(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 January 2013 (17.01.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/010010 A1

(51) International Patent Classification: *H04W 88/04* (2009.01)

(21) International Application Number: PCT/US2012/046516

(22) International Filing Date: 12 July 2012 (12.07.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/506,985 12 July 2011 (12.07.2011) US
13/546,970 11 July 2012 (11.07.2012) US

(71) Applicant *(for all designated States except US)*: **QUALCOMM INCORPORATED** [US/US]; ATTN: International IP Administration, 5775 Morehouse Drive, San Diego, California 92121-1714 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **DAMNJANOVIC, Aleksandar** [US/US]; 5775 Morehouse Drive, San Diego, California 92121 (US). **BHUSHAN, Naga** [US/US]; 5775 Morehouse Drive, San Diego, California 92121 (US). **HO, Saiyiu D.** [CA/US]; 5775 Morehouse Drive, San Diego, California 92121 (US). **WEI, Yongbin** [CN/US]; 5755 Morehouse Drive, San Diego, California 92121 (US). **MALLADI, Durga Prasad** [US/US]; 5775 Morehouse Drive, San Diego, California 92121 (US).

(74) Agents: **READ, Randol W.** et al.; Patterson & Sheridan, L.L.P./Qualcomm, 3040 Post Oak Blvd., Suite 1500, Houston, Texas 77056-6582 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

[Continued on next page]

(54) Title: SYSTEM DESIGN FOR USER EQUIPMENT RELAYS

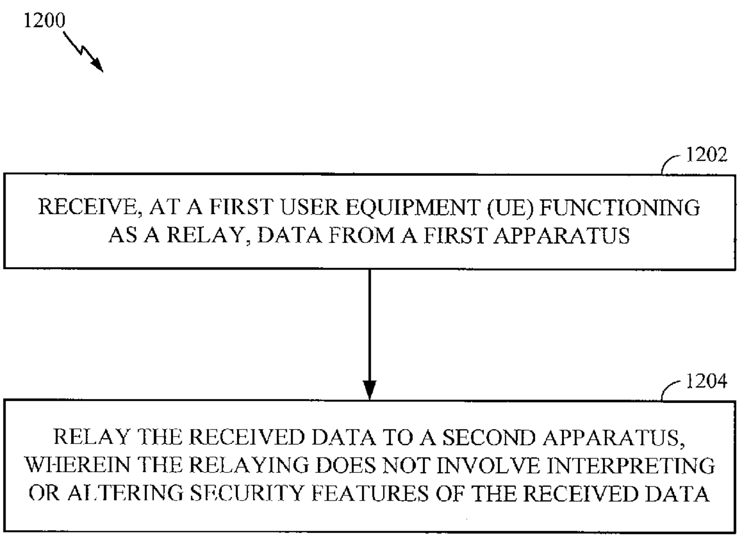

FIG. 12

(57) Abstract: Certain aspects of the present disclosure provide methods and apparatus related to various considerations for using systems comprising user equipment (UE) relays. One method generally includes receiving, at a UE functioning as a relay, data from a first apparatus; and relaying the received data to a second apparatus, wherein the relaying does not involve interpreting or altering security features of the received data.

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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

SYSTEM DESIGN FOR USER EQUIPMENT RELAYS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of priority to U.S. Provisional Application Serial No. 61/506,985, filed on July 12, 2011, which is expressly incorporated by reference herein in its entirety.

BACKGROUND

FIELD

[0002] Certain aspects of the disclosure generally relate to wireless communications and, more particularly, to various system considerations for using user equipment (UE) devices functioning as relays.

BACKGROUND

[0003] Wireless communication networks are widely deployed to provide various communication services such as voice, video, packet data, messaging, broadcast, etc. These wireless networks may be multiple-access networks capable of supporting multiple users by sharing the available network resources (e.g., bandwidth and transmit power). Examples of such multiple-access networks include Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, Single-Carrier FDMA (SC-FDMA) networks, 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) networks, and Long Term Evolution Advanced (LTE-A) networks.

[0004] A wireless communication network may include a number of base stations that can support communication with a number of user equipment devices (UEs). A UE may communicate with a base station via the downlink and uplink. The downlink (or forward link) refers to the communication link from the base station to the UE, and the uplink (or reverse link) refers to the communication link from the UE to the base station. A base station may transmit data and control information on the downlink to a UE and/or may receive data and control information on the uplink from the UE. This communication link may be established via a single-input single-output, multiple-input single-output or a multiple-input multiple-output (MIMO) system.

[0005] Wireless communication systems may comprise a donor base station that communicates with wireless terminals via a relay node, such as a relay base station. The relay node may communicate with the donor base station via a backhaul link and with the terminals via an access link. In other words, the relay node may receive downlink messages from the donor base station over the backhaul link and relay these messages to the terminals over the access link. Similarly, the relay node may receive uplink messages from the terminals over the access link and relay these messages to the donor base station over the backhaul link. The relay node may, thus, be used to supplement a coverage area and help fill "coverage holes."

SUMMARY

[0006] Certain aspects of the present disclosure generally relate to various design considerations for utilizing user equipments (UEs) as relays.

[0007] Certain aspects of the present disclosure provide a method for wireless communications. The method generally includes receiving, at a first user equipment (UE) functioning as a relay, data from a first apparatus; and relaying the received data to a second apparatus without interpreting or altering security features of the received data.

[0008] In an aspect of the disclosure, a first UE functioning as a relay for wireless communications is provided. The first UE generally includes a receiver configured to receive data from a first apparatus and a transmitter configured to relay the received data to a second apparatus without interpreting or altering security features of the received data.

[0009] In an aspect of the disclosure, a first UE functioning as a relay for wireless communications is provided. The first UE generally includes means for receiving data from a first apparatus and means for relaying the received data to a second apparatus without interpreting or altering security features of the received data.

[0010] In an aspect of the disclosure, a computer-program product for wireless communications is provided. The computer-program product generally includes a computer-readable medium having code for receiving, at a first UE functioning as a relay, data from a first apparatus and for relaying the received data to a second apparatus without interpreting or altering security features of the received data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The features, nature, and advantages of the present disclosure will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

[0012] FIG. 1 illustrates an example wireless communication system according to an aspect of the present disclosure.

[0013] FIG. 2 is a block diagram conceptually illustrating an example of a Node B in communication with a user equipment device (UE) in a wireless communication system, according to an aspect of the present disclosure.

[0014] FIG. 3 illustrates an example wireless communications system with a relay UE according to an aspect of the present disclosure.

[0015] FIG. 4 illustrates an example protocol stack for wireless communications via a relay UE, with end-to-end communications above a Radio Link Control (RLC) layer, according to an aspect of the present disclosure.

[0016] FIG. 5 illustrates an example protocol stack for wireless communications via a relay UE, with partial Radio Resource Control (RRC) functionality at the relay UE, according to an aspect of the present disclosure.

[0017] FIG. 6 is a system block diagram of an example relay UE deployment scenario with carrier aggregation, according to an aspect of the present disclosure.

[0018] FIG. 7 is a system block diagram of an example relay UE deployment scenario with carrier-aggregation-like features, according to an aspect of the present disclosure.

[0019] FIG. 8 is a system block diagram of an example single-carrier-aggregation-like relay UE deployment scenario, according to an aspect of the present disclosure.

[0020] FIG. 9 is a system block diagram of an example single-carrier-mode relay UE deployment scenario, according to an aspect of the present disclosure.

[0021] FIG. 10 is a call flow involving a relay UE for carrier aggregation mode, according to an aspect of the present disclosure.

[0022] FIG. 11 is a call flow involving a relay UE for non-carrier-aggregation mode, according to an aspect of the present disclosure.

[0023] FIG. 12 is a flow diagram of example operations for relaying data from the perspective of a UE relay, for example, according to an aspect of the present disclosure.

[0024] FIG. 13 is a call flow illustrating initial access of a relay UE with a base station in a single carrier mode, according to aspects of the present disclosure.

[0025] FIG. 14 is a call flow illustrating handover of a terminal UE between relay UEs served by a common base station, according to aspects of the present disclosure.

[0026] FIG. 15 is a call flow illustrating handover of a terminal UE between relay UEs served by different base stations, according to aspects of the present disclosure.

[0027] FIG. 16 is a call flow illustrating handover of a relay UE between different base stations, according to aspects of the present disclosure.

[0028] FIG. 17 is a call flow illustrating handover of a terminal UE from a relay UE to a first base station and handover of the relay UE from the first base station to a second base station, according to aspects of the present disclosure.

[0029] FIG. 18 is a call flow illustrating handover of a relay UE from a first base station to a second base station and handover of a terminal UE from the relay UE to the second base station, according to aspects of the present disclosure.

[0030] FIG. 19 is a call flow illustrating handover of a terminal UE from a first base station to a relay UE, according to aspects of the present disclosure.

[0031] FIG. 20 is a call flow illustrating initial access of a relay UE with a base station in a carrier aggregation mode, according to aspects of the present disclosure.

[0032] FIG. 21 is a call flow illustrating handover of a terminal UE between relay UEs served by a common base station in a carrier aggregation mode, according to aspects of the present disclosure.

