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(71) Applicant: KYOCERA CORPORATION [JP/JP]; 6 Takeda Tobadono-cho, Fushimi-ku, Kyoto, 612-8501 (JP).

(72) Inventors; and

(71) Applicants: CHANG, Henry [US/US]; c/o Kyocera International, Inc., Attention: Intellectual Property Department, 8611 Balboa Ave., San Diego, CA 92123-1580 (US). FUJISHIRO, Masato [JP/JP]; c/o Kyocera International, Inc., Attention: Intellectual Property Department, 8611 Balboa Ave., San Diego, CA 92123-1580 (US).

(74) Agent: CONNELL, Kathleen, L.; Kyocera International, Inc., Attention: Intellectual Property Department, 8611 Balboa Ave., San Diego, CA 92123-1580 (US).

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(54) Title: PATH SWITCH TO INDIRECT COMMUNICATION THROUGH RELAY UE DEVICE IN RRC CONNECTION STATE OTHER THAN RRC CONNECTED

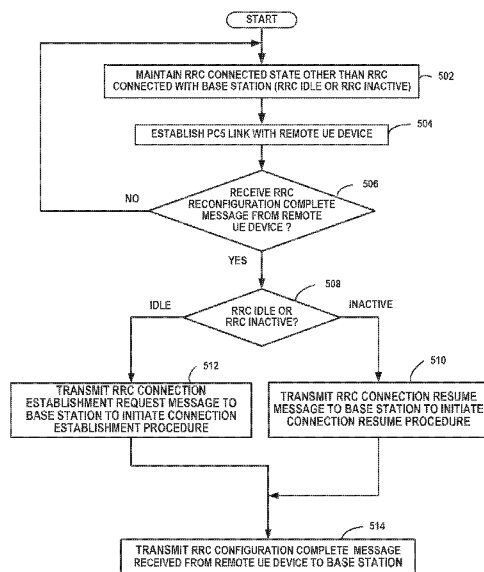


FIG. 5

(57) Abstract: A base station transmits a Radio Resource Control (RRC) Reconfiguration message to a remote user equipment (UE) device to initiate a path switch from direct communication with the remote UE device to indirect communication through a relay UE device. The relay UE device is an RRC connection state other than RRC Connected (RRC CONN) when the path switch is initiated. The remote UE device transmits an RRC Reconfiguration Complete message to the base station through the relay UE device. In response to receiving the RRC Reconfiguration Complete message, the relay UE performs RRC Connection Establishment with the base station when the relay UE device is in an RRC IDLE state and performs RRC Resume with the base station when the relay UE device is in an RRC INACTIVE state. The relay UE device transmits the RRC Reconfiguration Complete message to the base station.



**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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## PATH SWITCH TO INDIRECT COMMUNICATION THROUGH RELAY UE DEVICE IN RRC CONNECTION STATE OTHER THAN RRC CONNECTED

### CLAIM OF PRIORITY

5 **[0001]** The present application claims priority to Provisional Application No. 63/222,303, entitled "SERVICE CONTINUITY UNDER L2 SIDELINK RELAYING," docket number TPRO 00363 US, filed July 15, 2021, which is assigned to the assignee hereof and hereby expressly incorporated by reference in its entirety.

10

### FIELD

**[0002]** This invention generally relates to wireless communications and more particularly to management of wireless communication links using relay devices.

### BACKGROUND

15 **[0003]** Many wireless communication systems that employ several base stations that provide wireless service to user equipment (UE) devices enable sidelink communication between two or more UE devices where the UE devices can communicate directly with other UE devices. With sidelink communication, UE devices transmit data signals to each other over a communication link using the cellular resources instead of through a  
20 base station. Such Proximity Services (ProSe) communication is sometimes also referred to as device-to-device (D2D). In addition, one or more UE devices can be used as relay devices between a UE device and a destination where the relay device forwards data between a UE device and the destination. The destination may be a communication network or another UE device (destination UE device). Where the  
25 destination is the network, the relay functionality is typically referred to as UE-to-Network (U2N) relaying and the relay UE device establishes a communication path between the remote UE and a base station (gNB) or cell. In some situations, for example, the UE device may be out of the service area of the base station and the relay UE device provides a communication link routed from such an out-of-coverage (OoC)

-2-

UE device through a relay UE device to the base station. Where the destination device is another UE device (target UE device), the relaying functionality is typically referred to as UE-to-UE (U2U) relaying.

5

## SUMMARY

**[0004]** A base station transmits a Radio Resource Control (RRC) reconfiguration with Sync message to a remote user equipment (UE) device to initiate a path switch from direct communication with the remote UE device to indirect communication through a relay UE device. The relay UE device is in an RRC connection state other than RRC  
10 Connected (RRC CONN) when the path switch is initiated. The remote UE device transmits an RRC Reconfiguration Complete message to the base station through the relay UE device. In response to receiving the RRC Reconfiguration Complete message, the relay UE performs RRC Connection Establishment with the base station when the relay UE device is in an RRC IDLE state and performs RRC Resume with the base  
15 station when the relay UE device is in an RRC INACTIVE state. The relay UE device transmits the RRC Reconfiguration Complete message to the base station over a Uu communication link.

## BRIEF DESCRIPTION OF THE DRAWINGS

20 **[0005]** FIG. 1A is a block diagram of a communication system for an example where candidate relay UE devices transmit reference signals that are received by a remote UE device 108 where the candidate relay UE devices may be in any one of RRC connected states.

**[0006]** FIG. 1B is a block diagram of the communication system where the remote  
25 UE device transmits a measurement report to the base station.

**[0007]** FIG. 1C is a block diagram of the communication system where the remote UE device transmits an RRC Reconfiguration Complete message to the target relay UE device for relaying to the base station.

-3-

**[0008]** FIG. 1D is a block diagram of the communication system where the target relay UE device forwards the RRC Reconfiguration Complete message as an RRC Reconfiguration complete transmission to the base station.

**[0009]** FIG. 2 is a block diagram of an example of a base station.

5 **[0010]** FIG. 3 is a block diagram of an example of a UE device suitable for use as each of the UE devices.

**[0011]** FIG. 4A is a message diagram for an example of relay link management for direct to indirect path switching where the target relay UE device is in RRC INACTIVE.

10 **[0012]** FIG. 4B is a message diagram for an example of relay link management for direct to indirect path switching where the target relay UE device is in RRC IDLE.

**[0013]** FIG. 5 is a flow chart of an example of a method of managing path switching from direct to indirect communication links.

### DETAILED DESCRIPTION

15 **[0014]** As discussed above, a relay UE device provides connectivity between a remote UE device and a destination which can be another UE device (destination UE device) or a network. Where the destination is the network, the relay provides connectivity to a cell provided by a base station (gNB) of the network. The relayed connection between a remote UE device and target UE device is sometimes referred to as a UE to UE (U2U) relay connection. The relayed connection between a remote UE device and a base station (gNB) is sometimes referred to as a UE to network (U2N) relay connection. In some situations, the ultimate destination is a target UE device through the base station. In conventional systems where the relay connects to a base station (gNB), the relay UE device is required to meet certain criteria to function as a relay. For example, the relay UE device must be in coverage and have a cellular (Uu) communication link to the base station of sufficient quality in order to be available for U2N relaying functions.

25 **[0015]** Sidelink relaying functionality allows a remote UE that is out-of-coverage (OoC) to connect with the gNB or base station via a relay UE device. With UE-to-

Network (U2N) relaying, the relay UE needs to be in coverage of a cell and connected to the gNB. The relayed connection from the remote UE device to the base station (gNB) includes a PC5 link (sidelink) between the remote UE device and the relay UE device and the Uu link between the relay UE device and the gNB.

5 **[0016]** In some situations, a remote UE device is in direct communication with a base station (gNB) without communicating through a relay UE device, and the base station determines that the communication link to the remote UE device should be switched from the direct link to an indirect link through a relay UE device. In making the switch to an indirect link, however, the base station may choose to switch to an indirect  
10 relayed link provided by a relay UE device that is in an RRC state other than the RRC Connected state (RRC CONN). Latency may be minimized when switching to a relayed connection through a relay UE device in RRC CONN as compared to switching to a relayed connection through a relay UE device in an RRC idle state (RRC IDLE) or an RRC inactive state (RRC INACTIVE). In some situations, however, the path through the  
15 relay in RRC IDLE or RRC INACTIVE may be preferred. Accordingly, the base station may select the better path at the expense of latency. In other situations, a relay in RRC CONN may not be available, and the only indirect options include relays in IDLE or INACTIVE, since it is typically more power efficient to keep relay UE devices in IDLE or INACTIVE when there are no remote UE devices PC5-connected to the relay UE  
20 device. Also, current communication standards do not specify that the remote UE device limits the pool of candidate relay UE devices contained in the measurement report to any particular RRC state such as RRC CONN and do not specify that the remote UE indicates the states of the candidate relay UE devices listed in the measurement report.

