

PAGING INFORMATION FORWARDING IN RELAY COMMUNICATION

TECHNICAL FIELD

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

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may be otherwise known as an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. Each network
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, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers).
15 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 at least one U2N relay UE between a U2N remote UE and the network. In case there are two or more relay UEs between the remote UE and the network, an issue of
25 paging information forwarding should be studied.

SUMMARY

[0004] The present disclosure relates to a first relay UE, a second relay UE, a base station (BS), methods, apparatuses, processors, and computer readable medium for paging information forwarding in a relay communication. According to the proposed solution, a
30 first relay UE or a second relay UE may be used for monitoring paging occasion(s) for a

remote UE which is served by the first relay UE.

[0005] In some implementations, there is provided a first relay UE. The first relay UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the first relay UE to: receive, from a remote UE, a request comprising paging related information associated with the remote UE; and in accordance with a determination that a first condition is met, transmit, to a second relay UE, a first message at least comprising the paging related information associated with the remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE.

[0006] In some implementations, there is provided a second relay UE. The second relay UE comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the second relay UE to: receive, from a first relay UE, a first message at least comprising the paging related information associated with a remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that a fourth condition is met, monitor one or more paging occasions (POs) for the remote UE based on the paging related information associated with the remote UE.

[0007] In some implementations, there is provided a BS. The BS comprises at least one memory; and at least one processor coupled with the at least one memory and configured to cause the BS to: receive, from a second relay UE, a report comprising paging related information associated with a remote UE, wherein the second relay UE is connected to the base station, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and transmit, to the second relay UE, a dedicated radio resource control (RRC) message comprising one or more paging messages associated with the remote UE or the first relay UE.

[0008] In some implementations, there is provided a method performed by the first relay UE. The method comprises: receiving, from a remote UE, a request comprising paging related information associated with the remote UE; and in accordance with a determination that a first condition is met, transmitting, to a second relay UE, a first message at least comprising the paging related information associated with the remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE

is connected to the base station via the first relay UE and the second relay UE.

[0009] In some implementations, there is provided a method performed by the second relay UE. The method comprises: receiving, from a first relay UE, a first message at least comprising the paging related information associated with a remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that a fourth condition is met, monitoring one or more paging occasions for the remote UE based on the paging related information associated with the remote UE.

[0010] In some implementations, there is provided a method performed by the BS. The method comprises: receiving, from a second relay UE, a report comprising paging related information associated with a remote UE, wherein the second relay UE is connected to the base station, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and transmitting, to the second relay UE, a dedicated RRC message comprising one or more paging messages associated with the remote UE or the first relay UE.

[0011] 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 remote UE, a request comprising paging related information associated with the remote UE; and in accordance with a determination that a first condition is met, transmit, to a second relay UE, a first message at least comprising the paging related information associated with the remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE.

[0012] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a first relay UE, a first message at least comprising the paging related information associated with a remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and in accordance with a determination that a fourth condition is met, monitor one or more paging occasions for the remote UE based on the paging related information associated with the

remote UE.

[0013] In some implementations, there is provided a processor for wireless communication. The processor comprises at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a second relay UE, a report comprising
5 paging related information associated with a remote UE, wherein the second relay UE is connected to the base station, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE; and transmit, to the second relay UE, a dedicated RRC message comprising one or more paging messages associated with the remote UE or the first relay UE.

10 [0014] In some implementations of the methods and the first relay UE described herein, further comprising: in accordance with a determination that a second condition is met, monitoring one or more paging occasions for the remote UE based on the paging related information associated with the remote UE.

[0015] In some implementations of the methods and the first relay UE described herein,
15 further comprising: in accordance with a determination that a paging message for the remote UE is detected, transmitting, to the remote UE, the paging message based on identifier information in the paging message.

[0016] In some implementations of the methods and the first relay UE described herein, the first message further comprises paging related information associated with a further remote
20 UE, further comprising: transmitting, to the second relay UE, an updated message of the first message based on a determining one of: the further remote UE transits from an RRC idle or inactive state to an RRC connected state, a reception of signalling radio bearer 0 (SRB0) message from the further remote UE, a reception of an RRC setup message from the base station, or a reception of an indication to release the paging related information associated
25 with the further remote UE from the further remote UE.

[0017] In some implementations of the methods and the first relay UE described herein, further comprising: receiving, from the second relay UE, a third message comprising a paging message for the remote UE; and transmitting, to the remote UE, the paging message for the remote UE.

30 [0018] In some implementations of the methods and the first relay UE described herein, further comprising: receiving, from the second relay UE, a fourth message comprising a paging message for the first relay UE.

[0019] In some implementations of the methods and the first relay UE described herein, further comprising: in accordance with a determination that a third condition is met, transmitting, to the second relay UE, a second message indicating to the second relay UE to release the paging related information associated with the remote UE or the first relay UE;
5 and monitoring one or more paging occasions for the remote UE based on the paging related information associated with the remote UE.

[0020] In some implementations of the methods and the second relay UE described herein, further comprising: maintaining an association between the remote UE and the first relay UE; and in accordance with a determination that a paging message for the remote UE is detected,
10 transmitting, to the first relay UE, a third message comprising the paging message for the remote UE based on identifier information in the paging message.

[0021] In some implementations of the methods and the second relay UE described herein, further comprising: in accordance with a determination that a paging message for the first relay UE is detected, transmitting, to the first relay UE, a fourth message comprising a paging
15 message for the first relay UE based on identifier information in the paging message.

[0022] In some implementations of the methods and the second relay UE described herein, further comprising: receiving, from the first relay UE, an updated message of the first message, wherein the paging related information associated with the further remote UE is removed from the updated message.

[0023] In some implementations of the methods and the second relay UE described herein, further comprising: in accordance with a determination that the second relay UE is in an RRC connected state and configured without paging search space, transmitting, to the base station,
20 a report comprising the paging related information associated with the remote UE.

[0024] In some implementations of the methods and the second relay UE described herein, further comprising: receiving, from the base station, a dedicated RRC message comprising
25 one or more paging messages associated with the remote UE or the first relay UE.

[0025] In some implementations of the methods and the second relay UE described herein, further comprising: receiving, from the first relay UE, a second message indicating to release the paging related information associated with the remote UE; and releasing the paging
30 related information associated with the remote UE based on the second message.

