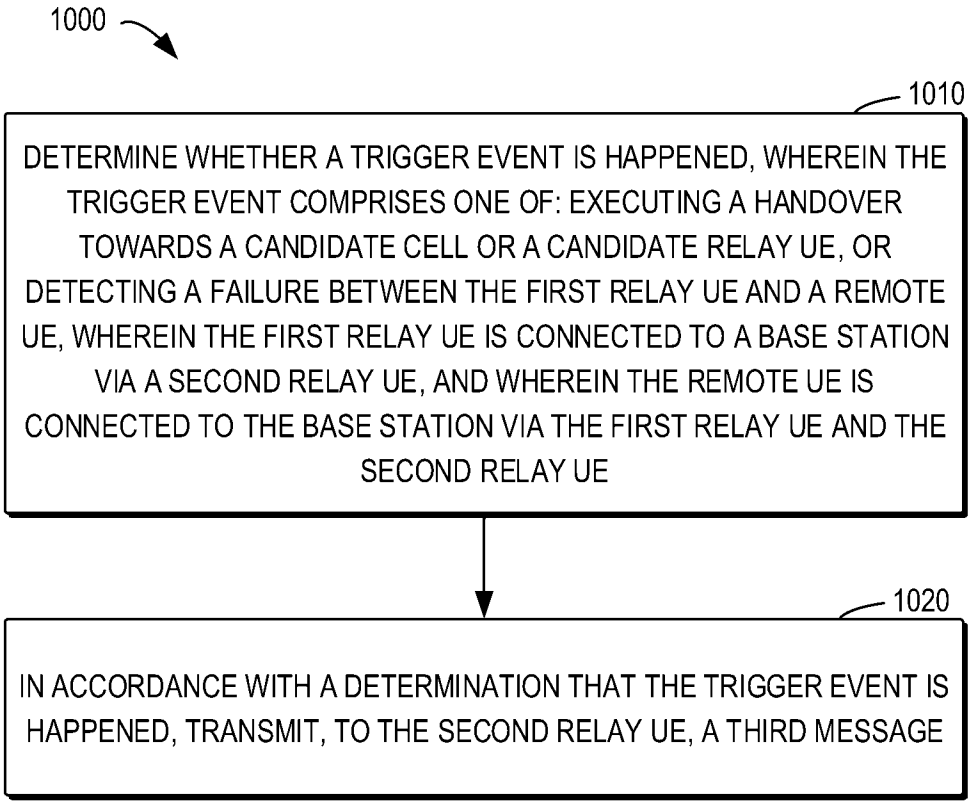
1000
1010
DETERMINE WHETHER A TRIGGER EVENT IS HAPPENED, WHEREIN THE TRIGGER EVENT COMPRISES ONE OF: EXECUTING A HANDOVER TOWARDS A CANDIDATE CELL OR A CANDIDATE RELAY UE, OR DETECTING A FAILURE BETWEEN THE FIRST RELAY UE AND A REMOTE UE, WHEREIN THE FIRST RELAY UE IS CONNECTED TO A BASE STATION VIA A SECOND RELAY UE, AND WHEREIN THE REMOTE UE IS CONNECTED TO THE BASE STATION VIA THE FIRST RELAY UE AND THE SECOND RELAY UE
1020
IN ACCORDANCE WITH A DETERMINATION THAT THE TRIGGER EVENT IS HAPPENED, TRANSMIT, TO THE SECOND RELAY UE, A THIRD MESSAGE

**FIG. 10**

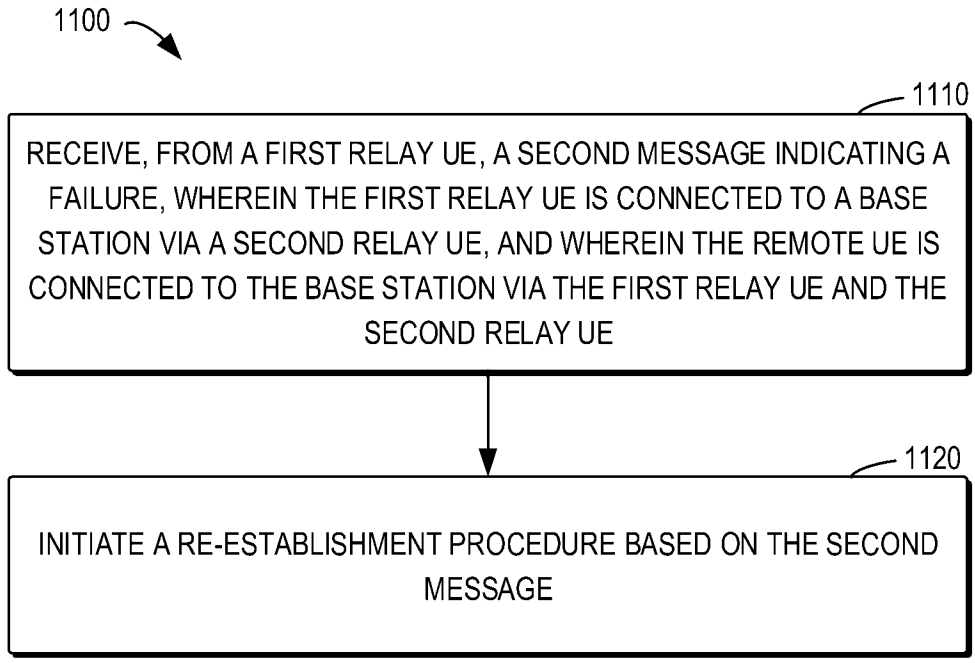
1100
1110
RECEIVE, FROM A FIRST RELAY UE, A SECOND MESSAGE INDICATING A FAILURE, WHEREIN THE FIRST RELAY UE IS CONNECTED TO A BASE STATION VIA A SECOND RELAY UE, AND WHEREIN THE REMOTE UE IS CONNECTED TO THE BASE STATION VIA THE FIRST RELAY UE AND THE SECOND RELAY UE
1120
INITIATE A RE-ESTABLISHMENT PROCEDURE BASED ON THE SECOND MESSAGE