25 **[0017]** For the examples herein, the base station sends an RRC Reconfiguration with Sync message to a remote UE device to initiate a path switch from direct link to an indirect link through a relay UE device that is currently in an RRC state other than RRC CONN. The remote UE sends an RRC Reconfiguration Complete message to the base station through the relay UE device, which triggers a procedure to transition the relay  
30 UE device to RRC CONN. In response to receiving the RRC Reconfiguration Complete

message, the relay UE performs RRC Connection Establishment with the base station when the relay UE device is in an RRC IDLE state and performs RRC Resume with the base station when the target relay UE device is in an RRC INACTIVE state. The relay UE device transmits the RRC Reconfiguration Complete message to the base station  
5 over the Uu communication link.

**[0018]** Although the techniques discussed herein may be applied to various types of systems and communication specifications, the devices of the example operate in accordance with at least one revision of the 3<sup>rd</sup> Generation Partnership Project (3GPP) New Radio (NR) V2X communication specification. The techniques discussed herein,  
10 therefore, may be adopted by one or more future revisions of communication specifications although the techniques may be applied to other communication specifications where sidelink or D2D is employed. More specifically the techniques may be applied to current and future releases of 3GPP NR specifications. For example, the techniques may also be applied to 3GPP NR (3GPP Rel-17) and 3GPP Rel-18.

**[0019]** FIG. 1A is a block diagram of a communication system 100 for an example where candidate relay UE devices 101-103 transmit reference signals 104-106 that are received by a remote UE device 108 where the candidate relay UE devices 101-103 may be in any one of RRC connected states. The candidate relay UE device 101-103 are within a cell coverage area 110 of a base station (gNB) 112. For the example, the  
20 first candidate relay UE device 101 is in the RRC inactive state (RRC INACTIVE), the second candidate relay UE device 102 is in the RRC connected state (RRC CONN), and the third candidate relay UE device 103 is in the RRC idle state (RRC IDLE).

**[0020]** The remote UE device 108 is in communication with the base station 112 over a direct Uu communication link 114. The remote UE device 108, therefore, is within  
25 the cell coverage area 110 when the scenario of the example discussed with reference to FIG.s 1A-D begins. The remote UE device 108 receives a reference signal 104, 105, 106 from each of the relay UE candidate devices 101, 102, 103. For the example, the reference signals 104-106 are sidelink discovery signals where the discovery signal may be a Model A discovery announcement message or a Model B response message.

**[0021]** FIG. 1B is a block diagram of the communication system 100 where the remote UE device 108 transmits a measurement report 120 to the base station 112. The remote UE device 108 generates the measurement report 120 based on measurements of the reference signals 104-106 received at the remote UE device 108. For the  
5 example, the measurement report 120 is generated in accordance with at least one revision of the 3GPP communication specification. The base station 112 receives the measurement report and determines that the remote UE device 108 should switch from the direct communication path to the base station 112 to an indirect communication path through a relay UE device. For the example, the base station 112 selects the candidate  
10 relay UE device 101 as the target relay UE device for the indirect communication path. The base station transmits an RRC Reconfiguration with Sync message 122 instructing the remote UE device 108 to switch to the indirect path through the candidate relay UE device 101. For the example discussed with reference to FIGs. 1A-D, therefore, the target relay UE device is in RRC INACTIVE when the remote UE device 108 receives  
15 the RRC Reconfiguration with Sync message 122.

**[0022]** FIG. 1C is a block diagram of the communication system 100 where the remote UE device 108 transmits an RRC Reconfiguration Complete message 124 to the target relay UE device (candidate relay UE device 101) for relaying to the base station 112. In response to receiving the RRC Reconfiguration with Sync message 122, the  
20 remote UE device establishes a sidelink (PC5 link) 126 with the candidate relay UE device 101. After the PC5 link is established, the remote UE device 108 transmits an RRC Reconfiguration Complete message 124 using the default configuration of SL-RLC1 to the candidate relay UE device 101 and intended for the base station 112. In response to receiving the RRC Reconfiguration Complete message 124, the target relay  
25 UE device 101 performs a procedure to resume the RRC CONN state with the base station 112. For the example, the target relay UE device 101 performs the resume procedure in accordance with at least one revision of the 3GPP communication specification, which typically includes at least transmitting an RRC Resume Request message to the base station 112, receiving an RRC Resume message from the base  
30 station 112, and transmitting an RRC Resume Complete message to the base station 112. After the procedure is performed, the RRC CONN state 128 is resumed.

-7-

**[0023]** In situations where the target relay UE device is a candidate relay UE device in RRC IDLE, the candidate relay UE device performs an RRC connection establishment procedure. If the target relay UE device is the candidate relay UE device 103, for example, the candidate relay UE device 103 performs an RRC establishment procedure in accordance with at least one revision of the 3GPP communication specification, which typically includes transmitting an RRC Establishment Request message to the base station 112, receiving an RRC Reconfiguration message from the base station 112, and transmitting an RRC Reconfiguration Complete message to the base station 112.

**[0024]** FIG. 1D is a block diagram of the communication system 100 where the target relay UE device (candidate relay UE device 101) forwards information related to the RRC Reconfiguration Complete message 124 in a remote reconfiguration complete relayed transmission 130 to the base station 112. After RRC CONN is resumed with the base station 112, the target relay UE device (candidate relay UE device 101) relays the Reconfiguration Complete message 124 to the base station 112, and the indirect communication path 132 between the remote UE device 108 and the base station 112, through the relay UE device 101, is established. For the example, the remote reconfiguration complete relayed transmission 130 is a Signaling Radio Bearer 1 (SRB1) message transmitted using Sidelink Relay Adaptation Protocol (SRAP) techniques.

**[0025]** FIG. 2 is a block diagram of an example of a base station 200 suitable for use as the base station 112 and any base station providing a cell or otherwise serving any of the UE devices. The base station 200 includes a controller 204, transmitter 206, and receiver 208, as well as other electronics, hardware, and code. The base station 200 is any fixed, mobile, or portable equipment that performs the functions described herein. The various functions and operations of the blocks described with reference to the base stations 112, 200 may be implemented in any number of devices, circuits, or elements. Two or more of the functional blocks may be integrated in a single device, and the functions described as performed in any single device may be implemented over several devices. The base station 200 may be a fixed device or apparatus that is

installed at a particular location at the time of system deployment. Examples of such equipment include fixed base stations or fixed transceiver stations. Although the base station may be referred to by different terms, the base station is typically referred to as a gNodeB or gNB when operating in accordance with one or more communication specifications of the 3GPP V2X operation. In some situations, the base station 200 may be mobile equipment that is temporarily installed at a particular location. Some examples of such equipment include mobile transceiver stations that may include power generating equipment such as electric generators, solar panels, and/or batteries. Larger and heavier versions of such equipment may be transported by trailer. In still other situations, the base station 200 may be a portable device that is not fixed to any particular location.

**[0026]** The controller 204 includes any combination of hardware, software, and/or firmware for executing the functions described herein as well as facilitating the overall functionality of the base station 200. An example of a suitable controller 204 includes code running on a microprocessor or processor arrangement connected to memory. The transmitter 206 includes electronics configured to transmit wireless signals. In some situations, the transmitter 206 may include multiple transmitters. The receiver 208 includes electronics configured to receive wireless signals. In some situations, the receiver 208 may include multiple receivers. The receiver 208 and transmitter 206 receive and transmit signals, respectively, through an antenna 210. The antenna 210 may include separate transmit and receive antennas. In some circumstances, the antenna 210 may include multiple transmit and receive antennas.

**[0027]** The transmitter 206 and receiver 208 in the example of FIG. 2 perform radio frequency (RF) processing including modulation and demodulation. The receiver 208, therefore, may include components such as low noise amplifiers (LNAs) and filters. The transmitter 206 may include filters and amplifiers. Other components may include isolators, matching circuits, and other RF components. These components in combination or cooperation with other components perform the base station functions. The required components may depend on the particular functionality required by the base station.

**[0028]** The transmitter 206 includes a modulator (not shown), and the receiver 208 includes a demodulator (not shown). The modulator modulates the signals to be transmitted as part of the downlink signals and can apply any one of a plurality of modulation orders. The demodulator demodulates any uplink signals received at the  
5 base station 200 in accordance with one of a plurality of modulation orders.