[0033] FIG. 22 is a call flow illustrating handover of a terminal UE between relay UEs served by different base stations in a carrier aggregation mode, according to aspects of the present disclosure.

[0034] FIG. 23 is a call flow illustrating handover of a relay UE between different base stations in a carrier aggregation mode, according to aspects of the present disclosure.

DESCRIPTION

[0035] Certain aspects of the present disclosure generally relate to various design considerations for utilizing user equipments (UEs) as relays between a base station (e.g., an evolved Node B or eNB) and other UEs, referred to herein as terminal UEs (or destination UEs).

[0036] For certain aspects, UE relays may serve as a simple data pipe and may not be involved in radio resource control (RRC) state control of the terminal UEs. For example, signals received by the UE relay from the eNB may be sent directly to the destination UE without any signal modification, such that the UE relay may seem transparent to a terminal UE.

[0037] Utilizing UE relays in this manner to relay data traffic from a base station (e.g., an evolved Node B or eNB) to other UEs, referred to herein as terminal UEs (or destination UEs) presents a number of design challenges.

[0038] For example, due to mobility of both terminal UEs and relay UEs, a number of different handover scenarios may be encountered. These example handover scenarios include handover of a terminal UE between relay UEs (served by the same eNB or different eNBs), handover of a terminal UE between a relay UE and eNB, and handover of a relay UE between different eNBs.

[0039] Techniques of the present disclosure provide techniques for addressing various such issues encountered when utilizing relay UEs in a relatively transparent manner.

[0040] The techniques described herein may be used for various wireless communication networks such as Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, Single-Carrier FDMA (SC-FDMA) networks, etc. The terms “networks” and “systems” are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes Wideband-CDMA (W-CDMA) and Low Chip Rate (LCR). cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), IEEE 802.11, IEEE 802.16, IEEE 802.20, Flash-OFDM®, etc. UTRA, E-UTRA, and GSM are part of Universal Mobile Telecommunication System (UMTS). Long Term Evolution (LTE) is an upcoming release of UMTS that uses E-UTRA. UTRA, E-UTRA, GSM, UMTS and LTE are described in documents from an organization named “3rd Generation Partnership Project” (3GPP). cdma2000 is described in documents from an organization named “3rd Generation Partnership Project 2” (3GPP2). These various radio technologies and standards are known in the art. For clarity, certain aspects of the techniques are described below for LTE, and LTE terminology is used in much of the description below.

[0041] Single carrier frequency division multiple access (SC-FDMA), which utilizes single carrier modulation and frequency domain equalization is a technique. SC-FDMA has similar performance and essentially the same overall complexity as those of OFDMA system. SC-FDMA signal has lower peak-to-average power ratio (PAPR) because of its inherent single carrier structure. SC-FDMA has drawn great attention, especially in the uplink communications where lower PAPR greatly benefits the mobile terminal in terms of transmit power efficiency. It is currently a working assumption for uplink multiple access scheme in 3GPP Long Term Evolution (LTE), or Evolved UTRA.

AN EXAMPLE WIRELESS COMMUNICATION SYSTEM

[0042] Referring to FIG. 1, a multiple access wireless communication system according to one embodiment is illustrated. An access point 100 (AP) includes multiple antenna groups, one including antenna 104 and antenna 106, another including antenna 108 and antenna 110, and yet another including antenna 112 and antenna 114. In FIG. 1, only two antennas are shown for each antenna group; however, more or fewer antennas may be utilized for each antenna group. Access terminal 116 (AT) is in communication with antennas 112 and 114, where antennas 112 and 114 transmit information to access terminal 116 over forward link 120 and receive information from access terminal 116 over reverse link 118. Access terminal 122 is in communication with antennas 106 and 108, where antennas 106 and 108 transmit information to access terminal 122 over forward link 126 and receive information from access terminal 122 over reverse link 124. In an FDD system, communication links 118, 120, 124, and 126 may use different frequency for communication. For example, forward link 120 may use a different frequency then that used by reverse link 118.

[0043] Each group of antennas and/or the area in which they are designed to communicate is often referred to as a sector of the access point. In the embodiment, antenna groups each are designed to communicate to access terminals in a sector, of the areas covered by access point 100.

[0044] In communication over forward links 120 and 126, the transmitting antennas of access point 100 utilize beamforming in order to improve the signal-to-noise ratio (SNR) of forward links for the different access terminals 116 and 122. Also, an access point using beamforming to transmit to access terminals scattered randomly through its coverage causes less interference to access terminals in neighboring cells than an access point transmitting through a single antenna to all its access terminals.

[0045] An access point (AP) may be a fixed station used for communicating with the terminals and may also be referred to as a base station (BS), a Node B, or some other terminology. An access terminal may also be called a mobile station (MS), user equipment (UE), a wireless communication device, terminal, user terminal (UT), or some other terminology.

[0046] FIG. 2 is a block diagram of an embodiment of a transmitter system 210 (also known as an access point) and a receiver system 250 (also known as an access terminal) in a MIMO system 200. At the transmitter system 210, traffic data for a number of data streams is provided from a data source 212 to a transmit (TX) data processor 214.

[0047] In an aspect, each data stream is transmitted over a respective transmit antenna. TX data processor 214 formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0048] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., BPSK, QSPK, *M*-PSK, or *M*-QAM) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream may be determined by instructions performed by processor 230.

[0049] The modulation symbols for all data streams are then provided to a TX MIMO processor 220, which may further process the modulation symbols (e.g., for OFDM). TX MIMO processor 220 then provides N_T modulation symbol streams to N_T transmitters (TMTR) 222a through 222t. In certain embodiments, TX MIMO processor 220 applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0050] Each transmitter 222 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. N_T modulated signals from transmitters 222a through 222t are then transmitted from N_T antennas 224a through 224t, respectively.

[0051] At receiver system 250, the transmitted modulated signals are received by N_R antennas 252a through 252r and the received signal from each antenna 252 is provided to a respective receiver (RCVR) 254a through 254r. Each receiver 254 conditions (e.g., filters, amplifies, and downconverts) a respective received signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0052] An RX data processor 260 then receives and processes the N_R received symbol streams from N_R receivers 254 based on a particular receiver processing technique to provide N_T "detected" symbol streams. The RX data processor 260 then demodulates, deinterleaves, and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor 260 is complementary to that performed by TX MIMO processor 220 and TX data processor 214 at transmitter system 210.

[0053] A processor 270 periodically determines which pre-coding matrix to use. Processor 270 formulates a reverse link message comprising a matrix index portion and a rank value portion.

[0054] The reverse link message may comprise various types of information regarding the communication link and/or the received data stream. The reverse link message is then processed by a TX data processor 238, which also receives traffic data for a number of data streams from a data source 236, modulated by a modulator 280, conditioned by transmitters 254a through 254r, and transmitted back to transmitter system 210.

[0055] At transmitter system 210, the modulated signals from receiver system 250 are received by antennas 224, conditioned by receivers 222, demodulated by a demodulator 240, and processed by a RX data processor 242 to extract the reserve link message transmitted by the receiver system 250. Processor 230 then determines which pre-coding matrix to use for determining the beamforming weights and then processes the extracted message.

[0056] In an aspect, logical channels are classified into Control Channels and Traffic Channels. Logical Control Channels comprise Broadcast Control Channel (BCCH) which is a DL channel for broadcasting system control information. Paging

Control Channel (PCCH) is a DL channel that transfers paging information. Multicast Control Channel (MCCH) is a point-to-multipoint DL channel used for transmitting Multimedia Broadcast and Multicast Service (MBMS) scheduling and control information for one or several MTCHs. Generally, after establishing an RRC connection, this channel is only used by UEs that receive MBMS (Note: old MCCH+MSCH). Dedicated Control Channel (DCCH) is a point-to-point bi-directional channel that transmits dedicated control information used by UEs having an RRC connection. In an aspect, Logical Traffic Channels comprise a Dedicated Traffic Channel (DTCH), which is a point-to-point bi-directional channel, dedicated to one UE, for the transfer of user information. Also, a Multicast Traffic Channel (MTCH) is a point-to-multipoint DL channel for transmitting traffic data.

[0057] In an aspect, Transport Channels are classified into DL and UL. DL Transport Channels comprise a Broadcast Channel (BCH), Downlink Shared Data Channel (DL-SDCH), and a Paging Channel (PCH), the PCH for support of UE power saving (DRX cycle is indicated by the network to the UE), broadcasted over entire cell and mapped to PHY resources which can be used for other control/traffic channels. The UL Transport Channels comprise a Scheduling Request (SR), a Physical Uplink Shared Channel (PUSCH), and a plurality of PHY channels. The PHY channels comprise a set of DL channels and UL channels.

[0058] In an aspect, a channel structure is provided that preserves low PAR (at any given time, the channel is contiguous or uniformly spaced in frequency) properties of a single carrier waveform.

