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(54) **SPLIT-CELL RELAY PACKET ROUTING**

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(57) **ABSTRACT**

Systems and methodologies are described that facilitate packet routing among relay eNBs in a wireless network. Packet data convergence protocol (PDCP) layer communications from a user equipment (UE) can terminate at a donor evolved Node B (eNB) and vice versa. In this regard, relay eNBs can forward PDCP layer communications over a routing protocol without locally processing the layer. The relay eNBs can, however, retrieve one or more parameters from a header of the PDCP layer for feedback to the donor eNB to assist in flow control, sequence number status transfer, and/or the like. In addition, routing identifier can be utilized to determine relay eNBs for receiving the packets. The routing identifier can additionally include an identifier of a radio bearer of the relay eNB communicating with the UE over which the PDCP layer communications are to be transmitted.

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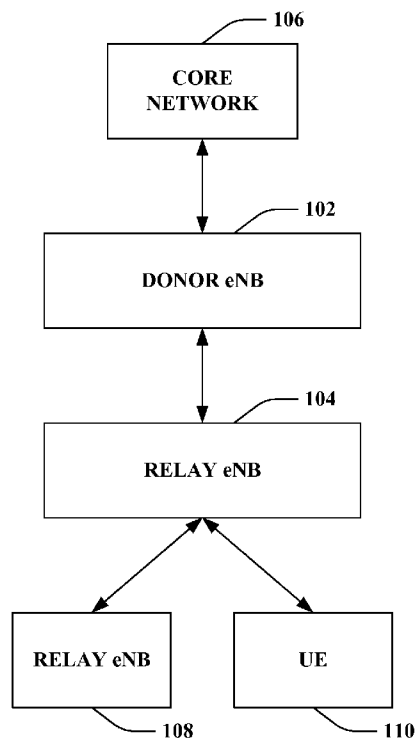
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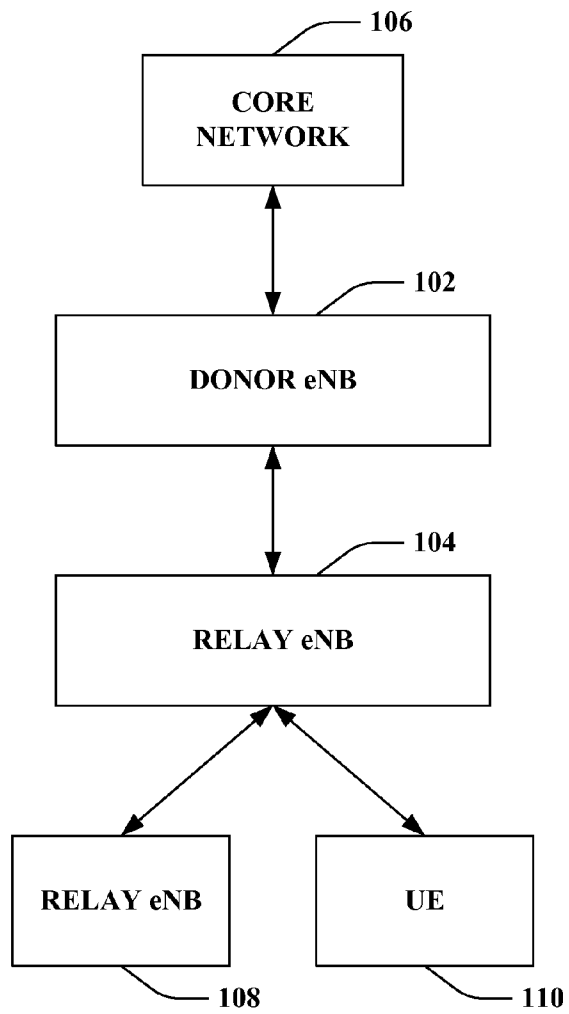
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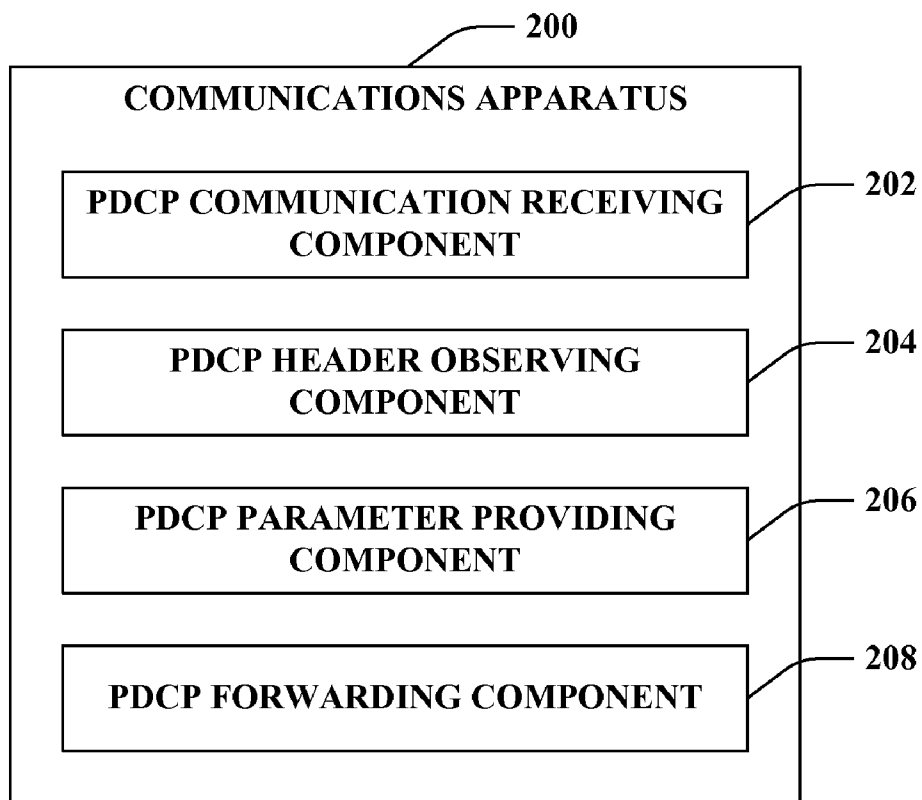
100



100



**FIG. 1**



**FIG. 2**

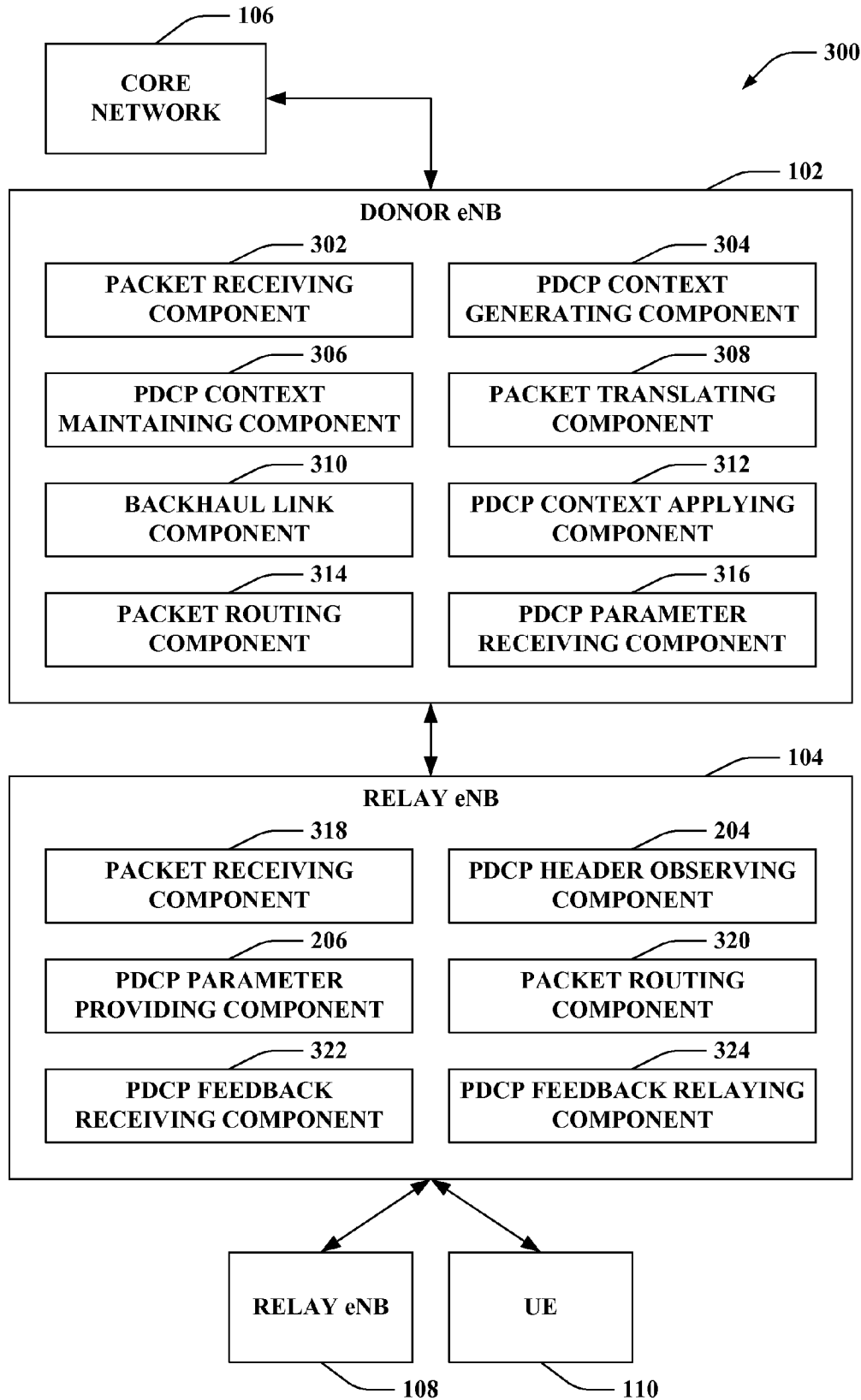


FIG. 3

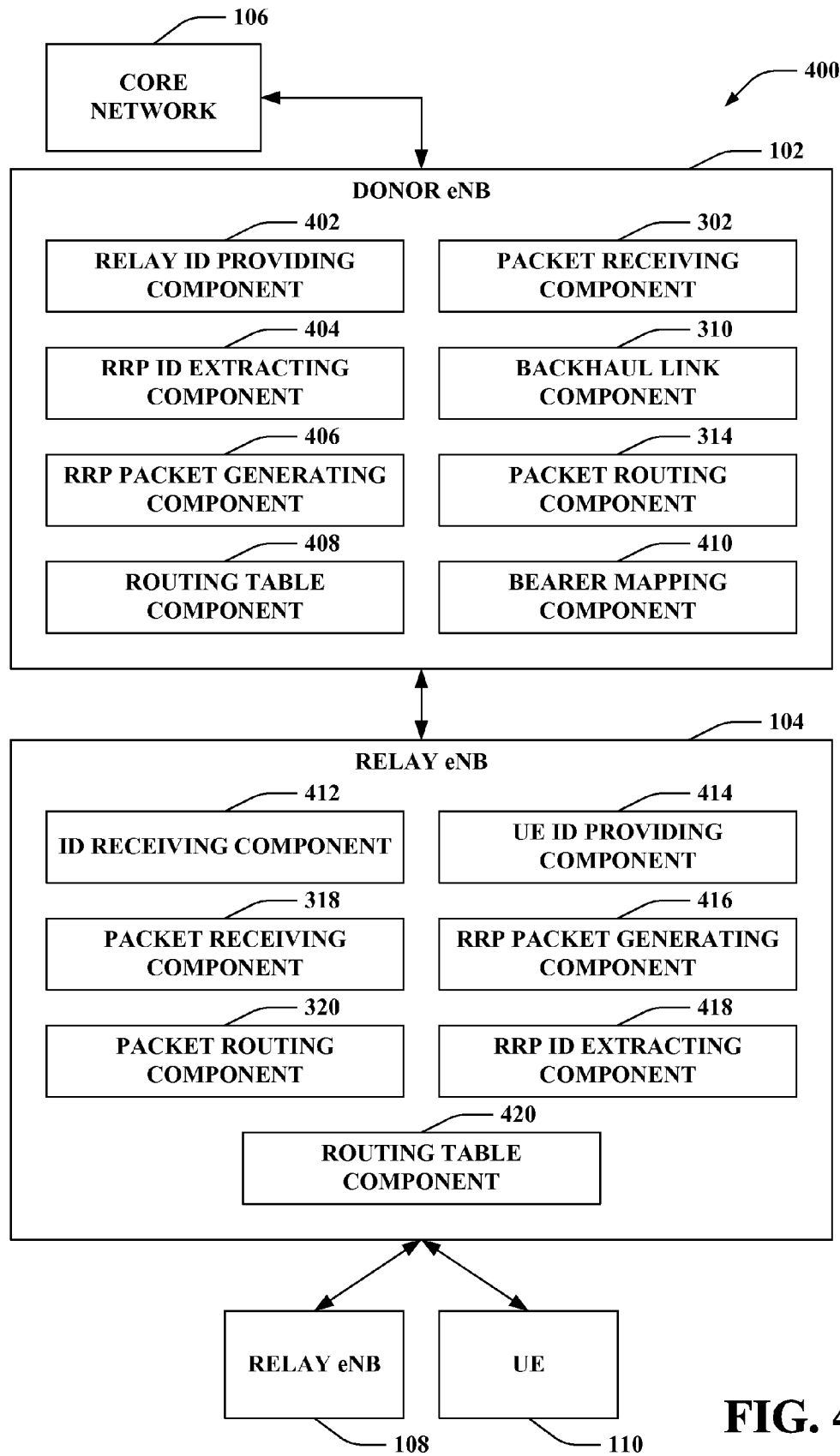


FIG. 4

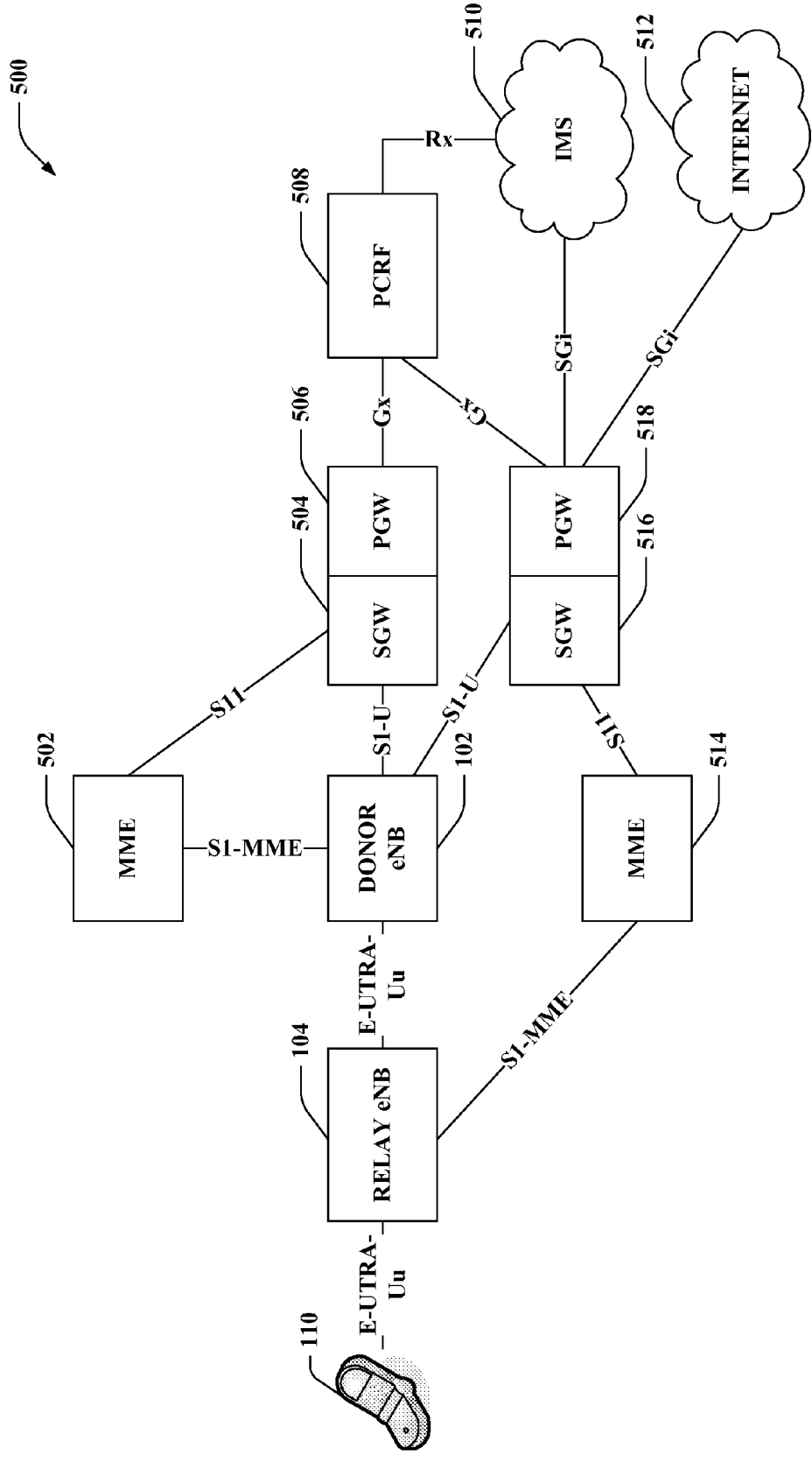
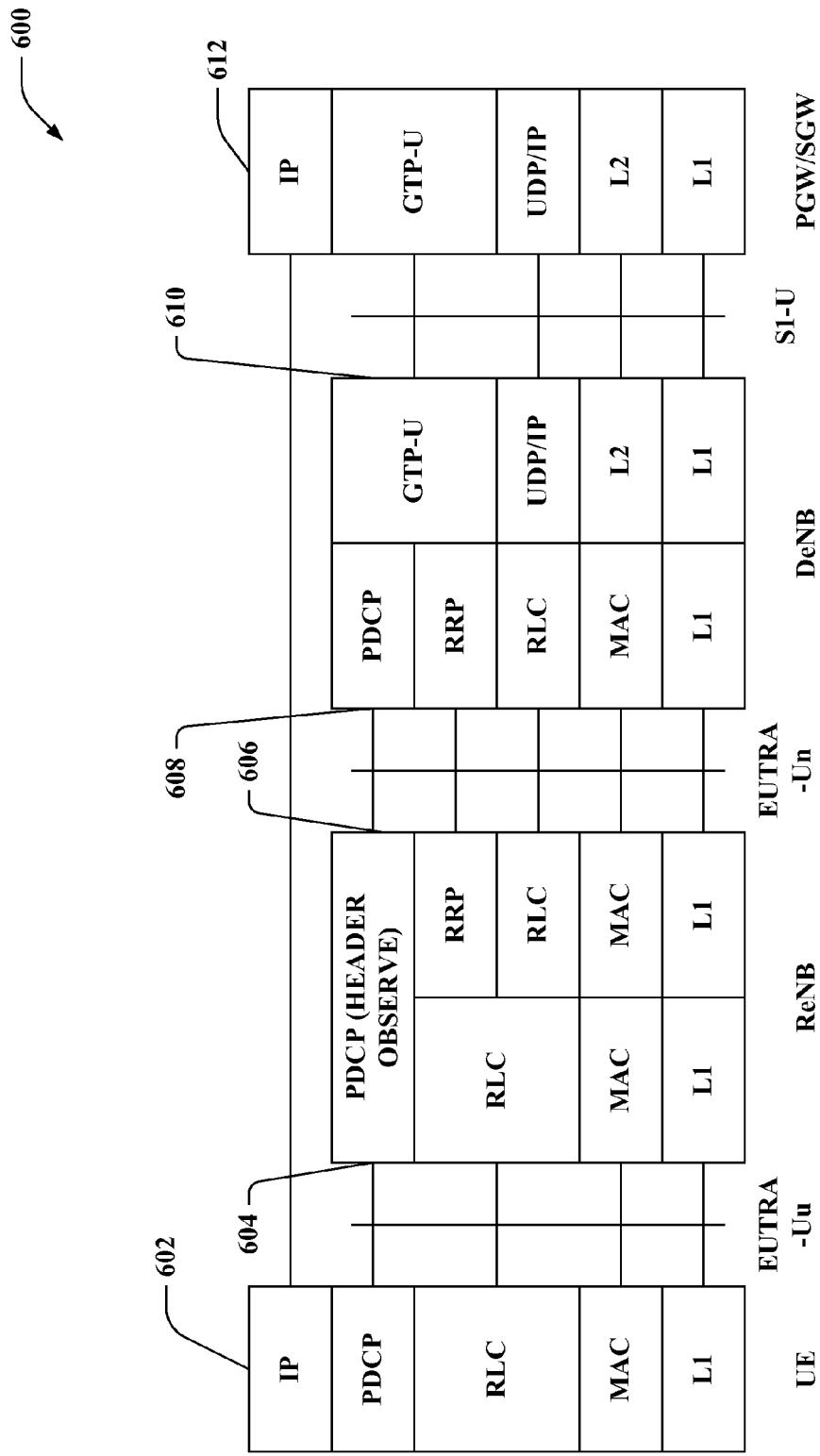