**[0029]** The base station 200 includes a communication interface 212 for transmitting and receiving messages with other base stations. The communication interface 212 may be connected to a backhaul or network enabling communication with other base stations. In some situations, the link between base stations may include at least some  
10 wireless portions. The communication interface 212, therefore, may include wireless communication functionality and may utilize some of the components of the transmitter 206 and/or receiver 208.

**[0030]** FIG. 3 is a block diagram of an example of a UE device 300 suitable for use as each of the UE devices 101-103, 108. In some examples, the UE device 300 is any  
15 wireless communication device such as a mobile phone, a transceiver modem, a personal digital assistant (PDA), a tablet, or a smartphone. In other examples, the UE device 300 is a machine type communication (MTC) device or Internet-of-Things (IOT) device. The UE device 300, therefore is any fixed, mobile, or portable equipment that performs the functions described herein. The various functions and operations of the  
20 blocks described with reference to UE device 300 may be implemented in any number of devices, circuits, or elements. Two or more of the functional blocks may be integrated in a single device, and the functions described as performed in any single device may be implemented over several devices.

**[0031]** The UE device 300 includes at least a controller 302, a transmitter 304 and a  
25 receiver 306. The controller 302 includes any combination of hardware, software, and/or firmware for executing the functions described herein as well as facilitating the overall functionality of a communication device. An example of a suitable controller 302 includes code running on a microprocessor or processor arrangement connected to memory. The transmitter 304 includes electronics configured to transmit wireless  
30 signals. In some situations, the transmitter 304 may include multiple transmitters. The

-10-

receiver 306 includes electronics configured to receive wireless signals. In some situations, the receiver 306 may include multiple receivers. The receiver 306 and transmitter 304 receive and transmit signals, respectively, through antenna 308. The antenna 308 may include separate transmit and receive antennas. In some  
5 circumstances, the antenna 308 may include multiple transmit and receive antennas.

**[0032]** The transmitter 304 and receiver 306 in the example of FIG. 3 perform radio frequency (RF) processing including modulation and demodulation. The receiver 306, therefore, may include components such as low noise amplifiers (LNAs) and filters. The transmitter 304 may include filters and amplifiers. Other components may include  
10 isolators, matching circuits, and other RF components. These components in combination or cooperation with other components perform the communication device functions. The required components may depend on the particular functionality required by the communication device.

**[0033]** The transmitter 304 includes a modulator (not shown), and the receiver 306  
15 includes a demodulator (not shown). The modulator can apply any one of a plurality of modulation orders to modulate the signals to be transmitted as part of the uplink signals. The demodulator demodulates the downlink signals in accordance with one of a plurality of modulation orders. The communication device 300 includes memory 310 in addition to memory that is part of the controller 302. Information such as a candidate relay  
20 prioritization list, which may be included in the remote reconfiguration complete relayed transmission 130, may be stored and maintained on the memory 310, the controller 302, or a combination of the two.

**[0034]** FIG. 4A is a message diagram 400 for an example of relay link management for direct to indirect path switching where the target relay UE device is in RRC  
25 INACTIVE. Although FIG. 4A shows three candidate relay UE devices 101-103, any number of candidate relay devices may be involved in the messaging. The example begins with the remote UE device 108 in direct communication 402 with the base station (gNB) 112 and with the first candidate relay UE device 101 in the RRC inactive state (RRC INACTIVE), the second candidate relay UE device 102 in the RRC Connected  
30 state (RRC CONN), and the third candidate relay UE device 103 in the RRC idle state

(RRC IDLE). Uplink data and downlink data are exchanged between the remote UE device 108 and the gNB 112 over the direct Uu communication link 402.

**[0035]** At transmission 404, a Model B discovery request is sent from the remote UE device 108 to the nearby candidate relay UE devices. In some situations, the Model B discovery request may be omitted. Accordingly, the arrow representing the Model B discovery request is illustrated with a dashed line to indicate that the transmission may not be needed. For example, where Model A discovery messages are received from the candidate relay UE devices, the Model B request may not be needed.

**[0036]** At transmission 406, a discovery message is sent from the candidate relay UE device 102. At transmission 408, a discovery message is sent from the candidate relay UE device 101. At transmission 410, a discovery message is sent from the candidate relay UE device 103. The discovery messages of the transmissions 406, 408, 410 may be Model A discovery announcement messages or may be Model B discovery response messages. The remote UE device 108 receives the discovery messages and evaluates received signals and information as part of the relay reselection procedure. For the examples, the remote UE device 108 measures the Sidelink Discovery Reference Signal Received Power (SD-RSRP) levels of the received discovery messages.

**[0037]** At transmission 412, the remote UE device 108 sends a measurement report to the gNB 112 where the measurement report includes signal quality measurements for candidate relay devices. Accordingly, the measurement report includes the signal quality measurements, such as the SD-RSRP levels, of the discovery signals 406, 408, 410.

**[0038]** At event 414, the gNB 112 determines that communication with the remote UE device 108 should be switched from a direct connection to an indirect connection via a target relay UE device. The decision by the gNB 112 to switch to indirect communication may be based on any combination of factors, such as which event triggered the measurement reporting, the SD-RSRP level(s), the RRC connection status, and the congestion level of the candidate relay UE (the gNB may know how many remote UE devices are already connected to a particular candidate relay UE). For

-12-

the example of FIG. 4A, the gNB 112 selects candidate relay UE device (UE 1) 101 as the target UE device.

**[0039]** At transmission 416, the gNB 112 transmits an RRC Reconfiguration with Sync message to the remote UE device 108. The RRC Reconfiguration with Sync message initiates the switch from the direct communication link 402 to an indirect communication link via the target candidate relay UE device 101.

**[0040]** At event 418, a PC5 connection is established between the remote UE device 108 and the target candidate relay UE device 101. In some situations, the PC5 connection may already be established, and event 418 is not needed.

**[0041]** At transmission 420, the remote UE device 108 sends an RRC Reconfiguration Complete message intended for the gNB 112 via the candidate relay UE device 101. The RRC Reconfiguration Complete message 420 is received at the target relay UE device 101 over the PC5 link.

**[0042]** In response to receiving the RRC Reconfiguration Complete message 420, the target relay UE device 101 begins the RRC Resume procedure by transmitting the RRC Resume Request at transmission 422.

**[0043]** The target relay UE device 101 and gNB 112 exchange messages to resume RRC CONN. For the example, the gNB 112 sends an RRC Resume message at transmission 424, and the target relay UE device 101 sends an RRC Resume Complete message 426. When the target relay UE device 101 is in RRC CONN, a Uu communication link 428 is established between the target relay UE device 101 and gNB 112.

**[0044]** At transmission 429, the gNB 112 sends an RRC Reconfiguration message to the target relay UE device 101 to configure both the sidelink Radio Link Control (RLC) configuration, the RLC configuration in the Uu link and the remote UE identifier (ID) to be used for the relay operation.

**[0045]** The target relay UE device 101 relays the RRC Reconfiguration Complete message received from the remote UE device 108 to the gNB 112 at transmission 430. Communication between the remote UE device 108 and the gNB 112 continues over the indirect communication link 432, which includes a relay connection through the relay UE device 101.

**[0046]** FIG. 4B is a message diagram 450 for an example of relay link management for direct to indirect path switching where the target relay UE device is in RRC IDLE. Although FIG. 4B shows three candidate relay UE devices 101-103, any number of candidate relay devices may be involved in the messaging. The example begins with  
5 the remote UE device 108 in direct communication 402 with the base station (gNB) 112 and with the first candidate relay UE device 101 in the RRC inactive state (RRC INACTIVE), the second candidate relay UE device 102 in the RRC Connected state (RRC CONN), and the third candidate relay UE device 103 in the RRC idle state (RRC IDLE). Uplink data and downlink data are exchanged between the remote UE device  
10 108 and the gNB 112 over the direct Uu communication link 402.

**[0047]** At transmission 404, a Model B discovery request is sent from the remote UE device 108 to the nearby candidate relay UE devices. In some situations, the Model B discovery request may be omitted. Accordingly, the arrow representing the Model B discovery request is illustrated with a dashed line to indicate that the transmission may  
15 not be needed. For example, where Model A discovery messages are received from the candidate relay UE devices, the Model B request may not be needed.