[0059] For the purposes of the present document, the following abbreviations (including abbreviations for various DL and UL PHY Channels) apply:

1xCSFB	Circuit Switched Fallback to 1xRTT
ABS	Almost Blank Subframe
ACK	Acknowledgement
ACLR	Adjacent Channel Leakage Ratio
AM	Acknowledged Mode
AMBR	Aggregate Maximum Bit Rate
ANR	Automatic Neighbour Relation

ARQ	Automatic Repeat Request
ARP	Allocation and Retention Priority
AS	Access Stratum
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BSR	Buffer Status Report
C/I	Carrier-to-Interference Power Ratio
CAZAC	Constant Amplitude Zero Auto-Correlation
CA	Carrier Aggregation
CBC	Cell Broadcast Center
CC	Component Carrier
CIF	Carrier Indicator Field
CMAS	Commercial Mobile Alert Service
CMC	Connection Mobility Control
CP	Cyclic Prefix
C-plane	Control Plane
C-RNTI	Cell RNTI
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CSA	Common Subframe Allocation
CSG	Closed Subscriber Group
DCCH	Dedicated Control Channel
DeNB	Donor eNB
DFTS	DFT Spread OFDM
DL	Downlink
DRB	Data Radio Bearer
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
DwPTS	Downlink Pilot Time Slot
ECGI	E-UTRAN Cell Global Identifier
ECM	EPS Connection Management
EMM	EPS Mobility Management
E-CID	Enhanced Cell-ID (positioning method)

eNB	E-UTRAN NodeB
EPC	Evolved Packet Core
EPS	Evolved Packet System
E-RAB	E-UTRAN Radio Access Bearer
ETWS	Earthquake and Tsunami Warning System
E-UTRA	Evolved UTRA
E-UTRAN	Evolved UTRAN
FDD	Frequency Division Duplex
FDM	Frequency Division Multiplexing
GERAN	GSM EDGE Radio Access Network
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile communication
GBR	Guaranteed Bit Rate
GP	Guard Period
HARQ	Hybrid ARQ
HO	Handover
HRPD	High Rate Packet Data
HSDPA	High Speed Downlink Packet Access
ICIC	Inter-Cell Interference Coordination
IP	Internet Protocol
LB	Load Balancing
LCG	Logical Channel Group
LCR	Low Chip Rate
LCS	LoCation Service
LIPA	Local IP Access
LPPa	LTE Positioning Protocol Annex
L-GW	Local Gateway
LTE	Long Term Evolution
MAC	Medium Access Control
MBMS	Multimedia Broadcast Multicast Service
MBR	Maximum Bit Rate
MBSFN	Multimedia Broadcast multicast service Single Frequency Network
MCCH	Multicast Control Channel

MCE	Multi-cell/multicast Coordination Entity
MCH	Multicast Channel
MCS	Modulation and Coding Scheme
MDT	Minimization of Drive Tests
MIB	Master Information Block
MIMO	Multiple Input Multiple Output
MME	Mobility Management Entity
MSA	MCH Subframe Allocation
MSI	MCH Scheduling Information
MSP	MCH Scheduling Period
MTCH	Multicast Traffic Channel
NACK	Negative Acknowledgement
NAS	Non-Access Stratum
NCC	Next Hop Chaining Counter
NH	Next Hop key
NNSF	NAS Node Selection Function
NR	Neighbour cell Relation
NRT	Neighbour Relation Table
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OTDOA	Observed Time Difference Of Arrival (positioning method)
P-GW	PDN Gateway
P-RNTI	Paging RNTI
PA	Power Amplifier
PAPR	Peak-to-Average Power Ratio
PBCH	Physical Broadcast CHannel
PBR	Prioritised Bit Rate
PCC	Primary Component Carrier
PCCH	Paging Control Channel
PCell	Primary Cell
PCFICH	Physical Control Format Indicator CHannel
PCH	Paging Channel
PCI	Physical Cell Identifier
PDCCH	Physical Downlink Control CHannel

PDSCH	Physical Downlink Shared CHannel
PDCP	Packet Data Convergence Protocol
PDN	Packet Data Network
PDU	Protocol Data Unit
PHICH	Physical Hybrid ARQ Indicator CHannel
PHY	Physical layer
PLMN	Public Land Mobile Network
PMCH	Physical Multicast CHannel
PRACH	Physical Random Access CHannel
PRB	Physical Resource Block
PSC	Packet Scheduling
PUCCH	Physical Uplink Control CHannel
PUSCH	Physical Uplink Shared CHannel
PWS	Public Warning System
QAM	Quadrature Amplitude Modulation
QCI	QoS Class Identifier
QoS	Quality of Service
RA-RNTI	Random Access RNTI
RAC	Radio Admission Control
RACH	Random Access Channel
RAT	Radio Access Technology
RB	Radio Bearer
RBC	Radio Bearer Control
RF	Radio Frequency
RIM	RAN Information Management
RLC	Radio Link Control
RN	Relay Node
RNC	Radio Network Controller
RNL	Radio Network Layer
RNTI	Radio Network Temporary Identifier
ROHC	Robust Header Compression
RRC	Radio Resource Control
RRM	Radio Resource Management
RU	Resource Unit

S-GW	Serving Gateway
S1-MME	S1 for the control plane
SCC	Secondary Component Carrier
SCell	Secondary Cell
SI	System Information
SIB	System Information Block
SI-RNTI	System Information RNTI
S1-U	S1 for the user plane
SAE	System Architecture Evolution
SAP	Service Access Point
SC-FDMA	Single Carrier – Frequency Division Multiple Access
SCH	Synchronization Channel
SDF	Service Data Flow
SDMA	Spatial Division Multiple Access
SDU	Service Data Unit
SeGW	Security Gateway
SFN	System Frame Number
SPID	Subscriber Profile ID for RAT/Frequency Priority
SR	Scheduling Request
SRB	Signalling Radio Bearer
SU	Scheduling Unit
TA	Tracking Area
TB	Transport Block
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TEID	Tunnel Endpoint Identifier
TFT	Traffic Flow Template
TM	Transparent Mode
TNL	Transport Network Layer
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UM	Unacknowledged Mode
UMTS	Universal Mobile Telecommunication System

U-plane	User plane
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network
UpPTS	Uplink Pilot Time Slot
VRB	Virtual Resource Block
X2-C	X2-Control plane
X2-U	X2-User plane

AN EXAMPLE RELAY SYSTEM

[0060] FIG. 3 illustrates an example wireless system 300 in which certain aspects of the present disclosure may be practiced. As illustrated, the system 300 includes a donor base station (BS) 302 (also known as donor access point or a donor evolved Node B (DeNB)) that communicates with a user equipment (UE) 304 via a relay node 306 (also known as a relay station or a relay). While the relay node 306 may comprise a relay base station (also known as a relay eNB), a UE (e.g., a cell phone) may also function as a relay for relaying transmissions for other UEs, as shown in FIG. 3. Such relays may be known as relay UEs, UE relays, or UEs functioning as relays.

[0061] The relay node 306 may communicate with the donor BS 302 via a backhaul link 308 and with the UE 304 via an access link 310. In other words, the relay node 306 may receive downlink messages from the donor BS 302 over the backhaul link 308 and relay these messages to the UE 304 over the access link 310. Similarly, the relay node 306 may receive uplink messages from the UE 304 over the access link 310 and relay these messages to the donor BS 302 over the backhaul link 308. In this manner, the relay node 306 may, thus, be used to supplement a coverage area and help fill "coverage holes."

EXAMPLE SYSTEM DESIGN FOR L2 UE RELAYS

[0062] As described above, the relay node 306 may comprise a UE relay. UE relays are UEs capable of relaying data traffic from an evolved Node B (eNB) to other UEs, known as terminal UEs or destination UEs. For certain aspects, UE relays may serve as a simple data pipe and may not be involved in radio resource control (RRC) state control of the terminal UEs. For example, signals received by the UE relay from the eNB may be sent directly to the destination UE without any signal modification, such that the UE relay may seem transparent to the destination UE. Furthermore, UE relays may provide unrestricted access therethrough. More specifically, a UE relay may not be involved with security in any way, and a UE relay may only be aware of the PHY/MAC/RLC configuration of the terminal UE to which the UE relay relays data traffic.

[0063] A UE relay may connect to an eNB as a regular UE (i.e., a UE without relay capability). In establishing this connection, the UE relay may be made aware of the physical (PHY), media access control (MAC), and the radio link control (RLC) configurations of the destination UE being served by the UE relay. This awareness may allow the UE relay to schedule traffic to the destination UE. This PHY/MAC/RLC configuration may be conveyed through RRC or higher layer signaling, which may involve new information elements (IEs) and information for each destination UE served by the UE relay. The RLC protocol termination points are the eNB and the destination UE; the UE relay may only implement segmentation and concatenation (i.e., reassembly) functionality of RLC.

[0064] FIG. 4 illustrates an example protocol stack 400 supporting the features and functionality of a UE relay as described above. In this protocol stack 400, the MAC layer is disposed above the PHY layer, and the RLC layer is disposed above the MAC layer. The Non-Access Stratum (NAS), RRC, and Packet Data Convergence Protocol (PDCP) layers are all end-to-end between the eNB/MME 402 and the terminal UE 406 without interception by the UE relay. Because PDCP provides security (e.g., ciphering) of user data, it may be desirable to keep PDCP end-to-end so user data of the UE is ciphered end-to-end and, thus, cannot be eavesdropped by the relay UE 404.