FIG. 5



**FIG. 6**

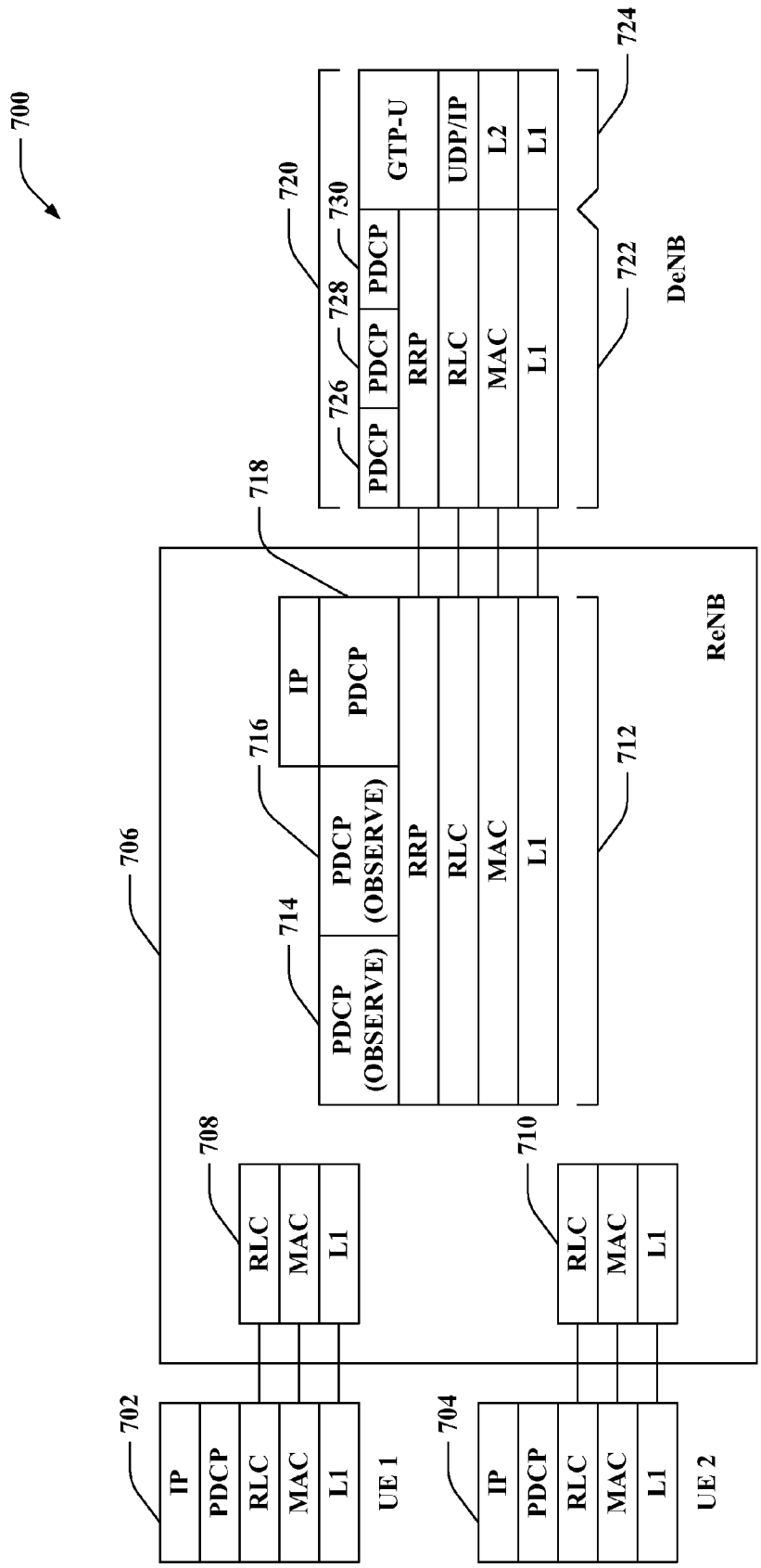
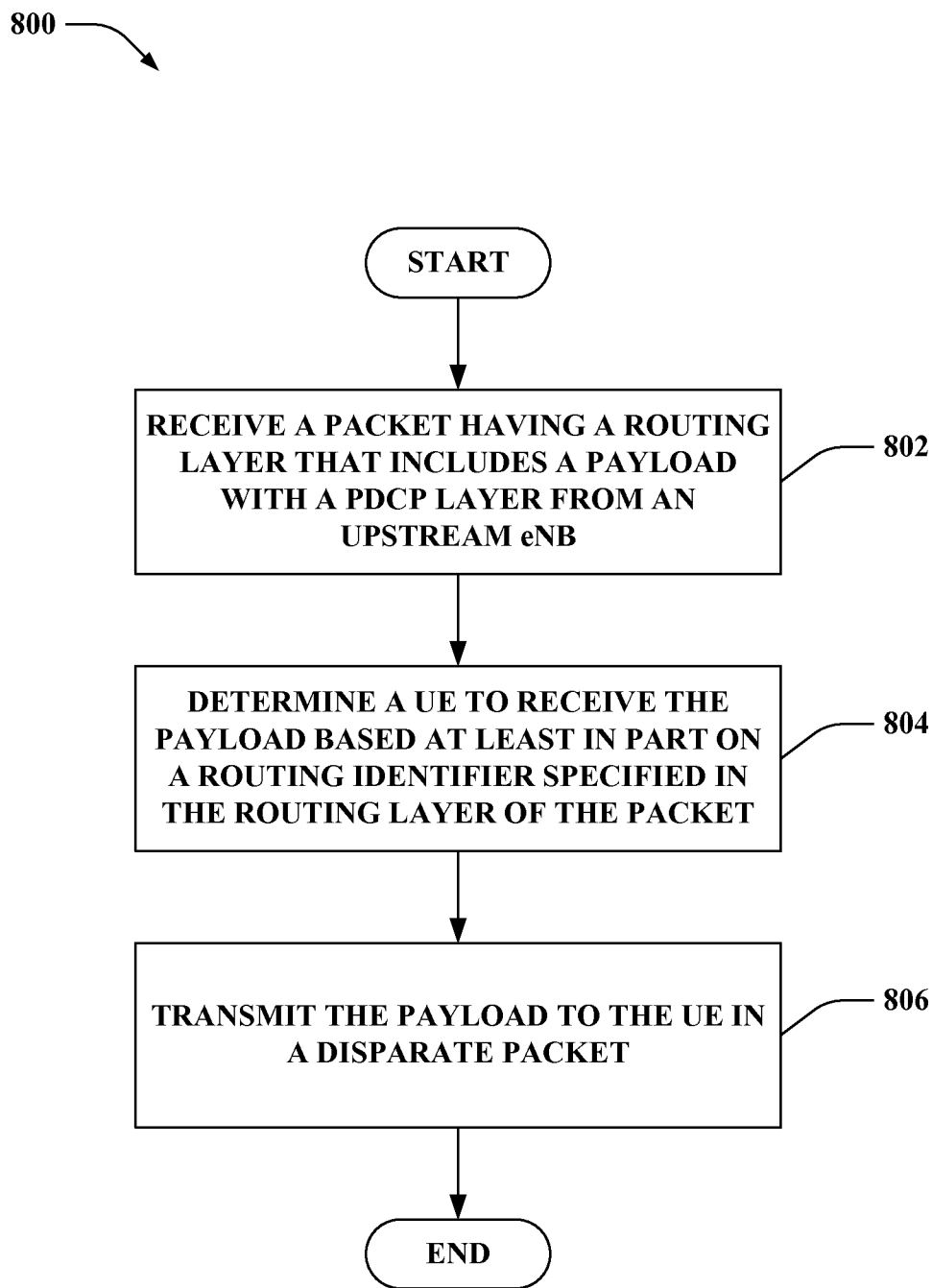
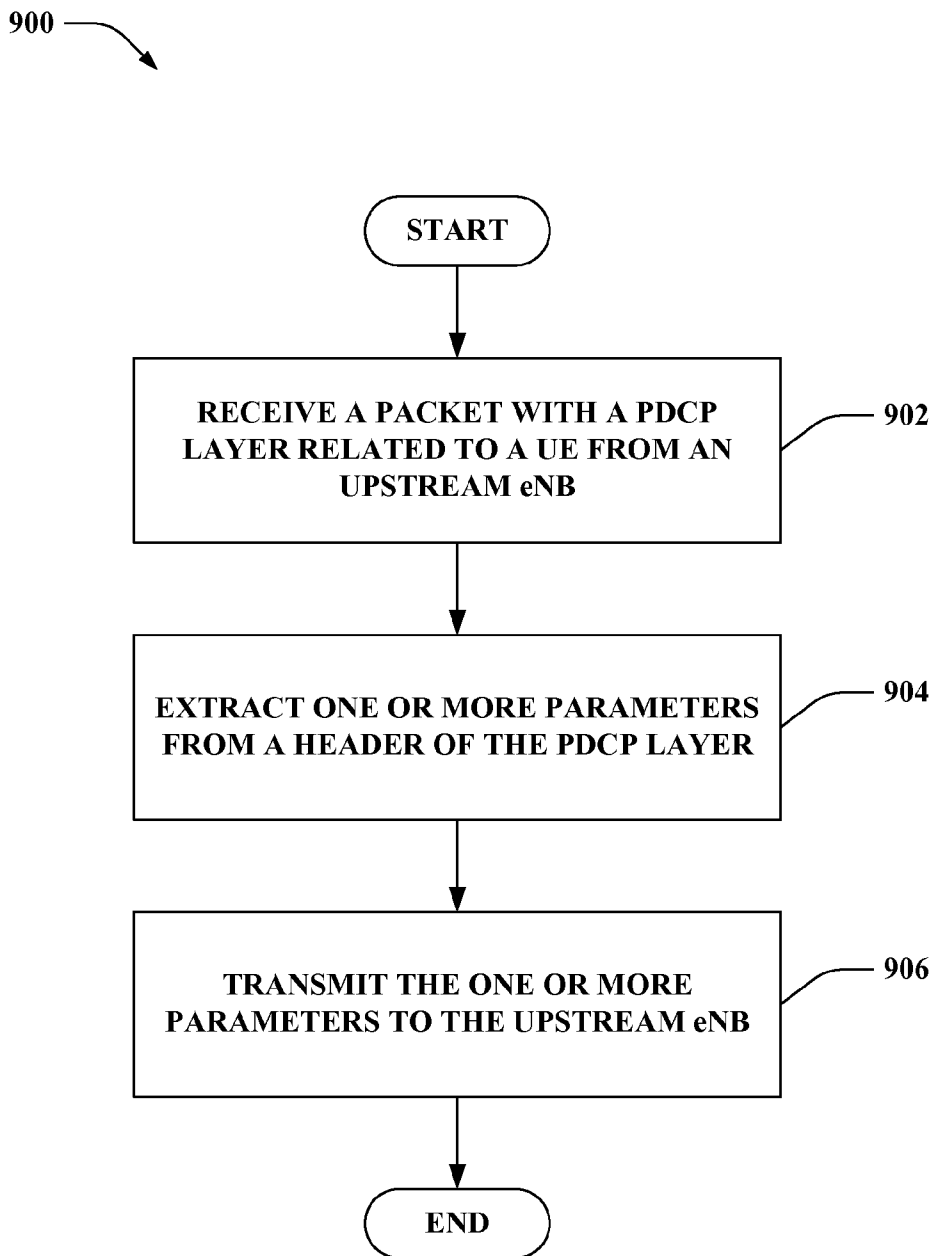