**[0048]** At transmission 406, a discovery message is sent from the candidate relay UE device 102. At transmission 408, a discovery message is sent from the candidate relay UE device 101. At transmission 410, a discovery message is sent from the  
20 candidate relay UE device 103. The discovery messages of the transmissions 406, 408, 410 may be Model A discovery announcement messages or may be Model B discovery response messages. The remote UE device 108 receives the discovery messages and evaluates received signals and information as part of the relay reselection procedure. For the examples, the remote UE device 108 measures the SD-RSRP levels of the  
25 received discovery messages.

**[0049]** At transmission 412, the remote UE device sends a measurement report to the gNB 112 where the measurement report includes signal quality measurements for candidate relay devices. Accordingly, the measurement report includes the signal quality measurements, such as the SD-RSRP levels, of the discovery signals 406, 408,  
30 410.

**[0050]** At event 414, the gNB 112 determines that communication with the remote UE device 108 should be switched from a direct connection to an indirect connection via a target relay UE device. The decision by the gNB 112 to switch to indirect communication may be based on any combination of factors, such as which event triggered the measurement reporting, the SD-RSRP level(s), the RRC connection status, and the congestion level of the candidate relay UE (the gNB may know how many remote UE devices are already connected to a particular candidate relay UE). For the example of FIG. 4B, the gNB 112 selects the candidate relay UE device (UE 3) 103 as the target UE device.

**[0051]** At transmission 416, the gNB 112 transmits an RRC Reconfiguration message to the remote UE device 108. The RRC Reconfiguration message initiates the switch from the direct communication link 402 to an indirect communication link via the target candidate relay UE device 103.

**[0052]** At event 418, a PC5 connection is established between the remote UE device 108 and the target candidate relay UE device 103. In some situations, the PC5 connection may already be established and event 418 is not needed.

**[0053]** At transmission 420, the remote UE device 108 sends an RRC Reconfiguration Complete message intended for the gNB 112 via the candidate relay UE device 103. The RRC Reconfiguration Complete message 420 is received at the target relay UE device 103 over the PC5 link.

**[0054]** In response to receiving the RRC Reconfiguration Complete message 420, the target relay UE device 103 begins the RRC establishment procedure by transmitting an RRC Establishment Request at transmission 452.

**[0055]** The target relay UE device 103 and gNB 112 exchange messages to establish RRC CONN. For the example, the gNB 112 sends an RRC Reconfiguration message at transmission 454, and the target relay UE device 103 sends an RRC Reconfiguration Complete message 456. When the target relay UE device 103 is in RRC CONN, a Uu communication link 428 is established between the target relay UE device 103 and gNB 112. At transmission 429, the gNB 112 sends an RRC

Reconfiguration message to the target relay UE device 103 to configure both the

sidelink RLC configuration, the RLC configuration in the Uu link and the remote UE ID to be used for the relay operation.

**[0056]** The target relay UE device 103 relays the RRC Reconfiguration Complete message received from the remote UE device 108 to the gNB 112 at transmission 430.

5 Communication between the remote UE device 108 and the gNB 112 continues over the indirect communication link 432 which includes a relay connection through the relay UE device 103.

**[0057]** FIG. 5 is a flow chart of an example of a method of managing path switching from direct to indirect communication links. The method is performed by UE device that can provide relay service to one or more remote UE devices and is in an RRC connection state other than RRC CONN. For the example, therefore, the method may be performed by a candidate relay UE device such as the candidate relay UE device (UE1) 101 and the candidate relay UE device (UE3) 103.

10

**[0058]** At step 502, an RRC connection state other than RRC CONN is maintained with a base station 112. For the example, therefore, the candidate relay UE device maintains RRC IDLE or RRC INACTIVE.

15

**[0059]** At step 504, a PC5 link is established with remote UE device 108. For the example, the candidate relay UE device receives a message in accordance with one or more revisions of the 3GPP communication specification to initiate the PC5 link.

20

**[0060]** At step 506, it is determined whether an RRC Reconfiguration Complete message is received from the remote UE device 108. The destination of the RRC Reconfiguration Complete is the base station 112. For the example, the relay UE device determines if SL-RLC1 from the remote UE device 108 has been received since the RRC Reconfiguration Complete is sent on the SL-RLC1 channel. If no RRC Reconfiguration Complete message is received from the remote UE device 108, the method returns to step 502. Otherwise, the method proceeds to step 508.

25

**[0061]** At step 508, it is determined whether the candidate relay UE device is in RRC IDLE or RRC INACTIVE. If the candidate relay UE device is in RRC INACTIVE, the method continues at step 510. If the candidate relay UE device is in RRC IDLE, the method continues at step 512.

30

**[0062]** At step 510, the relay UE device sends an RRC Resume Request message to the gNB 112. When in INACTIVE, therefore, the relay UE device initiates the connection resume procedure in response to receiving the RRC Reconfiguration Complete message from the remote UE device 108.

5 **[0063]** At step 512, the relay UE device sends an RRC Establishment Request message to the gNB 112. When in IDLE, therefore, the relay UE device initiates the connection establishment procedure in response to receiving the RRC Reconfiguration Complete message from the remote UE device 108.

10 **[0064]** After the relay UE device is in RRC CONN, the relay UE device relays the RRC Reconfiguration Complete message that was received from the remote UE device to the gNB 112 at step 514. Communication between the remote UE device 108 and gNB 112 continues over the indirect path through the relay UE device.

15 **[0065]** The techniques described above at least provide a mechanism for switching from in direct communication to indirect communication through a candidate relay UE device that is in an RRC connection state other than RRC CONN. When the relay UE device is in IDLE or INACTIVE, the relay UE device initiates a procedure to transition to RRC CONN in response to receiving an RRC Reconfiguration Complete message from a remote UE device.

20 **[0066]** Clearly, other embodiments and modifications of this invention will occur readily to those of ordinary skill in the art in view of these teachings. The above description is illustrative and not restrictive. This invention is to be limited only by the following claims, which include all such embodiments and modifications when viewed in conjunction with the above specification and accompanying drawings. The scope of the invention should, therefore, be determined not with reference to the above description,  
25 but instead should be determined with reference to the appended claims along with their full scope of equivalents.

-17-

**CLAIMS**

1. A relay user equipment (UE) device comprising:  
a controller configured to maintain the relay UE device in a Radio Resource  
5 Control (RRC) connection state with a base station other than RRC Connected (RRC  
CONN);  
a receiver configured to receive an RRC Reconfiguration Complete message  
directed to the base station from a remote UE device over a PC5 communication link;  
and  
10 a transmitter configured to:  
transmit, in response to receiving the RRC Reconfiguration Complete  
message, an RRC Connection Establishment Request message to the base  
station when a target relay UE device is in an RRC IDLE state,  
transmit, in response to receiving the RRC Reconfiguration Complete  
15 message, an RRC Resume Request message to the base station when the  
target relay UE device is in an RRC INACTIVE state, and  
transmit the RRC Reconfiguration Complete message to the base station  
over a Uu communication link established in response to one of the RRC  
Connection Establishment Request message and the RRC Resume Request  
20 message.
2. The relay UE device of claim 1, wherein the RRC Reconfiguration Complete  
message is transmitted by the remote UE device in response to receipt of an RRC  
Reconfiguration message at the remote UE device transmitted from the base station  
25 over a Uu direct communication link between the base station and the remote UE  
device, the RRC Reconfiguration message initiating a path switch from a direct  
communication link between the remote UE device and the base station to an indirect  
communication link between the remote UE device and the base station through the  
relay UE device.
- 30 3. The relay UE device of claim 1, wherein:

-18-

the receiver is further configured to receive an RRC Resume message after transmitting the RRC Resume Request message, and

the transmitter is further configured to transmit an RRC Resume Complete message after receiving the RRC Resume message.

5

4. The relay UE device of claim 1, wherein the transmitter and receiver are configured to operate in accordance with at least one revision of the 3<sup>rd</sup> Generation Partnership Project (3GPP) New Radio (NR) V2X communication specification.

10

5. A remote user equipment (UE) device comprising:

a transmitter configured to transmit a measurement report over a direct Uu communication link to a serving base station, the measurement report comprising a measurement of a signal transmitted from a candidate relay UE device in a Radio Resource Control (RRC) connection state other than RRC Connected (RRC CONN);

15 and

a receiver configured to receive, from the base station over the direct Uu communication link, an RRC Reconfiguration Message identifying a target relay UE device selected from the measurement report by the base station, the target relay UE device in an RRC connection state other than RRC Connected (RRC CONN),

20 the transmitter further configured to transmit an RRC Reconfiguration Complete message to the base station by transmitting the RRC Reconfiguration Complete message to the target relay UE device over a PC5 communication link,

the RRC Reconfiguration Complete message invoking the target relay UE device to perform RRC Connection Establishment with the base station when the target relay  
25 UE device is in an RRC IDLE state,

the RRC Reconfiguration Complete message invoking the target relay UE device to perform RRC Resume with the base station when the target relay UE device is in an RRC INACTIVE state.