[0065] FIG. 5 illustrates another example protocol stack 500 with partial RRC functionality at the relay UE 404. With this optional protocol stack 500, the relay UE 404 may independently configure the PHY/MAC/RLC configuration for the access link 310 (i.e., the relay-UE-to-destination-UE link), rather than simply being aware of the PHY/MAC/RLC configuration. In this case, the RRC layer is partially terminated at the relay UE 404. However, the relay UE may not be involved in RRC state control.

[0066] Various options exist for deploying relay UEs to relay data between terminal UEs and eNBs. For example, the relay UE may maintain the only direct connection with the terminal UE or the terminal UE may also maintain a direct connection with the eNB. Further, relay UEs may be deployed in single carrier systems or systems utilizing carrier aggregation. In such systems, a terminal UE may be served by an eNB on a first frequency (e.g., a primary component carrier or PCC), while the terminal U E is served by a relay UE on a second frequency (e.g., a secondary component carrier or SCC). FIGs. 6-9 illustrate examples of such deployment options.

[0067] FIG. 6 is a system block diagram 600 of an example relay UE deployment scenario with carrier aggregation, according to an aspect of the present disclosure. With carrier aggregation, the primary component carrier (PCC) may be on f1, and the secondary component carrier (SCC) may be on f2. As illustrated, the terminal UE 406 may be served on carrier frequency f1 by the eNB 402. However, the terminal UE 406 may be served by the relay UE 404 on carrier frequency f2 as shown. For certain aspects, f1 may be in the licensed spectrum, while f2 may be in the unlicensed spectrum, such that traffic may be offloaded to the unlicensed spectrum via the relay UE 404.

[0068] FIG. 7 is a system block diagram 700 of an example relay UE deployment scenario with carrier-aggregation-like features, according to an aspect of the present disclosure. In this deployment scenario, PCC may be on f1, and the SCC may also be on f1. The terminal UE 406 may be served on carrier frequency f1 by the eNB 402 and/or the relay UE 404. Time domain multiplexing (TDM) partitioning may be employed to avoid simultaneous reception at the UE 406. Utilizing TDM in this manner, the UE may be either receiving from or transmitting to either the eNB 402 or the relay UE 404.

[0069] FIG. 8 is a system block diagram 800 of an example single-carrier-aggregation-like relay UE deployment scenario, according to an aspect of the present disclosure. As illustrated, terminal UE 406 may communicate with the eNB exclusively on f1, while the relay UE 404 may communicate with the eNB 402 and terminal UE 406 via f1 and/or f2.

[0070] In this deployment scenario, the UE 406 may monitor the eNB 402 based on active (or on periods) of a discontinuous reception (DRX) procedure. During off periods, the UE may monitor the relay UE 404 instead. In this scenario, the terminal UE 406 may send or receive traffic from either the eNB 402 or the relay UE 404.

[0071] MAC signaling may be utilized to signal link change or flow control. For example a MAC signal may be sent from the eNB 402 to the relay UE 404 to activate/deactivate scheduling of traffic to the UE 406. Similarly, the relay UE 404 may send a MAC signal to the eNB 402 for the eNB to stop scheduling traffic to the relay UE. This instruction may possibly be for a given set of UEs 406. As another example, a MAC signal may be sent from the relay UE 404 to the UE 406 instructing the UE to tune to the eNB 402. Likewise, the eNB 402 may send a MAC signal to the UE 406 instructing the UE to monitor the relay UE 404. In addition, the UE 406 may send a MAC signal to the relay UE 404 instructing the relay UE to stop scheduling traffic to the UE 406 (or a set of terminal UEs). This may occur, for example, due to the start of monitoring the direct eNB link.

[0072] FIG. 9 is a system block diagram 900 of an example single-carrier-mode relay UE deployment scenario, according to an aspect of the present disclosure. As illustrated, the relay UE 404 may communicate with the eNB 402 via f1 exclusively and with the terminal UE 406 via f1 and/or f2.

[0073] In this deployment scenario, the UE 406 has access through the relay UE 404 only, with no direct communication with the eNB 402. In this case, there may be tunneling of signaling radio bearers through the relay UE 404. To maintain transparency, the relay UE may be involved in allowing the UE 406 access and mutual authentication.

[0074] FIG. 10 is a call flow 1000 illustrating what may be considered a baseline procedure for a carrier aggregation mode utilizing a relay UE, according to an aspect of the present disclosure.

[0075] At 1008, the relay UE 404 may perform the initial attach procedure as an ordinary UE (i.e., a UE without relay capability). The relay UE may then register with the eNB as a relay. This registration may be performed based on some criteria, such as measured reference signal received quality (RSRQ) and/or proximity detection of other

UEs, loading measure (such as utilized physical resource blocks, etc.) or other criteria. Almost anything may trigger the relay UE to register as a relay with the eNB. The eNB 402 may also configure the relay UE 404 to schedule data traffic for configured radio bearers for configured UEs. There may be different modes of routing traffic, but there is always a logical (virtual) connection between the UE 406 and the eNB 402.

[0076] At 1010, terminal UE 406 may perform measurements (e.g., of relay UE 404 and eNB 402) and report back to eNB 402. At 1012, carrier aggregation mode may be configured for certain aspects. In carrier aggregation mode, radio bearers may terminate at the eNB 402 and the UE 406 for eNB-to-UE connection, other than relay UE signaling traffic. Logical channels may terminate at the relay UE 404 (as shown at 1014) or may be end-to-end (as shown at 1016).

[0077] FIG. 11 is a call flow 1100 illustrating a baseline procedure for a non-carrier-aggregation mode, according to an aspect of the present disclosure. At 1102, the UE 406 may registered with and be configured by the eNB 402. With this procedure for a non-carrier-aggregation mode, radio bearers may terminate at the eNB 402 and the UE 406 for eNB-to-UE connection as illustrated at 1104, other than relay UE signaling traffic. Logical channels terminate at the relay UE, as shown at 1014.

[0078] To support the aforementioned system considerations for L2 UE relays, changes to current standards (e.g., present LTE standards) may be desired or required. For example, in the RRC (or higher) layer, signaling support may be added for registration and configuration of a relay UE, the potential mapping of radio bearers onto carrier frequencies (e.g., when RLC is not end-to-end between the eNB and the UE), tunneling of UE traffic on the backhaul link, and PHY/MAC/RLC configuration changes.

[0079] For the RLC layer, support may be added for segmentation and reassembly of first transmissions at the relay UE (e.g., when RLC is end-to-end between the eNB and the UE). For the MAC layer, there may be changes to the LTE standard in order to support a large number of radio bearers. For example, header changes may be involved in an effort to accommodate radio bearers mapping. In the PHY layer, support may be added for PUCCH on secondary component carriers. This change may help support hybrid automatic repeat-request (HARQ), unless the relay UE can decode PUCCH intended for the eNB.

[0080] FIG. 12 is a flow diagram of example operations 1200 for relaying data. The operations 1200 may be performed by any type of device acting as a relay, such as relay UE 404 shown in FIGs. 4-9 described above.

[0081] The operations begin, at 1202, with a first UE (e.g., a relay UE) receiving data from a first apparatus. At 1204, the first UE may relay the received data to a second apparatus. The relaying at 1204 may be performed without interpreting or altering security features of the data received at 1202.

[0082] If the operations 1200 are performed by a relay UE transmitting downlink data, the first apparatus would correspond to an eNB and the second apparatus would correspond to a terminal UE. If the operations 1200 are performed by a relay UE transmitting uplink data, the first apparatus would correspond to the terminal UE and the second apparatus would correspond to the eNB.

[0083] According to certain aspects, a protocol stack for the first UE may comprise a physical (PHY) layer, a media access control (MAC) layer disposed above the PHY layer, and a radio link control (RLC) layer disposed above the MAC layer. The relaying may be end-to-end between the first and second apparatuses without interception by the first UE for layers of the protocol stack above the RLC layer. For certain aspects, the first UE is made aware of the PHY/MAC/RLC configuration of the second apparatus. For other aspects, the operations 1200 may further comprise configuring a PHY/MAC/RLC configuration for an access link between the first UE and one of the first and second apparatuses.

[0084] As noted above, in some cases, multiple frequencies may be utilized for communicating between the relay UE, eNB, and terminal UE. For example, according to certain aspects, a relay UE may receive data from the first apparatus at 1202 via a first frequency band and may relay the data to the second apparatus via a second frequency band at 1204. One (or both) of the first and second frequency bands may be in an unlicensed spectrum. In some cases, both frequency bands may be in licensed spectrum.

[0085] For certain aspects, the first UE may be capable of carrier aggregation. For other aspects, the first UE may support functionality that is similar to carrier aggregation ("carrier-aggregation-like" functionality). In this case, rather than use separate frequencies, the relay UE may perform time division multiplexing (TDM) partitioning with signals sent directly from the first apparatus to the second apparatus in some time slots and signals sent via the UE relay sent in other time slots.