[0026] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the first condition comprises one of: the first relay UE is in an

RRC idle state or an RRC inactive state, the first relay UE is out-of-coverage of the base station, the first relay UE is in an RRC connected state and configured without paging search space, the first relay UE is in one of an RRC idle state, an RRC inactive state, or an RRC connected state, and a channel quality of a link between the first relay UE and the base station is less than a threshold, or the base station has configured that the second relay UE monitors the one or more paging occasions for the remote UE.

[0027] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the second condition comprises one of: the first relay UE is in coverage of the base station, the first relay UE is in one of an RRC idle state, an RRC inactive state, or an RRC connected state, the first relay UE is in one of an RRC idle state, an RRC inactive state, or an RRC connected state, and in the coverage of the base station, a channel quality of a link between the first relay UE and the base station is larger than a threshold, or the base station has configured that the first relay UE monitors the one or more paging occasions for the remote UE.

[0028] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the third condition comprises one of: the first relay UE transits from out-of-coverage to in-coverage, or the first relay UE transits from an RRC idle or inactive state to an RRC connected state.

[0029] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the fourth condition comprises one of: the second relay UE is in one of: an RRC idle state, an RRC inactive state, or an RRC connected state, or the second relay UE is in an RRC connected state and configured with paging search space.

[0030] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the transmission of the first message is triggered by one of: upon receiving the paging related information associated with the remote UE, upon the first relay UE transiting from an RRC connected state to an RRC idle or inactive state, or upon the first relay UE transiting from in-coverage to out-of-coverage.

[0031] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the paging related information associated with the remote UE comprises one of: a device identifier of the remote UE, a UE specific discontinuous reception (DRX) cycle, or a minimum value of two UE specific DRX cycles in case the remote UE is in an RRC inactive state.

[0032] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the first message further comprises: paging related information associated with the first relay UE, and wherein the first relay UE is in an RRC idle state or an RRC inactive state.

5 [0033] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the third message comprises a paging message for the remote UE. In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the third message further comprises a device identifier of the remote UE.

10 [0034] In some implementations of the methods, the first relay UE, the second relay UE, and the BS described herein, the report further comprises paging related information associated with the first relay UE.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIG. 1 illustrates an example of a wireless communications system in which some
15 embodiments of the present disclosure can be implemented;

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

[0037] FIG. 2B illustrates a schematic diagram of an example communication network in which some embodiments of the present disclosure can be implemented;

20 [0038] FIG. 3 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0039] FIG. 4 illustrates a signalling chart illustrating communication process in accordance with some example embodiments of the present disclosure;

[0040] FIG. 5 illustrates an example of a device that is suitable for implementing
25 embodiments of the present disclosure;

[0041] FIG. 6 illustrates an example of a processor that is suitable for implementing some embodiments of the present disclosure;

[0042] FIG. 7 illustrates a flowchart of an example method implemented at a first relay UE in accordance with aspects of the present disclosure;

30 [0043] FIG. 8 illustrates a flowchart of an example method implemented at a second relay

UE in accordance with aspects of the present disclosure; and

[0044] FIG. 9 illustrates a flowchart of an example method implemented at a BS in accordance with aspects of the present disclosure.

[0045] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0046] Principles of the present disclosure will now be described with reference to some embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below. In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0047] References in the present disclosure to “one embodiment,” “an example embodiment,” “an embodiment,” “some embodiments,” and the like indicate that the embodiment(s) described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases do not necessarily refer to the same embodiment(s). Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0048] It shall be understood that although the terms “first” and “second” or the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element could also be termed as a second element, and similarly, a second element could also be termed as a first element, without departing from the scope of embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the listed terms. In some examples, values, procedures, or apparatuses are referred to as “best,” “lowest,” “highest,” “minimum,” “maximum,” or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used

functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0049] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of embodiments. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “has,” “having,” “includes” and/or “including,” when used herein, specify the presence of stated features, elements, components and/or the like, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. For example, the term “includes” and its variants are to be read as open terms that mean “includes, but is not limited to.” The term “based on” is to be read as “based at least in part on.” The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other embodiment.” The use of an expression such as “A and/or B” can mean either “only A” or “only B” or “both A and B.” Other definitions, explicit and implicit, may be included below.

[0050] FIG. 1 illustrates an example of a wireless communications system 100 in which some embodiments of the present disclosure can be implemented. The wireless communications system 100 may include one or more network entities 102 (also referred to as network equipment (NE)), one or more UEs 104, a core network (CN) 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as a long term evolution (LTE) network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as a new radio (NR) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0051] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network

entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication
5 link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0052] 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,
10 etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some
15 implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols,
20 and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0053] 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
25 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)
30 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.

[0054] The one or more UEs 104 may be devices in different forms or having different

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

[0055] 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.

[0056] A network entity 102 may support communications with the CN 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the CN 106 through one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface). In some implementations, the network entities 102 may communicate with each other directly (e.g., between the network entities 102). In some other implementations, the network entities 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more network entities 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0057] 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.

5 [0058] 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
10 virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0059] 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
15 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
20 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.

[0060] Additionally, or alternatively, a functional split of the protocol stack may be
25 employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed
30 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).

[0061] A CU may be functionally split further into CU control plane (CU-CP) and CU user

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

[0062] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the CN 106.

[0063] The CN 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, N3, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via a network entity 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] 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.

[0070] In the context of the present disclosure, the term “proximity communication 5 (PC5) link” may be used interchangeably with PC5 interface, sidelink (SL), PC5 unicast link, SL unicast link, device-to-device (D2D) link, user-to-user link, UE-to-UE (U2U) link, or the like. The term “relay UE” may be used interchangeably with U2N relay UE, U2U relay UE, layer 2 (L2) relay UE, L2 U2N relay UE, L2 U2U relay UE, or the like. The term “relay UE ID” may be used interchangeably with link ID, path ID, L2 relay UE ID, or the like.

[0071] A wireless communications system may include one or more devices, such as one or more base stations and/or one or more UEs. In some implementations, two different UEs may communicate with each other via a PC5 link (PC5 interface), two different base stations may communicate with each other via an Xn link (Xn interface), and a UE and a base station
5 may communicate with each via a Uu link (Uu interface).

[0072] 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
10 UE 215. For example, the NG-eNB 213 may be an evolved long term evolution (eLTE) base station that supports an NG interface. In some embodiments, the sidelink transmission and reception over the PC5 link are supported when the UE 211 is inside Next Generation Radio Access Network (NG-RAN) coverage, irrespective of which RRC state the UE is in, and also supported when the UE 211 is outside NG-RAN coverage.