FIG. 7

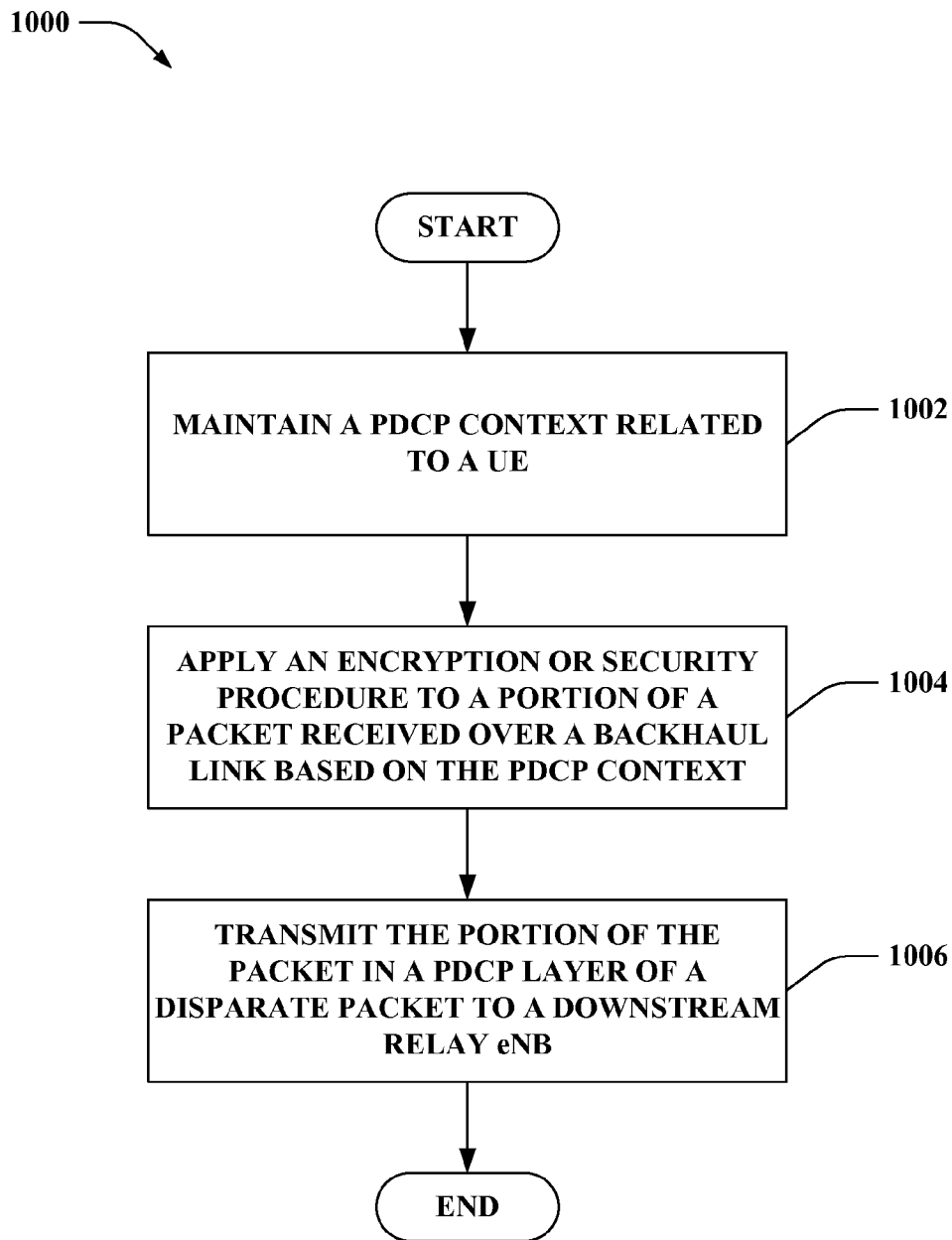




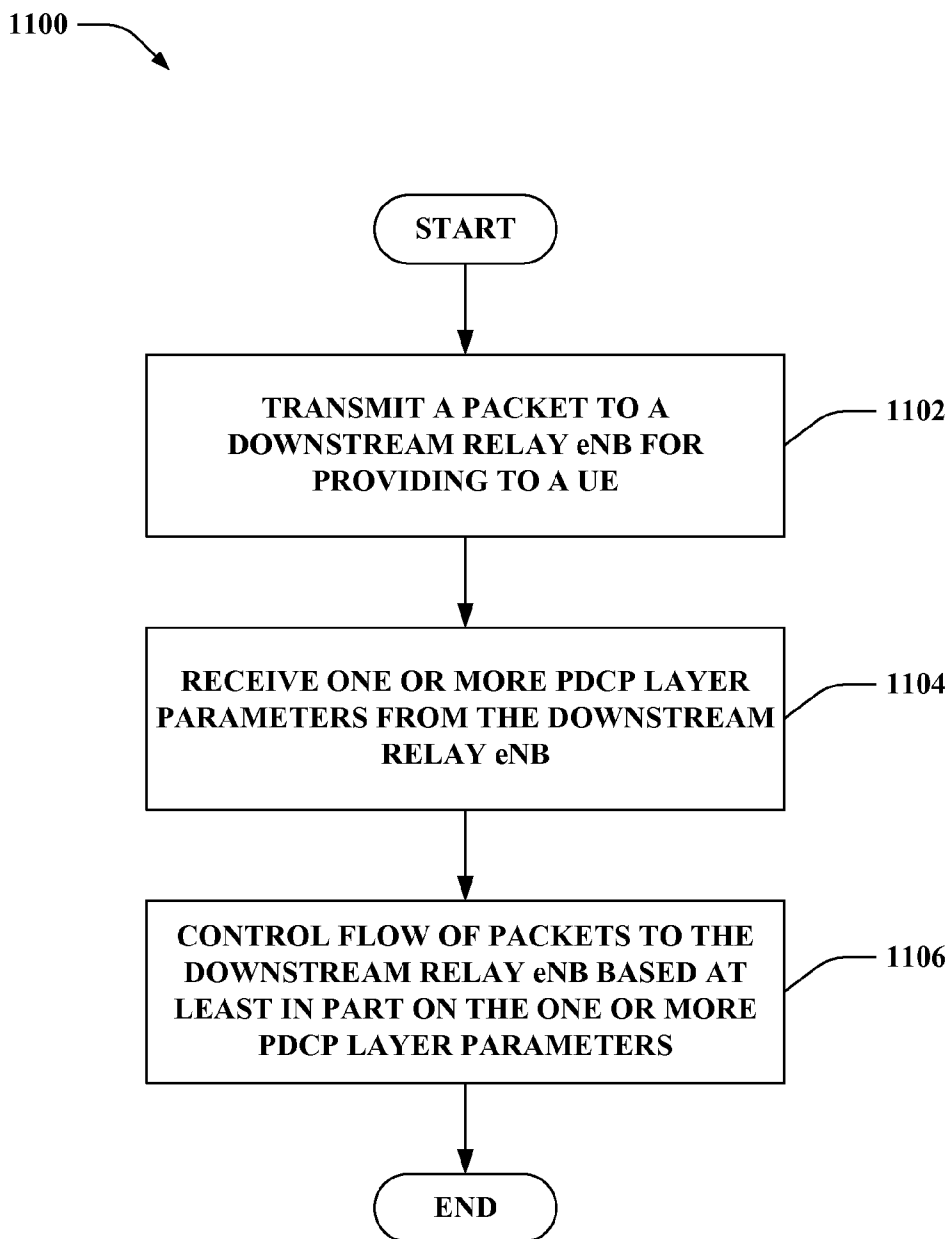
**FIG. 8**



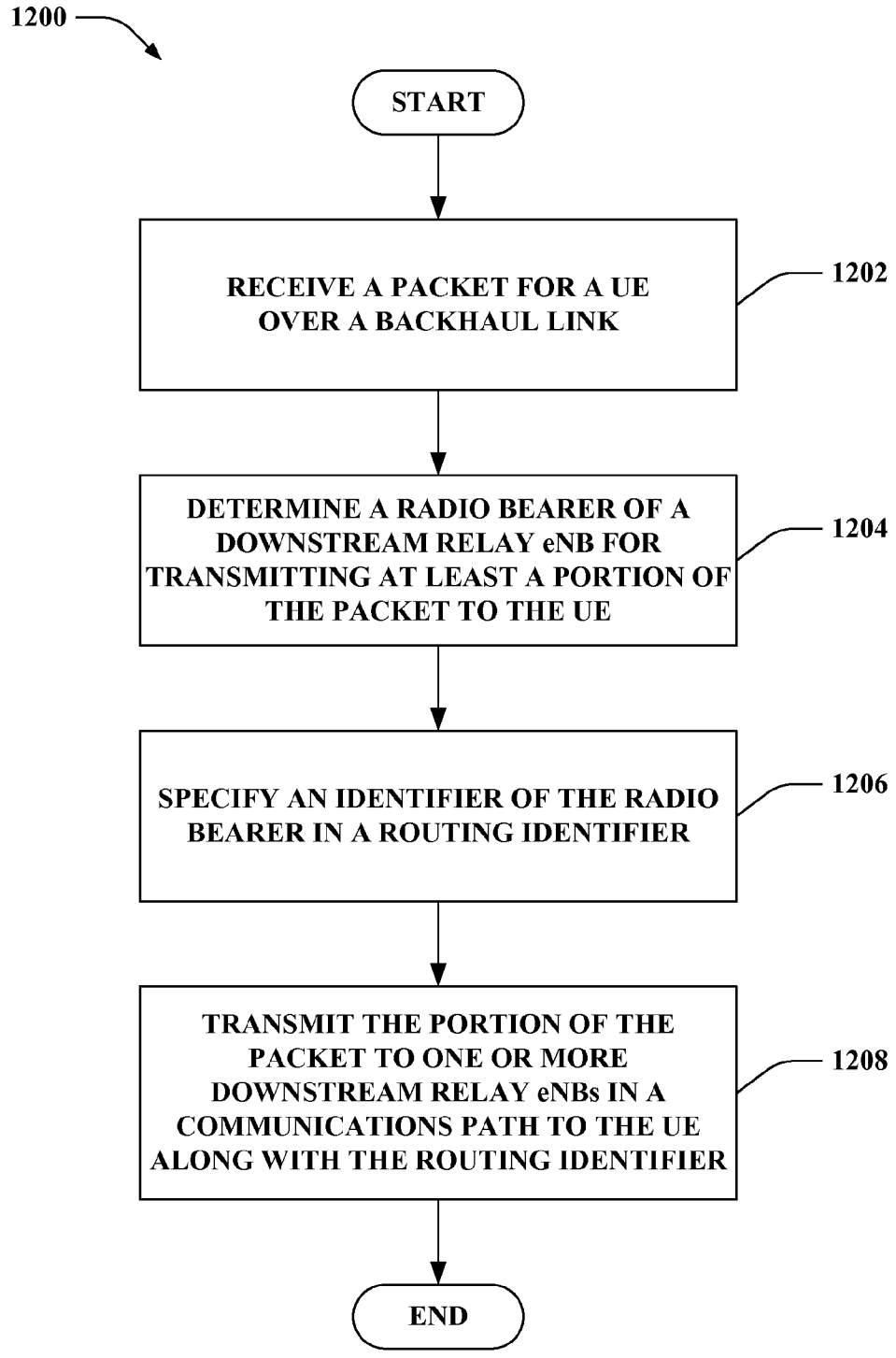
**FIG. 9**



**FIG. 10**



**FIG. 11**



**FIG. 12**



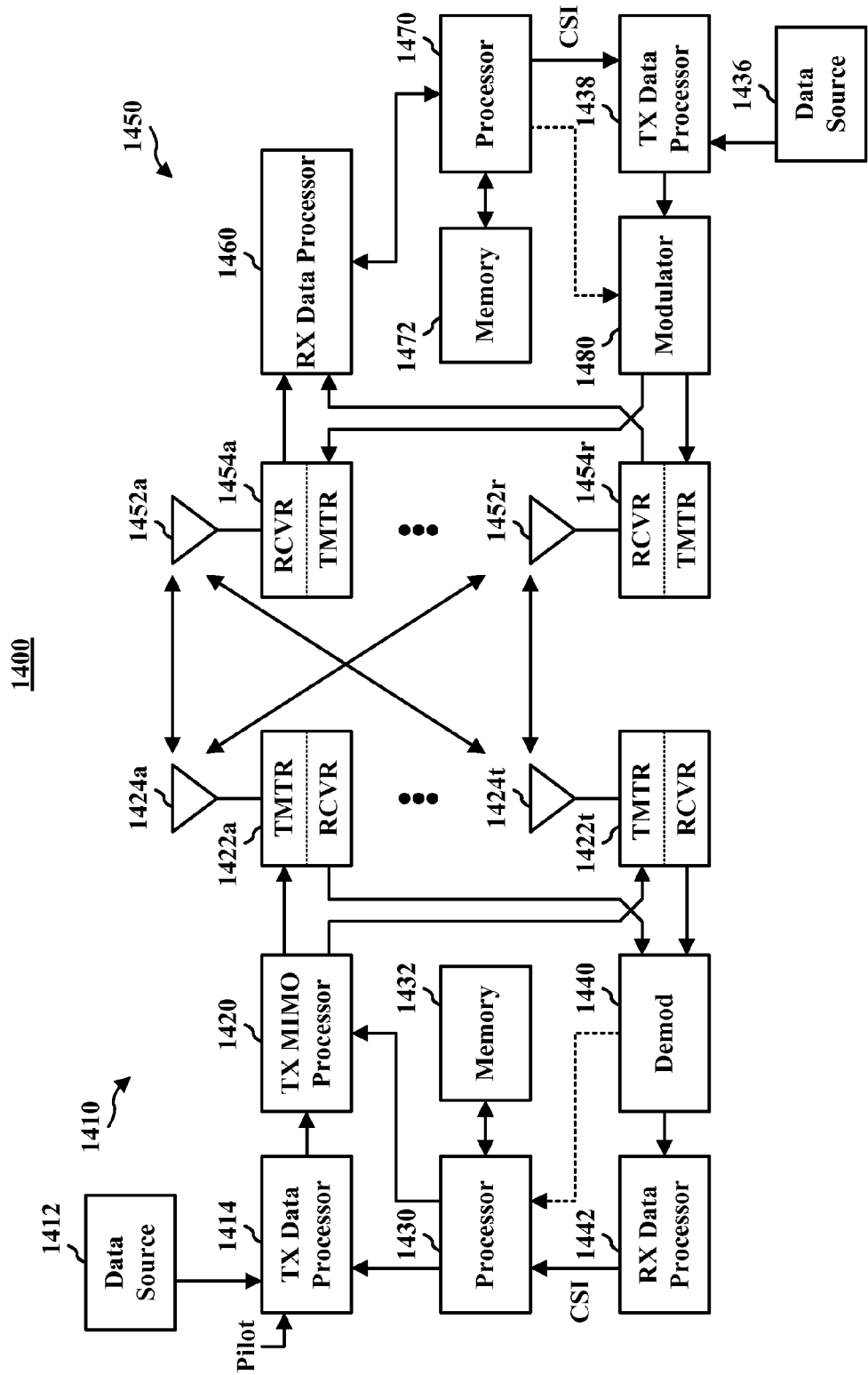
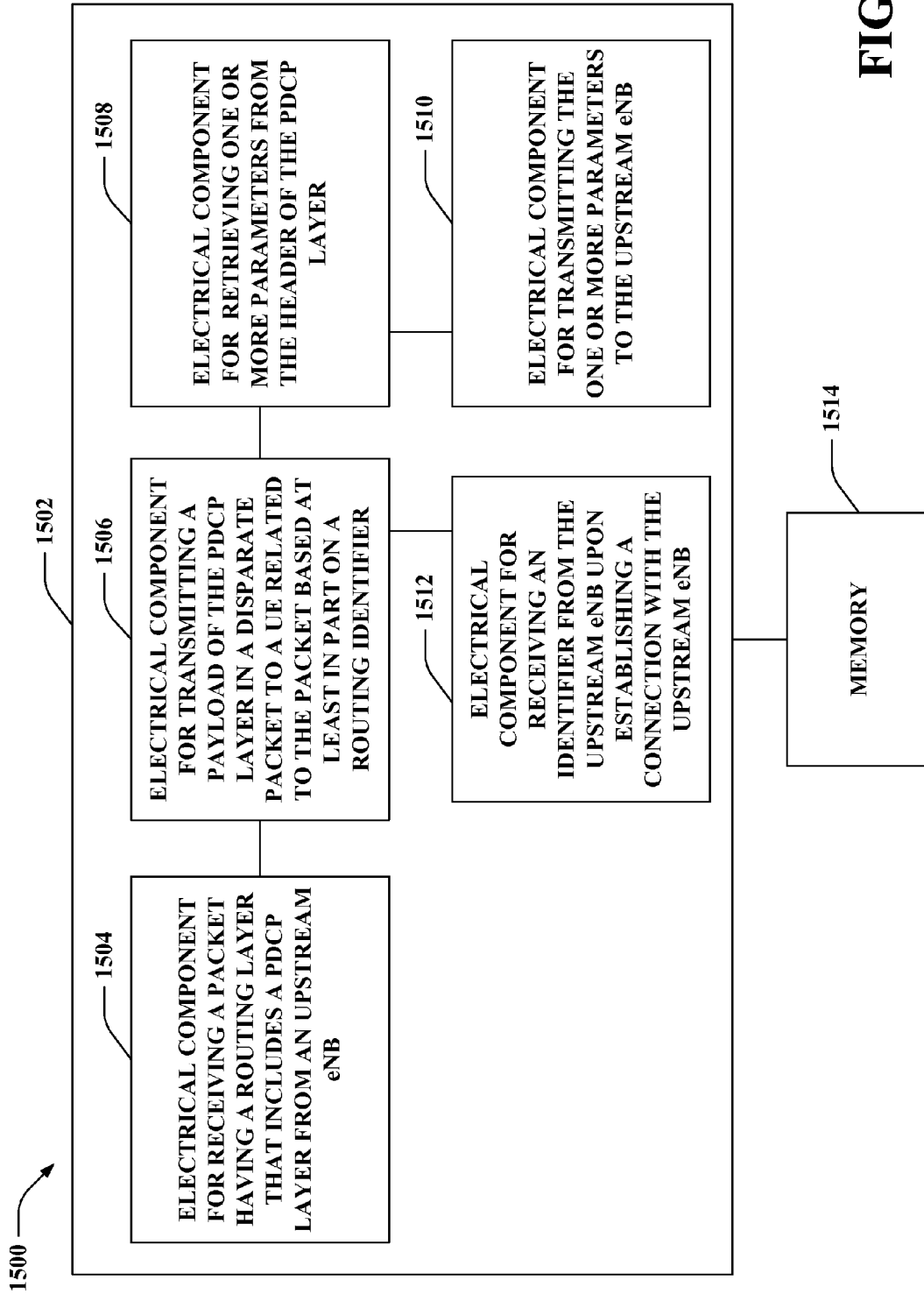


FIG. 14



**FIG. 15**



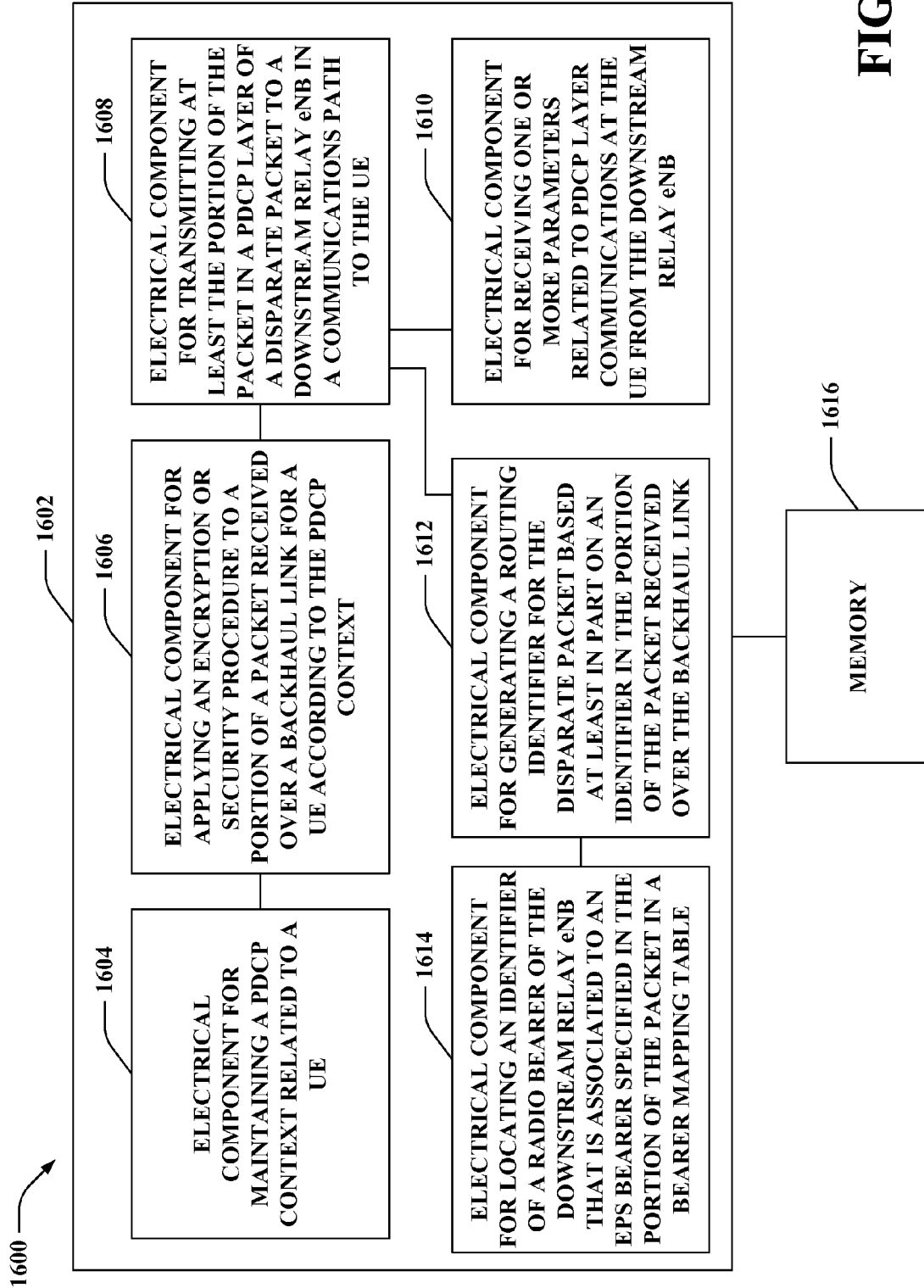


FIG. 16

**SPLIT-CELL RELAY PACKET ROUTING**

CLAIM OF PRIORITY UNDER 35 U.S.C. §119

**[0001]** The present Application for patent claims priority to Provisional Application No. 61/168,737 entitled “SPLIT-CELL BASED RELAY FOR LTE” filed Apr. 13, 2009, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

**BACKGROUND**

**[0002]** 1. Field

**[0003]** The following description relates generally to wireless communications, and more particularly to routing data packets among multiple access points.