[0086] For certain aspects, the first UE may receive, from the first apparatus, a control signal to activate or deactivate the relaying to the second apparatus. For other aspects, the first UE may transmit, to the second apparatus, a control signal directing the second apparatus to tune to the first apparatus. For yet other aspects, the first UE may receive, from the second apparatus, a control signal to stop the relaying to the second apparatus. For still other aspects, the first UE may transmit, to the first apparatus, a control signal directing the first apparatus to stop sending the data to the first UE.

[0087] For certain aspects, the first UE may determine a parameter and register with the first apparatus as a relay (e.g., a UE relay), based on the parameter. The parameter may comprise at least one of a reference signal received quality (RSRQ), a proximity of other UEs, or resource loading.

EXAMPLE CALL FLOWS FOR VARIOUS DEPLOYMENT SCENARIOS

[0088] FIGs. 13-23 are call flows illustrating various UE relay deployment scenarios described above, in greater detail. In general, FIGs. 13-19 are calls flows for single carrier mode (e.g., associated with the deployment scenario shown in FIG. 9), while FIGs. 20-23 are call flows for carrier aggregation mode (e.g., corresponding to the deployment scenario in FIG. 6).

[0089] FIG. 13 is a call flow 1300 illustrating an example initial access procedure, according to an aspect of the present disclosure. As illustrated, the relay UE 404 may first access eNB 402 as a UE (operations 0-8). Subsequently, rather than access the eNB 402 directly, operations for access performed by terminal UE 406 (e.g., operations 9-11, 15-16, and 20-21) may then be tunneled to eNB 402 via relay UE 404 (operations 12-14, 17-19, and 22).

[0090] As described above, due to mobility of both terminal UEs and relay UEs, a number of different handover scenarios may be encountered. These example handover scenarios, including handover of a terminal UE between relay UEs (served by the same eNB or different eNBs), handover of a terminal UE between a relay UE and eNB, and handover of a relay UE between different eNBs, are illustrated in FIGs. 14-23.

[0091] FIG. 14 is a call flow illustrating “backward” handover of terminal UE 406 between relay UEs 404_1 and 404_2, according to aspects of the present disclosure. FIG. 14 illustrates an “intra-eNB” handover where both relay UEs 404_1 and 404_2 are served by the same eNB 402. FIG. 15 illustrates an “inter-eNB” handover where the first relay UE 404_1 is served by a first eNB 402_1 and the second relay UE 404_2 is served by a second eNB 402_2.

[0092] As illustrated, in either case, measurements taken by terminal UE 406 (at operation 1) and a corresponding RRC connection reconfiguration message may be tunneled to/from a current serving eNB (at operations 2, 3, and 4), via relay UE 1 404_1. The terminal UE 406 may then perform random access procedures with relay UE2 (operations 5-7) with the RRC reconfiguration complete message tunneled to the eNB at 8. It may be noted that, in FIG. 14, operations 2, 3, 8, and 9 involve the single eNB 402, while in FIG. 15, operations 2 and 3 are performed with eNB 1 serving relay UE 1, while operations 8 and 9 are performed with eNB 2 serving relay UE 2.

[0093] FIG. 16 is a call flow illustrating handover of a relay UE between different base stations, according to aspects of the present disclosure. In this example, relay UE 404 is handed over from a first eNB 402_1 to the second eNB 402_2. While the UE 406 is served by the same relay UE 404 (before and after handover of relay UE 404), to maintain transparency, an RRC connection reconfiguration message is sent (at 7), as if the UE 1, itself, were handed over from eNB1 to eNB2.

[0094] FIG. 17 is a call flow illustrating handover of a terminal UE from a relay UE to a first base station and handover of the relay UE from the first base station to a second base station, according to aspects of the present disclosure. While operations 1-4 are the same as FIG. 16, an RRC reconfiguration message (sent at operation 5), causes the UE 406 to handover to eNB 1, while an RRC reconfiguration message (sent at operation 10), causes the relay UE 404 to handover from eNB 1 to eNB 2.

[0095] FIG. 18 is a call flow illustrating handover of a relay UE from a first base station to a second base station and handover of a terminal UE from the relay UE to the second base station, according to aspects of the present disclosure. This call flow is similar to the call flow shown in FIG. 17, except that both terminal UE 406 and relay UE are both handed over to eNB 2.

[0096] FIG. 19 is a call flow illustrating handover of a terminal UE from a first base station to a relay UE, according to aspects of the present disclosure. In this manner, the relay UE 404 may be introduced into communications between the eNB 402 and the UE 406, such that coverage may be extended as the UE 406 moves away from the eNB 402, for example.

[0097] As illustrated, the call flow assumes UE 406 is initially served by eNB 402. After sending a measurement report, an RRC reconfiguration message (sent at operation 2), causes the UE 406 to handover from eNB 402 to relay UE 404. Subsequent operations 5-8 correspond to similar operations shown in other figures, such as operations 7-10 of FIG. 14.

[0098] FIG. 20 is a call flow illustrating initial access of a relay UE with a base station in a carrier aggregation mode, according to aspects of the present disclosure. As illustrated, the operations for initial access shown in FIG. 20 may be similar to those shown in FIG. 13 (for single carrier mode) but RRC connection reconfiguration and RRC connection reconfiguration complete messages are exchanged directly between the eNB 402 and UE 406.

[0099] FIG. 21 is a call flow illustrating handover of a terminal UE between relay UEs served by a common base station in a carrier aggregation mode, according to aspects of the present disclosure. As illustrated, the operations shown in FIG. 21 may be similar to those shown in FIG. 14 (for single carrier mode handover between UE relays) but the measurement report, RRC connection reconfiguration and RRC connection reconfiguration complete messages are exchanged directly between the eNB 402 and UE 406, rather than tunneled through a relay UE.

[00100] FIG. 22 is a call flow illustrating handover of a terminal UE between relay UEs served by different base stations in a carrier aggregation mode, according to aspects of the present disclosure. As illustrated, the operations shown in FIG. 22 may

be similar to those shown in FIG. 15 (for single carrier mode handover between UE relays served by different eNBs) but the measurement report, RRC connection reconfiguration and RRC connection reconfiguration complete messages are exchanged directly between the terminal UE 406 and the eNBs.

[00101] In addition, terminal UE may perform random access procedures with the target eNB2, before performing random access procedures with the target relay UE 2. In this manner, eNB 2 and relay UE 2 may both serve the terminal UE (e.g., on different frequencies or on the same frequency via TDM) as discussed above.

[00102] FIG. 23 is a call flow illustrating handover of a relay UE between different base stations in a carrier aggregation mode, according to aspects of the present disclosure. As illustrated, the operations shown in FIG. 23 may be similar to those shown in FIG. 16 (for single carrier mode handover of a relay UE between eNBs) but the UE measurement report, RRC connection reconfiguration and RRC connection reconfiguration complete messages may be exchanged directly between the terminal UE 406 and the current and targeted eNBs involved in handover of the relay UE 404.

[00103] In the above-described carrier aggregation deployments of relay UEs, similar operations may be performed when handing over a terminal UE between eNBs and relay UEs, as when adding/removing secondary cells (SCells) or changing primary cells (PCells) in carrier aggregation scenarios.

[00104] For example, for a backward handover from the relay UE 404 to the first eNB 402_1 for communications involving the UE 406 and a handover of the relay UE 404 from the first eNB 402_1 to the second eNB 402_2, the UE 406 may use a similar or same call flow as removal of an SCell for carrier aggregation. For example, a relay UE 404 may use an LTE Rel 8 handover procedure followed by configuration of relay UE overhead information.

[00105] For a backward handover from the relay UE 404 to the second eNB 402_2 for communications involving the UE 406 and a handover of the relay UE 404 from the first eNB 402_1 to the second eNB 402_2, the UE 406 may use the same call flow as change of PCell. The relay UE 404 may use an LTE Rel 8 handover procedure followed by configuration of relay UE overhead information.

[00106] For a backward intra-eNB handover from the eNB 402 to the relay UE 404 for communications with the UE 406 (e.g., to introduce the relay UE 404 into communications between the eNB 402 and the UE 406), the UE may use the same call flow as change of SCell.

[00107] The various operations of methods described above may be performed by any suitable means capable of performing the corresponding functions. The means may include various hardware and/or software component(s) and/or module(s), including, but not limited to a circuit, an application specific integrated circuit (ASIC), or processor. Generally, where there are operations illustrated in Figures, those operations may have corresponding counterpart means-plus-function components with similar numbering.