[0073] Sidelink relay is introduced to support 5G ProSe UE-to-Network (U2N) Relay function to provide connectivity to the network for U2N Remote UE. A U2N Relay UE shall be in RRC_CONNECTED to perform relaying of unicast data. For L2 U2N Relay operation, the following RRC state combinations are supported:

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

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

[0074] A single unicast link is established between one L2 U2N Relay UE and one L2 U2N
25 Remote UE. The traffic of L2 U2N Remote UE via a given L2 U2N Relay UE and the traffic of the L2 U2N Relay UE shall be separated in different Uu Relay RLC channels.

[0075] In some cases, more than one relay UE is needed for a communication of the U2N remote UE.

[0076] FIG. 2B illustrates a schematic diagram of an example communication network 200
30 in which some embodiments of the present disclosure can be implemented. As shown in FIG. 2B, a remote UE 221-1 is connected to the base station 224 via a first relay UE 222-1 and a second relay UE 223, a remote UE 221-2 is connected to the base station 224 via a first

relay UE 222-2 and a second relay UE 223, and a remote UE 221-3 is connected to the base station 224 via a first relay UE 222-2 and a second relay UE 223.

[0077] As shown in FIG. 2B, the first relay UE 222-1 and the second relay UE 223 are located in coverage of the base station 224, while the remote UE 221-1, the remote UE 221-2, the remote UE 221-3, and the first relay UE 222-2 are out of the coverage of the base station 224.

[0078] For ease of description, the remote UE 221-1, the remote UE 221-2, and the remote UE 221-3 can be collectively or separately referred to as a remote UE 221, and the first relay UE 222-1 and the first relay UE 222-2 can be collectively or separately referred to as a first relay UE 222.

[0079] In the present disclosure, a remote UE 221 accesses the base station 224 via two relay UEs including a first relay UE 222 and a second relay UE 223, and the first relay UE 222 accesses (e.g. connects) the base station 224 via the second relay UE 223. For ease of description, the second relay UE 223 may also be called as a parent relay UE, a first hop relay UE, a top relay UE, etc. For ease of description, the first relay UE 222 may also be called as a child relay UE, a second hop relay UE, etc.

[0080] In some implementations, the first relay UE 222 (child relay UE) may be close to the remote UE 221, and the second relay UE 223 (parent relay UE) may be close to the base station 224.

[0081] In some implementations, the remote UE 221 is served by the first relay UE 222 (child relay UE), and the first relay UE 222 is served by the second relay UE 223 (parent relay UE). It is to be understood that there may be one or multiple remote UEs served by a same child relay UE, and there may be one or multiple child relay UEs served by a same parent relay UE.

[0082] With reference to FIG. 2B, the remote UE 221-1 is served by the first relay UE 222-1, the remote UE 221-2 and the remote UE 221-3 are served by the first relay UE 222-2, and the first relay UE 222-1 and the first relay UE 222-2 are served by the second relay UE 223.

[0083] In the relay communication, if a remote UE 221 is in an RRC connected state, then the first relay UE 222 (child relay UE) which serves the remote UE 221 should be in an RRC connected state. If a first relay UE 222 (child relay UE) is in an RRC connected state, then the second relay UE 223 (parent relay UE) which serves the first relay UE 222 (child relay UE) should be in an RRC connected state.

[0084] With reference to FIG. 2B, if the remote UE 221-2 is in an RRC connected state, then the first relay UE 222 (child relay UE) and the second relay UE 223 (parent relay UE) should be in an RRC connected state, while the remote UE 221-3 may be in one of: an RRC idle state, an RRC inactive state, or an RRC connected state.

5 [0085] In the relay communication, if all remote UEs served by a first relay UE 222 (child relay UE) are in an RRC idle state or an RRC inactive state, then the first relay UE 222 (child relay UE) is allowed to be configured in any of: an RRC connected state, an RRC idle state, or an RRC inactive state. If all child relay UEs served by a second relay UE 223 (parent relay UE) are in an RRC idle state or an RRC inactive state, then the second relay UE 223
10 (parent relay UE) is allowed to be configured in any of: an RRC connected state, an RRC idle state, or an RRC inactive state.

[0086] With reference to FIG. 2B, if the remote UE 221-1 in an RRC idle state or an RRC inactive state, then the first relay UE 222-1 (child relay UE) can be configured in any of: an RRC connected state, an RRC idle state, or an RRC inactive state.

15 [0087] With reference to FIG. 2B, if the first relay UE 222-2 (child relay UE) is in an RRC idle state or an RRC inactive state, then the remote UE 221-2 and the remote UE 221-3 should be in an RRC idle state or an RRC inactive state (i.e. should not be in an RRC connected state). If the second relay UE 223 (parent relay UE) is in an RRC idle state or an RRC inactive state, then the remote UE 221-1, the remote UE 221-2, the remote UE 221-3, the
20 first relay UE 222-1 and the first relay UE 222-2 should be in an RRC idle state or an RRC inactive state (i.e. should not be in an RRC connected state).

[0088] It is to be understood that the number of devices in FIG. 2B is given for the purpose of illustration without suggesting any limitations to the present disclosure. For example, there may be more relay UEs between the remote UE 221 and the base station 224. For
25 example, there may be another remote UE 225 served by the second relay UE 223 without via another first relay UE.

[0089] In the scenario of a relay communication between the remote UE 221 and the base station 224 via the first relay UE 222 and the second relay UE 223, the remote UE 221 may be in an RRC idle state or an RRC inactive state, in this case, how to enable paging
30 information forwarding needs to be discussed.

[0090] Reference is further made to FIG. 3, which illustrates a signalling chart illustrating communication process 300 in accordance with some example embodiments of the present

disclosure. The process 300 may involve the remote UE 221, the first relay UE 222, the second relay UE 223, and the base station 224 as shown in FIG. 2B. It is to be understood that the process 300 may also be applied to another scenario different from that shown in FIG. 2B, the present disclosure does not limit this aspect.

5 **[0091]** The remote UE 221 is connected to the BS 224 via the first relay UE 222 and the second relay UE 223, where the second relay UE 223 connects to the BS 224 via a Uu interface, and the first relay UE 222 connects to the BS 224 via the second relay UE. In some examples, the first relay UE 222 will access the BS 224 (i.e. serving gNB) via an L2 U2N relay UE (such as the second relay UE 223) before the remote UE 221 accesses the BS
10 224 via the two relay UEs 222 and 223.