**[0004]** 2. Background

**[0005]** Wireless communication systems are widely deployed to provide various types of communication content such as, for example, voice, data, and so on. Typical wireless communication systems may be multiple-access systems capable of supporting communication with multiple users by sharing available system resources (e.g., bandwidth, transmit power, . . . ). Examples of such multiple-access systems may include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, and the like. Additionally, the systems can conform to specifications such as third generation partnership project (3GPP), 3GPP long term evolution (LTE), ultra mobile broadband (UMB), and/or multi-carrier wireless specifications such as evolution data optimized (EV-DO), one or more revisions thereof, etc.

**[0006]** Generally, wireless multiple-access communication systems may simultaneously support communication for multiple mobile devices. Each mobile device may communicate with one or more access points (e.g., base stations) via transmissions on forward and reverse links. The forward link (or downlink) refers to the communication link from access points to mobile devices, and the reverse link (or uplink) refers to the communication link from mobile devices to access points. Further, communications between mobile devices and access points may be established via single-input single-output (SISO) systems, multiple-input single-output (MISO) systems, multiple-input multiple-output (MIMO) systems, and so forth. Access points, however, can be limited in geographic coverage area as well as resources such that mobile devices near edges of coverage and/or devices in areas of high traffic can experience degraded quality of communications from an access point.

**[0007]** Cell relays can be provided to expand network capacity and coverage area by facilitating communication between mobile devices and access points. For example, a cell relay can establish a backhaul link with a donor access point, which can provide access to a number of cell relays, and the cell relay can establish an access link with one or more mobile devices or additional cell relays. To mitigate modification to backend core network components, communication interfaces with the backend network components, such as S1-U, can terminate at the donor access point. Thus, the donor access point appears as a normal access point to backend network components. To this end, the donor access point can

route packets from the backend network components to the cell relays for communicating to the mobile devices.

**SUMMARY**

**[0008]** The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

**[0009]** In accordance with one or more aspects and corresponding disclosure thereof, various aspects are described in connection with facilitating routing packets between a donor eNB and one or more cell relay eNBs. In particular, a packet data convergence protocol (PDCP) layer of packets related to the cell relay eNB or a user equipment (UE) communicating with the cell relay eNB can be terminated at the donor eNB. In this regard, the donor eNB can handle security, encryption/decryption, etc. of communications with the cell relay eNB or the related UE, rather than handling such at each intermediary cell relay eNB, through which communications of the cell relay eNB or related UE are forwarded. Performing security, encryption/decryption, and similar procedures at the donor eNB increases efficiency of cell relay eNB and UE communications through the intermediary cell relay eNBs.

**[0010]** According to related aspects, a method is provided that includes receiving a packet having a routing layer that includes a payload with a PDCP layer from an upstream eNB and determining a UE to receive the payload based at least in part on a routing identifier specified in the routing layer of the packet. The method also includes transmitting the payload to the UE in a disparate packet.

**[0011]** Another aspect relates to a wireless communications apparatus. The wireless communications apparatus can include at least one processor configured to obtain a packet with a routing layer that comprises a PDCP layer from an upstream eNB and detect a UE for which the packet is intended based at least in part on a routing identifier specified in the routing layer. The at least one processor is further configured to transmit a payload of the PDCP layer to the UE in a disparate packet. The wireless communications apparatus also comprises a memory coupled to the at least one processor.

**[0012]** Yet another aspect relates to an apparatus. The apparatus includes means for receiving a packet having a routing layer that includes a PDCP layer from an upstream eNB and means for transmitting a payload of the PDCP layer in a disparate packet to a UE related to the packet based at least in part on a routing identifier specified in the routing layer of the packet.

**[0013]** Still another aspect relates to a computer program product, which can have a computer-readable medium including code for causing at least one computer to receive a packet having a routing layer that includes a payload with a PDCP layer from an upstream eNB. The computer-readable medium can also comprise code for causing the at least one computer to determine a UE to receive the payload based at least in part on a routing identifier specified in the routing layer of the packet and code for causing the at least one computer to transmit the payload to the UE in a disparate packet.

**[0014]** Moreover, an additional aspect relates to an apparatus including a packet receiving component that obtains a packet having a routing layer that includes a PDCP layer from an upstream eNB. The apparatus can further include a packet routing component that transmits a payload of the PDCP layer in a disparate packet to a UE related to the packet based at least in part on a routing identifier specified in the routing layer of the packet.

**[0015]** According to another aspect, a method is provided that includes maintaining a PDCP context related to a UE and applying an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE. The method further includes transmitting at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay eNB in a communications path to the UE.

**[0016]** Another aspect relates to a wireless communications apparatus. The wireless communications apparatus can include at least one processor configured to negotiate one or more parameters for communicating with a UE and to apply the one or more parameters to at least a portion of a packet for the UE received over a backhaul link. The at least one processor is further configured to transmit at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay eNB in a communications path to the UE. The wireless communications apparatus also comprises a memory coupled to the at least one processor.

**[0017]** Yet another aspect relates to an apparatus. The apparatus includes means for maintaining a PDCP context related to a UE and means for applying an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE. The apparatus also includes means for transmitting at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay eNB in a communications path to the UE.

**[0018]** Still another aspect relates to a computer program product, which can have a computer-readable medium including code for causing at least one computer to maintain a PDCP context related to a UE and code for causing the at least one computer to apply an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE. The computer-readable medium can also comprise code for causing the at least one computer to transmit at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay eNB in a communications path to the UE.

**[0019]** Moreover, an additional aspect relates to an apparatus including a PDCP context maintaining component that creates and stores a PDCP context related to a UE and a PDCP applying component that associates an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE. The apparatus can further include a packet routing component that transmits at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay eNB in a communications path to the UE.

**[0020]** To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various

aspects may be employed and this description is intended to include all such aspects and their equivalents.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0021]** FIG. 1 is an illustration of an example wireless communications system that facilitates providing relays for wireless networks.

**[0022]** FIG. 2 is an illustration of an example communications apparatus for employment within a wireless communications environment.

**[0023]** FIG. 3 is an illustration of an example wireless communications system that facilitates tunneling packet data convergence protocol (PDCP) layer communications through one or more relay eNBs.

**[0024]** FIG. 4 is an illustration of an example wireless communications system that facilitates generating routing identifiers for forwarding wireless communications.

**[0025]** FIG. 5 is an illustration of an example wireless communications system that utilizes cell relays to provide access to a wireless network.

**[0026]** FIG. 6 is an illustration of example protocol stacks that facilitate providing split-cell relay functionality for device communications.

**[0027]** FIG. 7 is an illustration of example protocol stacks that facilitate providing multiple PDCP contexts for routing communications in a wireless network.

**[0028]** FIG. 8 is an illustration of an example methodology for routing packets to user equipment (UE) without processing a PDCP layer.

**[0029]** FIG. 9 is an illustration of an example methodology that observes one or more PDCP header parameters of packets to be or that have been routed.

**[0030]** FIG. 10 is an illustration of an example methodology that communicates to UEs over a PDCP layer through one or more relay eNBs.

**[0031]** FIG. 11 is an illustration of an example methodology that controls flow of PDCP layer packets based on one or more parameters received from a relay eNB.

**[0032]** FIG. 12 is an illustration of an example methodology that specifies a radio bearer in a routing identifier for transmitting packets to a UE.

**[0033]** FIG. 13 is an illustration of a wireless communication system in accordance with various aspects set forth herein.

**[0034]** FIG. 14 is an illustration of an example wireless network environment that can be employed in conjunction with the various systems and methods described herein.

**[0035]** FIG. 15 is an illustration of an example system that facilitates routing packets from a donor eNB to a UE without processing a PDCP layer of the packets.

**[0036]** FIG. 16 is an illustration of an example system that facilitates providing packets to a relay eNB for forwarding to a UE.

#### DETAILED DESCRIPTION

**[0037]** Various aspects are now described with reference to the drawings. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more aspects. It may be evident, however, that such aspect(s) may be practiced without these specific details.

**[0038]** As used in this application, the terms “component,” “module,” “system” and the like are intended to include a

computer-related entity, such as but not limited to hardware, firmware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a computing device and the computing device can be a component. One or more components can reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components may communicate by way of local and/or remote processes such as in accordance with a signal having one or more data packets, such as data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems by way of the signal.

**[0039]** Furthermore, various aspects are described herein in connection with a terminal, which can be a wired terminal or a wireless terminal. A terminal can also be called a system, device, subscriber unit, subscriber station, mobile station, mobile, mobile device, remote station, remote terminal, access terminal, user terminal, terminal, communication device, user agent, user device, or user equipment (UE). A wireless terminal may be a cellular telephone, a satellite phone, a cordless telephone, a Session Initiation Protocol (SIP) phone, a wireless local loop (WLL) station, a personal digital assistant (PDA), a handheld device having wireless connection capability, a computing device, or other processing devices connected to a wireless modem. Moreover, various aspects are described herein in connection with a base station. A base station may be utilized for communicating with wireless terminal(s) and may also be referred to as an access point, a Node B, or some other terminology.

**[0040]** Moreover, the term “or” is intended to mean an inclusive “or” rather than an exclusive “or.” That is, unless specified otherwise, or clear from the context, the phrase “X employs A or B” is intended to mean any of the natural inclusive permutations. That is, the phrase “X employs A or B” is satisfied by any of the following instances: X employs A; X employs B; or X employs both A and B. In addition, the articles “a” and “an” as used in this application and the appended claims should generally be construed to mean “one or more” unless specified otherwise or clear from the context to be directed to a singular form.

**[0041]** The techniques described herein may be used for various wireless communication systems such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA and other systems. The terms “system” and “network” are often used interchangeably. A CDMA system may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes Wideband-CDMA (W-CDMA) and other variants of CDMA. Further, cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA system may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA system may implement a radio technology such as Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunication System (UMTS). 3GPP Long Term Evolution (LTE) is a release of UMTS that uses

E-UTRA, which employs OFDMA on the downlink and SC-FDMA on the uplink. UTRA, E-UTRA, UMTS, LTE and GSM are described in documents from an organization named “3rd Generation Partnership Project” (3GPP). Additionally, cdma2000 and UMB are described in documents from an organization named “3rd Generation Partnership Project 2” (3GPP2). Further, such wireless communication systems may additionally include peer-to-peer (e.g., mobile-to-mobile) ad hoc network systems often using unpaired unlicensed spectrums, 802.xx wireless LAN, BLUETOOTH and any other short- or long-range, wireless communication techniques.

**[0042]** Various aspects or features will be presented in terms of systems that may include a number of devices, components, modules, and the like. It is to be understood and appreciated that the various systems may include additional devices, components, modules, etc. and/or may not include all of the devices, components, modules etc. discussed in connection with the figures. A combination of these approaches may also be used.

**[0043]** Referring to FIG. 1, a wireless communication system **100** is illustrated that facilitates providing relay functionality in wireless networks. System **100** includes a donor eNB **102** that provides one or more relay eNBs, such as relay eNB **104**, with access to a core network **106**. Similarly, relay eNB **104** can provide one or more disparate relay eNBs, such as relay eNB **108**, or UEs, such as UE **110**, with access to the core network **106** via donor eNB **102**. Donor eNB **102**, which can also be referred to as a cluster eNB, can communicate with the core network **106** over a wired or wireless backhaul link, which can be an LTE or other technology backhaul link. In one example, the core network **106** can be a 3GPP LTE or similar technology network.

**[0044]** Donor eNB **102** can additionally provide an access link for relay eNB **104**, which can also be wired or wireless, LTE or other technologies, and the relay eNB **104** can communicate with the donor eNB **102** using a backhaul link over the access link of the donor eNB **102**. Relay eNB **104** can similarly provide an access link for relay eNB **108** and/or UE **110**, which can be a wired or wireless LTE or other technology link. In one example, donor eNB **102** can provide an LTE access link, to which relay eNB **104** can connect using an LTE backhaul, and relay eNB **104** can provide an LTE access link to relay eNB **108** and/or UE **110**. Donor eNB **102** can connect to the core network **106** over a disparate backhaul link technology. Relay eNB **108** and/or UE **110** can connect to the relay eNB **104** using the LTE access link to receive access to core network **106**, as described. A donor eNB and connected relay eNBs can be collectively referred to herein as a cluster.

**[0045]** According to an example, relay eNB **104** can connect to a donor eNB **102** at the link layer (e.g., media access control (MAC) layer) as would a UE in conventional LTE configurations. In this regard, donor eNB **102** can act as a conventional LTE eNB requiring no changes at the link layer or related interface (e.g., user-to-user (Uu), such as E-UTRA-Uu) to support the relay eNB **104**. In addition, relay eNB **104** can appear to UE **110** as a conventional eNB at the link layer, such that no changes are required for UE **110** to connect to relay eNB **104** at the link layer, for example. In addition, relay eNB **104** can configure procedures for resource partitioning between access and backhaul link, interference management, idle mode cell selection for a cluster, and/or the like. It is to be appreciated that relay eNB **104** can connect to additional donor eNBs, in one example.

[0046] With respect to transport layer communications, transport protocols related to relay eNB 108 or UE 110 communications can terminate at the donor eNB 102, referred to as cell relay functionality, since the relay eNB 104 is like a cell of the donor eNB 102. For example, in a cell relay configuration, donor eNB 102 can receive communications for the relay eNB 104 from the core network 106, terminate the transport protocol, and forward the communications to the relay eNB 104 over a disparate transport layer keeping the application layer substantially intact. It is to be appreciated that the forwarding transport protocol type can be the same as the terminated transport protocol type, but is a different transport layer established with the relay eNB 104.

[0047] Relay eNB 104 can determine a relay eNB or UE (e.g., relay eNB 108 or UE 110) related to the communications, and provide the communications to the relay eNB or UE (e.g., based on an identifier thereof within the communications). Similarly, donor eNB 102 can terminate the transport layer protocol for communications received from relay eNB 104, translate the communications to a disparate transport protocol, and transmit the communications over the disparate transport protocol to the core network 106 with the application layer intact for relay eNB 104 as a cell relay. In these examples, where relay eNB 104 is communicating with another relay eNB, the relay eNB 104 can support application protocol routing to ensure communications reach the correct relay eNB.

[0048] In an example, a packet data convergence protocol (PDCP) layer for relay eNB 108 (or related devices communicating therewith) and/or UE 110 can also be terminated at the donor eNB 102. In this example, for packets or other data received from relay eNB 108, UE 110, or other relay eNBs or UEs communicating with relay eNB 104, relay eNB 104 can forward the packets or other data to donor eNB 102 (and vice versa) without determining the PDCP payload. In this regard, security and encryption considerations can be handled at the donor eNB 102 and a node from which the packet or other data originated, which can be relay eNB 108, UE 110, etc. Thus, relay eNB 104 and/or other intermediary relay eNBs need not decrypt and re-encrypt communications (or apply other security procedures) upon receiving and forwarding the packets or other data.

[0049] For example, upon receiving packets from a relay eNB 108 or UE 110, relay eNB 104 can forward the packets to donor eNB 102, without analyzing the PDCP layer payload, based at least in part on an identifier or address specified in a radio link control (RLC) or similar layer. Similarly, relay eNB 104 can forward packets from donor eNB 102 to relay eNB 108 or UE 110 without processing the PDCP layer. In an example, relay eNB 104 can analyze a PDCP header of the packets to determine one or more parameters for communicating to donor eNB 102. For instance, to assist in flow control, sequence number (SN) status transfer, etc., relay eNB 104 can acquire one or more parameters from a header of a PDCP layer of a packet from donor eNB 102 to relay UE 110 (e.g., such as an SN or similar parameters), and specify the one or more parameters to donor eNB 102. In addition, for example, relay eNB 104 can send PDCP layer feedback information to donor eNB 102 related to communicating packets from donor eNB 102 to relay eNB 108 or UE 110.

[0050] In addition, donor eNB 102 can store PDCP layer contexts for each UE (e.g., UE 110), relay eNB (e.g., relay eNB 104), or other device with which donor eNB 102 ultimately communicates (e.g., via intermediary relay eNBs). In

this regard, donor eNB 102 can store and/or analyze the PDCP layer feedback according to a related context for relay eNB 108 or UE 110 for subsequent use in communicating with the relay eNB 108 or UE 110. Moreover, donor eNB 102, in an example, can multiplex PDCP layer communications over a single Un or other radio protocol interface with relay eNB 104 to provide PDCP instances to communicate with the related devices. It is to be appreciated, however, that donor eNB 102 can maintain less than one context per PDCP layer communication, and in one example, can have one PDCP context to handle substantially all PDCP layer communications therewith.

[0051] Turning to FIG. 2, illustrated is a communications apparatus 200 for employment within a wireless communications environment. The communications apparatus 200 can be a base station or a portion thereof, a mobile device or a portion thereof, or substantially any communications apparatus that receives data transmitted in a wireless communications environment. The communications apparatus 200 can include a PDCP communication receiving component 202 that obtains one or more packets having a PDCP layer, a PDCP header observing component 204 that retrieves one or more parameters of a PDCP header in the one or more packets, a PDCP parameter providing component 206 that communicates the one or more parameters to a disparate device (not shown), and a PDCP forwarding component 208 that transmits the packet having the PDCP layer to the disparate device.