30

6. The remote UE device of claim 5, wherein the signal is a Sidelink Discovery message.

7. The remote UE device of claim 5, wherein:

the measurement report comprises a plurality of measurements for a plurality of candidate relay UE devices,

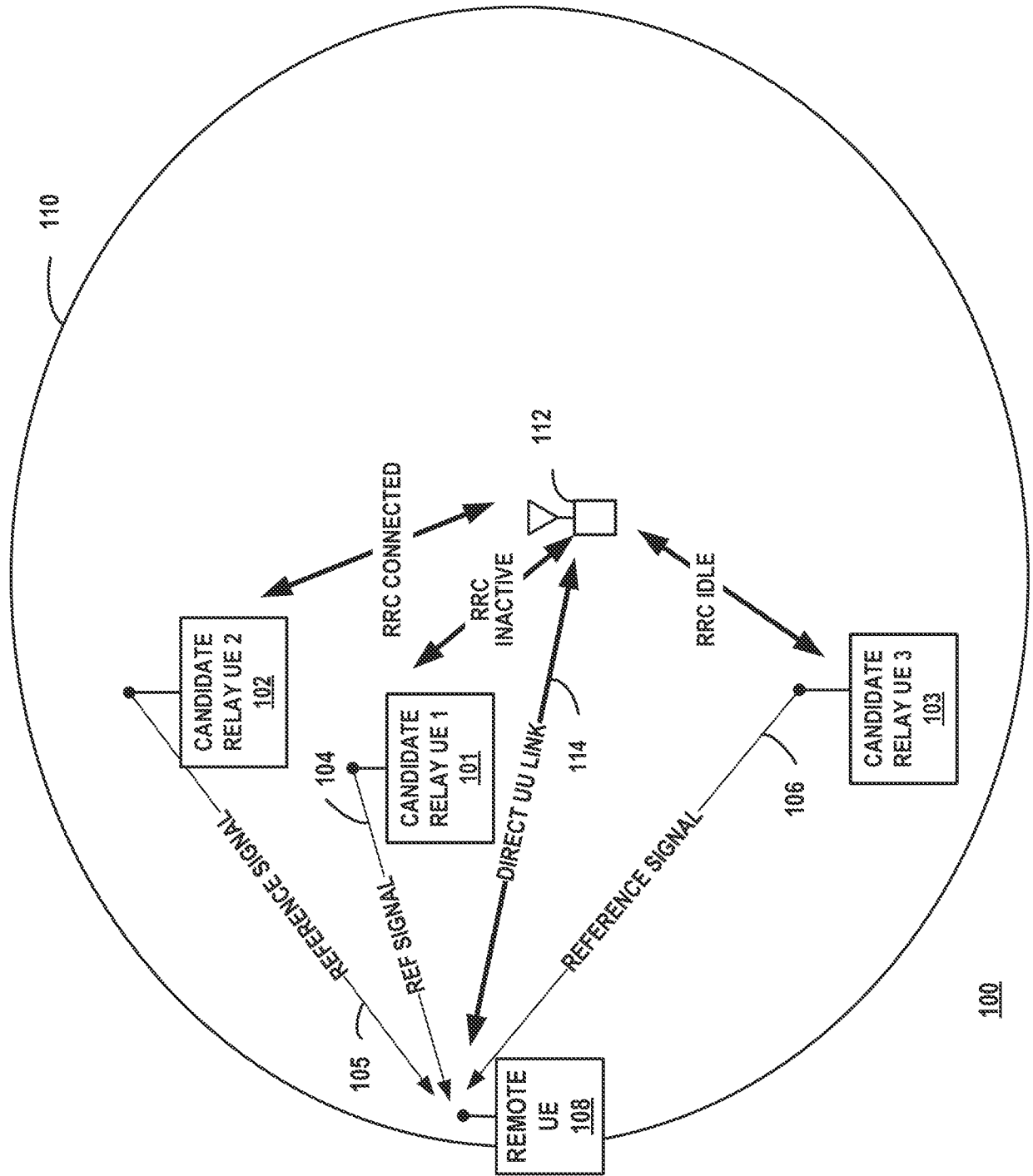
5 each measurement of the plurality of measurements corresponding to a different candidate relay UE device of the plurality of candidate relay UE devices, and at least one candidate relay UE device is in RRC CONN.

8. The remote UE device of claim 7, wherein at least one candidate relay UE device

10 is the target relay UE device.

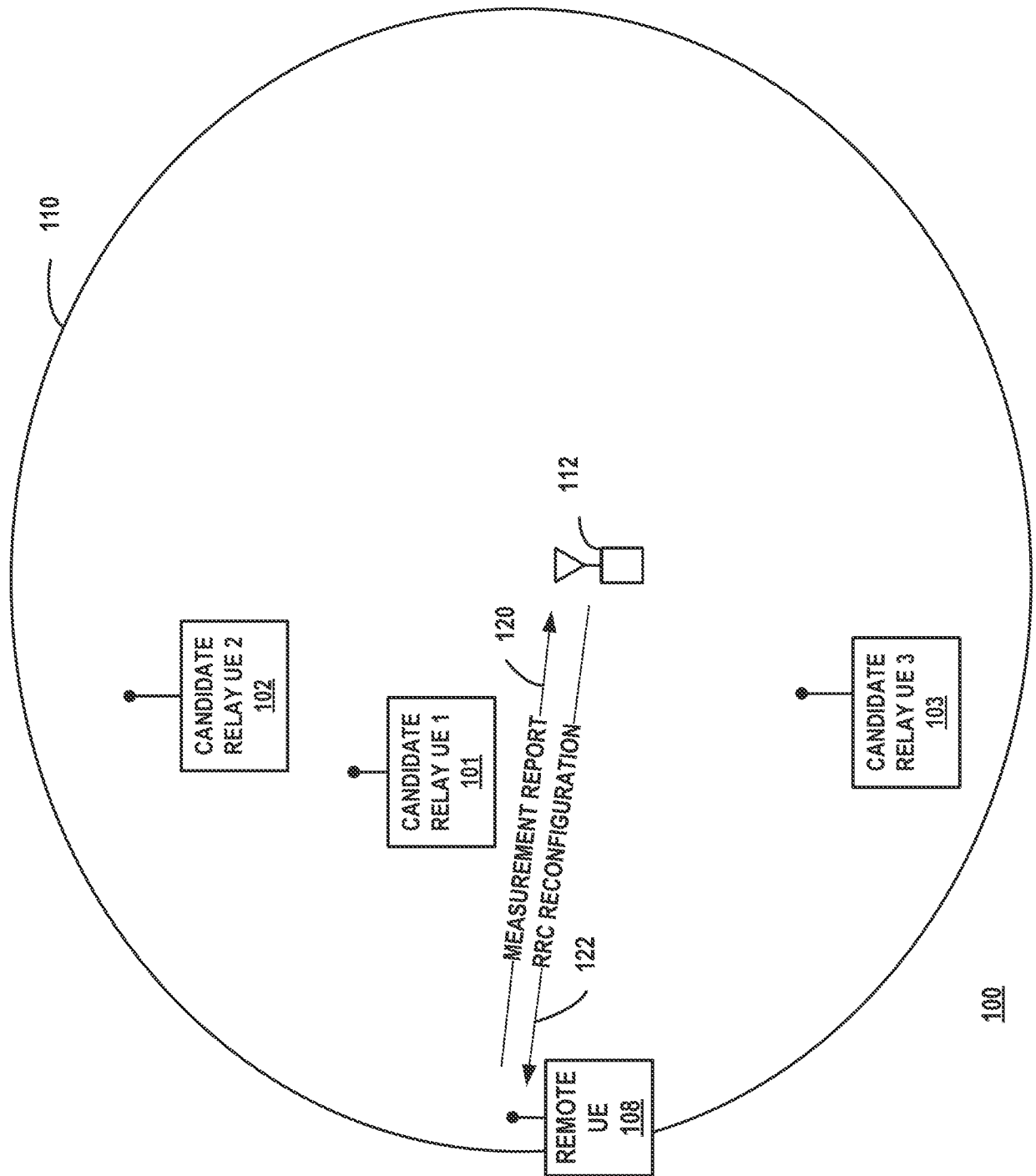
9. The remote UE device of claim 5, wherein the transmitter and receiver are configured to operate in accordance with at least one revision of the 3<sup>rd</sup> Generation Partnership Project (3GPP) New Radio (NR) V2X communication specification.