[0092] In some examples, if the remote UE 221 is in an RRC connected (RRC_CONNECTED) state, an end-to-end RRC connection between the remote UE 221 and the BS 224 is established. In some other examples, if the remote UE 221 is in an RRC idle (RRC_IDLE) state or an RRC inactive (RRC_INACTIVE) state, a paging monitoring
15 mechanism should be provided.

[0093] In the process 300, the remote UE 221 transmits paging related information associated with the remote UE 221 to the first relay UE 222 at 310. In some implementations, the paging related information associated with the remote UE 221 at 310 may be transmitted via a PC5 RRC message, such as a remote UE information sidelink
20 message.

[0094] In some embodiments, the paging related information associated with the remote UE 221 may include a device identifier of the remote UE 221. In some examples, the device identifier may be a 5G system temporary mobile subscription identifier (5G-S-TMSI).

[0095] In some embodiments, the paging related information associated with the remote
25 UE 221 may include a UE specific DRX cycle if the remote UE 221 is in an RRC idle state. In some embodiments, the paging related information associated with the remote UE 221 may include a minimum value of two UE specific DRX cycles if the remote UE 221 is in an RRC inactive state.

[0096] For instances, the remote UE 221 in an RRC idle state may provide 5G-S-TMSI and
30 UE specific DRX cycle (if configured by upper layer) to the first relay UE 222, for requesting to perform PO monitoring. For instances, the UE 221 in an RRC inactive state may provide the minimum value of two UE specific DRX cycles (if configured respectively by upper layer

and NG-RAN), 5G-S-TMSI, and I-RNTI to the first relay UE 222 for PO monitoring.

[0097] Upon receiving the paging related information associated with the remote UE 221 from the remote UE 221, the first relay UE 222 may determine to perform one or more operations. For example, the operation 320 or 330 may be performed. As such, options of which relay UE should be responsible for paging monitoring are provided in the present disclosure.

[0098] In some implementations, the first relay UE 222 may directly perform the operation 330 upon receiving the paging related information associated with the remote UE 221, for example, the second relay UE 223 (parent relay UE) is responsible for monitoring POs. In some embodiments, if there is end-to-end PC5 link between the remote UE 221 and the second relay UE 223 (parent relay UE), i.e. U2U relay communication, the remote UE 221 may transmit the paging related information associated with the remote UE 221 to the second relay UE 223 (parent relay UE) directly via the first relay UE 222 (child relay UE), while the paging related information associated with the remote UE 221 is transparent to the first relay UE 222 (child relay UE).

[0099] In some implementations, as shown in FIG. 3, the BS 224 may transmit a configuration to the second relay UE 223 and the first relay UE 222 at 302. In some embodiments, the configuration may be transmitted via broadcast signalling. In some embodiments, the configuration may indicate whether the first relay UE 222 or the second relay UE 223 should monitor POs for the remote UE(s).

[00100] In some examples, the configuration may be transmitted via dedicated signalling, for example, the configuration may indicate that the second relay UE 223 (or the first relay UE 222) should be responsible for PO monitoring for the remote UE(s), e.g. if the second relay UE 223 is in an RRC connected state.

[00101] In the process 300, the first relay UE 222 may determine whether a first condition or a second condition is met, and further determine to perform the operation 320 or 330.

[00102] In some implementations, the second condition may include one or more of: the first relay UE 222 is in coverage of the base station 224; the first relay UE 222 is in one of an RRC idle state, an RRC inactive state, or an RRC connected state; the first relay UE 222 is in one of an RRC idle state, an RRC inactive state, or an RRC connected state, and in the coverage of the base station; a channel quality of a link between the first relay UE 222 and the base station 224 is larger than a threshold, or the base station 224 has configured that the

first relay UE 222 monitors the one or more paging occasions for the remote UE 221.

[00103] In some examples, if the configuration at 302 indicates that the first relay UE 222 should perform PO monitoring for the remote UE 221, then the first relay UE 222 may determine to perform the operation 320.

- 5 **[00104]** In some examples, if the first relay UE 222 is in an RRC idle state or an RRC inactive state but is in coverage of the BS 224, then the first relay UE 222 may determine to perform the operation 320.

[00105] In some examples, if the first relay UE 222 is in an RRC connected state, then the first relay UE 222 may determine to perform the operation 320.

- 10 **[00106]** In some examples, if the first relay UE 222 is in an RRC connected state and a channel quality between the first relay UE 222 and the BS 224 is larger than a threshold, then the first relay UE 222 may determine to perform the operation 320. For example, the threshold of Uu channel may be configured, for the first relay UE 222 to determine whether to perform the operation 320.

- 15 **[00107]** In the operation 320, the first relay UE 222 monitors one or more POs for the remote UE 221 at 322, e.g. based on the paging related information associated with the remote UE 221 which is received at 310. In addition, if a paging message is detected, and identifier information included in the paging message is associated with the remote UE 221, the first relay UE 222 transmits the detected paging message to the remote UE 221 at 324. For
20 example, the paging message for the remote UE 221 at 324 may be transmitted via a PC5 RRC message, e.g. Uu message transfer in sidelink (*UuMessageTransferSidelink*).

- [00108]** In some examples, if both the remote UE 221 and the first relay UE 222 are in RRC_IDLE or RRC_INACTIVE, the first relay UE 222 monitors paging occasions of its connected remote UE 221. When the first relay UE 222 needs to monitor paging for the
25 remote UE 221, it should monitor all POs of the remote UE 221.

- [00109]** In some examples, if the first relay UE 222 is in RRC_CONNECTED and the remote UE 221 is in RRC_IDLE or RRC_INACTIVE, then (option 1) the first relay UE 222 monitors POs of the remote UE 221 if the active DL BWP of the first relay UE 222 is configured with common search space including paging search space; (option 2) the delivery of the remote
30 UE's paging can be performed through a dedicated RRC message from the BS 224 to the first relay UE 222 (e.g. via the second relay UE 223). The dedicated RRC message for delivering remote UE paging may contain one or more remote UE IDs (5G-S-TMSI or I-

RNTI). It is to be noted that it is up to network implementation to decide which of the above two options to use.

