

- (51) International Patent Classification:

H04W 76/15 (2018.01)
- (21) International Application Number:

PCT/CN2023/111819
- (22) International Filing Date:

08 August 2023 (08.08.2023)
- (25) Filing Language:

English
- (26) Publication Language:

English
- (71) Applicant: LENOVO (BEIJING) LIMITED [CN/CN]; 6 Shangdi West Road, Haidian District, Beijing 100085 (CN).
- (72) Inventors: WU, Lianhai; Lenovo HQ East, Building No. 1, No. 10 Xibeiwang East Road, Haidian District, Beijing 100094 (CN). YUE, Ran; Lenovo HQ East, Building No. 1, No. 10 Xibeiwang East Road, Haidian District, Beijing 100094 (CN). ZHUO, Yibin; Lenovo HQ East, Building No. 1, No. 10 Xibeiwang East Road, Haidian District, Beijing 100094 (CN).
- (74) Agent: KING & WOOD MALLESONS; 20th Floor, East Tower, World Financial Centre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: INDIRECT PATH CHANGE IN MULTI-PATH

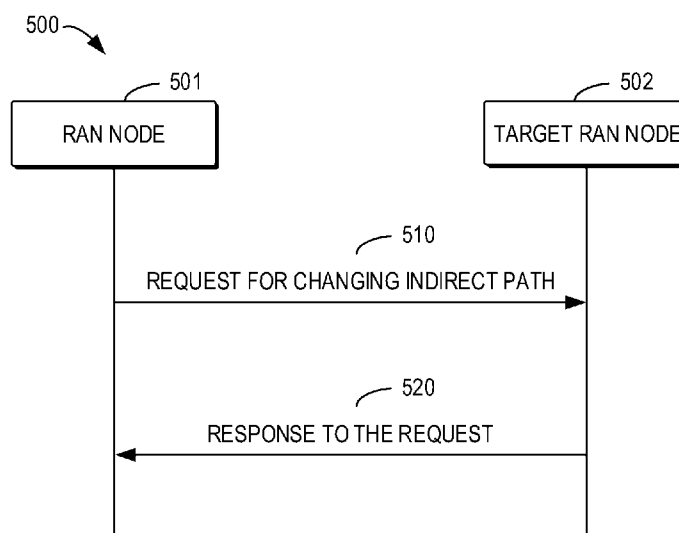


FIG. 5

(57) Abstract: Example embodiments of the present disclosure relate to RAN nodes, methods, apparatus, processors, and computer storage medium for indirect path change in multi-path scenario. A RAN node serving the UE may transmit a request for changing indirect path to a target RAN node. In addition, the target RAN node may transmit a response indicating a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request. As such, a procedure of changing the indirect path may be defined and the communication between the UE and the network side may be guaranteed.

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*
- *upon request of the applicant, before the expiration of the time limit referred to in Article 21(2)(a)*

INDIRECT PATH CHANGE IN MULTI-PATH

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to network units, methods, apparatuses, and computer readable medium for indirect path change
5 in multi-path 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
10 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,
15 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
20 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 a U2N relay UE between a U2N Remote UE and the network.

[0004] Currently, inter-gNB based multi-path is being discussed, for example, two different
25 gNBs may communicate with the UE via a direct path and an indirect path respectively. However, in case of the indirect path is needed to be changed, some details need to be further studied.

SUMMARY

[0005] The present disclosure relates to radio access network (RAN) nodes, methods,

apparatuses, and computer readable medium for indirect path change in multi-path scenario. According to the proposed solution, an indirect path between a second RAN node and a UE may be changed to a further indirect path between a target RAN node and the node.

[0006] In some implementations, there is provided a RAN node. The RAN node comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the RAN node to: transmit, to a target RAN node, a request for changing an indirect path associated with a UE, wherein the request for changing indirect path indicates at least one candidate target UE served by the target RAN node; and receive, from the target RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

[0007] In some implementations, there is provided a target RAN node. The target RAN node comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the target RAN node to: receive, from a RAN node, a request for changing an indirect path associated with a UE, wherein the request indicates at least one candidate target UE served by the target RAN node; and transmit, to the RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

[0008] In some implementations, there is provided a second RAN node. The second RAN node comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the second RAN node to: determine to change an indirect path between the second RAN node and a UE via a first relay UE to a further indirect path between the second RAN node and the UE via a second relay UE, the first relay UE and the second relay UE being served by the second RAN node; and transmit, to the UE, a reconfiguration message indicating the further indirect path or the second relay UE.

[0009] In some implementations, there is provided a first RAN node. The first RAN node comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the first RAN node to: receive, from a UE having a direct path with the first RAN node, failure information, wherein there is an indirect path between a second RAN node and the UE via a first relay UE, and wherein the failure information indicates a failure of the indirect path; and transmit, to the second RAN node, the failure

information indicating the failure of the indirect path.

[0010] In some implementations, there is provided a method performed by the RAN node. The method comprises: transmitting, to a target RAN node, a request for changing an indirect path associated with a UE, wherein the request for changing indirect path indicates at least one candidate target UE served by the target RAN node; and receiving, from the target RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

[0011] In some implementations, there is provided a method performed by the target RAN node. The method comprises: receiving, from a RAN node, a request for changing an indirect path associated with a UE, wherein the request indicates at least one candidate target UE served by the target RAN node; and transmitting, to the RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

[0012] In some implementations, there is provided a method performed by the second RAN node. The method comprises: determining to change an indirect path between the second RAN node and a UE via a first relay UE to a further indirect path between the second RAN node and the UE via a second relay UE, the first relay UE and the second relay UE being served by the second RAN node; and transmitting, to the UE, a reconfiguration message indicating the further indirect path or the second relay UE.

[0013] In some implementations, there is provided a method performed by the first RAN node. The method comprises: receiving, from a UE having a direct path with the first RAN node, failure information, wherein there is an indirect path between a second RAN node and the UE via a first relay UE, and wherein the failure information indicates a failure of the indirect path; and transmitting, to the second RAN node, the failure information indicating the failure of the indirect path.

[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: transmit, to a target RAN node, a request for changing an indirect path associated with a UE, wherein the request for changing indirect path indicates at least one candidate target UE served by the target RAN node; and receive, from the target RAN node, a response indicating one of the at least one candidate target UE as a target relay

UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

[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 RAN node, a request for changing an indirect path associated with a UE, wherein the request indicates at least one candidate target UE served by the target RAN node; and transmit, to the RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

[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: determine to change an indirect path between the second RAN node and a UE via a first relay UE to a further indirect path between the second RAN node and the UE via a second relay UE, the first relay UE and the second relay UE being served by the second RAN node; and transmit, to the UE, a reconfiguration message indicating the further indirect path or the second relay UE.

[0017] 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 UE having a direct path with the first RAN node, failure information, wherein there is an indirect path between a second RAN node and the UE via a first relay UE, and wherein the failure information indicates a failure of the indirect path; and transmit, to the second RAN node, the failure information indicating the failure of the indirect path.

[0018] In some implementations of the methods and the RAN nodes described herein, there is a direct path between a first RAN node and the UE, there is an indirect path between a second RAN node and the UE, and the RAN node is one of the first RAN node or the second RAN node.

[0019] In some implementations of the method and the RAN node described herein, the RAN node is the first RAN node, and further comprising: transmitting, to the second RAN node, a release request for releasing the indirect path with the UE.

[0020] In some implementations of the method and the RAN node described herein, the RAN node is the first RAN node, and further comprising: transmitting, to the UE, a

reconfiguration message indicating one of: the target RAN node, the target relay UE, a target cell which serves the target relay UE, or a configuration of the further indirect path between the UE and the target RAN node via the target relay UE.

[0021] In some implementations of the method and the RAN node described herein, the RAN node is the first RAN node, and further comprising: receiving, from the second RAN node having an indirect path with the UE, the request.

[0022] In some implementations of the method and the RAN node described herein, the RAN node is the second RAN node, and further comprising: in accordance with a determination that at least one signally radio bearer (SRB) is available for the indirect path, transmitting, to the UE, a configuration of the further indirect path between the UE and the target RAN node via the target relay UE.

[0023] In some implementations of the method and the RAN node described herein, the RAN node is the second RAN node, and further comprising: transmitting, to the first RAN node, a switching request for indirect path changing; and receiving, from the first RAN node, a confirmation of the switching request.

[0024] In some implementations of the method and the RAN node described herein, the RAN node is the second RAN node, and further comprising: in accordance with a determination that there is no SRB available for the indirect path, transmitting, to the first RAN node, a configuration of the further indirect path between the UE and the target RAN node via the target relay UE.

[0025] In some implementations of the method and the RAN node described herein, the RAN node is the second RAN node, and further comprising: receiving, from the first RAN node, failure information indicates a failure of the indirect path; and determining, based on the failure information, the request for changing indirect path.

[0026] In some implementations of the method and the target RAN node described herein, further comprising: selecting one from the at least one candidate relay UE as the target UE.

[0027] In some implementations of the method and the second RAN node described herein, further comprising: transmitting, to a first RAN node having a direct path with the UE, a notification indicating the further indirect path or the second relay UE.

[0028] In some implementations of the method and the second RAN node described herein, further comprising: receiving, from a first RAN node having a direct path with the UE, failure

information of the UE, wherein the failure information indicates a failure of the indirect path between the second RAN node and the UE via the first relay UE; and determining the second relay UE in response to receiving the failure information.

[0029] In some implementations of the method and the first RAN node described herein, further comprising: receiving, from the second RAN node, a notification indicating a further indirect path between the second RAN node and the UE via a second relay UE.

[0030] In some implementations of the methods and the RAN nodes described herein, the request comprises one of: an indication for changing an indirect path, at least one ID of the at least one candidate target UE, at least one cell ID indicating at least one cell serving the at least one candidate target UE, an indication indicating whether the at least one candidate target UE belongs to a same cell, or an ID of the UE.

[0031] In some implementations of the methods and the RAN nodes described herein, the response comprises one of: an ID of the target relay UE, or a configuration of a further indirect path between the UE and the target RAN node via the target relay UE.

[0032] In some implementations of the methods and the RAN nodes described herein, the response comprises one of: a rejection to the request, a cause of the rejection, or one or more suggested candidate relay UEs.

[0033] In some implementations of the methods and the RAN nodes described herein, the release request comprises one of: an ID of the target relay UE, or a cause value of the releasing.

[0034] In some implementations of the methods and the RAN nodes described herein, the RAN node is the first RAN node, the request is comprised in a secondary node (SN) addition request message, and the response is comprised in an SN addition request acknowledge message.

[0035] In some implementations of the methods and the RAN nodes described herein, the failure information indicates one of: a radio link failure (RLF) of a sidelink between the UE and the first relay UE, or an RLF of a Uu link between the first relay UE and the second RAN node.

[0036] In some implementations of the methods and the RAN nodes described herein, the request is comprised in a secondary node (SN) addition request message, and the response is comprised in an SN addition request acknowledge message.

[0037] In some implementations of the methods and the RAN nodes described herein, a multi-path indication is comprised in an SN addition trigger indication, and wherein the SN addition trigger indication is comprised in the SN addition request message.

5 [0038] In some implementations of the methods and the RAN nodes described herein, the notification comprises one of: an ID of the second relay UE, or a cell ID of a cell which serves the second relay UE.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] FIG. 1 illustrates an example of a wireless communications system in which some embodiments of the present disclosure can be implemented;

10 [0040] FIG. 2A illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

[0041] FIG. 2B illustrates an example RRC reconfiguration sidelink procedure;

[0042] FIG. 3A illustrates an example flow signalling for successful second indirect path addition;

15 [0043] FIG. 3B illustrates an example UE information procedure;

[0044] FIG. 4 illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

[0045] FIG. 5 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

20 [0046] FIG. 6A illustrates a signalling chart illustrating communication process where the inter-gNB indirect path changing is initiated by the first RAN node in accordance with some example embodiments of the present disclosure;

[0047] FIG. 6B illustrates a signalling chart illustrating communication process where the inter-gNB indirect path changing is initiated by the second RAN node in accordance with
25 some example embodiments of the present disclosure;

[0048] FIG. 7 illustrates a signalling chart illustrating communication process where the intra-gNB indirect path changing is initiated by the second RAN node in accordance with some example embodiments of the present disclosure;

[0049] FIG. 8 illustrates an example of a device that is suitable for implementing
30 embodiments of the present disclosure;

[0050] FIG. 9 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0051] FIG. 10 illustrates a flowchart of an example method implemented at a RAN node in accordance with aspects of the present disclosure;

5 [0052] FIG. 11 illustrates a flowchart of an example method implemented at a target RAN node in accordance with aspects of the present disclosure;

[0053] FIG. 12 illustrates a flowchart of an example method implemented at a second RAN node in accordance with aspects of the present disclosure; and

10 [0054] FIG. 13 illustrates a flowchart of an example method implemented at a first RAN node in accordance with some embodiments of the present disclosure.