[00108] For example, means for transmitting, means for relaying, or means for registering may comprise a transmitter (e.g., a transmitter 222) and/or an antenna 224 of the transmitter system 210 or a transmitter (e.g., a transmitter 254) and/or an antenna 252 of the receiver system 250 illustrated in FIG. 2. Means for receiving or means for registering may comprise a receiver (e.g., a receiver 254) and/or an antenna 252 of the receiver system 250 or a receiver (e.g., a receiver 222) and/or an antenna 224 of the transmitter system 210 illustrated in FIG. 2. Means for processing, means for determining, means for configuring, or means for registering may comprise a processing system, which may include at least one processor, such as the RX data processor 260, the processor 270, and/or the TX data processor 238 of the receiver system 250 or the RX data processor 242, the processor 230, and/or the TX data processor 214 of the transmitter system 210 illustrated in FIG. 2.

[00109] It is understood that the specific order or hierarchy of steps in the processes disclosed is an example of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the present disclosure. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[00110] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[00111] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[00112] The various illustrative 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.

[00113] The steps of a method or algorithm described in connection with the embodiments 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, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such 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. The processor and the storage medium may reside in an ASIC. 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.

[00114] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present disclosure. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the disclosure. Thus, the present disclosure is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

WHAT IS CLAIMED IS:

CLAIMS

1. A method for wireless communications, comprising:

receiving, at a first user equipment (UE) functioning as a relay, data from a first apparatus; and

relaying the data to a second apparatus without interpreting or altering security features of the data.

2. The method of claim 1, wherein the first apparatus comprises an evolved Node B (eNB) and the second apparatus comprises a second UE.

3. The method of claim 1, wherein the first apparatus comprises a second UE and the second apparatus comprises an evolved Node B (eNB).

4. The method of claim 1, wherein a protocol stack for the first UE comprises:

a physical (PHY) layer;

a media access control (MAC) layer disposed above the PHY layer; and

a radio link control (RLC) layer disposed above the MAC layer.

5. The method of claim 4, wherein the relaying is end-to-end between the first and second apparatuses without interception by the first UE for layers of the protocol stack above the RLC layer.

6. The method of claim 4, wherein the first UE is aware of a PHY/MAC/RLC configuration of the second apparatus.

7. The method of claim 4, further comprising configuring a PHY/MAC/RLC configuration for an access link between the first UE and one of the first and second apparatuses.

8. The method of claim 1, wherein the first UE is capable of carrier aggregation.

9. The method of claim 1, wherein the receiving comprises receiving the data from the first apparatus via a first frequency band and wherein the relaying comprises relaying the data to the second apparatus via a second frequency band.

10. The method of claim 9, wherein one of the first and second frequency bands is in an unlicensed spectrum.

11. The method of claim 1, wherein the relaying comprises time division multiplexing (TDM) partitioning with signals sent directly from the first apparatus to the second apparatus.

12. The method of claim 1, further comprising receiving, from the first apparatus, a control signal to activate or deactivate the relaying to the second apparatus.

13. The method of claim 1, further comprising transmitting, to the second apparatus, a control signal directing the second apparatus to tune to the first apparatus.

14. The method of claim 1, further comprising receiving, from the second apparatus, a control signal to stop the relaying to the second apparatus.

15. The method of claim 1, further comprising transmitting, to the first apparatus, a control signal directing the first apparatus to stop sending the data to the first UE.

16. The method of claim 1, further comprising:

determining a parameter; and

registering with the first apparatus as s relay based on the parameter.

17. The method of claim 16, wherein the parameter comprises at least one of a reference signal received quality (RSRQ), a proximity of other UEs, or resource loading.

18. A first user equipment (UE) configured to function as a relay for wireless communications, comprising:

a receiver configured to receive data from a first apparatus; and

a transmitter configured to relay the data to a second apparatus without interpreting or altering security features of the data.

19. The first UE of claim 18, wherein the first apparatus comprises an evolved Node B (eNB) and the second apparatus comprises a second UE.

20. The first UE of claim 18, wherein the first apparatus comprises a second UE and the second apparatus comprises an evolved Node B (eNB).

21. The first UE of claim 18, wherein a protocol stack for the first UE comprises:
a physical (PHY) layer;
a media access control (MAC) layer disposed above the PHY layer; and
a radio link control (RLC) layer disposed above the MAC layer.

22. The first UE of claim 21, wherein the relaying is end-to-end between the first and second apparatuses without interception by the first UE for layers of the protocol stack above the RLC layer.

23. The first UE of claim 21, wherein the first UE is aware of a PHY/MAC/RLC configuration of the second apparatus.

24. The first UE of claim 21, further comprising a processing system for configuring a PHY/MAC/RLC configuration for an access link between the first UE and one of the first and second apparatuses.

25. The first UE of claim 18, wherein the first UE is capable of carrier aggregation.

26. The first UE of claim 18, wherein the receiver is configured to receive the data from the first apparatus via a first frequency band and wherein the transmitter is configured to relay the data to the second apparatus via a second frequency band.

27. The first UE of claim 26, wherein one of the first and second frequency bands is in an unlicensed spectrum.

28. The first UE of claim 18, wherein the relaying comprises time division multiplexing (TDM) partitioning with signals sent directly from the first apparatus to the second apparatus.

29. The first UE of claim 18, wherein the receiver is configured to receive, from the first apparatus, a control signal to activate or deactivate the relaying to the second apparatus.

30. The first UE of claim 18, wherein the transmitter is configured to transmit, to the second apparatus, a control signal directing the second apparatus to tune to the first apparatus.

31. The first UE of claim 18, wherein the receiver is configured to receive, from the second apparatus, a control signal to stop the relaying to the second apparatus.

32. The first UE of claim 18, wherein the transmitter is configured to transmit, to the first apparatus, a control signal directing the first apparatus to stop sending the data to the first UE.

33. The first UE of claim 18, further comprising a processing system configured to:
determine a parameter; and
register with the first apparatus as the relay based on the parameter.

34. The first UE of claim 33, wherein the parameter comprises at least one of a reference signal received quality (RSRQ), a proximity of other UEs, or resource loading.

35. A first user equipment (UE) functioning as a relay for wireless communications, comprising:
means for receiving data from a first apparatus; and
means for relaying the data to a second apparatus without interpreting or altering security features of the data.

36. The first UE of claim 35, wherein the first apparatus comprises an evolved Node B (eNB) and the second apparatus comprises a second UE.

37. The first UE of claim 35, wherein the first apparatus comprises a second UE and the second apparatus comprises an evolved Node B (eNB).

38. The first UE of claim 35, wherein a protocol stack for the first UE comprises:
a physical (PHY) layer;
a media access control (MAC) layer disposed above the PHY layer; and
a radio link control (RLC) layer disposed above the MAC layer.

39. The first UE of claim 38, wherein the relaying is end-to-end between the first and second apparatuses without interception by the first UE for layers of the protocol stack above the RLC layer.

40. The first UE of claim 38, wherein the first UE is aware of a PHY/MAC/RLC configuration of the second apparatus.

41. The first UE of claim 38, further comprising means for configuring a PHY/MAC/RLC configuration for an access link between the first UE and one of the first and second apparatuses.

42. The first UE of claim 35, wherein the first UE is capable of carrier aggregation.

43. The first UE of claim 35, wherein the means for receiving is configured to receive the data from the first apparatus via a first frequency band and wherein the means for relaying is configured to relay the data to the second apparatus via a second frequency band.

44. The first UE of claim 43, wherein one of the first and second frequency bands is in an unlicensed spectrum.

45. The first UE of claim 35, wherein the relaying comprises time division multiplexing (TDM) partitioning with signals sent directly from the first apparatus to the second apparatus.

46. The first UE of claim 35, wherein the means for receiving is configured to receive, from the first apparatus, a control signal to activate or deactivate the relaying to the second apparatus.

47. The first UE of claim 35, further comprising means for transmitting, to the second apparatus, a control signal directing the second apparatus to tune to the first apparatus.

48. The first UE of claim 35, wherein the means for receiving is configured to receive, from the second apparatus, a control signal to stop the relaying to the second apparatus.

49. The first UE of claim 35, further comprising means for transmitting, to the first apparatus, a control signal directing the first apparatus to stop sending the data to the first UE.

50. The first UE of claim 35, further comprising:

means for determining a parameter; and

means for registering with the first apparatus as the relay based on the parameter.

51. The first UE of claim 50, wherein the parameter comprises at least one of a reference signal received quality (RSRQ), a proximity of other UEs, or resource loading.

52. A computer-program product for wireless communications, comprising:

a computer-readable medium comprising code for:

receiving, at a first user equipment (UE) functioning as a relay, data from a first apparatus; and

relaying the data to a second apparatus without interpreting or altering security features of the data.

53. The computer-program product of claim 52, wherein the first apparatus comprises an evolved Node B (eNB) and the second apparatus comprises a second UE.

54. The computer-program product of claim 52, wherein the first apparatus comprises a second UE and the second apparatus comprises an evolved Node B (eNB).

55. The computer-program product of claim 52, wherein a protocol stack for the first UE comprises:

a physical (PHY) layer;

a media access control (MAC) layer disposed above the PHY layer; and

a radio link control (RLC) layer disposed above the MAC layer.

56. The computer-program product of claim 55, wherein the relaying is end-to-end between the first and second apparatuses without interception by the first UE for layers of the protocol stack above the RLC layer.

57. The computer-program product of claim 55, wherein the first UE is aware of a PHY/MAC/RLC configuration of the second apparatus.