[00110] In some implementations, the first condition may include one or more of: the first relay UE 222 is in an RRC idle state or an RRC inactive state; the first relay UE 222 is out-
5 of-coverage of the base station; the first relay UE 222 is in an RRC connected state and configured without paging search space; the first relay UE 222 is in one of an RRC idle state, an RRC inactive state, or an RRC connected state, and a channel quality of a link between the first relay UE and the base station is less than a threshold; or the base station 224 has configured that the second relay UE 223 monitors the one or more paging occasions for the
10 remote UE 221.

[00111] In some examples, if the configuration at 302 indicates that the second relay UE 223 should perform PO monitoring for the remote UE 221, then the first relay UE 222 may determine to perform the operation 330.

[00112] In some examples, if the first relay UE 222 is in an RRC idle state or an RRC inactive
15 state but is out of coverage of the BS 224, then the first relay UE 222 may determine to perform the operation 330.

[00113] In some examples, if the first relay UE 222 is in an RRC connected state but configured without paging search space, then the first relay UE 222 may determine to perform the operation 330. In some examples, if the first relay UE 222 is in an RRC
20 connected state but configured without paging search space, then the first relay UE 222 may transmit a report to the BS 224, e.g. via the second relay UE 223.

[00114] In the operation 330, the first relay UE 222 transmits a first message to the second relay UE 223 at 332. In some implementations, the first message at 332 may be transmitted via a PC5 message, which may be a newly defined message such as a relay UE information
25 sidelink message.

[00115] In some implementations, the first message includes the paging related information associated with the remote UE 221. In some implementations, the first message may further include an identifier (ID) of the remote UE 221, such as an L2 destination ID of the remote UE 221.

[00116] In some implementations, there may be multiple remote UEs served by the first relay UE 222, in this case, the first message may include paging related information associated with one or multiple remote UEs served by the first relay UE 222. With reference to FIG.

2B, the remote UE 221-2 and the remote UE 221-3 are served by the first relay UE 222-2, the first relay UE 222-2 may receive paging related information associated with the remote UE 221-2 from the remote UE 221-2 and receive paging related information associated with the remote UE 221-3 from the remote UE 221-3, in this case, the first message may include
5 both the paging related information associated with the remote UE 221-2 and the paging related information associated with the remote UE 221-3. However, if the first relay UE 222-2 receives the paging related information associated with the remote UE 221-2 but does not receive the paging related information associated with the remote UE 221-3, then the first message includes the paging related information associated with the remote UE 221-2 but
10 not includes the paging related information associated with the remote UE 221-3.

[00117] In some implementations, the first relay UE 222 may be in an RRC idle state or an RRC inactive state, in this case, the first message may further include paging related information associated with the first relay UE 222.

[00118] In some example embodiments, the first message may be transmitted according to a trigger condition, that is the transmission of the first message may be triggered by one or
15 more following: upon receiving the paging related information associated with the remote UE 221, upon the first relay UE 222 transiting from an RRC connected state to an RRC idle or inactive state, or upon the first relay UE 222 transiting from in-coverage to out-of-coverage.

[00119] In some examples, upon a reception of the paging related information associated
20 with the remote UE 221, the first relay UE 222 transmits the first message. In some examples, if the first relay UE 222 transits from in coverage (in RRC idle/inactive state) to out of coverage (in RRC idle/inactive state), the first relay UE 222 transmits the first message. In some examples, if the first relay UE 222 transits from an RRC connected state to an RRC idle/inactive state, the first relay UE 222 transmits the first message.

[00120] In addition or alternatively, the first relay UE 222 may further transmit an updated
25 message (not shown in FIG. 3) of the first message to the second relay UE 223, e.g. if one or more events occur. In some embodiments, the updated message may include a difference with respect to the previous transmitted first message, or may be a new first message with full information independent from the previous transmitted first message.

[00121] Specifically, there may be multiple remote UE served by the first relay UE 222. In
30 some implementations, if a further remote UE transits from an RRC idle/inactive state to an RRC connected state, or if a further remote UE leaves the first relay UE 222 (e.g. not served

by the first relay UE 222 any more), the updated message may be transmitted.

[00122] In some examples, if one or more remote UEs transit to an RRC connected state, the updated message may be triggered. For example, upon a reception of SRB0 message from the BS 224 or upon a successful transition to the RRC connected state of one or more remote UEs or upon a reception of an RRC setup message from the BS 224, the updated message is triggered. For example, the updated message may indicate to the second relay UE 223 to release the paging related information associated with one or more remote UEs which have transited to the RRC connected state.

[00123] In some examples, if one or more remote UEs leaves the first relay UE 222, for example, the first relay UE 222 may receive an indication to release the paging related information from e.g. the one or more remote UEs, the updated message is triggered. For example, upon a reception the indication to release paging related information from e.g. the one or more remote UEs, the updated message may be triggered and the updated message may indicate to the second relay UE 223 to release the paging related information associated with one or more remote UEs.

[00124] The second relay UE 223 (parent relay UE) may trigger to perform PO monitoring at operation 333 or trigger a report to the BS 224 at operation 343.

[00125] In some implementations, the second relay UE 223 monitors paging occasions at 334. Specifically, if a fourth condition is met, the operation 333 may be performed. In some implementations, the fourth condition may include: the second relay UE 223 is in an RRC idle state or an RRC inactive state; or the second relay UE 223 is in an RRC connected state and configured with paging search space. In some examples, if the second relay UE 223 is in an RRC idle/inactive state, it may be triggered to monitor the POs. In some examples, if the second relay UE 223 is in an RRC connected state and configured with paging search space, it may be triggered to monitor the POs. For example, if the second relay UE 223 is in an RRC connected state and the active DL BWP of the second relay UE 223 is configured with common search space including paging search space, the second relay UE 223 may monitor POs of its served UEs, e.g. including the remote UE 221 and/or the first relay UE 222.

[00126] In some examples, the second relay UE 223 monitors all POs of the first relay UE 222 and the remote UE(s) 221 served by the first relay UE 222, e.g. based on the first message which may include the paging related information associated with the remote UE 221 and/or

the paging related information associated with the first relay UE 222.

[00127] In addition or alternatively, the second relay UE 223 may maintain an association between the remote UE 221 and the first relay UE 222.

[00128] In the operation 333, the second relay UE 223 transmits a third message to the first relay UE 222 at 336, where the third message includes a paging message for the remote UE 221. Specifically, if the second relay UE 223 receives a paging message for the remote UE 221, it may determine that the received paging message is for the remote UE 221, e.g. based on ID information included in the paging message. And then the second relay UE 223 may transmit the third message including the paging message for the remote UE 221, e.g. based on the association. For example, since the first relay UE 222 serves the remote UE 221, then the third message will be transmitted to the first relay UE 222.