[0055] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

15 [0056] 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
20 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.

[0057] 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
25 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
30 or not explicitly described.

[0058] 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
5 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,
10 or otherwise preferable to other selections.

[0059] 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,”
15 “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
20 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.

[0060] FIG. 1 illustrates an example of a wireless communications system 100 in which
25 some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be
30 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
5 time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0061] 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
10 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
15 signaling) over a Uu interface.

[0062] 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
20 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
25 112 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
30 any combination thereof.

[0063] 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.

[0064] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0065] 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.

[0066] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, 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 core network 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access

network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0067] 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.

[0068] 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)).

[0069] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaptation protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUs or RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU.

[0070] 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
5 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).

[0071] 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
10 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
15 communication links.

[0072] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME),
20 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,
25 etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0073] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data network 108 may include an application server 118. In some implementations,
30 one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the

established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0074] 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.

[0075] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0076] 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.

[0077] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0078] 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.

[0079] 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.

5 **[0080]** 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, layer 2 (L2) relay UE, L2 U2N relay UE, or the like. The term “relay UE ID” may be used interchangeably
10 with link ID, path ID, L2 relay UE ID, or the like.

[0081] 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, two different base stations may communicate with each other via an Xn link (Xn interface), and a UE and a base station may
15 communicate with each via a Uu link (Uu interface).

[0082] 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
20 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 and when the UE 211 is outside NG-RAN coverage.

25 **[0083]** FIG. 2B illustrates an example RRC reconfiguration sidelink procedure 220. As shown in FIG. 2B, a UE 221 may transmit an *RRCReconfigurationSidelink* message to a UE 222, and the UE 222 may transmit an *RRCReconfigurationCompleteSidelink* message back to the UE 221.

[0084] The purpose of the procedure 220 is to modify a PC5-RRC connection, e.g. to
30 establish/modify/release sidelink data radio bearers (DRBs), to configure NR sidelink measurement and reporting, to configure sidelink channel state indicator (CSI) reference signal resources.

[0085] The UE (such as the UE 221) may initiate the sidelink RRC reconfiguration procedure and perform an operation on the corresponding PC5-RRC connection in following cases:

- the release of sidelink DRBs associated with the peer UE (such as the UE 222),
- the establishment of sidelink DRBs associated with the peer UE,
- the modification for the parameters included in sidelink radio bearer-configuration (SLRB-Config) of sidelink DRBs associated with the peer UE,
- the configuration of the peer UE to perform NR sidelink measurement and report,
- the configuration of the sidelink CSI reference signal resources.

[0086] FIG. 3A illustrates an example flow signalling 310 for successful second indirect path addition. Specifically, a remote UE 311 may perform a measurement report to the serving gNB 313 at step 1. A second indirect path via a relay UE may be decided to be added by the serving gNB 313 at step 2. In addition, at step 3, an RRC reconfiguration for path addition may be transmitted from the serving gNB 313 to the remote UE 311. Accordingly, a PC5 connection between the remote UE 311 and the relay UE 312 may be established based on a PC5 connection establishment message at step 4, and an RRC reconfiguration message for remote UE 311 may be transmitted from the serving gNB 313 to the relay UE 312. As such, an indicate path is added after an RRC reconfiguration complete message at step 6, and data transmission or reception at step 7 may be performed.

[0087] FIG. 3B illustrates an example UE information procedure 320. The UE information procedure 320 may be used by the network to request the UE 321 to report information e.g., rlf-report or successful handover report (SHR). As shown in FIG. 3B, the network 322 initiates the procedure 320 by sending a UE Information Request message. The network 322 should initiate this procedure 320 only after successful security activation. The UE 321 reports a UE Information Response including rlf-report or SHR to the network 322 after receiving the UE Information Request message.

[0088] For analysis of connection failures, the UE makes the RLF Report available to the network. The UE stores the latest RLF Report, including both LTE and NR RLF report until the RLF report is fetched by the network or for 48 hours after the connection failure is detected. The UE only indicates RLF report availability and only provides the RLF report to the network if the current registered public land mobile network (RPLMN) is a PLMN that

was present in the UE's equivalent PLMN (EPLMN) List or was the RPLMN at the time the connection failure was detected. In case RLF happens in an Evolved UMTS Terrestrial Radio Access Network (E-UTRA) cell, the UE makes the LTE RLF Report available to NG-RAN nodes and eNB(s), and in case RLF happens in an NR cell, the UE makes the NR RLF Report available to gNB(s).

[0089] If the LTE RLF Report is reported to a NG-RAN node, and the last serving node is an E-UTRAN node, the NG-RAN node may transfer it to the E-UTRAN node by triggering the Uplink RAN configuration transfer procedure over NG, and the E-UTRAN node can take this into account.

[0090] As mentioned above, an indirect path may be added so that a remote UE may communicate with a base station via a relay UE. 3GPP is discussing a possibility of inter-gNB based multi-path, for example, whether a dual connectivity (DC) framework is reused. One way forward (WF) is that DC framework can be reused, and PCell may be configured in direct path. The second way forward is that non-DC framework is used, and there is no secondary cell group (SCG) in multi-path case. In Inter-gNB multi-path case, the indirect path may be changed, and some details need to be further studied.

[0091] Embodiments of the present disclosure provide a solution of communication. In the solution, one of a first RAN node or a second RAN node may transmit a request for changing indirect path to a target RAN node. In addition, the target RAN node may transmit back a response indicating a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request. As such, a procedure of changing the indirect path may be defined and the communication between the UE and the network side may be guaranteed. Principles and implementations of the present disclosure will be described in detail below with reference to the figures.

[0092] FIG. 4 illustrates a schematic diagram of an example communication network 400 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 4, the communication network 400 may include a first RAN node 410, a second RAN node 420, a third RAN node 430, and a UE 440.

[0093] The first RAN node 410 and the UE 440 may communicate with each other via a direct path. For example, the direct path may be associated with a Uu link there between. For example, the first RAN node 410 may be a serving network device of the UE 440, such as a serving gNB. The communication network 400 may further include a UE 422. In

some embodiments, there may be an indirect path between the UE 440 and the second RAN node 420. For example, there is an indirect path between the second RAN node 420 and the UE 440 via the UE 422. For example, the second RAN node 420 may communicate with the UE 422 via a Uu link, and the UE 440 may communicate with the UE 422 via a PC5 link. In this case, the UE 440 may be a remote UE, the UE 422 may be a relay UE. It is to be understood that the multi-path scenario may be based on a DC framework or a non-DC framework, the present disclosure does not limit this aspect.

[0094] With reference to FIG. 4, the communication network 400 may further include a UE 424 and a UE 432. For example, the UE 424 is served by the second RAN node 420, and the UE 432 is served by the third RAN node 430.

[0095] In some implementations, the indirect path between the second RAN node 420 and the UE 440 via the UE 422 may be change to: (1) a further indirect path between the third RAN node 430 and the UE 440 via the UE 432; or (2) a further indirect path between the second RAN node 420 and the UE 440 via the UE 424. Some detailed embodiments are provided below.

[0096] It is to be understood that the number of devices in FIG. 4 is given for the purpose of illustration without suggesting any limitations to the present disclosure.

[0097] Reference is further made to FIG. 5, which illustrates a signalling chart illustrating communication process 500 in accordance with some example embodiments of the present disclosure. The process 500 may involve a RAN node 501 and a target RAN node 502.

[0098] The process 500 may be applied to the communication network 400 in FIG. 4, with reference to FIG. 4, there is a direct path between the first RAN node 410 and the UE 440, and there is an indirect path between the second RAN node 420 and the UE 440 via the relay UE 422. The RAN node 501 may be the first RAN node 410 or the second RAN node 420, and the target RAN node 502 may be the third RAN node 430 in FIG. 4.

[0099] The UE 440 may be in (i.e., stays at) an RRC connected state, and the UE 440 may access the first RAN node 410 (such as serving gNB) via a direct path and access the second RAN node 420 via an indirect path. In some example embodiments, the UE 440 may transmit measurement results to the first RAN node 410 and the second RAN node 420 respectively.

[00100] In the process 500, the RAN node 501 transmits, at 510, a request for changing an indirect path associated with the UE 440 to the target RAN node 502. In some

implementations, the request may be an indirect path change request. In some implementations, the request may indicate at least one candidate target UE served by the target RAN node 502.

[00101] On the other side of communication, the target RAN node 502 receives the request for changing indirect path. In some implementations, the target RAN node 502 may determine whether to accept or reject the request.

[00102] In the process 500, the target RAN node 502 transmits, at 520, a response to the RAN node 501. In some implementations, the response may indicate a target relay UE for a further indirect path between the target RAN node 502 and the UE 440. In some other implementations, the response may indicate a rejection to the request.

[00103] In some implementations, the RAN node 501 may be the first RAN node 410, some detailed embodiments are discussed with reference to FIG. 6A. In some other implementations, the RAN node 502 may be the second RAN node 420, some detailed embodiments are discussed with reference to FIG. 6B.

[00104] FIG. 6A illustrates a signalling chart illustrating communication process 600 in accordance with some example embodiments of the present disclosure. The process 600 may involve a first RAN node 410, a second RAN node 420, a third RAN node 430, and a UE 440, as show in FIG. 4. It would be appreciated that the process 600 may be applied to other communication scenarios, which will not be described in detail.

[00105] The UE 440 may be in (i.e., stays at) an RRC connected state, and the UE 440 may access the first RAN node 410 (such as serving gNB) via a direct path and may access the second RAN node 420 via an indirect path. In some example embodiments, the UE 440 may transmit measurement results to the first RAN node 410 and the second RAN node 420 respectively.

[00106] In some implementations, the first RAN node 410 may decide to change the indirect path. In some examples, the first RAN node 410 may determine at least one candidate relay UE, e.g., based on the measurement results from the UE 440. In some examples, the first RAN node 410 may determine to change the relay UE of the indirect path from the relay UE 422 (served by the second RAN node 420) to a candidate relay UE served by the third RAN node 430.

[00107] In some other implementations, the second RAN node 420 may decide to change the indirect path. In some examples, the second RAN node 420 may determine at least one

candidate relay UE, e.g., based on the measurement results from the UE 440. In some examples, the second RAN node 420 may determine a change required message, and transmit (at 601) a change required message to the first RAN node 410. For example, in response to determining that the at least one candidate relay UE does not belong to the second RAN node 420, i.e., belongs to a different RAN node, the second RAN node 420 may transmit the change required message to the first RAN node 410.

[00108] In some examples, the change required message may include at least one ID of the at least one candidate relay UE, that is, at least one candidate relay UE ID is included. In some examples, the change required message may include at least one cell ID which indicates at least one cell serving the at least one candidate relay UE. In some examples, the change required message may include an indication which indicates whether the at least one candidate target UE belongs to a same cell or different cells.

[00109] In some examples, an indication for indirect path change for multi-path case may be included in the change required message. For example, the indication for indirect path change for multi-path case may be included in SN Addition Trigger Indication. For example, in case at least one candidate relay UE ID is included in the SN Addition Trigger Indication, the first RAN node 410 may consider that the purpose of the SN Addition Trigger Indication is to change the indirect path.

[00110] In some examples, the change required message may include an ID of the UE 440, that is, a remote UE ID is included.

[00111] In the process 600, the first RAN node 410 transmits, at 610, a request for changing indirect path to the third RAN node 430.

[00112] In some example embodiments, the request may be included in S-NODE ADDITION REQUEST message, e.g., if DC framework is used. In some other example embodiments, the request may be included in a new Xn message, e.g., an indirect path change request message.