**FIG. 11**

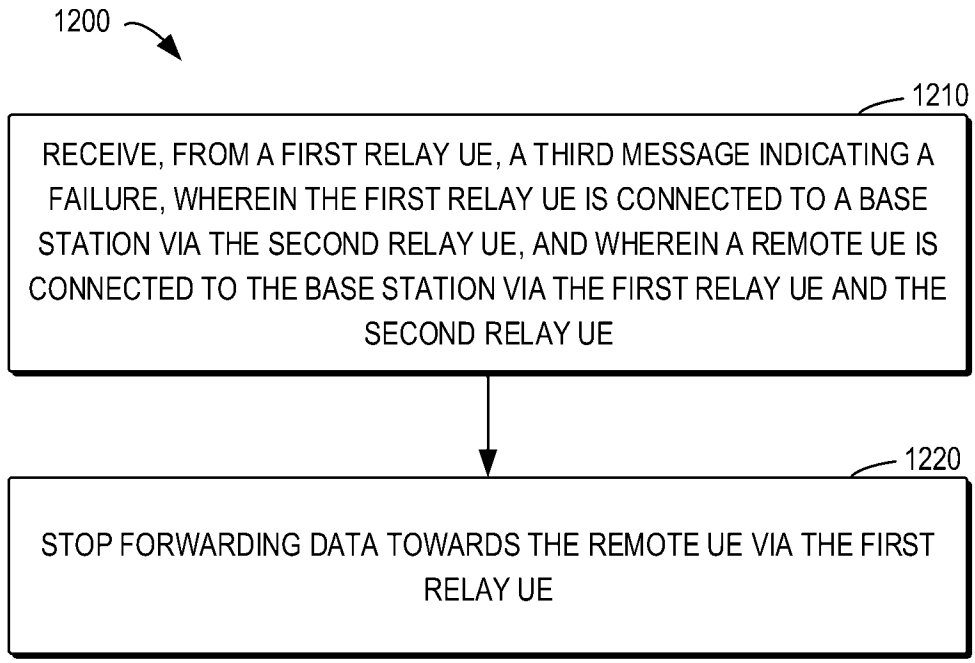
1200
1210
RECEIVE, FROM A FIRST RELAY UE, A THIRD MESSAGE INDICATING A FAILURE, WHEREIN THE FIRST RELAY UE IS CONNECTED TO A BASE STATION VIA THE SECOND RELAY UE, AND WHEREIN A REMOTE UE IS CONNECTED TO THE BASE STATION VIA THE FIRST RELAY UE AND THE SECOND RELAY UE
1220
STOP FORWARDING DATA TOWARDS THE REMOTE UE VIA THE FIRST RELAY UE

**FIG. 12**

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/CN2024/075386**

## A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/04(2009.01)i; H04W72/25(2023.01)i

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)

IPC: H04W,H04L

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)

CNABS,ENTXTC,VEN,3GPP,CNTXT,CNKI:first, second+, relay, bS, UE, trigge+, event, remote, station, message, RLF, U2N, NodeB, gNB

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | WO 2022027548 A1 (QUALCOMM INC) 10 February 2022 (2022-02-10)<br>see claims 1-30,description paragraphs 93-115,140-144 | 1-20 |
| Y | DE 102021113144 A1 (INTEL CORP) 25 November 2021 (2021-11-25)<br>see description paragraphs 38-50 | 1-20 |
| A | US 2023269809 A1 (QUALCOMM INC) 24 August 2023 (2023-08-24)<br>the whole document | 1-20 |
| A | US 2024023189 A1 (VIVO MOBILE COMMUNICATION CO LTD) 18 January 2024 (2024-01-18)<br>the whole document | 1-20 |

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| **28 October 2024** | **29 October 2024** |

| Name and mailing address of the ISA/CN | Authorized officer |
|---|---|
| **CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION**<br>**6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China** | **HE,LiLiang**<br>Telephone No. **(+86) 010-62412304** |

**INTERNATIONAL SEARCH REPORT**
**Information on patent family members**

International application No.
**PCT/CN2024/075386**

| Patent document cited in search report | | | Publication date (day/month/year) | Patent family member(s) | | | Publication date (day/month/year) |
|---|---|---|---|---|---|---|---|
| WO | 2022027548 | A1 | 10 February 2022 | EP | 4193680 | A1 | 14 June 2023 |
| | | | | EP | 4193680 | A4 | 17 April 2024 |
| | | | | US | 2023262564 | A1 | 17 August 2023 |
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| US | 2023269809 | A1 | 24 August 2023 | WO | 2022036501 | A1 | 24 February 2022 |
| | | | | EP | 4197280 | A1 | 21 June 2023 |
| | | | | EP | 4197280 | A4 | 01 May 2024 |
| US | 2024023189 | A1 | 18 January 2024 | KR | 20230138009 | A | 05 October 2023 |
| | | | | WO | 2022206612 | A1 | 06 October 2022 |
| | | | | JP | 2024508557 | A | 27 February 2024 |
| | | | | EP | 4287706 | A1 | 06 December 2023 |
| | | | | EP | 4287706 | A4 | 31 July 2024 |