[00129] In some examples, the third message may further include a device ID of the remote UE 221, which may be any one of: 5G-S-TMSI, I-RNTI, or an L2 source UE ID. For example, the third message may include following content in an IE “SL-TxResourceReqL2U2N-Relay”, where “sl-PagingIdentityRemoteUE” may indicate a device ID of the remote UE 221.

SL-TxResourceReqL2U2N-Relay-r17 ::=	SEQUENCE {
sl-DestinationIdentityL2U2N-r17	SL-DestinationIdentity-r16
OPTIONAL,	
sl-TxInterestedFreqListL2U2N-r17	SL-TxInterestedFreqList-r16,
sl-TypeTxSyncListL2U2N-r17	SEQUENCE (SIZE (1..maxNrofFreqSL-r16)) OF SL-
TypeTxSync-r16,	
sl-LocalID-Request-r17	ENUMERATED {true}
OPTIONAL,	
sl-PagingIdentityRemoteUE-r17	SL-PagingIdentityRemoteUE-r17
OPTIONAL,	
sl-PagingIdentityChildRelayUE-r19	SL-PagingIdentityChildRelayUE-r17
OPTIONAL,	
sl-CapabilityInformationSidelink-r17	OCTET STRING
OPTIONAL,	
...	
}	

[00130] In addition, the first relay UE 222 transmits the paging message for the remote UE 221 to the remote UE 221 at 338. For example, the paging message may be transmitted based on the device ID included in the third message. For example, the paging message for

the remote UE 221 at 338 may be transmitted via a PC5 RRC message, e.g. Uu message transfer in sidelink (*UuMessageTransferSidelink*).

5 [00131] It is to be understood that in case there is an end-to-end PC5 link between the second relay UE 223 and the remote UE 221, the third message may be transmitted to the remote UE 221 directly via the first relay UE, for example, the third message may be transparent to the first relay UE 222.

10 [00132] In the operation 333, the second relay UE 223 may transmit a fourth message to the first relay UE 222 at 337, where the fourth message includes a paging message for the first relay UE 222. Specifically, if the second relay UE 223 receives a paging message for the first relay UE 222, it may determine that the received paging message is for the first relay UE 222, e.g. based on ID information included in the paging message. And then the second relay UE 223 may transmit the fourth message including the paging message for the first relay UE 222.

15 [00133] In some embodiments, each of the third message and the fourth message may be a PC5 RRC message. In some embodiments, the third message and the fourth message may be implemented as or be combined into a same message.

20 [00134] In the operation 343, if the second relay UE 223 is in an RRC connected state and configured without paging search space, the second relay UE 223 transmits a report to the BS 224 at 344. For example, if the second relay UE 223 is in an RRC connected state and the active DL BWP of the second relay UE 223 is configured without common search space, the second relay UE 223 may transmit the report.

[00135] In some examples, the report may be carried in an RRC message, such as a SidelinkUEInformationNR message, for paging delivery purpose.

25 [00136] In some examples, the report may include the paging related information associated with the remote UE 221. In some examples, the report may include the paging related information associated with the first relay UE 222. In some examples, the report may further include a device ID of the remote UE 221 and/or a device ID of the first relay UE 222.

30 [00137] The BS 224 transmits a dedicated RRC message to the second relay UE 223 at 346. In this case, a delivery of the remote UE's paging and/or the first relay UE's paging can be performed through a dedicated RRC message from the BS 224 to the second relay UE 223. In some examples, the dedicated RRC message may include a device ID of the remote UE 221 and/or a device ID of the first relay UE 222.

[00138] In addition or alternatively, in the operation 330, the first relay UE 222 may further transmit (not shown in FIG. 3) a second message to the second relay UE 223, e.g. the second message may be transmitted after the first message. In some implementations, the second message may indicate to the second relay UE 223 to release the paging related information associated with the remote UE 221.

[00139] In some implementations, if a third condition is met, the second message may be triggered. In some examples, the third condition may include that the first relay UE 222 transits from out-of-coverage to in-coverage. In some examples, the third condition may include that the first relay UE 222 transits from an RRC idle/inactive state to an RRC connected state. For example, if the first relay UE 222 is able to perform PO monitoring, it may transmit the second message to the second relay UE 223.

[00140] As such, a solution of changing from a “parent relay UE based paging monitoring” to a “child relay UE based paging monitoring” is proposed, specifically, related UE behaviors are defined, and thus the paging information forwarding is enabled.

[00141] In some implementations, the second relay UE 223 may release the paging related information associated with the remote UE 221 based on the second message from the first relay UE.

[00142] In some implementations, the first relay UE 222 may further perform PO monitoring for the remote UE 221, e.g. after transmitting the second message. For example, the operation 320 may be referred.

[00143] FIG. 4 illustrates a signalling chart illustrating communication process 400 in accordance with some example embodiments of the present disclosure. The process 400 may involve the remote UE 221, the first relay UE 222, and the second relay UE 223 as shown in FIG. 2B. It is to be understood that the process 400 may also be applied to another scenario different from that shown in FIG. 2B, the present disclosure does not limit this aspect.

[00144] In the process 400, the remote UE 221 transmits a RemoteUEInformationSidelink message to the first relay UE 222 at 410. For example, the RemoteUEInformationSidelink message may be the message transmitted at 310 as shown in FIG. 3.

[00145] In the process 400, the first relay UE 222 transmits a RelayUEInformationSidelink message to the second relay UE 223 at 420. For example, the RelayUEInformationSidelink message may be the first message transmitted at 332 as shown in FIG. 3. As an example, content of an IE “RelayUEInformationSidelink” may be:

RelayUEInformationSidelink-r19-IEs ::=	SEQUENCE {
sl-RequestedSIB-List-r17	SetupRelease { SL-RequestedSIB-List-r17 }
OPTIONAL, -- Need M	
sl-PagingInfo-RemoteUE-r17	SetupRelease { SL-PagingInfo-RemoteUE-r17 }
OPTIONAL, -- Need M	
SL-PagingInfo-RemoteUE-List-r19	SetupRelease { SL-PagingInfo-RemoteUE-List-r19 }
OPTIONAL, -- Need M	
sl-PagingInfo-childRelayUE-r19	SetupRelease { SL-PagingInfo-childRelayUE-
r17 }	OPTIONAL, -- Need M
lateNonCriticalExtension	OCTET STRING
OPTIONAL,	
nonCriticalExtension	SEQUENCE { }
OPTIONAL	
}	
SL-RequestedSIB-List-r17 ::=	SEQUENCE (SIZE (maxSIB-MessagePlus1-r17)) OF SL-
SIB-ReqInfo-r17	
SL-PagingInfo-RemoteUE-List-r19 ::=	SEQUENCE (SIZE (maxnumberofremoteUE-r19))
OF SL-PagingInfo-RemoteUE-r17	
SL-PagingInfo-RemoteUE-r17 ::=	SEQUENCE {
sl-PagingIdentityRemoteUE-r17	SL-PagingIdentityRemoteUE-r17,
sl-PagingCycleRemoteUE-r17	PagingCycle
OPTIONAL -- Need M	
}	
SL-PagingInfo-ChildRelayUE-r19 ::=	SEQUENCE {
sl-PagingIdentityChildRelayUE-r17	SL-PagingIdentityChildRelayUE-r17,
sl-PagingCycleChildRelayUE-r17	PagingCycle
OPTIONAL -- Need M	
}	

[00146] According to embodiments shown in FIGS. 3-4, a solution of paging information forwarding is proposed. When a remote UE is in an RRC idle/inactive state, a first relay UE or a second relay UE may perform PO monitoring. For example, the first relay UE may forward the paging related information associated with the remote UE to the second relay UE, and thus the second relay UE may perform PO monitoring for the remote UE.

[00147] FIG. 5 illustrates an example of a device 500 that is suitable for implementing embodiments of the present disclosure. The device 500 may be an example of a RAN node

as described herein. The device 500 may support wireless communication with the remote UE 221, the first relay UE 222, the second relay UE 223, the BS 224, or any combination thereof. The device 500 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 502, a memory 504, a transceiver 506, and, optionally, an I/O controller 508. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00148] The processor 502, the memory 504, the transceiver 506, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[00149] In some implementations, the processor 502, the memory 504, the transceiver 506, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504).

[00150] For example, the processor 502 may support wireless communication at the device 500 in accordance with examples as disclosed herein. The processor 502 may be configured to operable to support a means for actions discussed above.

[00151] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 502 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 502. The

processor 502 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 504) to cause the device 500 to perform various functions of the present disclosure.

5 [00152] The memory 504 may include random access memory (RAM) and read-only memory (ROM). The memory 504 may store computer-readable, computer-executable code including instructions that, when executed by the processor 502 cause the device 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 502 but may cause
10 a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 504 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[00153] The I/O controller 508 may manage input and output signals for the device 500.
15 The I/O controller 508 may also manage peripherals not integrated into the device 500. In some implementations, the I/O controller 508 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 508 may utilize an operating system such as iOS®, ANDROID®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller
20 508 may be implemented as part of a processor, such as the processor 506. In some implementations, a user may interact with the device 500 via the I/O controller 508 or via hardware components controlled by the I/O controller 508.

[00154] In some implementations, the device 500 may include a single antenna 510. However, in some other implementations, the device 500 may have more than one antenna
25 510 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 506 may communicate bi-directionally, via the one or more antennas 510, wired, or wireless links as described herein. For example, the transceiver 506 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver.
30 The transceiver 506 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 510 for transmission, and to demodulate packets received from the one or more antennas 510. The transceiver 506 may include one or more transmit chains, one or more receive chains, or a combination thereof.

[00155] 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
5 such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmit chain may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmit chain may also include one or more antennas 510 for transmitting
10 the amplified signal into the air or wireless medium.

[00156] A receive chain may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receive chain may include one or more antennas 510 for receive the signal over the air or wireless medium. The receive chain may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the
15 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.

[00157] FIG. 6 illustrates an example of a processor 600 that is suitable for implementing some embodiments of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may
20 optionally include at least one memory 604, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[00158] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein.
30

The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[00159] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[00160] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[00161] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[00162] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602
5 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple
10 processors and the memory 604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[00163] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more
15 ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which
20 determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more
25 ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[00164] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for operations described in some embodiments of the present disclosure.

[00165] FIG. 7 illustrates a flowchart of a method 700 performed by a first relay UE in
30 accordance with aspects of the present disclosure. The operations of the method 700 may be implemented by a device or its components as described herein. For example, the operations of the method 700 may be performed by the first relay UE 222 in FIG. 2B. In some implementations, the device may execute a set of instructions to control the function

elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00166] At 710, the method may include receiving, from a remote UE, a request comprising paging related information associated with the remote UE. The operations of 710 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 710 may be performed by the first relay UE 222 as described with reference to FIG. 2B.

[00167] At 720, the method may include in accordance with a determination that a first condition is met, transmitting, to a second relay UE, a first message at least comprising the paging related information associated with the remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 720 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 720 may be performed by the first relay UE 222 as described with reference to FIG. 2B.

[00168] FIG. 8 illustrates a flowchart of a method 800 performed by a second relay UE in accordance with aspects of the present disclosure. The operations of the method 800 may be implemented by a device or its components as described herein. For example, the operations of the method 800 may be performed by the second relay UE 223 in FIG. 2B. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[00169] At 810, the method may include receiving, from a first relay UE, a first message at least comprising the paging related information associated with a remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 810 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 810 may be performed by the second relay UE 223 as described with reference to FIG. 2B.

[00170] At 820, the method may include in accordance with a determination that a fourth condition is met, monitoring one or more paging occasions for the remote UE based on the paging related information associated with the remote UE. The operations of 820 may be

performed in accordance with examples as described herein. In some implementations, aspects of the operations of 820 may be performed by the second relay UE 223 as described with reference to FIG. 2B.

5 [00171] FIG. 9 illustrates a flowchart of a method 900 performed by a BS in accordance with aspects of the present disclosure. The operations of the method 900 may be implemented by a device or its components as described herein. For example, the operations of the method 900 may be performed by the BS 224 in FIG. 2B. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform
10 aspects of the described functions using special-purpose hardware.

[00172] At 910, the method may include receiving, from a second relay UE, a report comprising paging related information associated with a remote UE, wherein the second relay UE is connected to the base station, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE. The operations of 910 may be
15 performed in accordance with examples as described herein. In some implementations, aspects of the operations of 910 may be performed by the BS 224 as described with reference to FIG. 2B.