[00113] In some examples, the request may include at least one ID of the at least one candidate relay UE. For example, at least one candidate relay UE ID may be included in the request, where the at least one candidate relay UE is served by the third RAN node 430. In some examples, the request may include at least one cell ID which indicates at least one cell serving the at least one candidate relay UE. For example, the request may include one or more candidate relay UE IDs and corresponding cell ID(s).

[00114] In some examples, the request may include an indication which indicates whether the at least one candidate target UE belongs to a same cell or different cells.

[00115] In some examples, an indication for indirect path change for multi-path case may be included in the request. For example, the indication for indirect path change for multi-path case may be included in SN Addition Trigger Indication. For example, in case at least one candidate relay UE ID is included in the SN Addition Trigger Indication, the first RAN node 410 and the third RAN node 430 may consider that the purpose of the SN Addition Trigger Indication is to change the indirect path.

[00116] In some examples, the request may include an ID of the UE 440, that is, a remote UE ID is included.

[00117] In the process 600, the third RAN node 430 transmits, at 620, a response to the request for changing indirect path to the first RAN node 410.

[00118] In some example embodiments, the third RAN node 430 may reject the request. In some examples, the response may include a rejection to the request. In some examples, the response may include a cause of the rejection. For example, the cause may indicate an overload of the at least one candidate relay UE. For example, the third RAN node 430 cannot find the at least one candidate relay UE (e.g., the possible reason is that the at least one candidate relay UE moves to other cells), and the cause may indicate no found relay. For example, the cause may indicate relay UE leaving, e.g., the at least one candidate relay UE is moving outside coverage of the third RAN node 430. In some examples, the response may include one or more suggested candidate relay UEs, for example, the first RAN node 410 may generate another request based on the suggestion from the third RAN node 430.

[00119] In some examples embodiments, the third RAN node 430 may accept the request.

[00120] In some examples, if the at least one candidate relay UE is one candidate relay UE (such as UE 432 in FIG. 4), that is, only one candidate relay UE ID is included in the request, the third RAN node 430 may determine whether the candidate relay UE (such as UE 432 in FIG. 4) can be used as a target relay UE. For example, if accepted, the third RAN node 430 may transmit the response which includes a configuration related to the target relay UE, such as the relay UE 432 in FIG. 4. For example, the response may include a configuration of a further indirect path between the third RAN node 430 and the UE 440 via the target relay UE 432.

[00121] In some other examples, if the at least one candidate relay UE includes multiple

candidate relay UEs, that is, multiple candidate relay UE IDs are included in the request, the third RAN node 430 may determine (select) one of the multiple candidate relay UEs as the target relay UE, e.g., the relay UE 432 is selected. For example, the response may include an ID of the target relay UE 432 and a configuration of a further indirect path between the third RAN node 430 and the UE 440 via the target relay UE 432.

[00122] In addition or alternatively, the further indirect path may be established between the third RAN node 430 and the UE 440 via the relay UE 432.

[00123] In addition or alternatively, as shown in FIG. 6A, the first RAN node 410 may transmit a release request to the second RAN node 420 at 630, where the release request is used for releasing the indirect path between the second RAN node 420 and the UE 440. In the present disclosure, the release request may also be referred to as a release indication, a request message for releasing, a releasing message, or the like, the present disclosure does not limit this aspect.

[00124] In some examples, the release request may include an ID of the target relay UE (i.e., a UE ID of the relay UE 432). In some examples, the release request may include a cause value of the releasing, for example, a new cause value (such as a better PC5 link) may be used.

[00125] In addition or alternatively, as shown in FIG. 6A, the first RAN node 410 may transmit a reconfiguration message to the UE 440 at 640, where the reconfiguration message may be associated with the indirect path changing. For example, the reconfiguration message may include an ID of the third RAN node 430. For example, the reconfiguration message may include an ID of the target relay UE 432. For example, the reconfiguration message may include a cell ID of a target cell which serves the target relay UE 432. For example, the reconfiguration message may include a configuration of a further indirect path between the third RAN node 430 and the UE 440 via the target relay UE 432.

[00126] FIG. 6B illustrates a signalling chart illustrating communication process 650 in accordance with some example embodiments of the present disclosure. The process 650 may involve a first RAN node 410, a second RAN node 420, a third RAN node 430, and a UE 440, as show in FIG. 4. It would be appreciated that the process 650 may be applied to other communication scenarios, which will not be described in detail.

[00127] The UE 440 may be in (i.e., stays at) an RRC connected state, and the UE 440 may access the first RAN node 410 (such as serving gNB) via a direct path and may access the

second RAN node 420 via an indirect path. In some example embodiments, the UE 440 may transmit measurement results to the first RAN node 410 and the second RAN node 420 respectively.

[00128] In the process 650, the second RAN node 420 transmits, at 660, a request for changing indirect path to the third RAN node 430.

[00129] In some other implementations, the second RAN node 420 may decide to change the indirect path. In some examples, the second RAN node 420 may determine at least one candidate relay UE, e.g., based on the measurement results from the UE 440. In some examples, the second RAN node 420 may determine the request for changing indirect path, and transmit (at 660) the request to the third RAN node 430. For example, in response to determining that the at least one candidate relay UE does not belong to the second RAN node 420, i.e., belongs to the third RAN node 430, the second RAN node 420 may transmit the request to the third RAN node 430.

[00130] In some examples, the second RAN node 420 may determine the request for changing indirect path in response to receiving failure information from the first RAN node 410.

[00131] In addition or alternatively, as shown in FIG. 6B, the UE 440 may transmit failure information to the first RAN node 410 via the direct path at 641. In some examples, the UE 440 may detect an RLF of the sidelink between the UE 440 and the UE 422. In some other examples, the UE 440 may receive a notification message or a release message from the UE 422, where the notification message or the release message may indicate an RLF of the sidelink between the UE 440 and the UE 422, and/or where the notification message or the release message may indicate an RLF of the Uu link between the UE 422 and the second RAN node 420. For example, the failure information from the UE 440 to the first RAN node 410 may be included in a failure report, for example, the failure report may further include measurement results related to at least one candidate relay UE and corresponding cell(s).

[00132] In addition or alternatively, as shown in FIG. 6B, the first RAN node 410 may transmit the failure information to the second RAN node 420 via an Xn interface at 642. In some examples, the failure information may be associated with the indirect path between the second RAN node 420 and the UE 440. For example, the failure information may indicate a failure of the indirect path between the second RAN node 420 and the UE 440. For

example, the failure information may indicate an RLF of the sidelink between the UE 440 and the UE 422, and/or indicate an RLF of the Uu link between the UE 422 and the second RAN node 420. In some examples, the failure information may further include measurement results related to at least one candidate relay UE and corresponding cell(s).

5 [00133] In some examples, the second RAN node 420 may select one candidate relay UE, which is served by the third RAN node 430.

[00134] In some example embodiments, the request from the second RAN node 420 to the third RAN node 430 may be included in a new Xn message, e.g., an indirect path change request message.

10 [00135] In some examples, the request may include at least one ID of the at least one candidate relay UE. For example, at least one candidate relay UE ID may be included in the request, where the at least one candidate relay UE is served by the third RAN node 430. In some examples, the request may include at least one cell ID which indicates at least one cell serving the at least one candidate relay UE. For example, the request may include one
15 or more candidate relay UE IDs and corresponding cell ID(s). As a specific example, in case only one candidate relay UE (which is served by the third RAN node 430) is selected by the second RAN node 420, the request may include an ID of the one candidate relay UE and its corresponding cell ID.

[00136] In some examples, the request may include an indication which indicates whether
20 the at least one candidate target UE belongs to a same cell or different cells.

[00137] In some examples, an indication for indirect path change for multi-path case may be included in the request. In some examples, the request may include an ID of the UE 440, that is, a remote UE ID is included.

[00138] In the process 650, the third RAN node 430 transmits, at 670, a response to the
25 request for changing indirect path to the second RAN node 420.

[00139] In some example embodiments, the third RAN node 430 may reject the request. In some examples, the response may include a rejection to the request. In some examples, the response may include a cause of the rejection. For example, the cause may indicate an overload of the at least one candidate relay UE. For example, the third RAN node 430
30 cannot find the at least one candidate relay UE (e.g., the possible reason is that the at least one candidate relay UE moves to other cells), and the cause may indicate no found relay. For example, the cause may indicate relay UE leaving, e.g., the at least one candidate relay

UE is moving outside coverage of the third RAN node 430. In some examples, the response may include one or more suggested candidate relay UEs, for example, the second RAN node 420 may generate another request based on the suggestion from the third RAN node 430.

[00140] In some examples embodiments, the third RAN node 430 may accept the request.

5 **[00141]** In some examples, if the at least one candidate relay UE is one candidate relay UE (such as UE 432 in FIG. 4), that is, only one candidate relay UE ID is included in the request, the third RAN node 430 may determine whether the candidate relay UE (such as UE 432 in FIG. 4) can be used as a target relay UE. For example, if accepted, the third RAN node 430 may transmit the response which includes a configuration related to the target relay UE, such as the relay UE 432 in FIG. 4. For example, the response may include a configuration of a further indirect path between the third RAN node 430 and the UE 440 via the target relay UE 432.

[00142] In some other examples, if the at least one candidate relay UE includes multiple candidate relay UEs, that is, multiple candidate relay UE IDs are included in the request, the third RAN node 430 may determine (select) one of the multiple candidate relay UEs as the target relay UE, e.g., the relay UE 432 is selected. For example, the response may include an ID of the target relay UE 432 and a configuration of a further indirect path between the third RAN node 430 and the UE 440 via the target relay UE 432.

20 **[00143]** In addition or alternatively, the further indirect path may be established between the third RAN node 430 and the UE 440 via the relay UE 432.

[00144] In addition or alternatively, the second RAN node 420 may transmit a switching request for indirect path changing to the first RAN node 410. In some implementations, the first RAN node 410 may transmit a confirmation of the switching request to the second RAN node 420. For example, the second RAN node 420 may indicate the path switching to the first RAN node 410 by the switching request. For example, the confirmation may indicate that the second RAN node 420 is allowed to transmit a configuration to the UE 440.

30 **[00145]** In addition or alternatively, as shown in FIG. 6B, the second RAN node 420 may transmit a configuration to the UE 440 at 680, if at least one SRB is configured in the indirect path. In some examples, if at least one SRB is configured in the indirect path, in response to receiving the confirmation of the switching request from the first RAN node 410, the second RAN node 420 may transmit the configuration to the UE 440 at 680. In some other examples, if no SRB is configured in the indirect path, the second RAN node 420 may

transmit the configuration to the first RAN node 410, and the first RAN node 410 may further forward the configuration to the UE 440.

[00146] In some examples, the configuration to the UE 440 may be associated with the indirect path changing. For example, the configuration to the UE 440 may include an ID of the third RAN node 430. For example, the configuration to the UE 440 may include an ID of the target relay UE 432. For example, the configuration to the UE 440 may include a cell ID of a target cell which serves the target relay UE 432. For example, the configuration to the UE 440 may include a configuration of a further indirect path between the third RAN node 430 and the UE 440 via the target relay UE 432.

[00147] According to some embodiments described with reference to FIGS. 5-6B, a solution for inter-gNB relay changing is proposed. In some embodiments, the first RAN node or the second RAN node may initiate a changing of the indirect path. Accordingly, a further indirect path between a third RAN node and the UE via a target relay UE may be established. As such, the indirect path may be changed from the relay UE 422 (or the second RAN node 420) to the relay UE 432 (or the third RAN node 430).

[00148] Reference is further made to FIG. 7, which illustrates a signalling chart illustrating communication process 700 in accordance with some example embodiments of the present disclosure. The process 700 may involve the first RAN node 410, the second RAN node 420, and the UE 440 in FIG. 4.

[00149] The process 700 may be applied to the communication network 400 in FIG. 4, with reference to FIG. 4, there is a direct path between the first RAN node 410 and the UE 440, and there is an indirect path between the second RAN node 420 and the UE 440 via the relay UE 422. It would be appreciated that the process 700 may be applied to other communication scenarios, which will not be described in detail.

[00150] The UE 440 may be in (i.e., stays at) an RRC connected state, and the UE 440 may access the first RAN node 410 (such as serving gNB) via a direct path and access the second RAN node 420 via an indirect path. In some example embodiments, the UE 440 may transmit measurement results to the first RAN node 410 and the second RAN node 420 respectively.