[0052] According to an example, PDCP communication receiving component 202 can obtain a packet from a device (not shown), which can include a PDCP layer among other layers. For example, the packet can have layers that comprise the PDCP layer, such as a layer 1 (L1), MAC layer, RLC layer, etc., and/or layers within the PDCP layer, such as internet protocol (IP) layer, or substantially any application or higher layer that supports control or user plane message exchange between the communications apparatus 200 and another device. PDCP header observing component 204 can obtain one or more parameters from a PDCP header of the packet. For example, the one or more parameters can be one or more PDCP layer communication parameters, which can relate to SNs or similar parameters in the PDCP header. PDCP parameter providing component 206 can subsequently transmit the one or more parameters to the disparate device to facilitate flow control, SN status transfer, etc. PDCP forwarding component 208 can provide the packet to the disparate device. In this regard, communications apparatus 200 can relay packets (e.g., one or more PDCP packets) from the device to the disparate device without disrupting the PDCP layer, decrypting the PDCP layer, and/or the like, which can improve efficiency in packet routing.

[0053] Turning now to FIG. 3, an example wireless communication system 300 that facilitates routing packets in a wireless network without disrupting a PDCP layer is illustrated. System 300 includes a donor eNB 102 that provides relay eNB 104 (and/or other relay eNBs) with access to core network 106. Additionally, as described, relay eNB 104 can provide relay eNB 108 and UE 110 with access to the core network 106 through the donor eNB 102. Moreover, for example, there can be multiple relay eNBs 104 between the donor eNB 102 and relay eNB 108 or UE 110. In addition, it is to be appreciated that relay eNB 108 can comprise the components of relay eNB 104 and provide similar functionality, in one example. Moreover, donor eNB 102 can be a

macrocell access point, femtocell access point, picocell access point, mobile base station, and/or the like. Relay eNBs **104** (and relay eNB **108**) can similarly be mobile or stationary relay nodes that communicate with donor eNB **102** (and relay eNB **104**) over a wireless or wired backhaul, as described.

**[0054]** Donor eNB **102** comprises a packet receiving component **302** that obtains a packet from a relay eNB or UE, a PDCP context generating component **304** that can create a local context for the relay eNB or UE to facilitate subsequent PDCP layer communicating, a PDCP context maintaining component **306** that can store or otherwise manage one or more created PDCP contexts, a packet translating component **308** that processes the packet (e.g., the PDCP layer payload) according to a related PDCP context, which can include decrypting the packet, applying security to the packet, and/or the like, to determine an application layer or other portion of the packet in the PDCP layer payload for forwarding to an upstream network component, a backhaul link component **310** that can communicate the packet to a core network **106** and/or receive a corresponding packet in response, a PDCP context applying component **312** that can associate the corresponding packet or another packet received over backhaul link component **310** to a PDCP context based on a determined destination node (e.g., relay eNB or UE) of the packet, a packet routing component **314** that can provide the corresponding packet to an intermediary relay eNB or other entity in a communications path to the destination node, and a PDCP parameter receiving component **316** that obtains one or more PDCP parameters in a header of the packet received from the relay eNB or UE.

**[0055]** Relay eNB **104** can include a packet receiving component **318** that obtains a packet from one or more disparate relay eNBs or UEs over an uplink connection and/or obtains a packet from a donor eNB over a downlink connection, a PDCP header observing component **204** that determines one or more parameters in a PDCP header of one or more of the packets, a PDCP parameter providing component **206** that transmits the one or more parameters in the PDCP header(s) to a donor eNB, a packet routing component **320** that provides a packet received over the uplink connection to a donor eNB or one or more relay eNBs in a communications path to the donor eNB and provides a packet received over the downlink connection to one or more destination nodes (e.g., a relay eNB or UE) or one or more intermediary relay eNBs in a communications path to the destination node, a PDCP feedback receiving component **322** that obtains communications metrics from the destination node (e.g., through one or more intermediary relay eNBs) regarding communications over the PDCP layer, and a PDCP feedback relaying component **324** that provides the communications metrics to the donor eNB.

**[0056]** According to an example, UE **110** can establish a connection with relay eNB **104** to communicate with core network **106** via donor eNB **102** (and/or one or more intermediary relay eNBs, in one example). UE **110** can subsequently transmit a packet to the relay eNB **104** for providing to donor eNB **102**. The packet can comprise multiple layers to facilitate communication and routing in the wireless network. For example, the packet can include a PDCP layer (e.g., between an application layer and a radio transport layer). The packet can also include a layer for routing the packet among multiple relay eNBs, in one example. Packet receiving component **318** can obtain the packet from UE **110**.

**[0057]** Packet routing component **320** can provide the packet from UE **110** to donor eNB **102**. Packet receiving

component **302** can obtain the packet, and PDCP context maintaining component **306** selects a related PDCP context for the packet. If no PDCP context yet exists for UE **110**, PDCP context generating component **304** can create a PDCP context. As part of creating the PDCP context for UE **110**, PDCP context generating component **304** can negotiate an encryption/decryption key or other security parameters with the UE **110**. This can include communicating such information to the UE **110** (e.g., via relay eNB **104**) as part of an acknowledgement of receiving the packet, receiving such information from UE **110** (e.g., via relay eNB **104**) in the packet or upon subsequent request, and/or the like. Moreover, it is to be appreciated that establishing the PDCP context for UE **110** can additionally or alternatively be part of a separate procedure (e.g., during connection establishment, and/or the like).

**[0058]** The PDCP context maintaining component **306** can select the related PDCP context for the packet based on an identifier in the packet, such as an identifier in one or more layers of the packet (e.g., a relay routing protocol (RRP) layer, as described, an IP layer, etc.) that corresponds to the related PDCP context. Packet translating component **308** can process the packet from the UE **110** according to the related PDCP context and/or one or more parameters thereof. As described, this can include decrypting the packet according to a key at the PDCP layer previously negotiated between donor eNB **102** and UE **110**, or similar procedures to determine a payload of the packet at the PDCP layer. Thus, the PDCP layer is terminated at donor eNB **102**. Backhaul link component **310** can create a disparate packet for transmitting the payload to core network **106**, such as a general packet radio service (GPRS) tunneling protocol (GTP) packet, including the payload in the packet. Backhaul link component **310** can transmit the disparate packet to the core network **106**. In one example, backhaul link component **310** can include an identifier of the UE **110** or the related PDCP context in the disparate packet to facilitate associating response packets with the UE **110** or the related PDCP context.

**[0059]** According to an example, core network **106** can transmit a responding packet (or another packet) intended for UE **110**, to donor eNB **102**, which can be received at backhaul link component **310**. PDCP context maintaining component **306** can determine a stored PDCP context for the responding packet, which can be based on an identifier of the context, an identifier of UE **110**, etc., in the responding packet. Packet translating component **308** can generate a packet for transmitting to downstream nodes, which can include multiple layers, such as an RLC layer for radio transmissions. PDCP context applying component **312** can create a PDCP layer for the packet and include an application layer or higher layer portion of the responding packet as the PDCP payload (e.g., an IP layer of the responding packet). In addition, PDCP context applying component **312** can include one or more parameters from the determined PDCP context in the PDCP layer of the generated packet, such as security parameters, and/or can modify the packet at the PDCP layer based on the determined PDCP context (e.g., encrypt the PDCP payload).

**[0060]** In one example, PDCP context maintaining component **306** can store the generated packet in a buffer related to the UE **110** to facilitate flow control. For example, PDCP context maintaining component **306** establishes and/or maintains the PDCP buffer for the UE **110**, and the PDCP buffer can include packets received from core network **106** until the packets are transmitted by packet routing component **314** to

relay eNB 104. Packet routing component 314 can transmit the generated packet (e.g., from the buffer) to relay eNB 104 for forwarding to UE 110. It is to be appreciated that packet routing component 314 can have previously associated relay eNB 104 with UE 110 (e.g., by using a routing table or similar function that maps a received or generated identifier of the UE 110 or a related bearer of the UE 110 to an identifier of relay eNB 104, as described herein). In one example, packet routing component 314 can transmit packets from the PDCP buffer according to a timer, one or more received parameters, as described below, and/or the like.

[0061] In this example, packet receiving component 318 can obtain the generated packet, and packet routing component 320 can provide the packet to UE 110. Similarly, as described, packet routing component 320 can route packets based on an identifier established with the UE 110, based on a maintained routing table or similar function that maps such an identifier, and/or the like. The identifier can have been previously established between UE 110 and relay eNB 104, donor eNB 102, etc., as described herein, and can have been provided to each node in the communications path between UE 110 and donor eNB 102. It is to be appreciated, in one example, that there can be other intermediary relay eNBs between relay eNB 104 and UE 110, in which case packet routing component 320 can forward the packet to the next intermediary relay eNB based on the routing table, the established identifier, etc. In this regard, the routing table or similar function that can be part of packet routing component 320 can map the identifier in the packet received from donor eNB 102 to the next node in the communications path to the destination node.

[0062] In addition, for example, PDCP header observing component 204 can obtain one or more parameters from a PDCP header of the PDCP layer of the packet received from donor eNB 102, such as a SN or a similar parameter, and PDCP parameter providing component 206 can transmit the one or more parameters to donor eNB 102. This can be subsequent to receiving the packet at packet receiving component 318 and/or forwarding the packet by packet routing component 320, as described. In this example, PDCP parameter receiving component 316 can obtain the one or more parameters from the PDCP header and can provide the one or more parameters to PDCP context maintaining component 306, packet receiving component 302, and/or the like to assist flow control, SN status transfer message transmission, etc. at donor eNB 102.

[0063] In this regard, for example, PDCP context maintaining component 306 can utilize a SN parameter received by PDCP parameter receiving component 316 to control the flow of packets to relay eNB 104. For example, if a difference between the received SN and an SN of a packet in the PDCP buffer for UE 110 is over a threshold level, packet routing component 314 can slow the flow of packets to relay eNB 104 (e.g., according to a parameter of the PDCP context modified by the PDCP context maintaining component 306, etc.). Similarly, if the difference is less than a threshold, packet routing component 314 can obtain one or more packets from the buffer in the PDCP context maintaining component 306 (e.g., or empty the buffer in one example) for transmitting to relay eNB 104. In this regard, the donor eNB 102 controls the flow of packets to relay eNB 104 based on communications parameters between the relay eNB 104 and UE 110.

[0064] In addition, at the request of donor eNB 102 or otherwise, relay eNB 104 can transmit feedback received

from UE 110 (via one or more intermediary relay eNBs where present, which can have similar components to receive and relay feedback parameters) regarding the PDCP layer to donor eNB 102. In this example, PDCP feedback receiving component 322 can receive one or more feedback parameters from UE 110, and PDCP feedback relaying component 324 can provide the one or more feedback parameters to donor eNB 102, such as a last PDCP packet data unit (PDU) sent to UE 110, a last PDCP PDU received from donor eNB 102, and/or the like. PDCP parameter receiving component 316 can obtain the one or more feedback parameters and provide the parameters to PDCP context maintaining component 306, which can modify a related PDCP context based on the one or more feedback parameters (e.g., empty the queue related to the PDCP context based on the last PDCP PDU received by UE 110). Where intermediary relay eNBs exist between relay eNB 104 and donor eNB 102, the intermediary relay eNBs can also comprise a PDCP feedback receiving component 322 that obtains PDCP feedback parameters from relay eNB 104 and a PDCP feedback relaying component 324 that forwards the PDCP feedback parameters to donor eNB 102 or one or more additional intermediary relay eNBs.

[0065] For instance, relay eNB 104 can handover UE 110 communications to another relay eNB (not shown), which can be in the cluster of donor eNB 102. In this example, PDCP feedback relaying component 324 can provide one or more parameters to assist in handover to donor eNB 102, which can be received at PDCP parameter receiving component 316. For example, PDCP feedback receiving component 322 can obtain SN information related to communicating with UE 110, such as the last PDCP PDU sent to UE 110, a last PDCP PDU received from donor eNB 102, and/or the like. In this example, PDCP feedback relaying component 324 can transmit the SN information to donor eNB 102 upon providing a handover command to UE 110. Where intermediary relay eNBs exist between relay eNB 104 and donor eNB 102, the intermediary relay eNBs can similarly include a PDCP feedback receiving component 322 and PDCP feedback relaying component 324, as described, that act in conjunction to forward the SN information up to donor eNB 102. PDCP parameter receiving component 316 can obtain the SN information and utilize such to facilitate handover. For example, based on the last PDCP PDU sent to UE 110, packet routing component 314 can forward packets to a new relay eNB serving UE 110 starting at the next SN from the last PDCP PDU received by UE 110.

[0066] In another example, PDCP parameter providing component 206 can retrieve one or more local PDCP parameters for providing to donor eNB 102 or an immediate upstream relay eNB where one or more intermediary relay eNBs exist between relay eNB 104 and donor eNB 102. In one example, upon request or otherwise, PDCP parameter providing component 206 can determine and transmit a sequence number of a last downlink PDCP PDU sent to UE 110, a sequence number of the last downlink PDCP PDU received from donor eNB 102 or the immediate upstream relay eNB where present, a maximum size of a PDCP layer buffer that stores packets for transmitting to UE 110, and/or the like, to donor eNB 102 or the immediate upstream relay eNB where present. PDCP parameter receiving component 316 can obtain the parameters, and packet routing component 314 can utilize the parameters in transmitting or controlling flow of packets to relay eNB 104, as described. For example, the packet routing component 314 of donor eNB 102 (or a

similar component of an immediate upstream relay eNB where present) can determine whether to modify a rate of transmitting packets to relay eNB 104 based on a difference between the last downlink PDCP PDU sent to UE 110 and the sequence number of the last PDCP PDU received from donor eNB 102. Similarly, packet routing component 314 can determine whether to modify the rate of transmitting packets to relay eNB 104 based on the maximum buffer size (e.g., where the difference is within a threshold of the maximum buffer size). In another example, PDCP parameter providing component 206 can determine a utilization of the buffer and transmit that to the immediate upstream eNB, which can indicate whether to slow or speed flow of packets. Additionally, in this regard, PDCP parameter providing component 206 can determine whether the immediate upstream eNB should slow or speed packet delivery and can issue an appropriate command thereto.

[0067] Further, in an example, relay eNB 104 can provide the foregoing functionality to a plurality of UEs or other devices. In this regard, for example, a PDCP header observing component 204, a PDCP parameter providing component 206, and/or a packet routing component 320 can be provided for each UE or other device. Thus, the PDCP header observing components 204, PDCP parameter providing components 206, and/or packet routing components 320 can operate in parallel increasing efficiency of the packet routing and/or flow control. In addition, packet routing components 320 can forward the packets to donor eNB 102 over other lower protocol layer instances, as described, as well. In another example, however, a single instance of PDCP header observing component 204, PDCP parameter providing component 206, and/or packet routing component 320 or any number of instances in between can be utilized to support the plurality of UEs or other devices. In either case, as shown, PDCP is terminated at the donor eNB 102. Therefore, relay eNB 104 (and other relay eNBs) need not decrypt communications upon receiving and forwarding to donor eNB 102. This increases efficiency for routing packets in a wireless network.

[0068] Referring to FIG. 4, an example wireless communication system 400 that facilitates routing packets in a wireless network is illustrated. System 400 includes a donor eNB 102 that provides relay eNB 104 (and/or other relay eNBs) with access to core network 106. Additionally, as described, relay eNB 104 can provide relay eNB 108 and UE 110 with access to the core network 106 through the donor eNB 102. Moreover, for example, there can be multiple relay eNBs 104 between the donor eNB 102 and relay eNB 108 or UE 110. In addition, it is to be appreciated that relay eNB 108 can comprise the components of relay eNB 104 and provide similar functionality, in one example. Moreover, donor eNB 102 can be a macrocell access point, femtocell access point, picocell access point, mobile base station, and/or the like. Relay eNBs 104 (and relay eNB 108) can similarly be mobile or stationary relay nodes that communicate with donor eNB 102 (and relay eNB 104) over a wireless or wired backhaul, as described.

[0069] Donor eNB 102 comprises a relay identifier (ID) providing component 402 that retrieves and provides an ID to one or more relay eNBs, a packet receiving component 302 that obtains one or more communication packets from the one or more relay eNBs, an RRP ID extracting component 404 that determines a relay identifier from one or more communications packets, a backhaul link component 310 that communicates with core network 106 to provide access thereto to one or more relay eNBs or UEs, an RRP packet generating

component 406 that creates a response packet including an RRP layer for communicating to one or more downstream relay eNBs or UEs, a packet routing component 314 that provides the response packet to the one or more downstream relay eNBs or UEs, a routing table component 408 that can maintain mappings of relay IDs to identifiers of next relay eNBs in a communications path to relay eNBs represented by the relay IDs, if one or more such intermediary relay eNBs are present, and a bearer mapping component 410 that stores associations between evolved packet system (EPS) or similar core network 106 bearers to radio bearers of one or more downstream relay eNBs directly communicating with a UE.

[0070] Relay eNB 104 can comprise an ID receiving component 412 that obtains an ID from a donor eNB 102 to include in subsequent communications therewith, a UE ID providing component 414 that obtains or generates an ID for a UE communicating with relay eNB 104 and provisions the ID to the UE, a packet receiving component 318 that obtains a communications packet from the UE or donor eNB 102, an RRP packet generating component 416 that creates a packet having an RRC layer for communicating UE data with a donor eNB or one or more upstream relay eNBs, a packet routing component 320 that transmits the packet to the donor eNB, one or more upstream relay eNBs or the UE, an RRP ID extracting component 418 that determines an RRP identifier in a packet intended for the UE and received from the donor eNB or one or more relay eNBs, and a routing table component 420 that can maintain mappings of relay IDs to identifiers of next relay eNBs in a communications path to the UE, if one or more such intermediary relay eNBs are present.

[0071] According to an example, relay ID providing component 402 can generate an identifier for relay eNB 104, for example, when establishing an initial connection therewith, during connection re-establishment, and/or the like. As described, the connection between donor eNB 102 and relay eNB 104 can be a wired and/or wireless link (e.g., a wireless link can include established radio bearers that communicate using a wireless technology, such as LTE, and/or the like). Relay ID providing component 402 can transmit the relay ID to relay eNB 104, and ID receiving component 412 can obtain the ID. In an example, where intermediary relay eNBs exist between donor eNB 102 and relay eNB 104, routing table component 408 can store the identifier with an identifier of the next downstream intermediary relay eNB in a communications path to relay eNB 104 for appropriate routing. Similarly, UE ID providing component 414 can create or otherwise receive an identifier for UE 110, for example, when establishing or re-establishing a connection therewith, etc., and can transmit the ID to UE 110 for subsequent use in communicating with relay eNB 104. In addition, UE ID providing component 414 can store the ID in the routing table component 420 along with a disparate identifier received from UE 110, resources related to communicating with the UE 110, and/or the like.