[00173] At 920, the method may include transmitting, to the second relay UE, a dedicated RRC message comprising one or more paging messages associated with the remote UE or
20 the first relay UE. The operations of 920 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 920 may be performed by the BS 224 as described with reference to FIG. 2B.

[00174] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise
25 modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[00175] 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
30 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).

5 [00176] 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,
10 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.

[00177] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program
15 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
20 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.

[00178] 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
25 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).
30 Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be

construed in the same manner as the phrase “based at least in part on.” Further, as used herein, including in the claims, a “set” may include one or more elements.

[00179] 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
5 person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A first relay user equipment (UE) comprising:
at least one memory; and
5 at least one processor coupled with the at least one memory and configured to cause the first relay UE to:
receive, from a remote UE, a request comprising paging related information associated with the remote UE; and
in accordance with a determination that a first condition is met, transmit, to a
10 second relay UE, a first message at least comprising the paging related information associated with the remote UE, wherein the first relay UE is connected to a base station via the second relay UE, and wherein the remote UE is connected to the base station via the first relay UE and the second relay UE.
- 15 2. The first relay UE of claim 1, wherein the at least one processor is further configured to cause the first relay UE to:
in accordance with a determination that a second condition is met, monitor one or more paging occasions for the remote UE based on the paging related information associated with the remote UE.
20
3. The first relay UE of claim 2, wherein the second condition comprises one of:
the first relay UE is in coverage of the base station,
the first relay UE is in one of a radio resource control (RRC) idle state, an RRC inactive state, or an RRC connected state,
25 the first relay UE is in one of an RRC idle state, an RRC inactive state, or an RRC connected state, and in the coverage of the base station,
a channel quality of a link between the first relay UE and the base station is larger than a threshold, or
the base station has configured that the first relay UE monitors the one or more paging
30 occasions for the remote UE.
4. The first relay UE of claim 2, wherein the at least one processor is further configured to cause the first relay UE to:

in accordance with a determination that a paging message for the remote UE is detected, transmit, to the remote UE, the paging message based on identifier information in the paging message.

- 5 5. The first relay UE of claim 1, wherein the first condition comprises one of:
the first relay UE is in an RRC idle state or an RRC inactive state,
the first relay UE is out-of-coverage of the base station,
the first relay UE is in an RRC connected state and configured without paging search
space,
10 the first relay UE is in one of an RRC idle state, an RRC inactive state, or an RRC
connected state, and a channel quality of a link between the first relay UE and the base station
is less than a threshold, or
the base station has configured that the second relay UE monitors the one or more
paging occasions for the remote UE.

- 15 6. The first relay UE of claim 1, wherein the transmission of the first message is
triggered by one of:
upon receiving the paging related information associated with the remote UE,
upon the first relay UE transiting from an RRC connected state to an RRC idle or
20 inactive state, or
upon the first relay UE transiting from in-coverage to out-of-coverage.

7. The first relay UE of claim 1, wherein the first message further comprises
paging related information associated with a further remote UE, and wherein the at least one
25 processor is further configured to cause the first relay UE to:
transmit, to the second relay UE, an updated message of the first message based on a
determining one of:
the further remote UE transits from an RRC idle or inactive state to an RRC
connected state,
30 a reception of signalling radio bearer 0 (SRB0) message from the further remote
UE,
a reception of an RRC setup message from the base station, or
a reception of an indication to release the paging related information associated
with the further remote UE from the further remote UE.

8. The first relay UE of claim 1, wherein the paging related information associated with the remote UE comprises one of:

- a device identifier of the remote UE,
- 5 a UE specific discontinuous reception (DRX) cycle, or
- a minimum value of two UE specific DRX cycles in case the remote UE is in an RRC inactive state.

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

receive, from the second relay UE, a third message comprising a paging message for the remote UE; and
transmit, to the remote UE, the paging message for the remote UE.

10. The first relay UE of claim 9, wherein the third message further comprises a
15 device identifier of the remote UE.

11. The first relay UE of claim 1, wherein the first message further comprises:
paging related information associated with the first relay UE, and wherein the first relay UE
20 is in an RRC idle state or an RRC inactive state.

12. The first relay UE of claim 11, wherein the at least one processor is further
configured to cause the first relay UE to:
receive, from the second relay UE, a fourth message comprising a paging message
25 for the first relay UE.

13. The first relay UE of claim 1, wherein the at least one processor is further
configured to cause the first relay UE to:
in accordance with a determination that a third condition is met, transmit, to the
30 second relay UE, a second message indicating to the second relay UE to release the paging
related information associated with the remote UE or the first relay UE; and
monitor one or more paging occasions for the remote UE based on the paging related
information associated with the remote UE.

14. The first relay UE of claim 13, wherein the third condition comprises one of:
the first relay UE transits from out-of-coverage to in-coverage, or
the first relay UE transits from an RRC idle or inactive state to an RRC connected
state.

5

15. A second relay user equipment (UE) comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause
the second relay UE to:

10 receive, from a first relay UE, a first message at least comprising the paging
related information associated with a remote UE, wherein the first relay UE is connected to
a base station via the second relay UE, and wherein the remote UE is connected to the base
station via the first relay UE and the second relay UE; and

in accordance with a determination that a fourth condition is met, monitor one
15 or more paging occasions for the remote UE based on the paging related information
associated with the remote UE.

16. The second relay UE of claim 15, wherein the fourth condition comprises one
of:

20 the second relay UE is in one of: a radio resource control (RRC) idle state, an RRC
inactive state, or an RRC connected state, or

the second relay UE is in an RRC connected state and configured with paging search
space.

25 17. The second relay UE of claim 15, wherein the at least one processor is further
configured to cause the second relay UE to:

maintain an association between the remote UE and the first relay UE; and

in accordance with a determination that a paging message for the remote UE is
detected, transmit, to the first relay UE, a third message comprising the paging message for
30 the remote UE based on identifier information in the paging message.

18. The second relay UE of claim 17, wherein the third message further comprises
a device identifier of the remote UE.

19. A base station comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause
the base station to:

5 receive, from a second relay UE, a report comprising paging related information
associated with a remote UE, wherein the second relay UE is connected to the base station,
and wherein the remote UE is connected to the base station via the first relay UE and the
second relay UE; and

transmit, to the second relay UE, a dedicated radio resource control (RRC)
10 message comprising one or more paging messages associated with the remote UE or the first
relay UE.

20. The base station of claim 19, wherein the report further comprises paging related
information associated with the first relay UE.

15