[00151] In the process 700, the second RAN node 420 determines to change the indirect path at 710.

[00152] In some examples, the second RAN node 420 may determine at least one candidate

relay UE, e.g., based on the measurement results from the UE 440. For example, in response to determining that the at least one candidate relay UE belongs to the second RAN node 420, the second RAN node 420 may determine a reconfiguration.

[00153] In some examples, the second RAN node 420 may determine the request for changing indirect path in response to receiving failure information from the first RAN node 410.

[00154] In addition or alternatively, as shown in FIG. 7, the UE 440 may transmit failure information to the first RAN node 410 via the direct path at 701. In some examples, the UE 440 may detect an RLF of the sidelink between the UE 440 and the UE 422. In some other examples, the UE 440 may receive a notification message or a release message from the UE 422, where the notification message or the release message may indicate an RLF of the sidelink between the UE 440 and the UE 422, and/or where the notification message or the release message may indicate an RLF of the Uu link between the UE 422 and the second RAN node 420. For example, the failure information from the UE 440 to the first RAN node 410 may be included in a failure report, for example, the failure report may further include measurement results related to at least one candidate relay UE and corresponding cell(s).

[00155] In addition or alternatively, as shown in FIG. 7, the first RAN node 410 may transmit the failure information to the second RAN node 420 via an Xn interface at 702. In some examples, the failure information may be associated with the indirect path between the second RAN node 420 and the UE 440. For example, the failure information may indicate a failure of the indirect path between the second RAN node 420 and the UE 440. For example, the failure information may indicate an RLF of the sidelink between the UE 440 and the UE 422, and/or indicate an RLF of the Uu link between the UE 422 and the second RAN node 420. In some examples, the failure information may further include measurement results related to at least one candidate relay UE and corresponding cell(s).

[00156] In some examples, the second RAN node 420 may select one candidate relay UE which is served by the second RAN node 420. For example, the candidate relay UE is the relay UE 424 in FIG. 4.

[00157] In the process 700, the second RAN node 420 transmits a reconfiguration message to the UE 440 at 720. In some examples, the reconfiguration message may indicate the relay UE 424, or indicate the further indirect path between the second RAN node 420 and the

UE 440 via the relay UE 424.

[00158] In addition or alternatively, the further indirect path may be established between the second RAN node 420 and the UE 440 via the relay UE 424.

[00159] In addition or alternatively, as shown in FIG. 7, the second RAN node 420 may transmit a notification to the first RAN node 410 at 730. In some example embodiments, the notification may indicate that the further indirect path between the second RAN node 420 and the UE 440 via the relay UE 424 is established. In some examples, the notification from the second RAN node 420 to the first RAN node 410 may include an ID of the relay UE 424. In some examples, the notification from the second RAN node 420 to the first RAN node 410 may include an ID of a cell which serves the relay UE 424.

[00160] According to some embodiments described with reference to FIG. 7, a solution for intra-gNB relay changing is proposed. In some embodiments, the second RAN node may initiate a changing of the indirect path. Accordingly, a further indirect path between the second RAN node and the UE via another relay UE may be established. As such, the indirect path may be changed from the relay UE 422 (served by the second RAN node 420) to the relay UE 424 (served by the second RAN node 420).

[00161] According to some example embodiments described above, a solution an inter-gNB relay change or an intra-gNB relay change is proposed. In this case, the Xn enhancement may be achieved for a multi-path case including a direct path and an indirect path.

[00162] FIG. 8 illustrates an example of a device 800 that is suitable for implementing embodiments of the present disclosure. The device 800 may be an example of a RAN node as described herein. The device 800 may support wireless communication with the first RAN node 410, the second RAN node 420, the third RAN node 430, or any combination thereof. The device 800 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 802, a memory 804, a transceiver 806, and, optionally, an I/O controller 808. 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).

[00163] The processor 802, the memory 804, the transceiver 806, 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 802, the

memory 804, the transceiver 806, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[00164] In some implementations, the processor 802, the memory 804, the transceiver 806, 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 802 and the memory 804 coupled with the processor 802 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804).

[00165] For example, the processor 802 may support wireless communication at the device 800 in accordance with examples as disclosed herein. The processor 802 may be configured to operable to support a means for transmitting, to a target RAN node, a request for changing an indirect path associated with a UE, wherein the request for changing indirect path indicates at least one candidate target UE served by the target RAN node; and means for receiving, from the target RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request. The processor 802 may be configured to operable to support a means for receiving, from a RAN node, a request for changing an indirect path associated with a UE, wherein the request indicates at least one candidate target UE served by the target RAN node; and means for transmitting, to the RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request. The processor 802 may be configured to operable to support a means for determining to change an indirect path between the second RAN node and a UE via a first relay UE to a further indirect path between the second RAN node and the UE via a second relay UE, the first relay UE and the second relay UE being served by the second RAN node; and means for transmitting, to the UE, a reconfiguration message indicating the further indirect path or the second relay UE. The processor 802 may be configured to operable to support a means for receiving, from a UE having a direct path with the first RAN node, failure information, wherein there is an indirect path between a second RAN node and the UE via a first relay UE,

and wherein the failure information indicates a failure of the indirect path; and means for transmitting, to the second RAN node, the failure information indicating the failure of the indirect path.

[00166] The processor 802 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 802 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 802. The processor 802 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 804) to cause the device 800 to perform various functions of the present disclosure.

[00167] The memory 804 may include random access memory (RAM) and read-only memory (ROM). The memory 804 may store computer-readable, computer-executable code including instructions that, when executed by the processor 802 cause the device 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. In some implementations, the code may not be directly executable by the processor 802 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 804 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.

[00168] The I/O controller 808 may manage input and output signals for the device 800. The I/O controller 808 may also manage peripherals not integrated into the device 800. In some implementations, the I/O controller 808 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 808 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 808 may be implemented as part of a processor, such as the processor 806. In some implementations, a user may interact with the device 800 via the I/O controller 808 or via hardware components controlled by the I/O controller 808.

[00169] In some implementations, the device 800 may include a single antenna 810.

However, in some other implementations, the device 800 may have more than one antenna 810 (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 806 may communicate bi-directionally, via the one or more antennas 810, wired, or wireless links as described herein. For example, the transceiver 806 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 806 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 810 for transmission, and to demodulate packets received from the one or more antennas 810. The transceiver 806 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00170] 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 810 for transmitting the amplified signal into the air or wireless medium.

[00171] 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 810 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.

[00172] FIG. 9 illustrates an example of a processor 900 that is suitable for implementing some embodiments of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various

operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 900. One or more of these components may be in electronic communication or
5 otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00173] The processor 900 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,
10 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 900) 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),
15 magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00174] The controller 902 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 900 to cause the
20 processor 900 to support various operations in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00175] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to
30 decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein.

Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

5 [00176] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

10 [00177] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 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 902 and/or the processor 900 may be configured to execute computer-readable instructions stored
15 in the memory 904 to cause the processor 900 to perform various functions. For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 may include multiple memories. One or more of the
20 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.

[00178] The one or more ALUs 900 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 900 may reside within or on a processor chipset (e.g., the processor 900). In some
25 other implementations, the one or more ALUs 900 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 900 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 900 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 900 be configured with a
30 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 900 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more

ALUs 900 to handle conditional operations, comparisons, and bitwise operations.

[00179] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The processor 900 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

5 **[00180]** FIG. 10 illustrates a flowchart of a method 1000 performed by a RAN node 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 RAN node 501 in FIG. 5, which may be a first RAN node 410 or a second RAN node 420 in FIG. 4. In some
10 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.

[00181] At 1010, the method may include transmitting, to a target RAN node, a request for changing an indirect path associated with a UE, where the request for changing indirect path
15 indicates at least one candidate target UE served by the target RAN node. 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 RAN node 410 or the second RAN node 420 as described with reference to FIG. 4.

[00182] At 1020, the method may include receiving, from the target RAN node, a response
20 indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request. 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 RAN node 410 or the second RAN node 420 as described with reference to FIG. 4.

25 **[00183]** FIG. 11 illustrates a flowchart of a method 1100 performed by a target RAN node 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 target RAN node 502 in FIG. 5, which may be the third RAN node 430 in FIG. 4. In some implementations, the device may
30 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.

[00184] At 1110, the method may include receiving, from a RAN node, a request for changing an indirect path associated with a UE, where the request indicates at least one candidate target UE served by the target RAN node. 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 third RAN node 430 as described with reference to FIG. 4.

[00185] At 1120, the method may include transmitting, to the RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request. 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 third RAN node 430 as described with reference to FIG. 4.

[00186] FIG. 12 illustrates a flowchart of a method 1200 performed by a second RAN node 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 RAN node 420 in FIG. 4. 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.

[00187] At 1210, the method may include determining to change an indirect path between the second RAN node and a UE via a first relay UE to a further indirect path between the second RAN node and the UE via a second relay UE, where the first relay UE and the second relay UE are served by the second RAN node. 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 RAN node 420 as described with reference to FIG. 4.

[00188] At 1220, the method may include transmitting, to the UE, a reconfiguration message indicating the further indirect path or the second 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 RAN node 420 as described with reference to FIG. 4.

[00189] FIG. 13 illustrates a flowchart of a method 1300 performed by a first RAN node in

accordance with aspects of the present disclosure. The operations of the method 1300 may be implemented by a device or its components as described herein. For example, the operations of the method 1300 may be performed by the first RAN node 410 in FIG. 4. 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.

[00190] At 1310, the method may include receiving, from a UE having a direct path with the first RAN node, failure information, where there is an indirect path between a second RAN node and the UE via a first relay UE, and where the failure information indicates a failure of the indirect path. The operations of 1310 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1310 may be performed by the first RAN node 410 as described with reference to FIG. 4.

[00191] At 1320, the method may include transmitting, to the second RAN node, the failure information indicating the failure of the indirect path. The operations of 1320 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1320 may be performed by the first RAN node 410 as described with reference to FIG. 4.

[00192] 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.

[00193] 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).

[00194] 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,
5 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.

[00195] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program
10 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
15 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.

[00196] 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
20 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).
25 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,
30 including in the claims, a “set” may include one or more elements.

[00197] 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.

What is claimed is:

1. A radio access network (RAN) node comprising:

at least one memory; and

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

5 the RAN node to:

transmit, to a target RAN node, a request for changing an indirect path associated with a user equipment (UE), wherein the request for changing indirect path indicates at least one candidate target UE served by the target RAN node; and

10 receive, from the target RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the target RAN node or indicating a rejection to the request.

2. The RAN node of claim 1, wherein there is a direct path between a first RAN node and the UE, there is an indirect path between a second RAN node and the UE, and the

15 RAN node is one of the first RAN node or the second RAN node.

3. The RAN node of claim 1, wherein the request comprises one of:

an indication for changing an indirect path,

at least one ID of the at least one candidate target UE,

20 at least one cell ID indicating at least one cell serving the at least one candidate target UE,

an indication indicating whether the at least one candidate target UE belongs to a same cell, or

an ID of the UE.

25

4. The RAN node of claim 1, wherein the response comprises one of:

an ID of the target relay UE, or

a configuration of the further indirect path between the UE and the target RAN node via the target relay UE.

30

5. The RAN node of claim 1, wherein the response comprises one of:

a rejection to the request,

a cause of the rejection, or

one or more suggested candidate relay UEs.

6. The RAN node of claim 2, wherein the RAN node is the first RAN node, and the at least one processor is further configured to cause the RAN node to:

5 transmit, to the second RAN node, a release request for releasing the indirect path with the UE.

7. The RAN node of claim 6, wherein the release request comprises one of:
an ID of the target relay UE, or
10 a cause value of the releasing.

8. The RAN node of claim 2, wherein the RAN node is the first RAN node, and the at least one processor is further configured to cause the RAN node to:

transmit, to the UE, a reconfiguration message indicating one of:

15 the target RAN node,
the target relay UE,
a target cell which serves the target relay UE, or
a configuration of the further indirect path between the UE and the target RAN
node via the target relay UE.

9. The RAN node of claim 2, wherein the RAN node is the first RAN node, and the at least one processor is further configured to cause the RAN node to:

receive, from the second RAN node having an indirect path with the UE, the request.