[0072] In addition, relay eNB 104 can communicate with donor eNB 102 during UE 110 connection establishment to perform authentication with core network 106 for the UE 110, bearer establishment, and/or the like. During bearer establishment for the UE 110, for example, core network 106 can assign an EPS bearer to UE 110. Relay eNB 104 can associate a radio bearer with the EPS bearer for transmitting data received over the EPS bearer to UE 110. In one example, the bearer of relay eNB 104 can be assigned by the core network 106, donor eNB 102, and/or the like. In any case, donor eNB



**102** can be notified of the bearer of relay eNB **104** associated with the EPS bearer, and bearer mapping component **410** can store a mapping for the EPS bearer to an identifier of the radio bearer of relay eNB **104** (and/or an identifier of the relay eNB **104** or UE **110**). Where there are additional intermediary relay eNBs between donor eNB **102** and relay eNB **104**, bearer mapping component **410** associates the EPS bearer and an identifier of the radio bearer of the relay eNB that communicates directly with the UE (in this case, relay eNB **104**).

**[0073]** Once connection is established, packet receiving component **318** can obtain a communications packet from UE **110**. For example, the communications packet can include multiple layers, such as an L1 layer, MAC layer, RLC layer, PDCP layer, IP layer, etc. RRP packet generating component **416** can create another packet for forwarding a payload of the communications packet between other intermediary relay eNBs and/or donor eNB **102**. The RRP packet can comprise L1, MAC, and RLC layers related to communicating with relay eNB **104**, for example, and the RRP packet generating component **416** can create an RRP layer over the RLC layer. The RRP layer can include an RRP identifier, as described herein, to facilitate routing the packet among the various relay eNBs and/or donor eNB **102**. For example, the RRP packet generating component **416** can additionally generate the RRP identifier, which can include the relay ID and the UE ID described above. In addition, for example, the RRP identifier can include the bearer identifier of relay eNB **104** assigned to transmit communications intended for UE **110**, described above. In one example, the RRP identifier can have a format similar to the following:

Relay ID	UE ID	Relay Radio Bearer ID
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**[0074]** RRP packet generating component **416**, for example, can include upper layers of the received packet (e.g., PDCP, IP, etc.) in the payload of the generated packet, and packet routing component **320** can provide the packet to donor eNB **102** (e.g., or one or more intermediary relay eNBs in a communications path to donor eNB **102**). Packet receiving component **302** can obtain the packet from relay eNB **104**. RRP ID extracting component **404** can detect the RRP ID in the RRP layer of the received packet. Backhaul link component **310** can communicate a higher layer (e.g., application layer, such as an IP layer) payload to core network **106** and can specify the RRP ID, or a portion thereof, in the communication. In this regard, core network **106** can include the RRP ID, or portion thereof, in any subsequent responses received over backhaul link component **310**. It is to be appreciated, in an alternative example, that routing table component **408** can store the RRP ID, or portion thereof, mapped to a disparate identifier utilized to communicate data related to UE **110** to core network **106**, and upon receiving response data, routing table component **408** can locate the appropriate RRP ID, or portion thereof, mapped to the corresponding identifier in the response data.

**[0075]** In either case, upon backhaul link component **310** receiving response data from core network **106**, RRP packet generating component **406** can create a response packet for transmitting to UE **110** through one or more relay eNBs. The response packet can have a similar structure to the packet

previously obtained from relay eNB **104** by the packet receiving component **302**; in this regard, the response packet can have a similar RRP layer that comprises the RRP ID received in the response data over backhaul link component **310** (or as mapped to an identifier received in the response data, as described), which can be an identifier of relay eNB **104** in this example. RRP packet generating component **406** can additionally include the response data in a payload of the response packet. Moreover, bearer mapping component **410** can determine a radio bearer of the relay eNB directly communicating with UE **110** (relay eNB **104** in this example) to utilize in communicating the response data to UE **110**. As described, the radio bearer can have been mapped to an EPS bearer for UE **110** in the core network **106**. Thus, based on an EPS bearer identifier received from core network **106** (e.g., in a TEID of a GTP packet comprising the response data), bearer mapping component **410** can determine the appropriate radio bearer identifier of relay eNB **104** and include the radio bearer identifier in the RRP ID, which can entail specifying the radio bearer identifier in the RRP ID.

**[0076]** Packet routing component **314** can determine a relay eNB for receiving the response packet based at least in part on the RRP ID. For example, packet routing component **314** can forward the response packet to relay eNB **104**, as indicated in the RRP ID. In another example, where there are intermediary relay eNBs between donor eNB **102** and relay eNB to **104**, routing table component **408** locates an identifier of the next intermediary downstream relay eNB in a communications path to relay eNB **104** from a stored association (as described). In this regard, packet routing component **314** can forward the response packet to the next intermediary relay eNB.

**[0077]** In this example, packet receiving component **318** can obtain the response packet. RRP ID extracting component **418** can obtain the RRP ID from the RRP layer of the response packet. As described, the RRP ID can include an ID of UE **110**. In this regard, packet routing component **320** can transmit a payload of one or more higher layers of the response packet, or at least a portion thereof, to UE **110**. For example, packet routing component **320** can transmit a PDCP layer payload over an RLC layer established with UE **110** without the RRP layer utilized between donor eNB **102** and relay eNB **104** for routing the response packet. In an example, routing table component **420** can store a mapping between the UE ID and an identifier of a bearer of UE **110**, and packet routing component **320** can route the response packet to UE **110** (e.g., over resources assigned thereto) based on the mapping.

**[0078]** In another example, a disparate UE (not shown) attached to relay eNB **108** (or one or more relay eNBs attached thereto) can communicate with donor eNB **102** via relay eNBs **104** and **108**. In this example, relay ID providing component **402** can generate an identifier for relay eNB **108** (or one or more relay eNBs attached thereto) and forward the identifier to relay eNB **104** for provisioning to relay eNB **108**. In this example, ID receiving component **412** can obtain the identifier, and routing table component **420** can associate the identifier to a disparate identifier of relay eNB **108**, such as a bearer identifier, resources assigned thereto, and/or the like, to facilitate subsequent packet routing thereto. Thus, upon packet receiving component **318** obtaining response packets from donor eNB for the disparate UE, RRP ID extracting component **418** can retrieve the RRP ID. Where the relay ID in the RRP ID is not an identifier previously assigned to relay

eNB 104, packet routing component 320 can utilize routing table component 420 to determine a mapping of the relay ID to a disparate relay eNB (e.g., relay eNB 108 or one or more relay eNBs attached thereto). In this example, packet routing component 320 can forward the response packet to relay eNB 108 based on the mapping. Relay eNB 108 can thus receive the packet and forward a payload to the disparate UE over a radio bearer specified in the RRP ID, as described above with respect to relay eNB 104.

[0079] Now turning to FIG. 5, an example wireless communication network 500 that provides split-cell relay functionality is depicted. Network 500 includes a UE 110 that communicates with a relay eNB 104, as described, to receive access to a wireless network. Relay eNB 104 can communicate with a donor eNB 102 to provide access to a wireless network, and as described, donor eNB 102 can communicate with an MME 502 and/or SGW 504 that relate to the relay eNB 104. SGW 504 can connect to or be coupled with a PGW 506, which provides network access to SGW 504 and/or additional SGWs. PGW 506 can communicate with a PCRF 508 to authenticate/authorize UE 110 to use the network, which can utilize an IMS 510 to provide addressing to the UE 110 and/or relay eNB 104.

[0080] According to an example, MME 502 and/or SGW 504 and PGW 506 can be related to donor eNB 102 serving substantially all relay eNBs in the cluster. Donor eNB 102 can also communicate with an SGW 516 and PGW 518 that relate to the UE 110, such that the PGW 518 can assign UE 110 a network address to facilitate tunneling communications thereto through the relay eNB 104, donor eNB 102, and SGW 516. Moreover, for example, SGW 516 can communicate with an MME 514 to facilitate control plane communications to and from the UE 110. It is to be appreciated that MME 502 and MME 514 can be the same MME, in one example. PGW 518 can similarly communicate with a PCRF 508 to authenticate/authorize UE 110, which can communicate with an IMS 510. In addition, PGW 518 can communicate directly with the IMS 510 and/or internet 512.

[0081] In an example, UE 110 can communicate with the relay eNB 104 over one or more radio protocol interfaces, such as an E-UTRA-Uu interface, as described, and the relay eNB 104 can communicate with the donor eNB 102 using one or more radio protocol interfaces, such as an E-UTRA-Uu interface, E-UTRA-Un interface or other interface. As described, relay eNB 104 can leave a PDCP layer of packets from UE 110 intact, while retrieving one or more parameters from the PDCP header. In this regard, encryption/decryption, security, and other procedures can be performed by UE 110 and donor eNB 102, such that relay eNB 104 does not need to perform such tasks. Donor eNB 102 communicates with the MME 502 using an S1-MME interface and the SGW 504 and PGW 506 over an S1-U interface, as depicted. The transport layers used over the S1-MME and S1-U interfaces are terminated at the donor eNB 102, as described. In this regard, upon receiving communications for the relay eNB 104 from the MME 502 or SGW 504, donor eNB 102 decouples the application layer from the transport layer by defining a new transport layer packet and transmitting the application layer communication to the relay eNB 104 in the new transport layer packet (over the E-UTRA-Un interface, in one example).

[0082] Upon transmitting control plane communications from the relay eNB 104 to the MME 502, donor eNB 102 can indicate an identifier of the relay eNB 104 (e.g., in an S1-AP message), and MME 502 can transmit the identifier in

responding communications to the donor eNB 102. When transmitting data plane communications from relay eNB 104 to SGW 504, donor eNB 102 can insert an identifier for the relay eNB 104 (and/or UE 110 or one or more related bearers), such as an RRP ID. In this example, donor eNB 102 can insert the identifier in the TEID of a GTP-U header, etc. SGW 504 can transmit the TEID in a responding GTP-U header such that donor eNB 102 can determine the relay eNB 104, or one or more downstream relay eNBs, is to receive the translated packet, as described above. For example, this can be based at least in part on locating at least a portion of the TEID in a routing table at donor eNB 102. These foregoing functionalities can mitigate the need for UDP/IP routing on the backhaul link between various eNBs, for example. In addition, headers can be compressed, in one example, as described. As shown, MME 502 can communicate with SGW 504, and MME 514 to SGW 516, using an S11 interface. PGWs 506 and 518 can communicate with PCRF 508 over a Gx interface. Furthermore, PCRF 508 can communicate with IMS 510 using an Rx interface, and PGW 518 can communicate with IMS 510 and/or the internet 512 using an SGI interface.

[0083] Referring to FIG. 6, example protocol stacks 600 are illustrated that facilitate communicating in a wireless network to provide split-cell relay functionality for data (e.g., user) plane communications. A UE protocol stack 602 is shown comprising an L1 layer, MAC layer, an RLC layer, a PDCP layer, and an IP layer. A relay eNB (ReNB) access link protocol stack 604 is depicted having an L1 layer, MAC layer, RLC layer, and PDCP header observation, as described to retrieve one or more parameters, along with an ReNB backhaul link protocol stack 606 having an L1 layer, MAC layer, RLC layer, and an RRP layer, which is used to route packets among multiple ReNBs and/or donor eNBs (DeNB). A DeNB access link protocol stack 608 is also shown having an L1 layer, MAC layer, RLC layer, RRP layer, and a PDCP layer, which is terminated at the DeNB as described, along with a DeNB backhaul link protocol stack 610 having an L1 layer, L2 layer, a user datagram protocol (UDP)/IP layer, and a GTP-U layer to maintain communications with a PGW/SGW using an address assigned by the PGW/SGW. PGW/SGW protocol stack 612 has an L1 layer, L2, layer, UDP/IP layer, GTP-U layer, and an IP layer related to an address assigned to the UE.

[0084] According to an example, a UE can communicate with an ReNB to receive access to a PGW/SGW. In this regard, UE can communicate over L1, MAC, RLC, and PDCP layers with the ReNB over using a EUTRA-Uu interface, as shown between protocol stacks 602 and 604. The UE can tunnel IP layer communications through the ReNB and other entities to the PGW/SGW, which assigns an IP address to the UE, as shown between protocol stacks 602 and 612. To facilitate such tunneling, the ReNB communicates with a DeNB over L1, MAC, RLC, and RRP layers using an EUTRA-Un interface, as shown between protocol stacks 606 and 608. As described, the RRP layer can be generated to include an RRP ID, which can comprise an identifier of the ReNB (e.g., assigned by the DeNB) and an identifier of the UE (e.g., assigned by the ReNB). As described, the ReNB and DeNB can route packets to/from the UE, through various intermediary ReNBs in one example, using the RRP ID. In addition, upon receiving packets from DeNB for the UE, ReNB can extract one or more parameters from a PDCP layer of com-

munications and provide them to the DeNB, as described, to assist in flow control, SN status transfer, and/or other purposes.

**[0085]** The DeNB can receive UE communications from the ReNB and terminate the PDCP layer. This can include applying encryption/decryption, security procedures, and/or the like, such that ReNB need not perform such procedures for UE communication. The DeNB can transmit the PDCP payload to the PGW/SGW, after applying such procedures, in a GTP-U layer payload over L1, L2, and UDP/IP layers. Similarly, the DeNB can receive packets from the PGW/SGW and can create and transmit a packet comprising the GTP-U payload in a PDCP layer of the packet. As described, the packet can also include an RRP layer with a corresponding RRP ID to appropriately route the packet based on identifiers within the RRP ID. The ReNB can receive the packet from DeNB and can forward the PDCP payload to the UE over L1, MAC, and RLC layers.

**[0086]** Referring to FIG. 7, example protocol stacks **700** are illustrated that facilitate communicating in a wireless network to provide split-cell relay functionality for data (e.g., user) plane communications. A protocol stack **702** for UE **1** is shown comprising an L1 layer, MAC layer, an RLC layer, a PDCP layer, and an IP layer, as well as a similar protocol stack **704** for UE **2**. ReNB protocol stacks **706** are additionally shown including access link protocol stacks **708** and **710**, which comprise L1, MAC, and RLC layers, that respectively receive communications from UE **1** and UE **2**. ReNB protocol stacks **706** also include a backhaul link protocol stack **712** having an L1 layer, MAC layer, RLC layer, an RRP layer, which is used to route packets among multiple ReNBs and/or a donor eNBs (DeNB), and a PDCP layer comprising multiplexed PDCP contexts **714**, **716**, and **718**. DeNB protocol stacks **720** are also depicted including an access link protocol stack **722** and a backhaul link protocol stack **724**. The DeNB access link protocol stack **722** can include an L1 layer, MAC layer, RLC layer, RRP layer, and a PDCP layer comprising multiplexed PDCP contexts **726**, **728**, and **730**, and the DeNB backhaul link protocol stack **724** can include an L1 layer, L2 layer, a UDP/IP layer, and a GTP-U layer to maintain communications with a PGW/SGW.

**[0087]** According to an example, UEs **1** and **2** can communicate with an ReNB to receive access to a core network via a DeNB. In this regard, UEs **1** and **2** can communicate over L1, MAC, and RLC layers, with the ReNB, as shown between protocol stacks **702** and **708**, as well as protocol stacks **704** and **710**. The UE can tunnel PDCP and/or IP layer communications through the ReNB to other network components. To facilitate such tunneling, the ReNB communicates with a DeNB over L1, MAC, RLC, and RRP layers for UE **1** and UE **2** communications, as shown between protocol stacks **712** and **722**. Similarly, DeNB can tunnel PDCP and/or IP layer communications to UEs **1** and **2** through ReNB, as shown. In addition, multiple PDCP observe contexts **714** and **716** can be generated by the ReNB to tunnel the communications to the DeNB as shown. In one example, PDCP context **714** can evaluate one or more parameters in a packet header of the PDCP layer received from protocol stack **722** intended for UE **1** (e.g., ReNB can determine the intended UE from an identifier in the RRP layer, as described). The ReNB can provide the one or more parameters to the DeNB, in one example, and the DeNB can utilize the parameters in PDCP context **726**, and/or one or more additional parameters as described, for

flow control with UE **1**, SN status transfer message processing, and/or the like, as described.

**[0088]** Similarly, PDCP observe context **716** can retrieve one or more parameters from a packet header of the PDCP layer received from protocol stack **722** intended for UE **2**. The ReNB, as described can provide the one or more parameters to the DeNB, which can utilize the one or more parameters at PDCP context **728** to control flow, and/or the like. In addition, PDCP context **718** can relate to explicit PDCP layer communication between the ReNB and DeNB (e.g., where communication originates from and/or is terminated at the ReNB). DeNB can utilize PDCP context **730** to interpret communications for ReNB. Thus, DeNB, as described, can maintain separate PDCP contexts, in one example, for communicating with multiple UEs and/or ReNBs. In another example, however, ReNB backhaul link protocol stack **712** can include a single PDCP layer for all UE communications instead of separate contexts to handle the UEs, or a certain number of multiplexed PDCP contexts that can each handle one or more UE communications. In addition, in this example, DeNB access link protocol stack **722** can include a single PDCP context. In either case, PDCP can terminate at DeNB to provide end-to-end encrypting/decryption, security procedures, and/or the like therewith.

**[0089]** Referring to FIGS. **8-12**, methodologies relating to routing packets using split-cell relays are illustrated. While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of acts, it is to be understood and appreciated that the methodologies are not limited by the order of acts, as some acts may, in accordance with one or more aspects, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a methodology in accordance with one or more aspects.

**[0090]** Turning to FIG. **8**, an example methodology **800** that facilitates routing a packet to a UE without processing a PDCP layer thereof is illustrated. At **802**, a packet having a routing layer that includes a payload with a PDCP layer can be received from an upstream eNB. In one example, the upstream eNB can be a donor eNB. In addition, for example, the routing layer can be an RRP layer having an RRP ID related to the UE. At **804**, a UE to receive the payload can be determined based at least in part on a routing identifier specified in the routing layer of the packet. At **806**, the payload can be transmitted to the UE in a disparate packet. Thus, for example, the identifier of the UE in the routing identifier can be utilized to determine resources over which to transmit the payload in the disparate packet to the UE. In addition, the PDCP layer is forwarded in a disparate packet to the UE; in this regard, the PDCP layer can be generated at the donor eNB, as described, and terminated at the UE, and vice versa for uplink communications. Moreover, in one example, the routing identifier can specify a radio bearer to utilize in transmitting the payload to the UE in the disparate packet, and the radio bearer can be utilized at **806** in this regard.