15



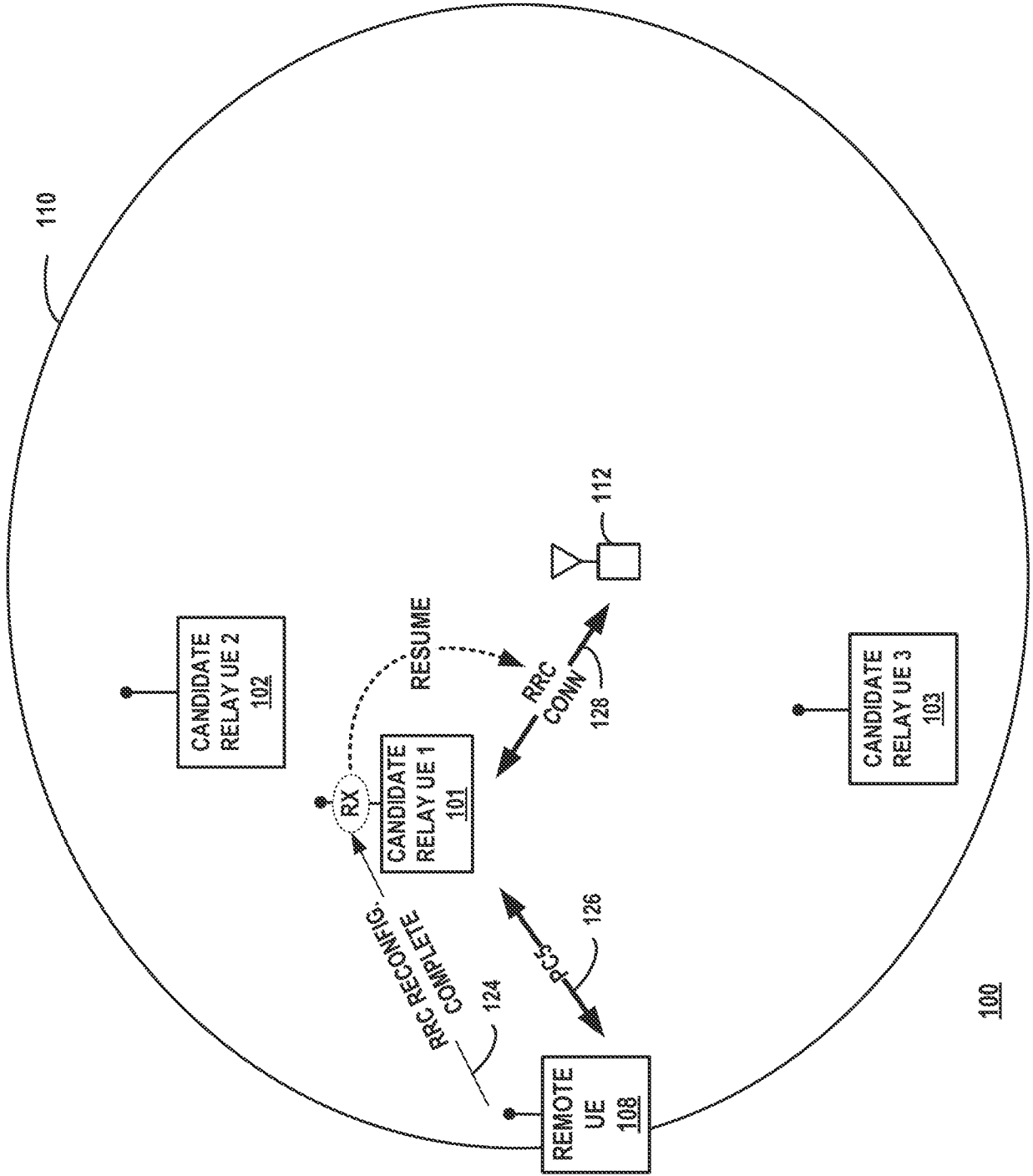
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FIG. 1A



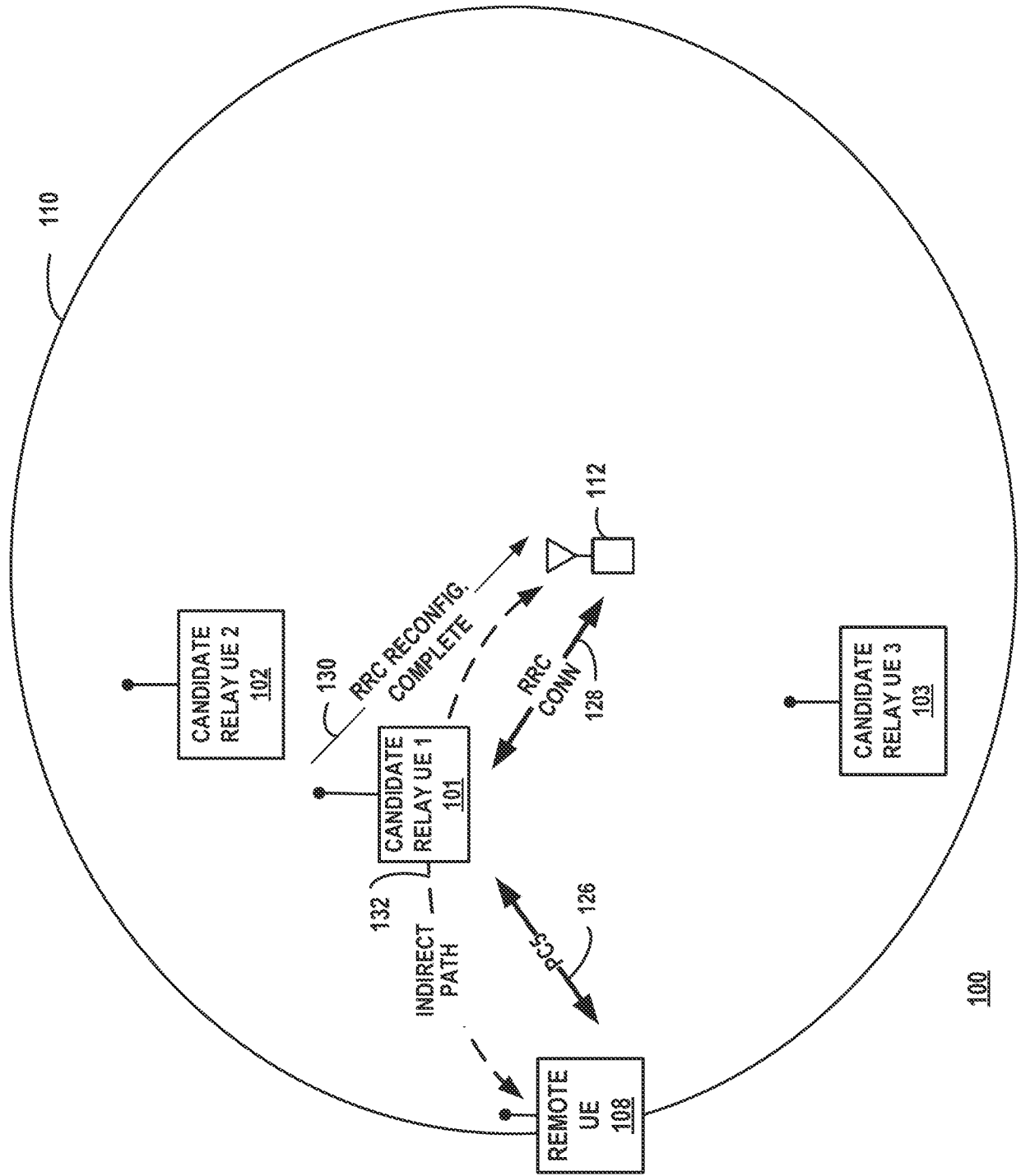
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FIG. 1B