25 10. The RAN node of claim 2, wherein the RAN node is the first RAN node, the request is comprised in a secondary node (SN) addition request message, and the response is comprised in an SN addition request acknowledge message.

30 11. The RAN node of claim 10, wherein a multi-path indication is comprised in an SN addition trigger indication, and wherein the SN addition trigger indication is comprised in the SN addition request message.

12. The RAN node of claim 2, wherein the RAN node is the second RAN node, and the at least one processor is further configured to cause the RAN node to:

in accordance with a determination that at least one signally radio bearer (SRB) is available for the indirect path, transmit, to the UE, a configuration of the further indirect path between the UE and the target RAN node via the target relay UE.

5 13. The RAN node of claim 12, wherein the at least one processor is further configured to cause the RAN node to:

transmit, to the first RAN node, a switching request for indirect path changing; and
receive, from the first RAN node, a confirmation of the switching request.

10 14. The RAN node of claim 2, wherein the RAN node is the second RAN node, and the at least one processor is further configured to cause the RAN node to:

in accordance with a determination that there is no SRB available for the indirect path, transmit, to the first RAN node, a configuration of the further indirect path between the UE and the target RAN node via the target relay UE.

15

15. A target radio access network (RAN) node comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the target RAN node to:

20

receive, from a RAN node, a request for changing an indirect path associated with a user equipment (UE), wherein the request indicates at least one candidate target UE served by the target RAN node; and

transmit, to the RAN node, a response indicating one of the at least one candidate target UE as a target relay UE for a further indirect path between the UE and the
25 target RAN node or indicating a rejection to the request.

16. The target RAN node of claim 15, wherein the request comprises one of:

an indication for changing an indirect path,

at least one ID of the at least one candidate target UE,

30

at least one cell ID indicating at least one cell serving the at least one candidate target UE,

an indication indicating whether the at least one candidate target UE belongs to a same cell, or

an ID of the UE.

17. The target RAN node of claim 15, wherein the response comprises one of:
an ID of the target relay UE, or
a configuration of the further indirect path between the UE and the target RAN node

5 via the target relay UE.

18. The target RAN node of claim 15, wherein the response comprises one of:
a rejection to the request,
a cause of the rejection, or
10 one or more suggested candidate relay UEs.

19. A method performed by a radio access network (RAN) node, comprising:
transmitting, to a target RAN node, a request for changing an indirect path associated
with a user equipment (UE), wherein the request for changing indirect path indicates at least
15 one candidate target UE served by the target RAN node; and

receiving, from the target RAN node, a response indicating one of the at least one
candidate target UE as a target relay UE for a further indirect path between the UE and the
target RAN node or indicating a rejection to the request.

20. A method performed by a target radio access network (RAN) node, comprising:
receiving, from a RAN node, a request for changing an indirect path associated with
a user equipment (UE), wherein the request indicates at least one candidate target UE served
by the target RAN node; and

transmitting, to the RAN node, a response indicating one of the at least one candidate
25 target UE as a target relay UE for a further indirect path between the UE and the target RAN
node or indicating a rejection to the request.