58. The computer-program product of claim 55, further comprising code for configuring a PHY/MAC/RLC configuration for an access link between the first UE and one of the first and second apparatuses.

59. The computer-program product of claim 52, wherein the first UE is capable of carrier aggregation.

60. The computer-program product of claim 52, wherein the receiving comprises receiving the data from the first apparatus via a first frequency band and wherein the relaying comprises relaying the data to the second apparatus via a second frequency band.

61. The computer-program product of claim 60, wherein one of the first and second frequency bands is in an unlicensed spectrum.

62. The computer-program product of claim 52, wherein the relaying comprises time division multiplexing (TDM) partitioning with signals sent directly from the first apparatus to the second apparatus.

63. The computer-program product of claim 52, further comprising code for receiving, from the first apparatus, a control signal to activate or deactivate the relaying to the second apparatus.

64. The computer-program product of claim 52, further comprising code for transmitting, to the second apparatus, a control signal directing the second apparatus to tune to the first apparatus.

65. The computer-program product of claim 52, further comprising code for receiving, from the second apparatus, a control signal to stop the relaying to the second apparatus.

66. The computer-program product of claim 52, further comprising code for transmitting, to the first apparatus, a control signal directing the first apparatus to stop sending the data to the first UE.

67. The computer-program product of claim 52, further comprising code for:
determining a parameter; and
registering with the first apparatus as the relay based on the parameter.

68. The computer-program product of claim 67, wherein the parameter comprises at least one of a reference signal received quality (RSRQ), a proximity of other UEs, or resource loading.

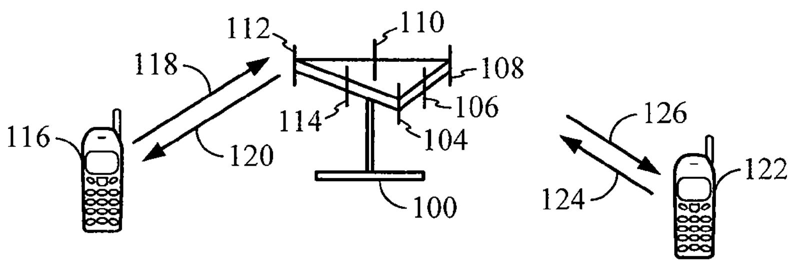

112
110
108
118
106
114
104
116
120
126
122
124
100

FIG. 1

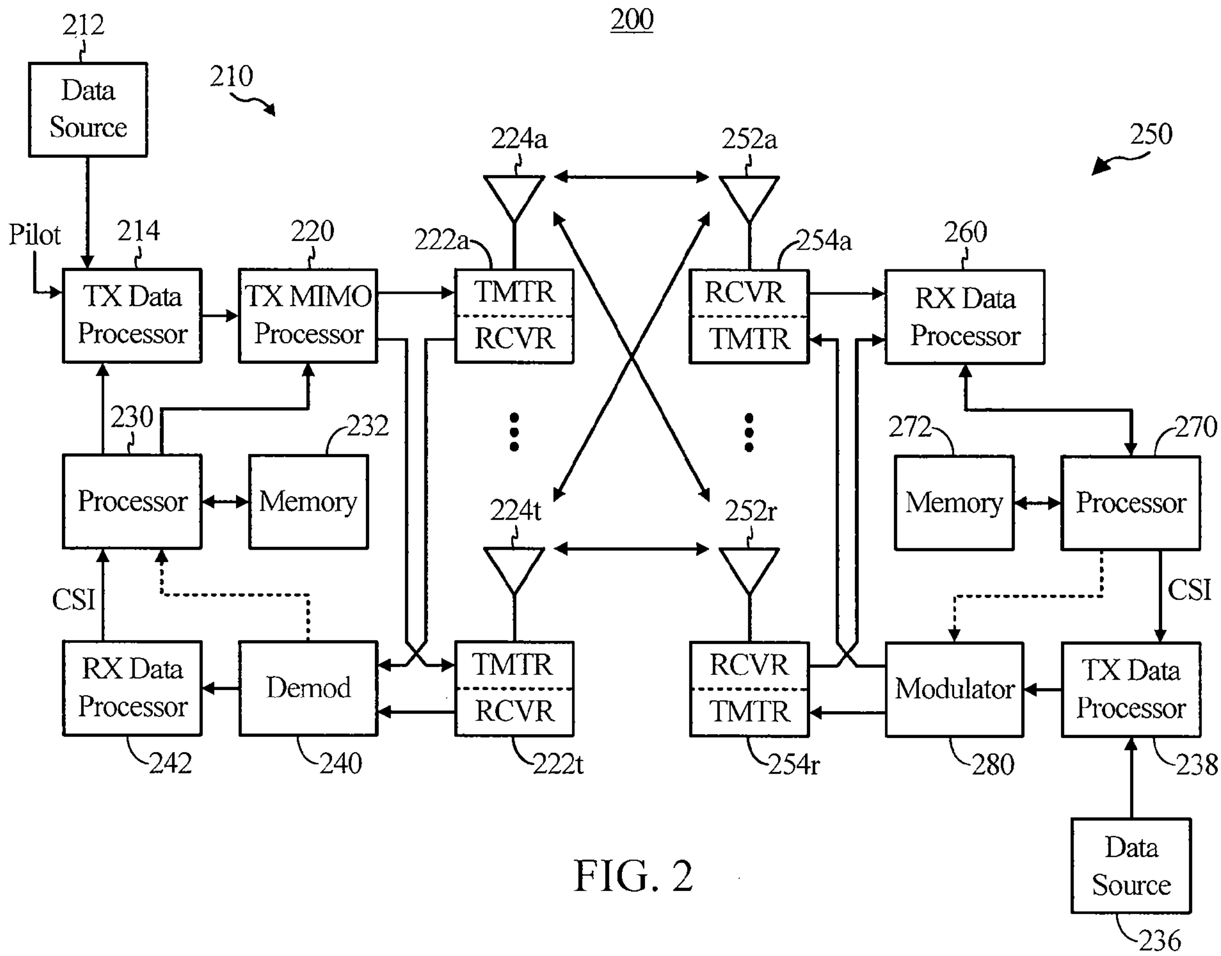

200
212
Data Source
210
250
224a
252a
Pilot
214
220
222a
254a
260
TX Data Processor
TX MIMO Processor
TMTR
RCVR
RCVR
TMTR
RX Data Processor
230
232
272
270
Processor
Memory
Memory
Processor
224t
252r
CSI
CSI
RX Data Processor
Demod
TMTR
RCVR
RCVR
TMTR
Modulator
TX Data Processor
242
240
222t
254r
280
238
Data Source
236