**[0091]** Referring to FIG. **9**, an example methodology **900** is shown that facilitates observing PDCP header parameters in routing communications to a UE. At **902**, a packet with a PDCP layer related to a UE can be received from an upstream eNB. As described, in one example, a donor eNB can have

generated the PDCP layer payload. At **904**, one or more parameters can be extracted from a header of the PDCP layer. For example, the one or more parameters can relate to an SN of the PDCP layer. At **906**, the one or more parameters can be transmitted to the upstream eNB. Thus, for example, the upstream eNB can utilize the one or more parameters for flow control, to assist in SN status transfer message, and/or the like. As described, for example, the upstream eNB can have a buffer for controlling flow of downstream packets. Where an SN related to the last packet forwarded to the UE is received and is over a threshold difference from an SN of a packet in the buffer, for example, the upstream can slow the flow of packets.

**[0092]** Turning to FIG. **10**, an example methodology **1000** that facilitates maintaining a PDCP context for a UE for communicating packets through one or more relay eNBs is illustrated. At **1002**, a PDCP context related to a UE can be maintained. For example, the UE context can be initialized upon establishing communications with the UE (e.g., through one or more relay eNBs) and can include one or more parameters related to communicating with the UE over a PDCP layer, such as encryption parameters, security procedure information, and/or the like, as described. At **1004**, an encryption or security procedure can be applied to a portion of a packet received over a backhaul link based on the PDCP context. At **1006**, the portion of the packet can be transmitted in a PDCP layer of a disparate packet to a downstream relay eNB. As described, the downstream relay eNB can forward the packet to the UE (e.g., through one or more intermediary relay eNBs or otherwise) without processing the PDCP layer.

**[0093]** Referring to FIG. **11**, an example methodology **1100** is shown that facilitates processing one or more PDCP layer parameters received from a downstream relay eNB related to communicating with a UE. At **1102**, a packet can be transmitted to a downstream relay eNB for providing to a UE. As described, in one example, the downstream relay eNB can be in a communications path to the UE, and the packet can include a PDCP layer that terminates at the UE. Thus, the downstream relay eNB can forward the PDCP layer to the UE without processing the layer. As described, however, the downstream relay eNB can communicate one or more parameters in the PDCP header to assist in flow control. At **1104**, one or more PDCP layer parameters can be received from the downstream relay eNB. The one or more parameters, for example, can include an SN of a packet, such as a last packet transmitted to the UE. At **1106**, flow of the packets to the downstream relay eNB can be controlled based at least in part on the one or more PDCP layer parameters. Thus, for example, where a difference between the SN and an SN of a packet in a buffer to be transmitted to the downstream relay eNB is above a threshold, flow of packets to the downstream relay eNB can be slowed. On the other hand, for example, where the difference is below a threshold, one or more packets in the buffer can be transmitted to the downstream relay eNB for providing to the UE, as described.

**[0094]** Turning to FIG. **12**, an example methodology **1200** that facilitates preparing packets for routing to a UE is illustrated. At **1202**, a packet for a UE can be received over a backhaul link. For example, the packet can be received from one or more core network components. At **1204**, a radio bearer of a downstream relay eNB can be determined for transmitting at least a portion of the packet to the UE. For instance, the radio bearer can be determined by locating an association between an EPS bearer identifier related to the

packet (and/or an identifier of the downstream relay eNB) and the radio bearer identifier in a bearer mapping table that stores such associations. At **1206**, an identifier of the radio bearer can be specified in a routing identifier. At **1208**, the portion of the packet can be transmitted to one or more downstream relay eNBs in a communication path to the UE along with the routing identifier. As described, a downstream relay eNB that communicates directly with the UE can transmit the portion of the packet over the radio bearer indicated in the routing identifier.

**[0095]** It will be appreciated that, in accordance with one or more aspects described herein, inferences can be made regarding controlling flow of packets according to one or more PDCP parameters, transmitting PDCP parameters to upstream eNBs to control flow, and/or other aspects described herein. As used herein, the term to “infer” or “inference” refers generally to the process of reasoning about or inferring states of the system, environment, and/or user from a set of observations as captured via events and/or data. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states, for example. The inference can be probabilistic—that is, the computation of a probability distribution over states of interest based on a consideration of data and events. Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether or not the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources.

**[0096]** Referring now to FIG. **13**, a wireless communication system **1300** is illustrated in accordance with various embodiments presented herein. System **1300** comprises a base station **1302** that can include multiple antenna groups. For example, one antenna group can include antennas **1304** and **1306**, another group can comprise antennas **1308** and **1310**, and an additional group can include antennas **1312** and **1314**. Two antennas are illustrated for each antenna group; however, more or fewer antennas can be utilized for each group. Base station **1302** can additionally include a transmitter chain and a receiver chain, each of which can in turn comprise a plurality of components associated with signal transmission and reception (e.g., processors, modulators, multiplexers, demodulators, demultiplexers, antennas, etc.), as will be appreciated by one skilled in the art.

**[0097]** Base station **1302** can communicate with one or more mobile devices such as mobile device **1316** and mobile device **1322**; however, it is to be appreciated that base station **1302** can communicate with substantially any number of mobile devices similar to mobile devices **1316** and **1322**. Mobile devices **1316** and **1322** can be, for example, cellular phones, smart phones, laptops, handheld communication devices, handheld computing devices, satellite radios, global positioning systems, PDAs, and/or any other suitable device for communicating over wireless communication system **1300**. As depicted, mobile device **1316** is in communication with antennas **1312** and **1314**, where antennas **1312** and **1314** transmit information to mobile device **1316** over a forward link **1318** and receive information from mobile device **1316** over a reverse link **1320**. Moreover, mobile device **1322** is in communication with antennas **1304** and **1306**, where antennas **1304** and **1306** transmit information to mobile device **1322** over a forward link **1324** and receive information from

mobile device **1322** over a reverse link **1326**. In a frequency division duplex (FDD) system, forward link **1318** can utilize a different frequency band than that used by reverse link **1320**, and forward link **1324** can employ a different frequency band than that employed by reverse link **1326**, for example. Further, in a time division duplex (TDD) system, forward link **1318** and reverse link **1320** can utilize a common frequency band and forward link **1324** and reverse link **1326** can utilize a common frequency band.

[0098] Each group of antennas and/or the area in which they are designated to communicate can be referred to as a sector of base station **1302**. For example, antenna groups can be designed to communicate to mobile devices in a sector of the areas covered by base station **1302**. In communication over forward links **1318** and **1324**, the transmitting antennas of base station **1302** can utilize beamforming to improve signal-to-noise ratio of forward links **1318** and **1324** for mobile devices **1316** and **1322**. Also, while base station **1302** utilizes beamforming to transmit to mobile devices **1316** and **1322** scattered randomly through an associated coverage, mobile devices in neighboring cells can be subject to less interference as compared to a base station transmitting through a single antenna to all its mobile devices. Moreover, mobile devices **1316** and **1322** can communicate directly with one another using a peer-to-peer or ad hoc technology (not shown).

[0099] According to an example, system **1300** can be a multiple-input multiple-output (MIMO) communication system. Further, system **1300** can utilize substantially any type of duplexing technique to divide communication channels (e.g., forward link, reverse link, . . . ) such as FDD, FDM, TDD, TDM, CDM, and the like. In addition, communication channels can be orthogonalized to allow simultaneous communication with multiple devices over the channels; in one example, OFDM can be utilized in this regard. Thus, the channels can be divided into portions of frequency over a period of time. In addition, frames can be defined as the portions of frequency over a collection of time periods; thus, for example, a frame can comprise a number of OFDM symbols. The base station **1302** can communicate to the mobile devices **1316** and **1322** over the channels, which can be create for various types of data. For example, channels can be created for communicating various types of general communication data, control data (e.g., quality information for other channels, acknowledgement indicators for data received over channels, interference information, reference signals, etc.), and/or the like.

[0100] FIG. 14 shows an example wireless communication system **1400**. The wireless communication system **1400** depicts one base station **1410** and one mobile device **1450** for sake of brevity. However, it is to be appreciated that system **1400** can include more than one base station and/or more than one mobile device, wherein additional base stations and/or mobile devices can be substantially similar or different from example base station **1410** and mobile device **1450** described below. In addition, it is to be appreciated that base station **1410** and/or mobile device **1450** can employ the systems (FIGS. 1-5 and 13), protocol stacks (FIG. 6-7) and/or methods (FIGS. 8-12) described herein to facilitate wireless communication therebetween.

[0101] At base station **1410**, traffic data for a number of data streams is provided from a data source **1412** to a transmit (TX) data processor **1414**. According to an example, each data stream can be transmitted over a respective antenna. TX

data processor **1414** formats, codes, and interleaves the traffic data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0102] The coded data for each data stream can be multiplexed with pilot data using orthogonal frequency division multiplexing (OFDM) techniques. Additionally or alternatively, the pilot symbols can be frequency division multiplexed (FDM), time division multiplexed (TDM), or code division multiplexed (CDM). The pilot data is typically a known data pattern that is processed in a known manner and can be used at mobile device **1450** to estimate channel response. The multiplexed pilot and coded data for each data stream can be modulated (e.g., symbol mapped) based on a particular modulation scheme (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM), etc.) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream can be determined by instructions performed or provided by processor **1430**.

[0103] The modulation symbols for the data streams can be provided to a TX MIMO processor **1420**, which can further process the modulation symbols (e.g., for OFDM). TX MIMO processor **1420** then provides  $N_T$  modulation symbol streams to  $N_T$  transmitters (TMTR) **1422a** through **1422t**. In various aspects, TX MIMO processor **1420** applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0104] Each transmitter **1422** receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. Further,  $N_T$  modulated signals from transmitters **1422a** through **1422t** are transmitted from  $N_T$  antennas **1424a** through **1424t**, respectively.

[0105] At mobile device **1450**, the transmitted modulated signals are received by  $N_R$  antennas **1452a** through **1452r** and the received signal from each antenna **1452** is provided to a respective receiver (RCVR) **1454a** through **1454r**. Each receiver **1454** conditions (e.g., filters, amplifies, and downconverts) a respective signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0106] An RX data processor **1460** can receive and process the  $N_R$  received symbol streams from  $N_R$  receivers **1454** based on a particular receiver processing technique to provide  $N_T$  "detected" symbol streams. RX data processor **1460** can demodulate, deinterleave, and decode each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor **1460** is complementary to that performed by TX MIMO processor **1420** and TX data processor **1414** at base station **1410**.

[0107] A processor **1470** can periodically determine which precoding matrix to utilize as discussed above. Further, processor **1470** can formulate a reverse link message comprising a matrix index portion and a rank value portion.

[0108] The reverse link message can comprise various types of information regarding the communication link and/or the received data stream. The reverse link message can be processed by a TX data processor **1438**, which also receives traffic data for a number of data streams from a data source

1436, modulated by a modulator 1480, conditioned by transmitters 1454a through 1454r, and transmitted back to base station 1410.

[0109] At base station 1410, the modulated signals from mobile device 1450 are received by antennas 1424, conditioned by receivers 1422, demodulated by a demodulator 1440, and processed by a RX data processor 1442 to extract the reverse link message transmitted by mobile device 1450. Further, processor 1430 can process the extracted message to determine which precoding matrix to use for determining the beamforming weights.

[0110] Processors 1430 and 1470 can direct (e.g., control, coordinate, manage, etc.) operation at base station 1410 and mobile device 1450, respectively. Respective processors 1430 and 1470 can be associated with memory 1432 and 1472 that store program codes and data. Processors 1430 and 1470 can also perform computations to derive frequency and impulse response estimates for the uplink and downlink, respectively.

[0111] With reference to FIG. 15, illustrated is a system 1500 that facilitates routing packets to a UE without processing a PDCP layer payload thereof. For example, system 1500 can reside at least partially within a base station, mobile device, etc. It is to be appreciated that system 1500 is represented as including functional blocks, which can be functional blocks that represent functions implemented by a processor, software, or combination thereof (e.g., firmware). System 1500 includes a logical grouping 1502 of electrical components that can act in conjunction. For instance, logical grouping 1502 can include an electrical component for receiving a packet having a routing layer that includes a PDCP layer from an upstream eNB 1504. For example, as described, the routing layer can include a routing identifier that specifies a relay eNB communicating with the UE to receive the packet, an identifier of the UE, and/or an identifier of a radio bearer of the relay eNB over which the packet is to be transmitted. Additionally, logical grouping 1502 can include an electrical component for transmitting a payload of the PDCP layer in a disparate packet to a UE related to the packet based at least in part on a routing identifier 1506.

[0112] As described, the UE can be identified from the routing identifier, as can a radio bearer over which the disparate packet can be transmitted to the UE by electrical component 1506. Moreover, logical grouping 1502 can include an electrical component for retrieving one or more parameters from the header of the PDCP layer 1508. In addition, logical grouping 1502 can include an electrical component for transmitting the one or more parameters to the upstream eNB 1510. Thus, the PDCP header can be observed, as described, without processing the PDCP payload. In addition, the one or more parameters can relate to a SN at the PDCP layer, which can be utilized by the upstream eNB for flow control, to assist in SN status transfer, and/or the like, as described. Moreover, logical grouping 1502 can include an electrical component for receiving an identifier from the upstream eNB upon establishing a connection with the upstream eNB 1512. As described, this identifier can be utilized by the upstream eNB in generating the routing identifier. Additionally, system 1500 can include a memory 1514 that retains instructions for executing functions associated with electrical components 1504, 1506, 1508, 1510, and 1512. While shown as being external to memory 1514, it is to be understood that one or more of electrical components 1504, 1506, 1508, 1510, and 1512 can exist within memory 1514.

[0113] With reference to FIG. 16, illustrated is a system 1600 that facilitates routing packets to a UE through one or more relay eNBs. For example, system 1600 can reside at least partially within a base station, mobile device, etc. It is to be appreciated that system 1600 is represented as including functional blocks, which can be functional blocks that represent functions implemented by a processor, software, or combination thereof (e.g., firmware). System 1600 includes a logical grouping 1602 of electrical components that can act in conjunction. For instance, logical grouping 1602 can include an electrical component for maintaining a PDCP context related to a UE 1604. For example, as described, PDCP context can be established upon initiating communications with the UE and can include one or more parameters for encoding a PDCP layer for the UE. Additionally, logical grouping 1602 can include an electrical component for applying an encryption or security procedure to a portion of a packet received over a backhaul link for a UE according to the PDCP context 1606.

[0114] Moreover, logical grouping 1602 can include an electrical component for transmitting at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay eNB in a communications path to the UE 1608. In this regard, as described, the downstream relay eNB can forward the PDCP layer to the UE without processing a payload thereof. The downstream relay eNB can, however, determine one or more parameters in a header of the PDCP packet to assist in flow control, etc., as described. Thus, logical grouping 1602 can include an electrical component for receiving one or more parameters related to PDCP layer communications at the UE from the downstream relay eNB 1610.

[0115] In addition, logical grouping 1602 can include an electrical component for generating a routing identifier for the disparate packet based at least in part on an identifier in the portion of the packet received over the backhaul link 1612. As described, the routing identifier can include an identifier of a downstream relay eNB connected to the UE, an identifier or the UE, an identifier of the radio bearer over which the relay eNB is to transmit the PDCP layer to the UE, and/or the like. Also, logical grouping 1602 can include an electrical component for locating an identifier of a radio bearer of the downstream relay eNB that is associated to an EPS bearer specified in the portion of the packet in a bearer mapping table 1614. Additionally, system 1600 can include a memory 1616 that retains instructions for executing functions associated with electrical components 1604, 1606, 1608, 1610, 1612, and 1614. While shown as being external to memory 1616, it is to be understood that one or more of electrical components 1604, 1606, 1608, 1610, 1612, and 1614 can exist within memory 1616.

[0116] The various illustrative logics, logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but, in the alternative, the processor may be any conventional 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, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration. Additionally, at least one processor may comprise one or more modules operable to perform one or more of the steps and/or actions described above.

**[0117]** Further, the steps and/or actions of a method or algorithm described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium may be coupled to the processor, such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. Further, in some aspects, the processor and the storage medium may reside in an ASIC. Additionally, the ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal. Additionally, in some aspects, the steps and/or actions of a method or algorithm may reside as one or any combination or set of codes and/or instructions on a machine readable medium and/or computer readable medium, which may be incorporated into a computer program product.

**[0118]** In one or more aspects, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions, procedures, etc. may be stored or transmitted as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage medium may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection may be termed a computer-readable medium. For example, if software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where disks usually reproduce data magnetically, while discs usually reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

**[0119]** While the foregoing disclosure discusses illustrative aspects and/or embodiments, it should be noted that various changes and modifications could be made herein without departing from the scope of the described aspects and/or embodiments as defined by the appended claims. Furthermore, although elements of the described aspects and/or embodiments may be described or claimed in the singular, the

plural is contemplated unless limitation to the singular is explicitly stated. Additionally, all or a portion of any aspect and/or embodiment may be utilized with all or a portion of any other aspect and/or embodiment, unless stated otherwise. Furthermore, to the extent that the term “includes” is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term “comprising” as “comprising” is interpreted when employed as a transitional word in a claim. Furthermore, although elements of the described aspects and/or aspects may be described or claimed in the singular, the plural is contemplated unless limitation to the singular is explicitly stated. Additionally, all or a portion of any aspect and/or embodiment may be utilized with all or a portion of any other aspect and/or embodiment, unless stated otherwise.

What is claimed is:

1. A method, comprising:

receiving a packet having a routing layer that includes a payload with a packet data convergence protocol (PDCP) layer from an upstream evolved Node B (eNB); determining a user equipment (UE) to receive the payload based at least in part on a routing identifier specified in the routing layer of the packet; and

transmitting the payload to the UE in a disparate packet.