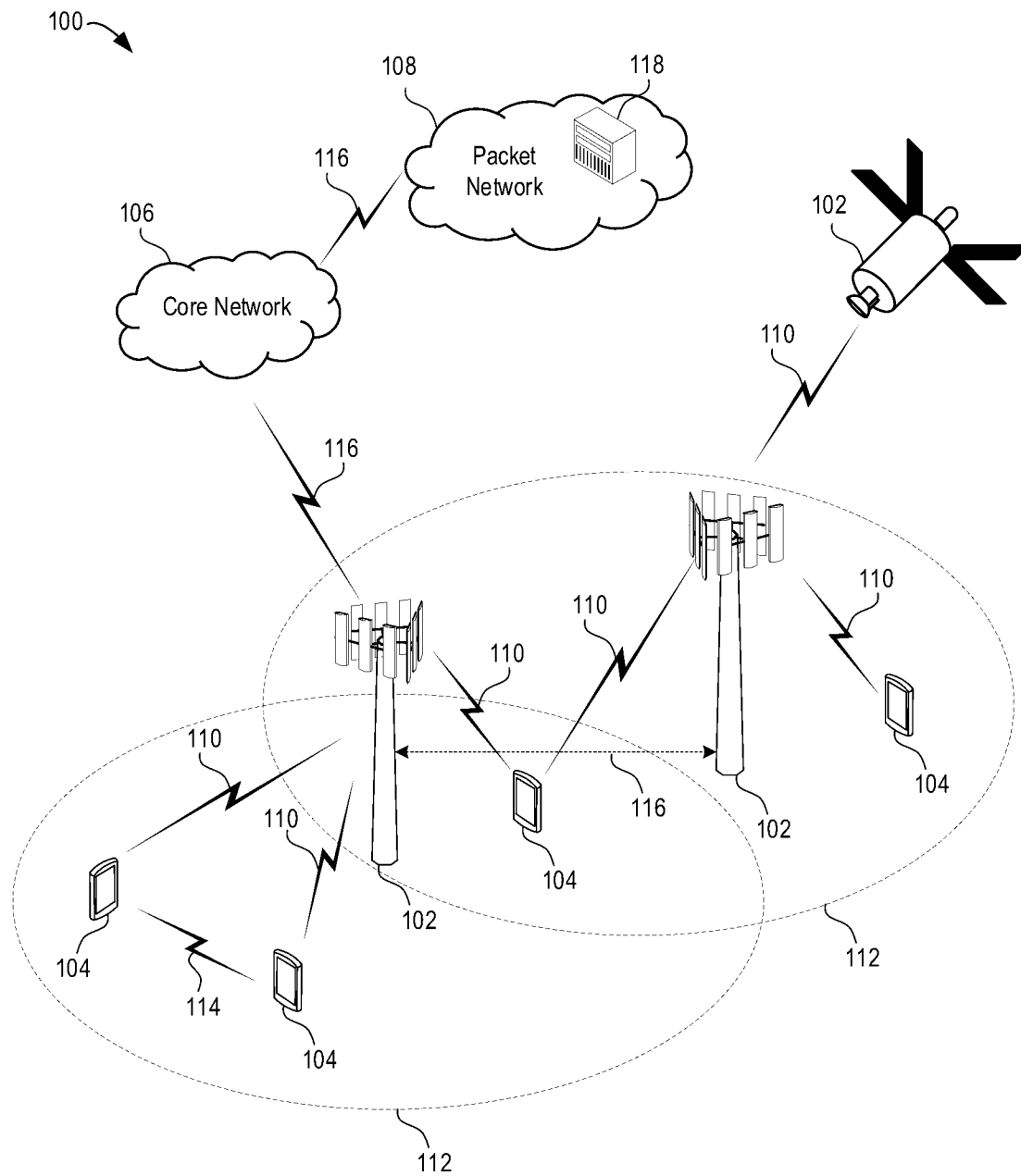


FIG. 1

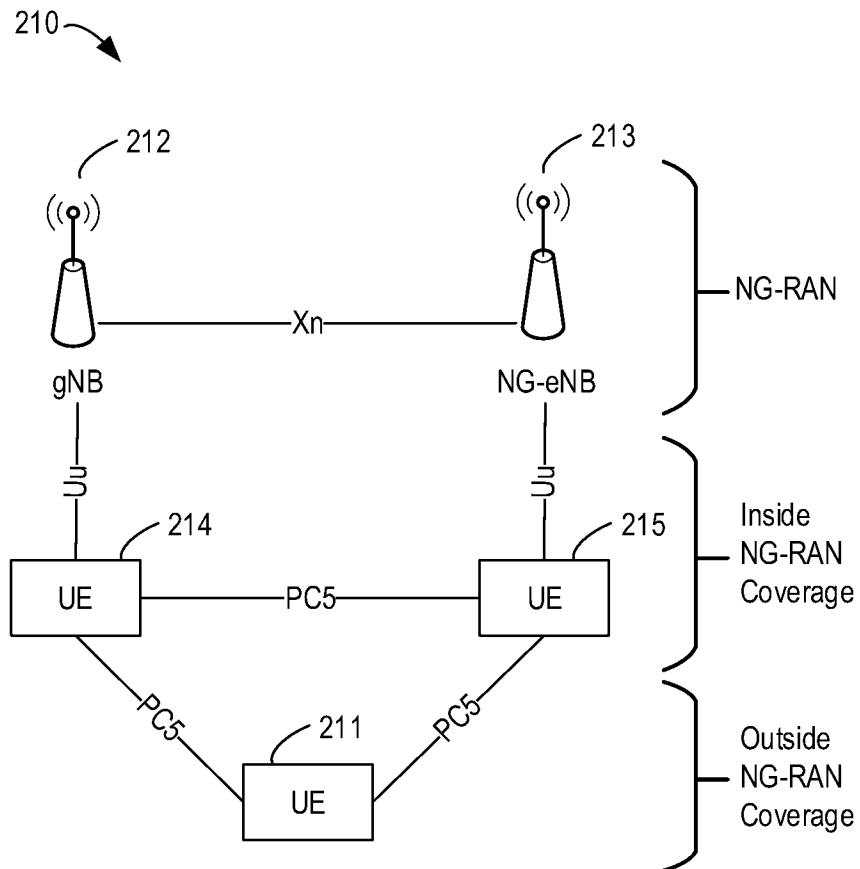


FIG. 2A

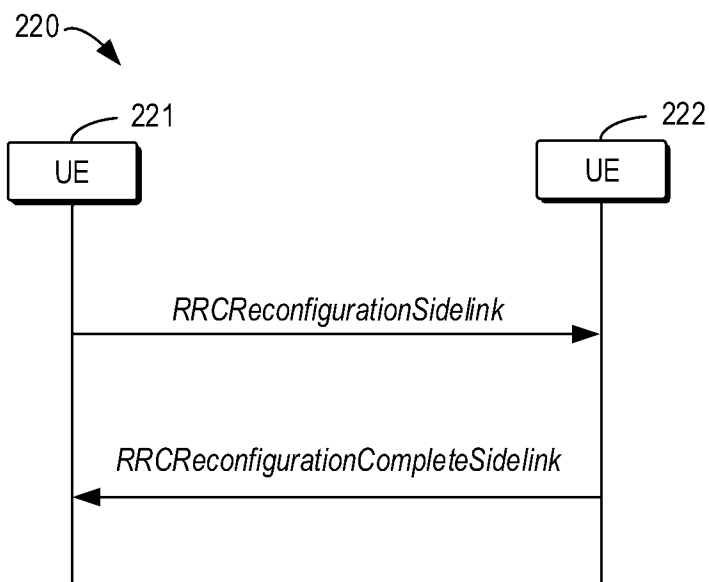


FIG. 2B

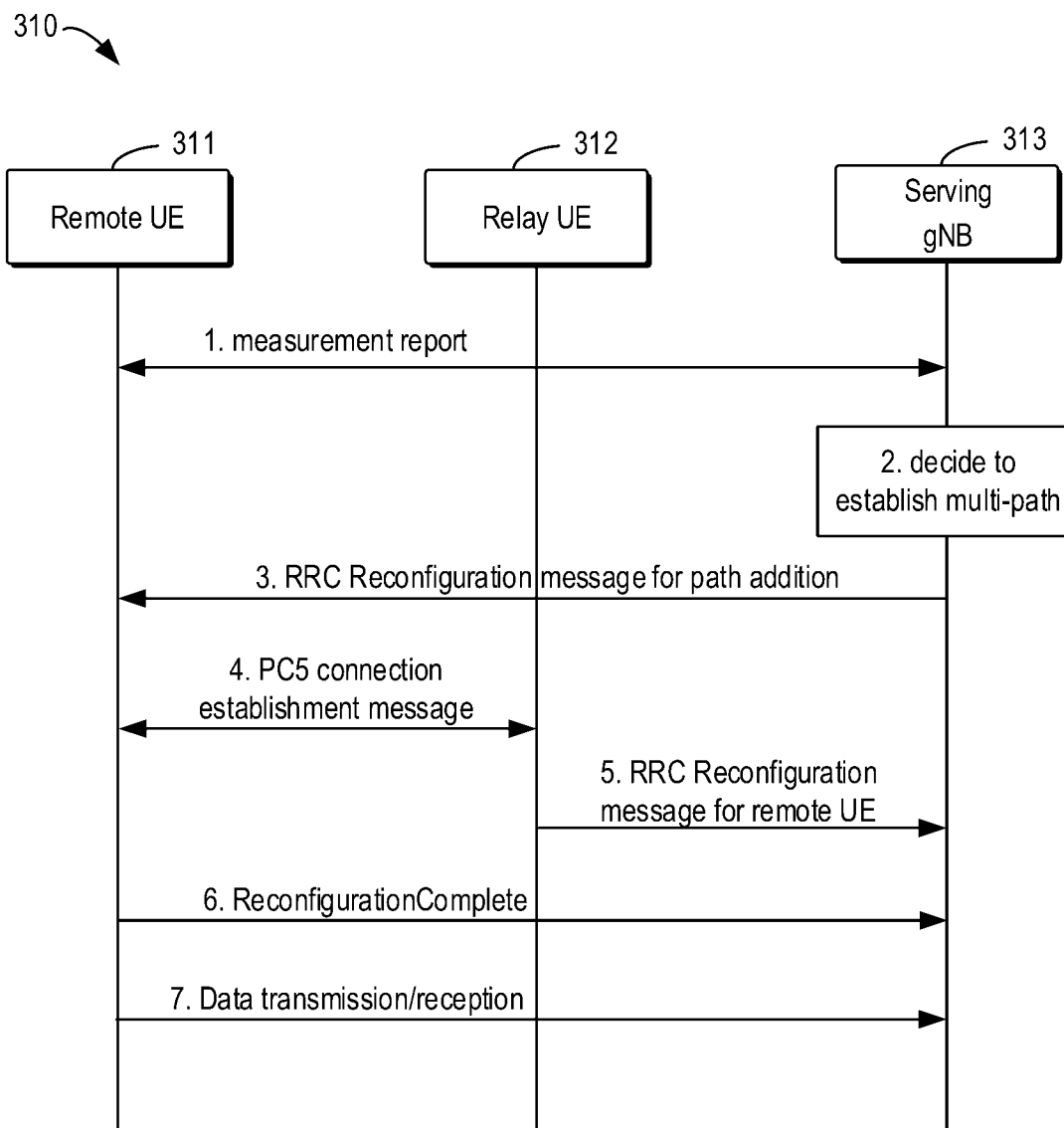


FIG. 3A

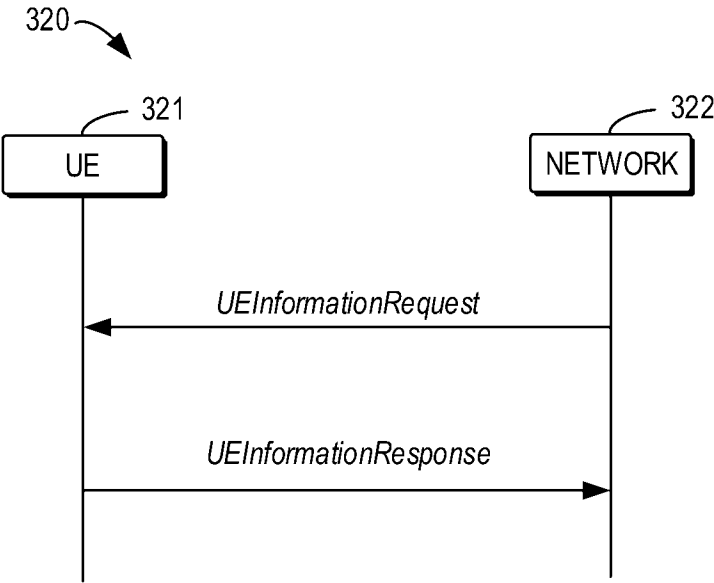


FIG. 3B

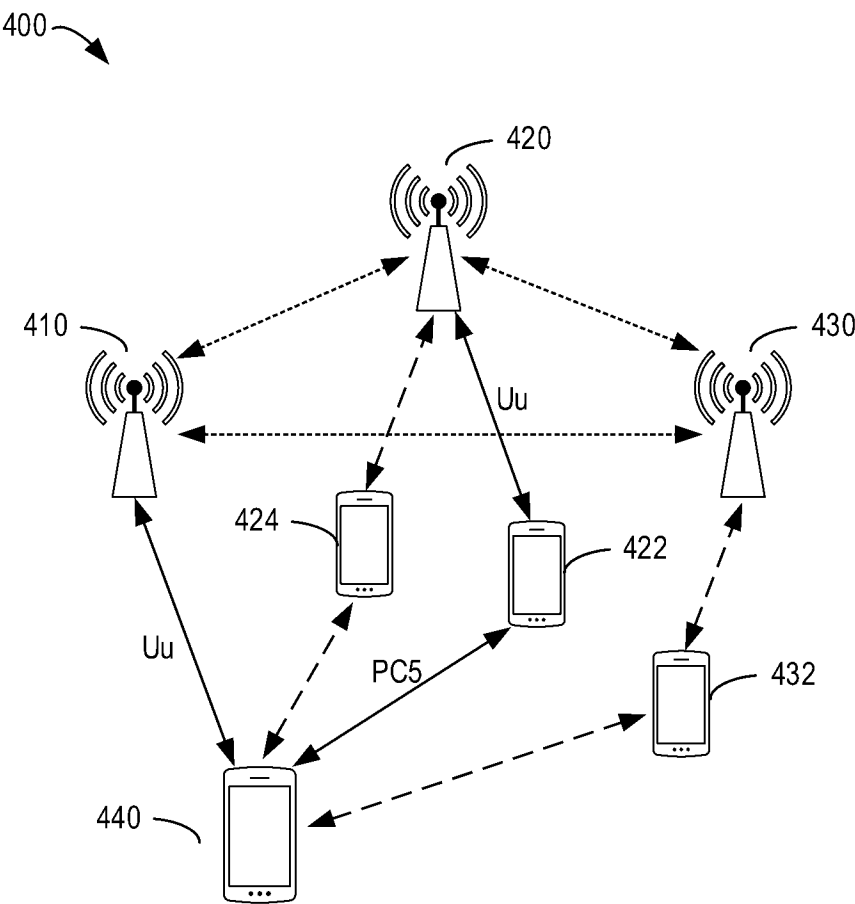


FIG. 4

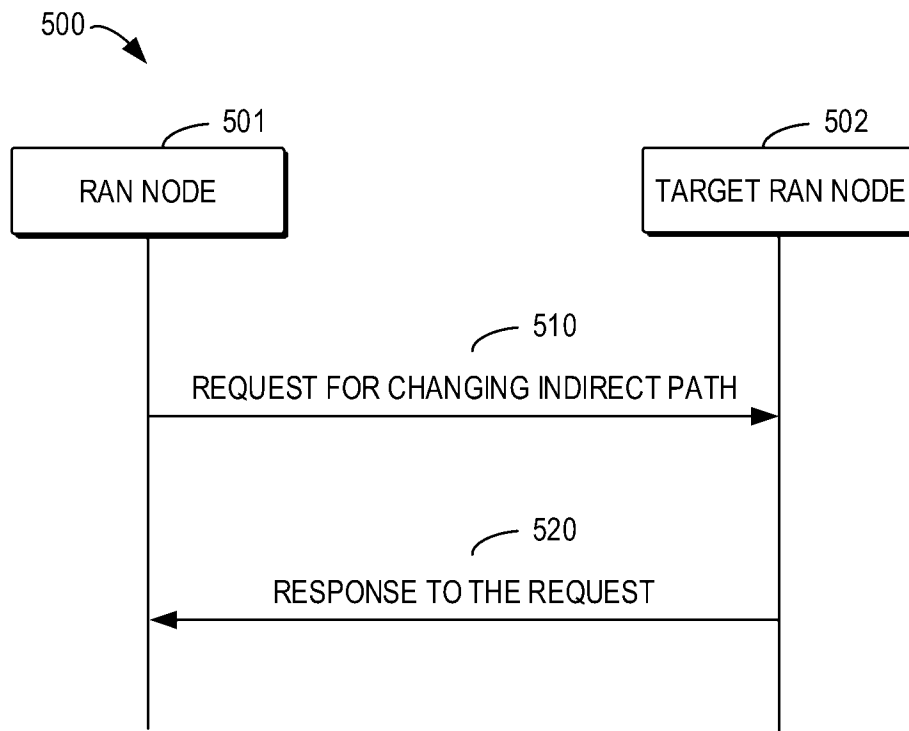


FIG. 5

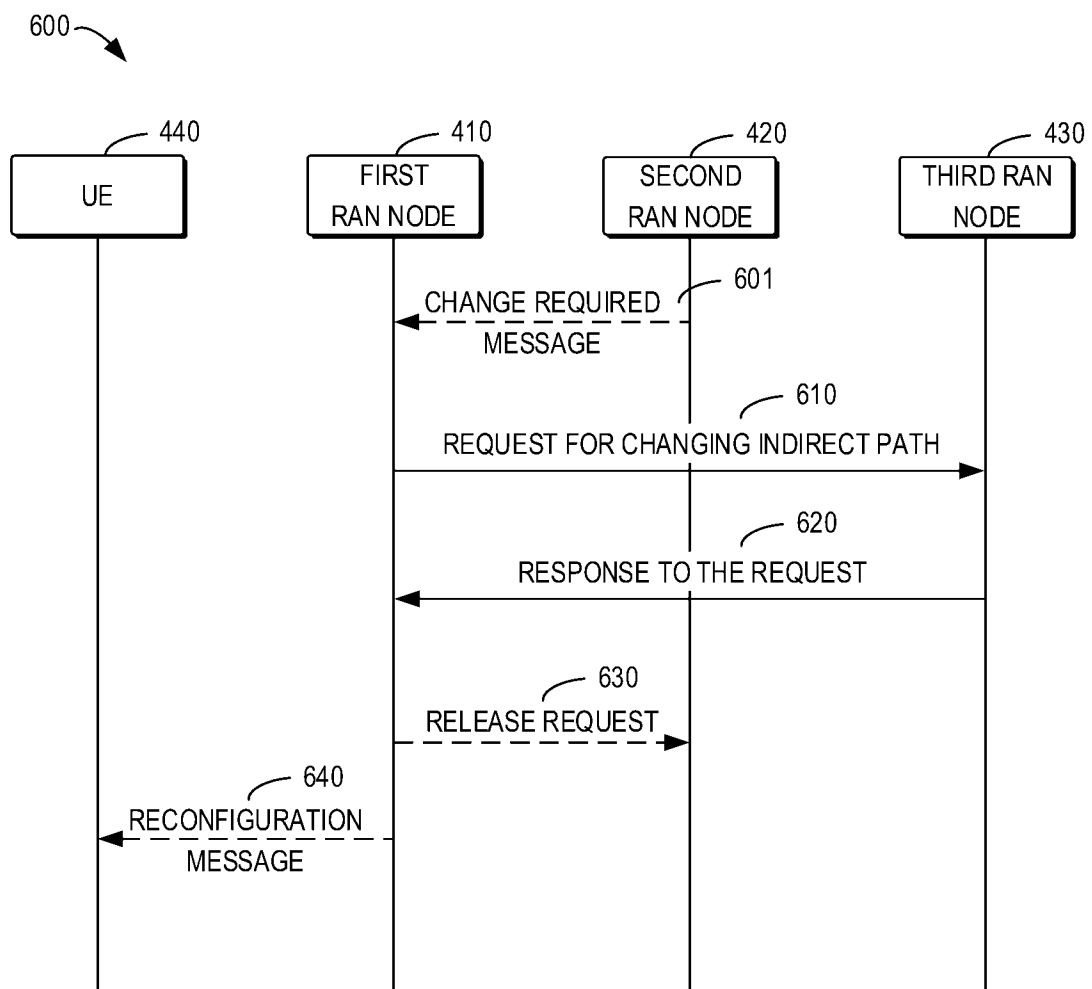


FIG. 6A

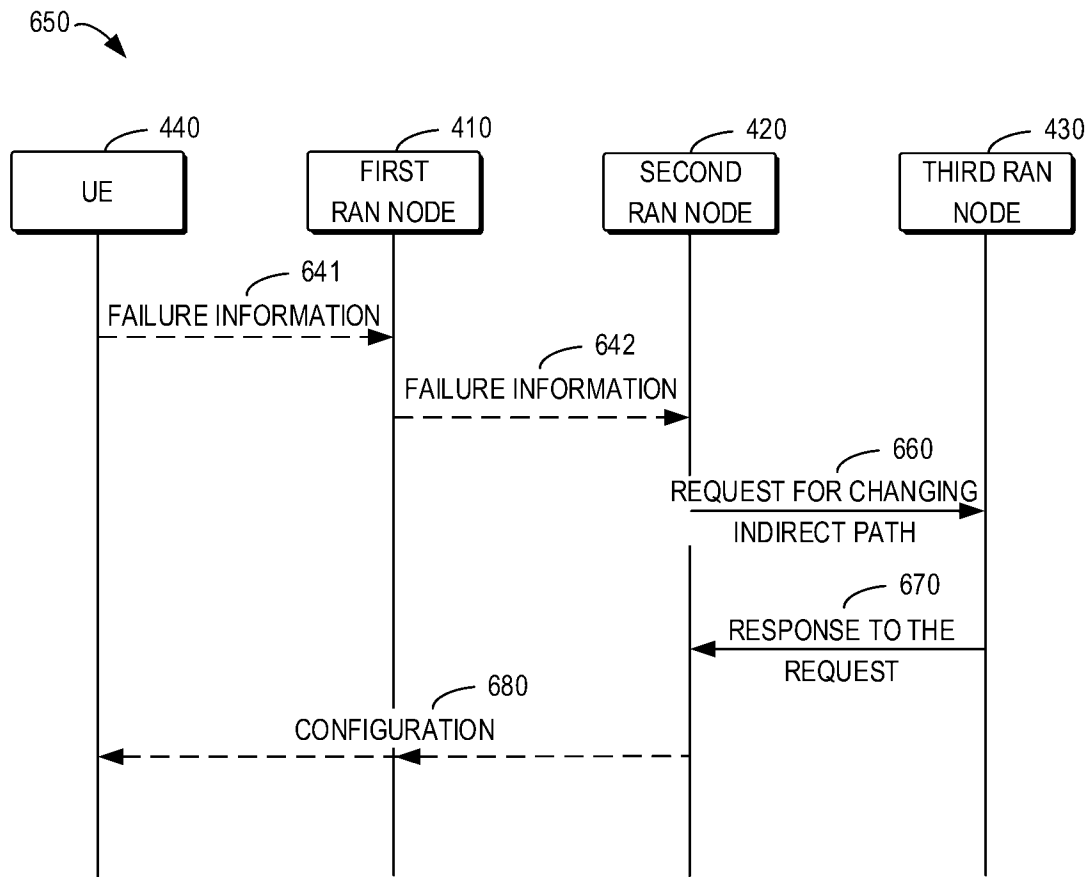


FIG. 6B

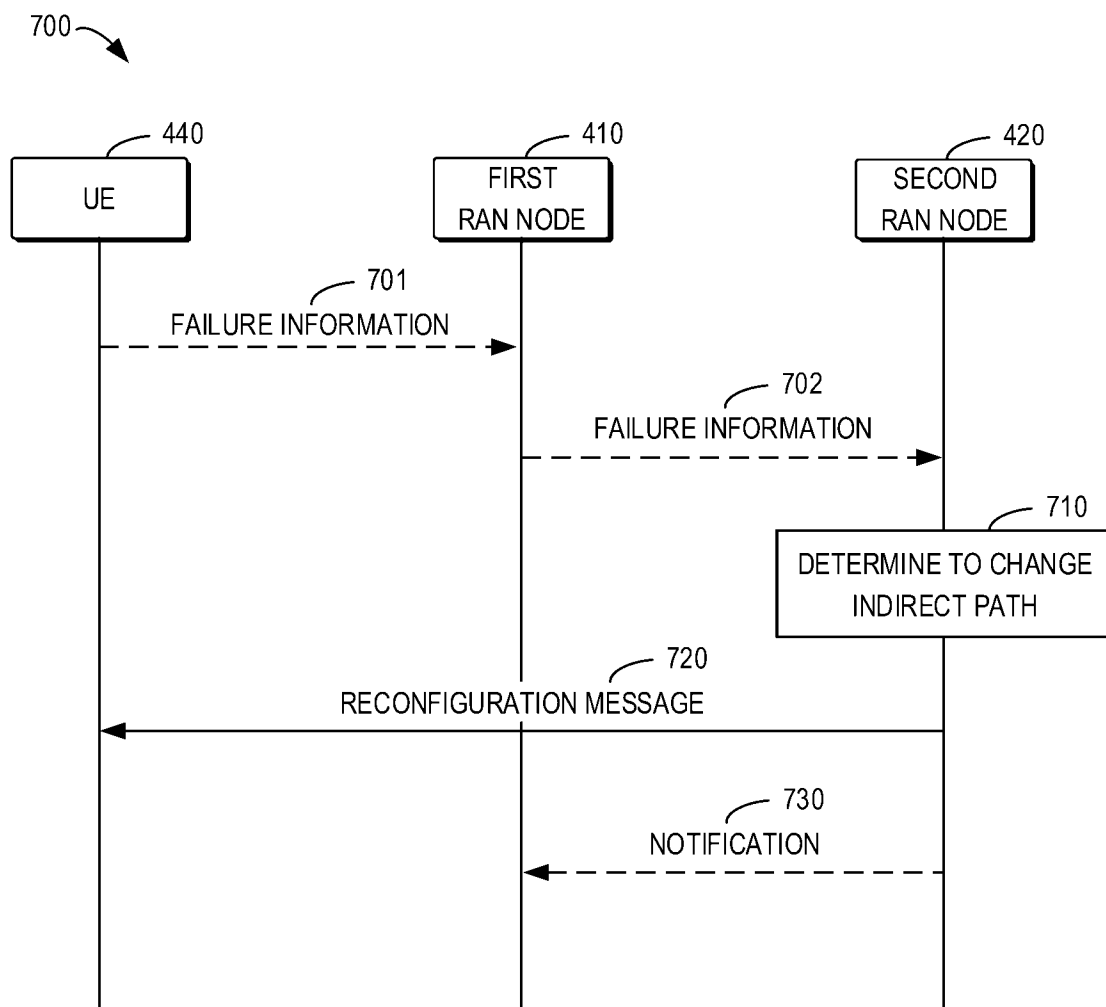


FIG. 7

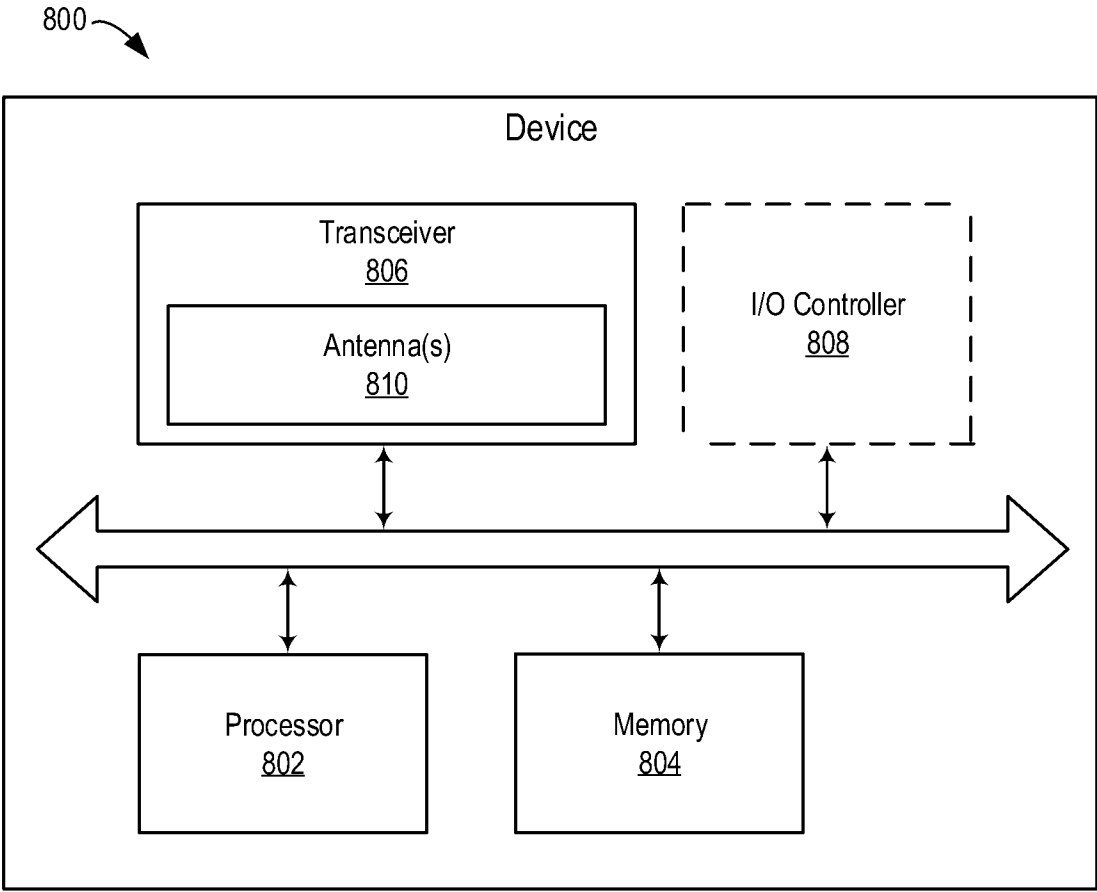


FIG. 8

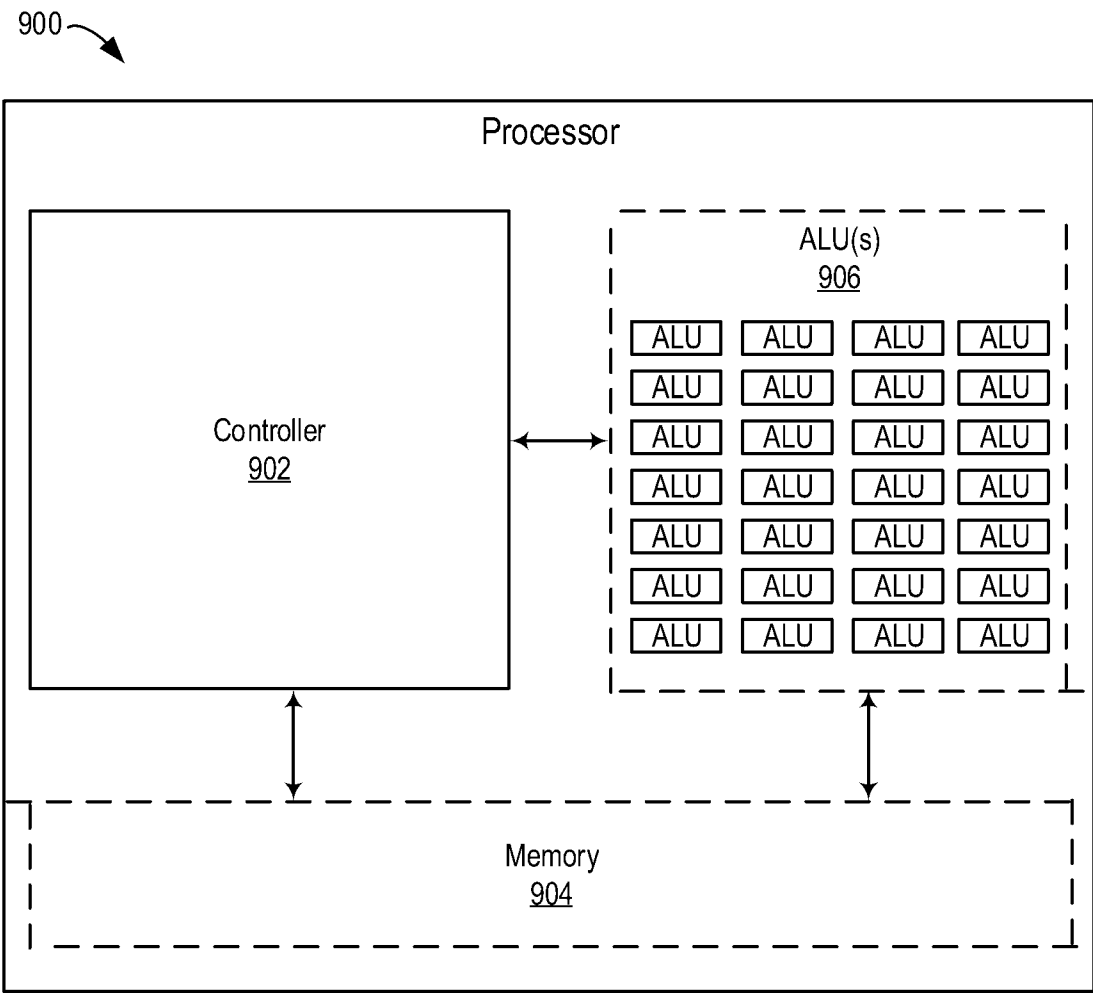


FIG. 9

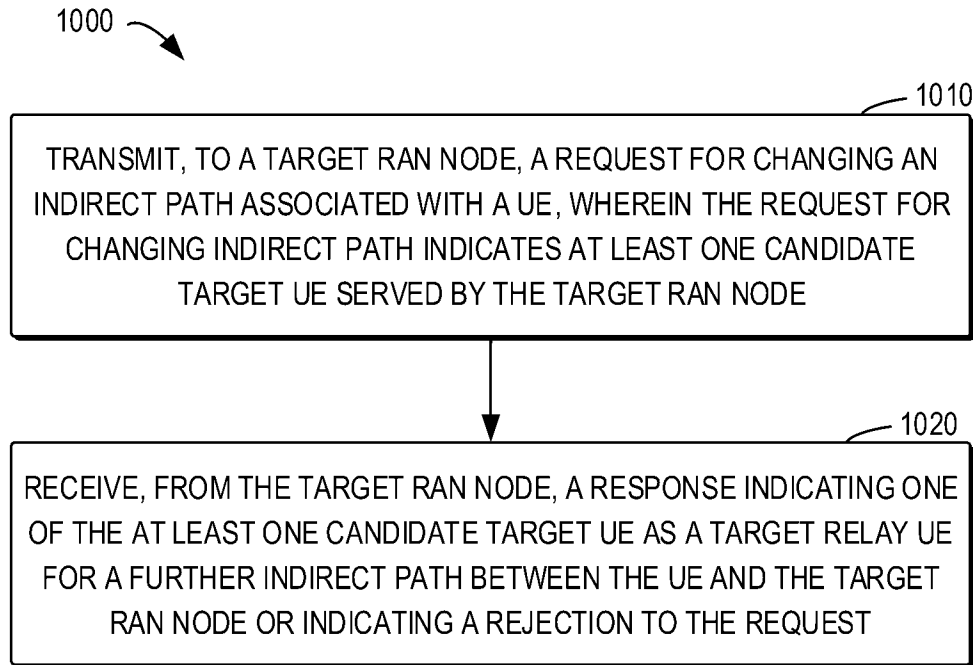


FIG. 10

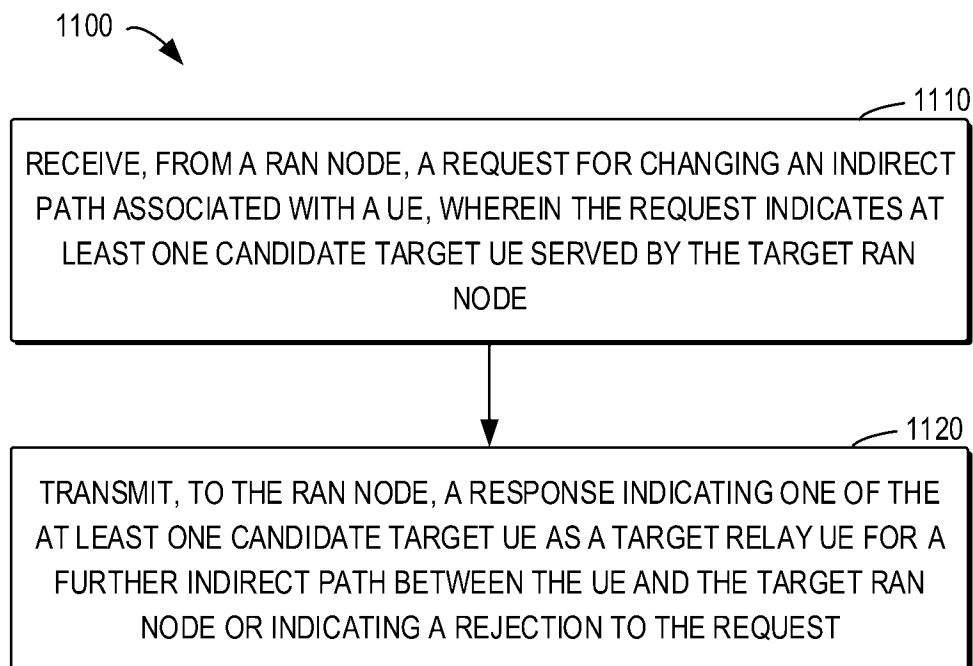


FIG. 11

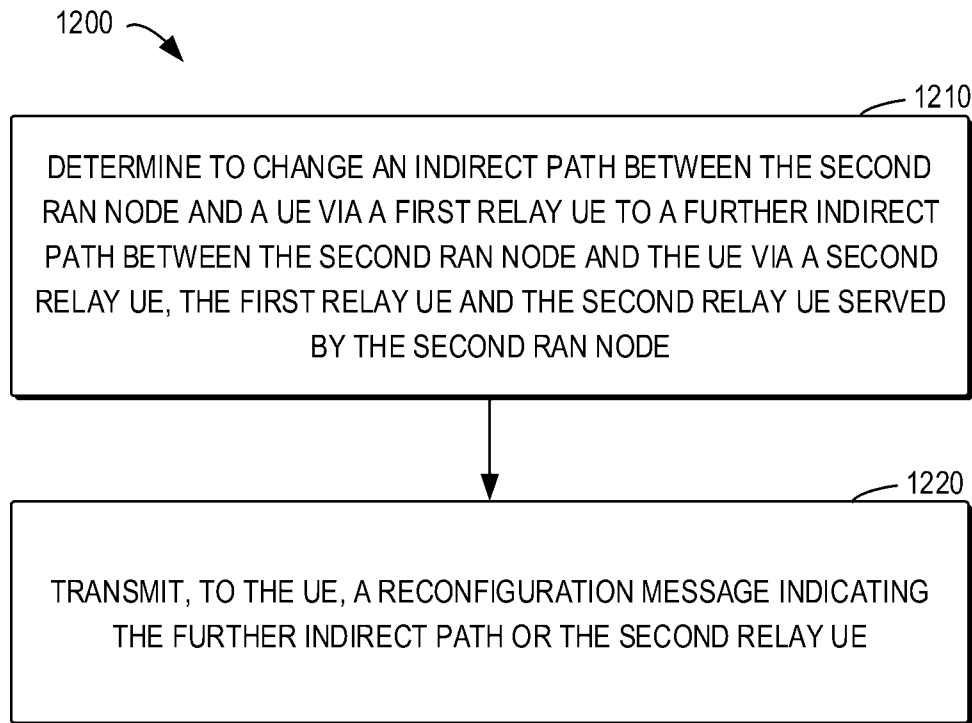


FIG. 12

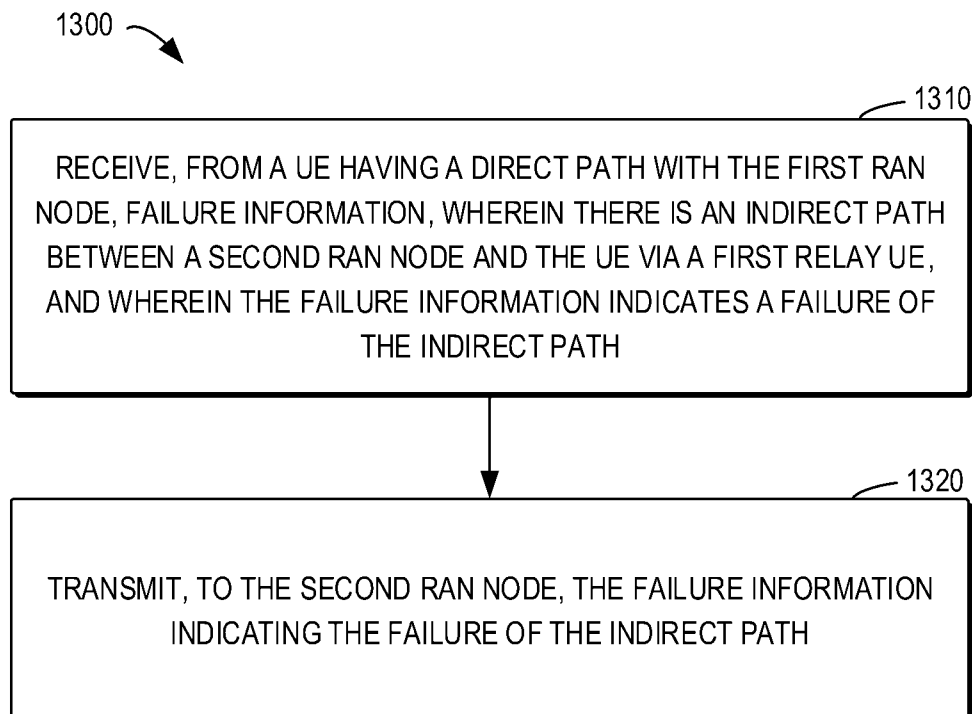


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/111819

A. CLASSIFICATION OF SUBJECT MATTER

H04W 76/15(2018.01)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

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)

CNTXT, ENTXT, DWPI, 3GPP: handover, switch, indirect path, relay UE, target, candidate, ID

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3955635 A1 (NOKIA TECHNOLOGIES OY) 16 February 2022 (2022-02-16) description, paragraphs 0002-0257, and figures 1-9	1-20