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FIG. 1C



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FIG. 1D

5/8

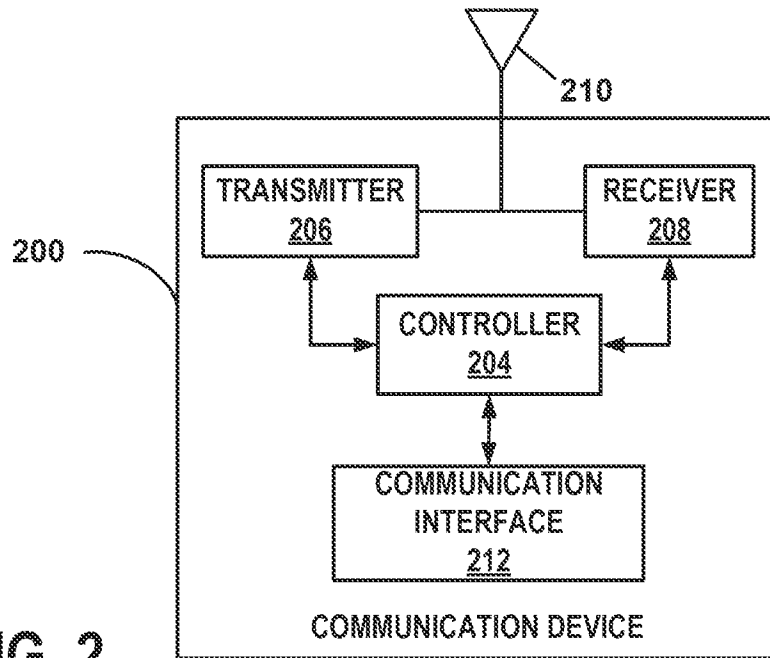


FIG. 2

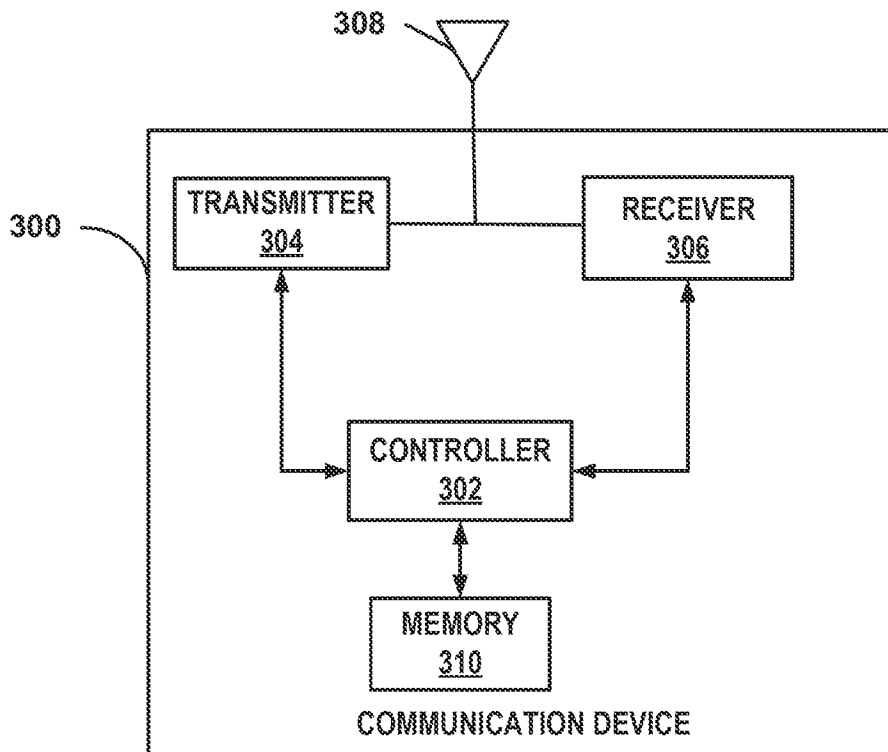


FIG. 3

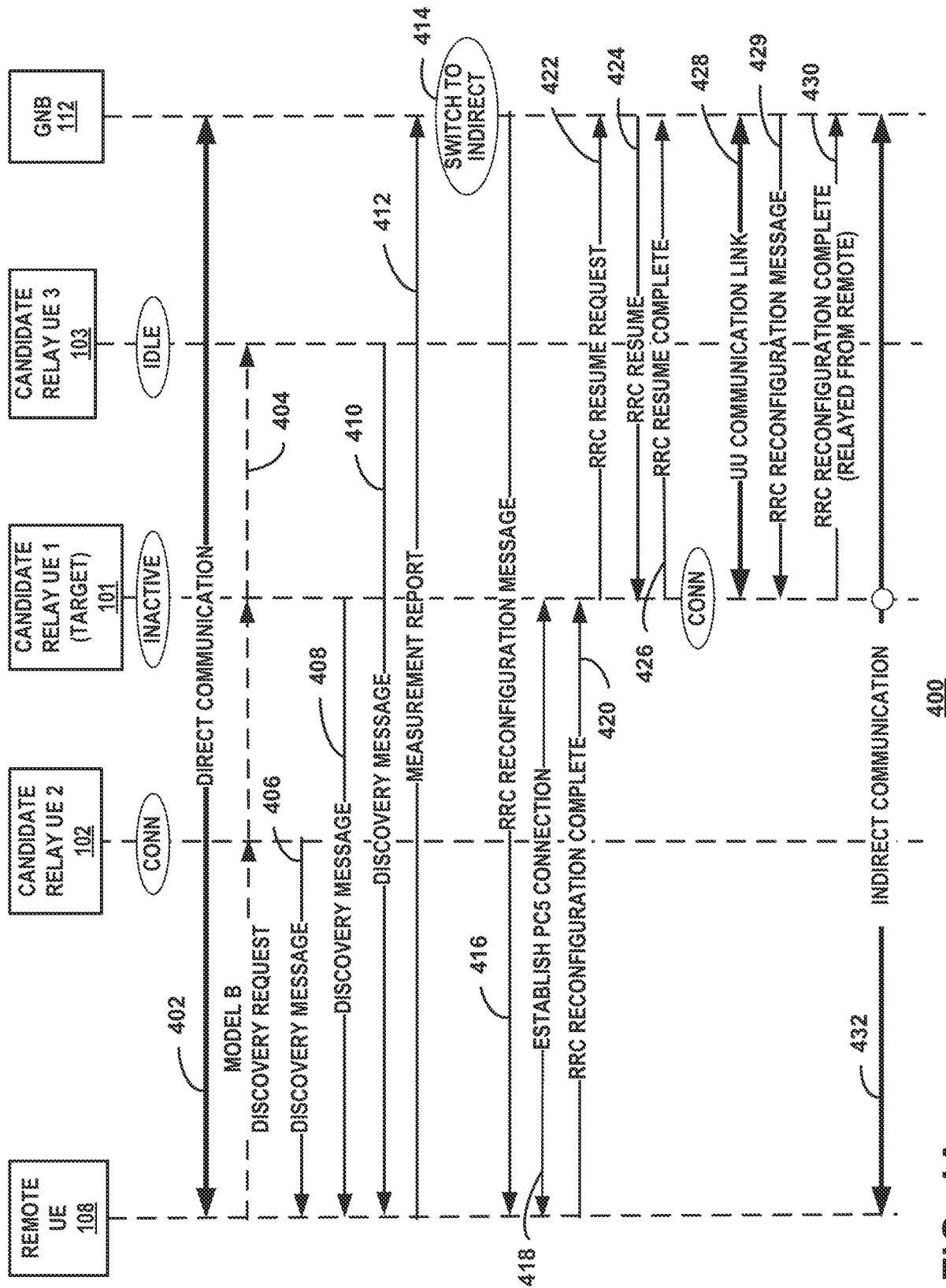


FIG. 4A

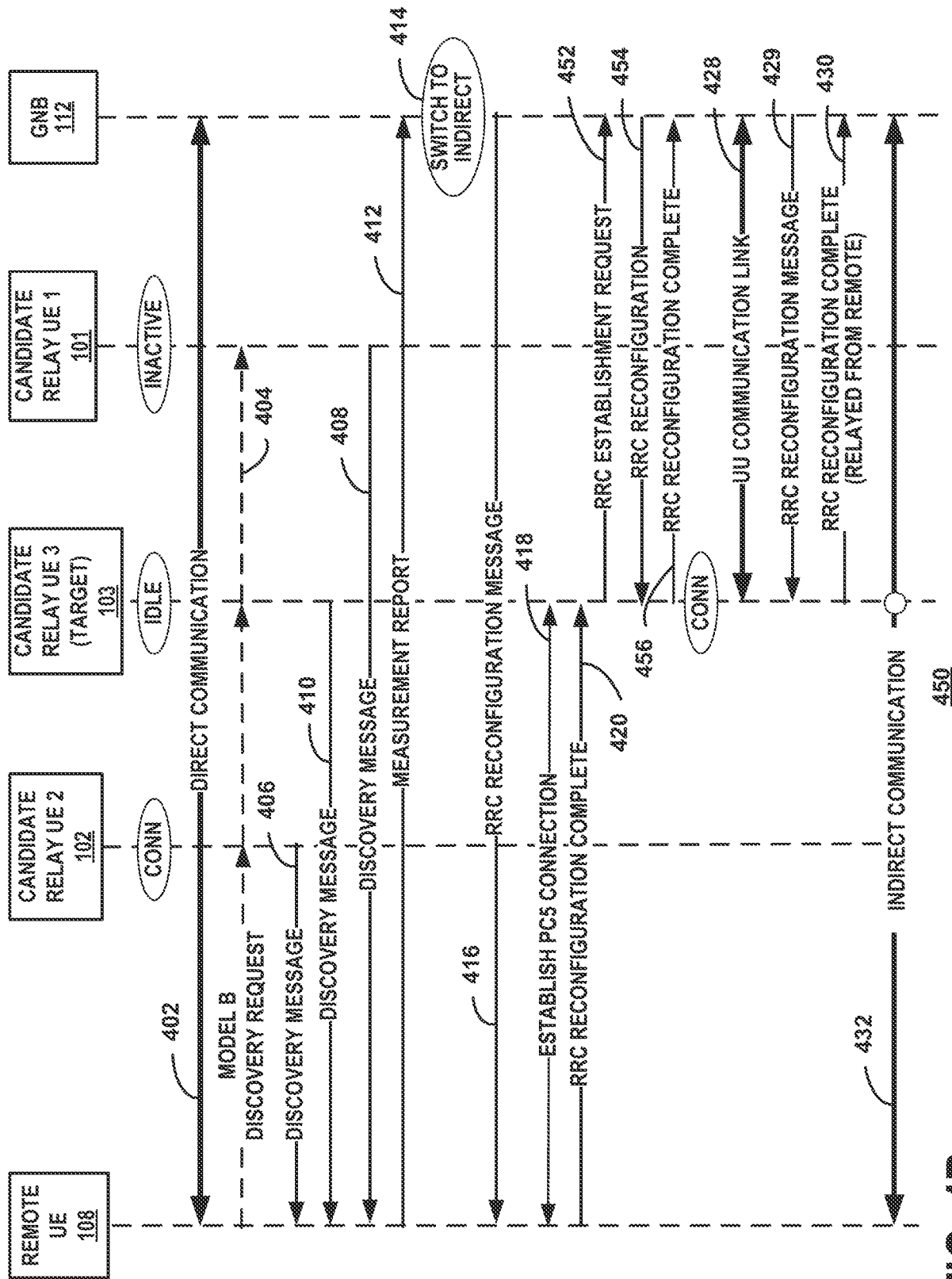
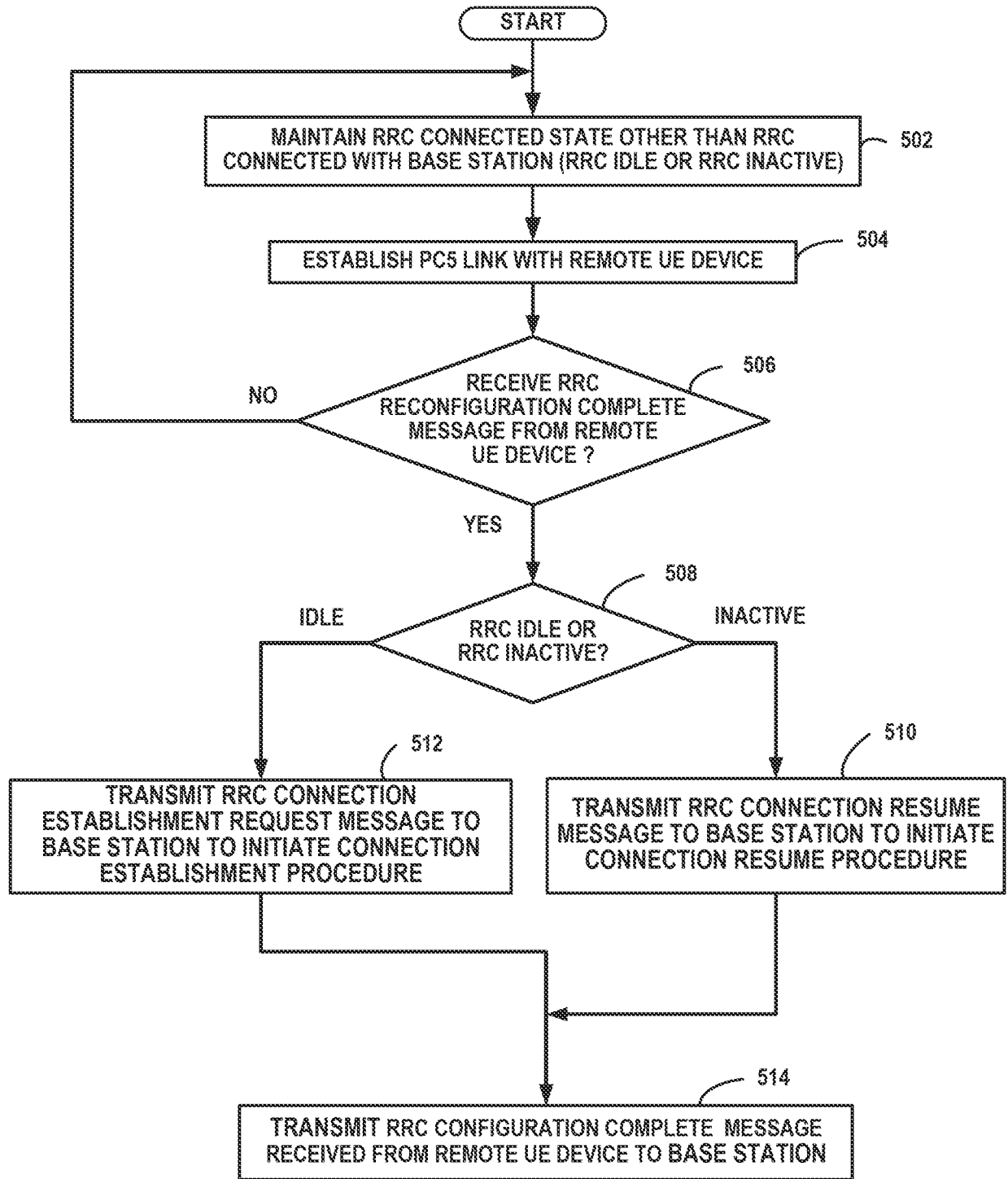


FIG. 4B

8/8



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FIG. 5

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2022/037067

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
H04W 40/12(2009.01)i; H04W 76/14(2018.01)i; H04W 76/27(2018.01)i; H04W 24/10(2009.01)i; H04W 8/00(2009.01)i; H04W 88/04(2009.01)i; H04W 92/18(2009.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) H04W 40/12(2009.01); H04W 36/14(2009.01); H04W 36/18(2009.01)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: RRC(radio resource control), connected, state, IDLE, INACTIVE, RRC reconfiguration complete, relay, remote, Resume		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	HUAWEI et al., 'Discussion on path switch for L2 UE to NW Relay', R2-2104132, 3GPP TSG RAN WG2 Meeting #113bis-e, 02 April 2021 sections 1-2.4.1	1-9
Y	ZTE et al., 'Discussion on Relay selection in Sidelink relay', R2-2104977, 3GPP TSG RAN WG2 Meeting #114-e, 11 May 2021 section 2.2	1-9
A	QUALCOMM INCORPORATED, 'RRC state and essential RRC procedures in L2 U2N relay', R2-2008966, 3GPP TSG RAN WG2 Meeting #112-e, 23 October 2020 sections 1-2.5	1-9
A	OPPO, 'Discussion on service continuity in NR sidelink relay', R2-2104894, 3GPP TSG RAN WG2 Meeting #114-e, 11 May 2021 sections 1-2.2	1-9
A	US 2019-0387446 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 19 December 2019 (2019-12-19) paragraphs [0102]-[0492]; and figures 1-14	1-9
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> 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 <b>04 November 2022</b>		Date of mailing of the international search report <b>04 November 2022</b>
Name and mailing address of the ISA/KR <b>Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon 35208, Republic of Korea</b> Facsimile No. +82-42-481-8578		Authorized officer <b>KO, Jae Yong</b> Telephone No. +82-42-481-8212

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

International application No. <b>PCT/US2022/037067</b>
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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2019-0387446 A1	19 December 2019	CN 109417695 A	01 March 2019
		CN 109417695 B	23 October 2020
		EP 3562182 A1	30 October 2019
		EP 3562182 B1	16 September 2020
		US 10945179 B2	09 March 2021
		WO 2018-129875 A1	19 July 2018
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