2. The method of claim 1, further comprising extracting one or more parameters from a header of the PDCP layer.

3. The method of claim 2, further comprising transmitting the one or more parameters extracted from the header of the PDCP layer to the upstream eNB.

4. The method of claim 3, wherein the extracting the one or more parameters from the header of the PDCP layer includes extracting a sequence number related to the PDCP layer of the payload, and transmitting the one or more parameters includes transmitting the sequence number to the upstream eNB.

5. The method of claim 1, further comprising maintaining a buffer that stores the packet received from the upstream eNB until the transmitting the payload to the UE in the disparate packet.

6. The method of claim 5, further comprising providing one or more parameters related to the buffer to the upstream eNB.

7. The method of claim 1, further comprising establishing a connection with the upstream eNB and receiving an identifier for communicating with the upstream eNB.

8. The method of claim 7, wherein the routing layer is a relay routing protocol layer and the routing identifier includes the identifier for communicating with the upstream eNB, an identifier of the UE, and an identifier of a radio bearer over which to transmit the payload to the UE in the disparate packet.

9. A wireless communications apparatus, comprising:

at least one processor configured to:

obtain a packet with a routing layer that comprises a packet data convergence protocol (PDCP) layer from an upstream evolved Node B (eNB);

detect a user equipment (UE) for which the packet is intended based at least in part on a routing identifier specified in the routing layer; and

transmit a payload of the PDCP layer to the UE in a disparate packet; and

a memory coupled to the at least one processor.



**10.** The wireless communications apparatus of claim **9**, wherein the at least one processor is further configured to retrieve one or more parameters from a header of the PDCP layer.

**11.** The wireless communications apparatus of claim **10**, wherein the at least one processor is further configured to provide the one or more parameters to the upstream eNB.

**12.** The wireless communications apparatus of claim **11**, wherein the one or more parameters includes a sequence number related to the PDCP layer.

**13.** The wireless communications apparatus of claim **9**, wherein the at least one processor is further configured to maintain a buffer that stores the packet until the at least one processor transmits the payload of the PDCP layer to the UE.

**14.** The wireless communications apparatus of claim **13**, wherein the at least one processor is further configured to provide one or more parameters related to the buffer to the upstream eNB.

**15.** The wireless communications apparatus of claim **9**, wherein the at least one processor is further configured to receive an identifier for communicating with the upstream eNB upon establishing a connection with the upstream eNB.

**16.** The wireless communications apparatus of claim **15**, wherein the routing identifier includes the identifier for communicating with the upstream eNB, an identifier of the UE, and an identifier of a radio bearer over which to transmit the payload of the PDCP layer to the UE in the disparate packet.

**17.** An apparatus, comprising:

means for receiving a packet having a routing layer that includes a packet data convergence protocol (PDCP) layer from an upstream evolved Node B (eNB); and

means for transmitting a payload of the PDCP layer in a disparate packet to a user equipment (UE) related to the packet based at least in part on a routing identifier specified in the routing layer of the packet.

**18.** The apparatus of claim **17**, further comprising means for retrieving one or more parameters from a header of the PDCP layer.

**19.** The apparatus of claim **18**, further comprising means for transmitting the one or more parameters to the upstream eNB.

**20.** The apparatus of claim **19**, wherein the one or more parameters includes a sequence number related to the PDCP layer.

**21.** The apparatus of claim **17**, wherein the means for transmitting the payload maintains a buffer that stores the packet at least until the means for transmitting transmits the payload of the PDCP layer in the disparate packet to the UE.

**22.** The apparatus of claim **21**, further comprising means for transmitting one or more parameters related to the buffer to the upstream eNB.

**23.** The apparatus of claim **17**, further comprising means for receiving an identifier from the upstream eNB upon establishing a connection with the upstream eNB.

**24.** The apparatus of claim **23**, wherein the routing identifier includes the identifier received from the upstream eNB, an identifier of the UE, and an identifier of a radio bearer over which the means for transmitting is to transmit the payload of the PDCP layer in the disparate packet to the UE.

**25.** A computer program product, comprising:

a computer-readable medium comprising:

code for causing at least one computer to receive a packet having a routing layer that includes a payload

with a packet data convergence protocol (PDCP) layer from an upstream evolved Node B (eNB);

code for causing the at least one computer to determine a user equipment (UE) to receive the payload based at least in part on a routing identifier specified in the routing layer of the packet; and

code for causing the at least one computer to transmit the payload to the UE in a disparate packet.

**26.** The computer program product of claim **25**, wherein the computer-readable medium further comprises code for causing the at least one computer to extract one or more parameters from a header of the PDCP layer.

**27.** The computer program product of claim **26**, wherein the computer-readable medium further comprises code for causing the at least one computer to transmit the one or more parameters extracted from the header of the PDCP layer to the upstream eNB.

**28.** The computer program product of claim **27**, wherein the one or more parameters includes a sequence number related to the PDCP layer of the payload.

**29.** The computer program product of claim **25**, wherein the computer-readable medium further comprises code for causing the at least one computer to maintain a buffer that stores the packet received from the upstream eNB, along with other packets received from the upstream eNB, until the code for causing the at least one computer to transmit transmits the payload to the UE in the disparate packet.

**30.** The computer program product of claim **29**, wherein the computer-readable medium further comprises code for causing the at least one computer to provide one or more parameters related to the buffer to the upstream eNB.

**31.** The computer program product of claim **25**, wherein the computer-readable medium further comprises code for causing the at least one computer to receive an identifier for communicating with the upstream eNB upon establishing a connection with the upstream eNB.

**32.** The computer program product of claim **31**, wherein the routing identifier includes the identifier for communicating with the upstream eNB, an identifier of the UE, and an identifier of a radio bearer over which the code for causing the at least one computer to transmit transmits the payload to the UE in the disparate packet.

**33.** An apparatus, comprising:

a packet receiving component that obtains a packet having a routing layer that includes a packet data convergence protocol (PDCP) layer from an upstream evolved Node B (eNB); and

a packet routing component that transmits a payload of the PDCP layer in a disparate packet to a user equipment (UE) related to the packet based at least in part on a routing identifier specified in the routing layer of the packet.

**34.** The apparatus of claim **33**, further comprising a PDCP header observing component that retrieves one or more parameters from a header of the PDCP layer.

**35.** The apparatus of claim **34**, further comprising a PDCP parameter providing component that transmits the one or more parameters to the upstream eNB.

**36.** The apparatus of claim **35**, wherein the one or more parameters includes a sequence number related to the PDCP layer.

**37.** The apparatus of claim **33**, wherein the packet routing component further maintains a buffer that stores the packet at



least until the packet routing component transmits the payload of the PDCP layer in the disparate packet to the UE.

**38.** The apparatus of claim **37**, further comprising a PDCP parameter providing component that transmits one or more parameters related to the buffer to the upstream eNB.

**39.** The apparatus of claim **33**, further comprising an ID receiving component that obtains an identifier from the upstream eNB upon establishing a connection with the upstream eNB.

**40.** The apparatus of claim **39**, wherein the routing identifier includes the identifier received from the upstream eNB, an identifier of the UE, and an identifier of a radio bearer over which the packet routing component transmits the payload of the PDCP layer in the disparate packet to the UE.

**41.** A method, comprising:

maintaining a packet data convergence protocol (PDCP) context related to a user equipment (UE);

applying an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE; and

transmitting at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay evolved Node B (eNB) in a communications path to the UE.

**42.** The method of claim **41**, further comprising receiving one or more parameters related to PDCP layer communications at the UE from the downstream relay eNB.

**43.** The method of claim **42**, wherein the receiving the one or more parameters includes receiving a PDCP layer sequence number of the packet from the downstream relay eNB.

**44.** The method of claim **43**, further comprising transmitting one or more PDCP packets in a buffer of the PDCP context related to the UE to the downstream relay eNB based at least in part on the PDCP layer sequence number.

**45.** The method of claim **42**, wherein the receiving the one or more parameters includes receiving an index of a last downlink PDCP packet data unit (PDU) sent to the UE by the downstream relay eNB, an index of a last downlink PDCP PDU received at the downstream relay eNB, or a maximum size of a PDCP layer buffer at the downstream relay eNB.

**46.** The method of claim **41**, further comprising generating a routing identifier for the disparate packet based at least in part on an identifier in the portion of the packet received over the backhaul link.

**47.** The method of claim **46**, further comprising determining the downstream relay eNB based at least in part on a portion of the routing identifier.

**48.** The method of claim **47**, wherein the determining the downstream relay eNB includes locating an identifier of the downstream relay eNB in a routing table based at least in part on the portion of the routing identifier.

**49.** The method of claim **46**, further comprising generating the disparate packet to include a relay routing protocol layer that comprises the PDCP layer and the routing identifier.

**50.** The method of claim **49**, further comprising:

determining a radio bearer of the downstream relay eNB for transmitting the PDCP layer of the packet to the UE based at least in part on a bearer mapping table that associates evolved packet system (EPS) bearers with radio bearers of one or more downstream relay eNBs; and

specifying an identifier of the radio bearer as a portion of the routing identifier.

**51.** A wireless communications apparatus, comprising: at least one processor configured to:

negotiate one or more parameters for communicating with a user equipment (UE);

apply the one or more parameters to at least a portion of a packet for the UE received over a backhaul link; and

transmit at least the portion of the packet in a packet data convergence protocol (PDCP) layer of a disparate packet to a downstream relay evolved Node B (eNB) in a communications path to the UE; and

a memory coupled to the at least one processor.

**52.** The wireless communications apparatus of claim **51**, wherein the at least one processor is further configured to receive one or more PDCP layer communication parameters related to PDCP layer communications at the UE from the downstream relay eNB.

**53.** The wireless communications apparatus of claim **52**, wherein the one or more PDCP layer communication parameters includes a PDCP layer sequence number of the packet from the downstream relay eNB.

**54.** The wireless communications apparatus of claim **53**, wherein the at least one processor is further configured to transmit one or more PDCP packets having a PDCP layer from a buffer related to the UE to the downstream relay eNB based at least in part on the PDCP layer sequence number.

**55.** The wireless communications apparatus of claim **52**, wherein the one or more PDCP layer communication parameters includes an index of a last downlink PDCP packet data unit (PDU) sent to the UE by the downstream relay eNB, an index of a last downlink PDCP PDU received at the downstream relay eNB, or a maximum size of a PDCP layer buffer at the downstream relay eNB.

**56.** The wireless communications apparatus of claim **51**, wherein the at least one processor is further configured to generate a routing identifier for a routing layer of the disparate packet based at least in part on an identifier specified in at least the portion of the packet received over the backhaul link.

**57.** The wireless communications apparatus of claim **56**, wherein the at least one processor is further configured to select the downstream relay eNB for transmitting the disparate packet to based at least in part on a portion of the routing identifier.

**58.** The wireless communications apparatus of claim **57**, wherein the at least one processor selects the downstream relay eNB based at least in part on locating an identifier of the downstream relay eNB associated with the portion of the routing identifier in a routing table.

**59.** The wireless communications apparatus of claim **56**, wherein the at least one processor is further configured to create the disparate packet including a relay routing protocol layer that comprises the portion of the packet in the PDCP layer and the routing identifier.

**60.** The wireless communications apparatus of claim **59**, wherein the at least one processor is further configured to:

maintain a bearer mapping table that associates radio bearer identifiers of downstream relay eNBs to evolved packet system (EPS) bearers;

locate an identifier of a radio bearer of the downstream relay eNB in the bearer mapping table that is associated to an EPS bearer specified in at least the portion of the packet; and

specify the identifier of the radio bearer of the downstream relay eNB in the routing identifier.

- 61.** An apparatus, comprising:  
 means for maintaining a packet data convergence protocol (PDCP) context related to a user equipment (UE);  
 means for applying an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE; and  
 means for transmitting at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay evolved Node B (eNB) in a communications path to the UE.
- 62.** The apparatus of claim **61**, further comprising means for receiving one or more parameters related to PDCP layer communications at the UE from the downstream relay eNB.
- 63.** The apparatus of claim **62**, wherein the one or more parameters includes a PDCP layer sequence number of the packet.
- 64.** The apparatus of claim **63**, wherein the means for transmitting the packet further transmits one or more other packets from a buffer related to the PDCP context based at least in part on the PDCP layer sequence number.
- 65.** The apparatus of claim **62**, wherein the one or more parameters includes an index of a last downlink PDCP packet data unit (PDU) sent to the UE by the downstream relay eNB, an index of a last downlink PDCP PDU received at the downstream relay eNB, or a maximum size of a PDCP layer buffer at the downstream relay eNB.
- 66.** The apparatus of claim **61**, further comprising means for generating a routing identifier for the disparate packet based at least in part on an identifier in at least the portion of the packet received over the backhaul link.
- 67.** The apparatus of claim **66**, wherein the means for transmitting the packet in the PDCP layer of the disparate packet selects the downstream relay eNB based at least in part on a portion of the routing identifier.
- 68.** The apparatus of claim **67**, wherein the means for transmitting the packet in the PDCP layer of the disparate packet selects the downstream relay eNB based further at least in part on locating an identifier of the downstream relay eNB in a routing table based at least in part on the portion of the routing identifier.
- 69.** The apparatus of claim **66**, wherein the means for generating the routing identifier further creates the disparate packet to include a relay routing protocol layer that comprises the PDCP layer and the routing identifier.
- 70.** The apparatus of claim **69**, further comprising means for locating an identifier of a radio bearer of the downstream relay eNB that is associated to an evolved packet system (EPS) bearer specified in at least the portion of the packet in a bearer mapping table that maps radio bearer identifiers of downstream relay eNBs to EPS bearers, wherein the means for generating the routing identifier specifies the identifier of the radio bearer in a portion of the routing identifier.
- 71.** A computer program product, comprising:  
 a computer-readable medium comprising:  
 code for causing at least one computer to maintain a packet data convergence protocol (PDCP) context related to a user equipment (UE);  
 code for causing the at least one computer to apply an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE; and  
 code for causing the at least one computer to transmit at least the portion of the packet in a PDCP layer of a disparate packet to a downstream relay evolved Node B (eNB) in a communications path to the UE.
- 72.** The computer program product of claim **71**, wherein the computer-readable medium further comprises code for causing the at least one computer to receive one or more parameters related to PDCP layer communications at the UE from the downstream relay eNB.
- 73.** The computer program product of claim **72**, wherein the one or more parameters includes a PDCP layer sequence number of the packet.
- 74.** The computer program product of claim **73**, wherein the computer-readable medium further comprises code for causing the at least one computer to transmit one or more PDCP packets in a buffer of the PDCP context related to the UE to the downstream relay eNB based at least in part on the PDCP layer sequence number.
- 75.** The computer program product of claim **72**, wherein the one or more parameters includes an index of a last downlink PDCP packet data unit (PDU) sent to the UE by the downstream relay eNB, an index of a last downlink PDCP PDU received at the downstream relay eNB, or a maximum size of a PDCP layer buffer at the downstream relay eNB.
- 76.** The computer program product of claim **71**, wherein the computer-readable medium further comprises code for causing the at least one computer to generate a routing identifier for the disparate packet based at least in part on an identifier in the portion of the packet received over the backhaul link.
- 77.** The computer program product of claim **76**, wherein the computer-readable medium further comprises code for causing the at least one computer to determine the downstream relay eNB based at least in part on a portion of the routing identifier.
- 78.** The computer program product of claim **77**, wherein the code for causing the at least one computer to determine the downstream relay eNB locates an identifier of the downstream relay eNB in a routing table based at least in part on the portion of the routing identifier.
- 79.** The computer program product of claim **76**, wherein the computer-readable medium further comprises code for causing the at least one computer to generate the disparate packet to include a relay routing protocol layer that comprises the PDCP layer and the routing identifier.
- 80.** The computer program product of claim **79**, wherein the computer-readable medium further comprises:  
 code for causing the at least one computer to determine a radio bearer of the downstream relay eNB for transmitting the PDCP layer of the packet to the UE based at least in part on a bearer mapping table that associates evolved packet system bearers with radio bearers of one or more downstream relay eNBs; and  
 code for causing the at least one computer to specify an identifier of the radio bearer as a portion of the routing identifier.
- 81.** An apparatus, comprising:  
 a packet data convergence protocol (PDCP) context maintaining component that creates and stores a PDCP context related to a user equipment (UE);  
 a PDCP applying component that associates an encryption or security procedure to at least a portion of a packet received over a backhaul link for the UE according to the PDCP context related to the UE; and  
 a packet routing component that transmits at least the portion of the packet in a PDCP layer of a disparate packet

to a downstream relay evolved Node B (eNB) in a communications path to the UE.

**82.** The apparatus of claim **81**, further comprising a PDCP parameter receiving component that obtains one or more parameters related to PDCP layer communications at the UE from the downstream relay eNB.

**83.** The apparatus of claim **82**, wherein the one or more parameters includes a PDCP layer sequence number of the packet.

**84.** The apparatus of claim **83**, wherein the packet routing component further transmits one or more other packets from a buffer related to the PDCP context based at least in part on the PDCP layer sequence number.

**85.** The apparatus of claim **82**, wherein the one or more parameters includes an index of a last downlink PDCP packet data unit (PDU) sent to the UE by the downstream relay eNB, an index of a last downlink PDCP PDU received at the downstream relay eNB, or a maximum size of a PDCP layer buffer at the downstream relay eNB.

**86.** The apparatus of claim **81**, further comprising a relay routing protocol (RRP) packet generating component that specifies a routing identifier for the disparate packet based at

least in part on an identifier in at least the portion of the packet received over the backhaul link.

**87.** The apparatus of claim **86**, wherein the packet routing component selects the downstream relay eNB based at least in part on a portion of the routing identifier.

**88.** The apparatus of claim **87**, wherein the packet routing component selects the downstream relay eNB based further at least in part on locating an identifier of the downstream relay eNB in a routing table based at least in part on the portion of the routing identifier.

**89.** The apparatus of claim **86**, wherein the RRP packet generating component further creates the disparate packet to include an RRP layer that comprises the PDCP layer and the routing identifier.

**90.** The apparatus of claim **89**, further comprising a bearer mapping component that locates an identifier of a radio bearer of the downstream relay eNB that is associated to an evolved packet system (EPS) bearer specified in at least the portion of the packet in a bearer mapping table that maps radio bearer identifiers of downstream relay eNBs to EPS bearers, wherein the RRP packet generating component specifies the identifier of the radio bearer in a portion of the routing identifier.

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