X	US 2023129388 A1 (MEDIATEK SINGAPORE PTE. LTD.) 27 April 2023 (2023-04-27) description, paragraphs 0019-0053, and figures 1-9	1-20
X	WO 2022151003 A1 (QUALCOMM INC.) 21 July 2022 (2022-07-21) description, paragraphs 0050-0257, and figures 1-16	1-20
X	WO 2022151146 A1 (QUALCOMM INC.) 21 July 2022 (2022-07-21) description, paragraphs 0064-0363, and figures 1-18	1-20
A	CN 116261185 A (CHINA TELECOM CORPORATION LIMITED) 13 June 2023 (2023-06-13) the whole document	1-20
A	WO 2023005351 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)) 02 February 2023 (2023-02-02) the whole document	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

“D” document cited by the applicant in the international application

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

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

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

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

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

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

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

“&” document member of the same patent family

Date of the actual completion of the international search

07 April 2024

Date of mailing of the international search report

10 April 2024

Name and mailing address of the ISA/CN

**CHINA NATIONAL INTELLECTUAL PROPERTY
ADMINISTRATION**
6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing
100088, China

Authorized officer

WANG,GuoGang

Telephone No. (+86) 010-53961755

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/111819

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HUAWEI et al. "Service continuity for L2 UE-to-Network relay R2-2008048" <i>3GPP TSG-RAN WG2 Meeting #111 electronic</i> , 28 August 2020 (2020-08-28), pages 1-6	1-20

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2023/111819

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
EP	3955635	A1	16 February 2022	WO	2022033833	A1	17 February 2022
				US	2024031877	A1	25 January 2024
				CN	116114377	A	12 May 2023
US	2023129388	A1	27 April 2023	EP	4171124	A1	26 April 2023
				TW	202325066	A	16 June 2023
				CN	116017612	A	25 April 2023
				WO	2023065298	A1	27 April 2023
WO	2022151003	A1	21 July 2022	CN	116686344	A	01 September 2023
				EP	4278695	A1	22 November 2023
				IN	202327033491	A	08 December 2023
				US	2024007922	A1	04 January 2024
WO	2022151146	A1	21 July 2022	CN	116762469	A	15 September 2023
				EP	4278688	A1	22 November 2023
				IN	202327032922	A	01 December 2023
				US	2024031890	A1	25 January 2024
CN	116261185	A	13 June 2023	None			
WO	2023005351	A1	02 February 2023	CN	117643093	A	01 March 2024