FIG. 2

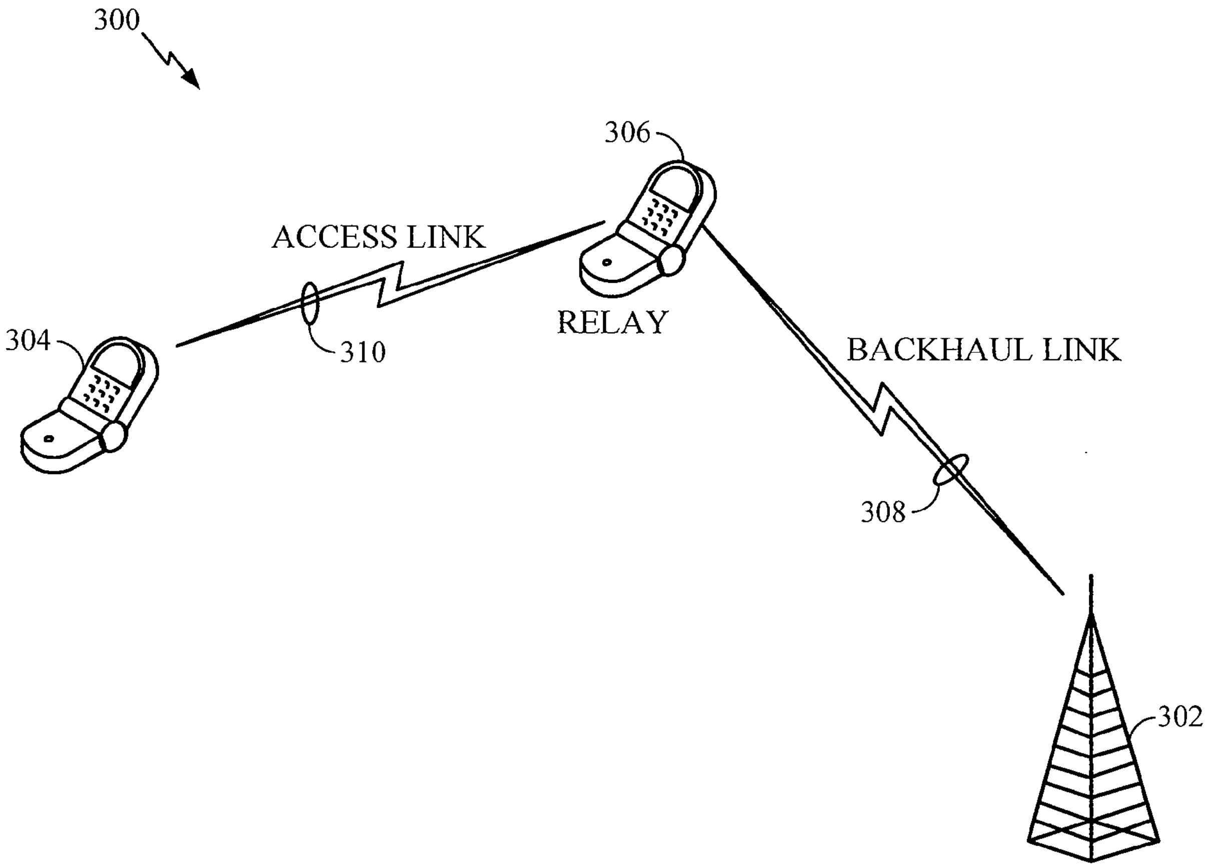


FIG. 3

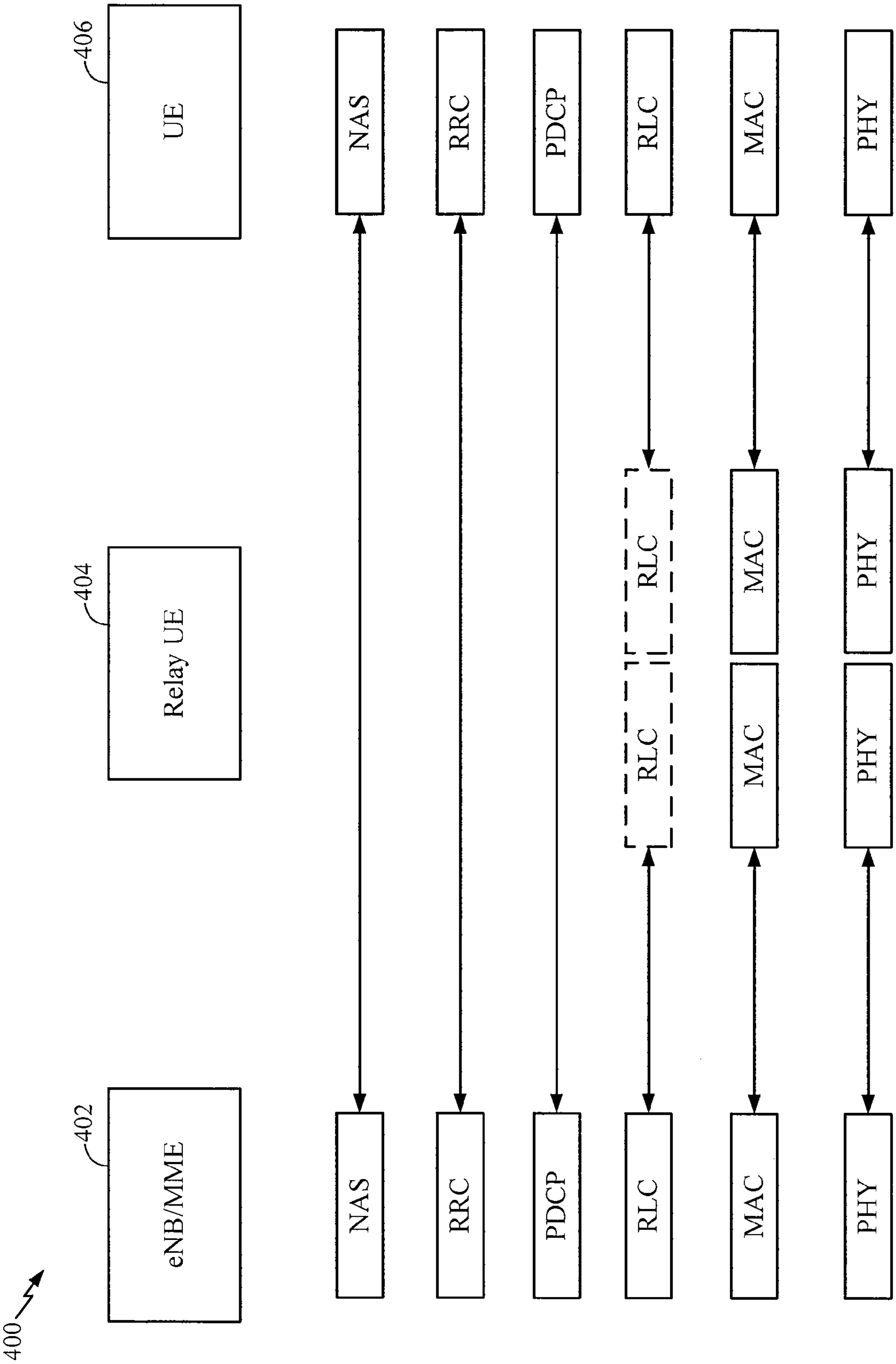

400
402
eNB/MME
404
Relay UE
406
UE
NAS
RRC
PDCP
RLC
MAC
PHY
NAS
RRC
PDCP
RLC
MAC
PHY
RLC
MAC
PHY
RLC
MAC
PHY

FIG. 4

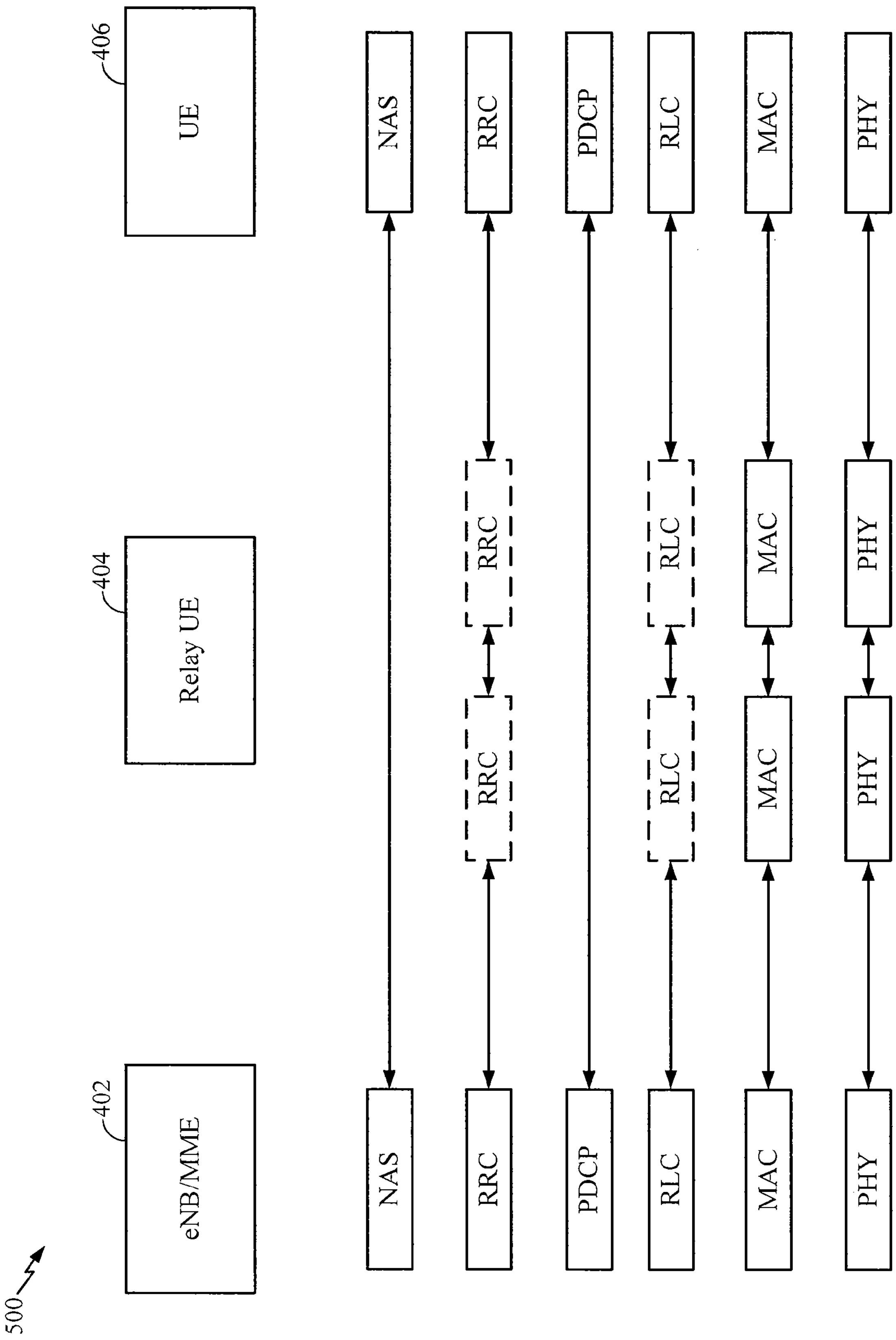

406
UE
404
Relay UE
402
eNB/MME
500
NAS
RRC
PDCP
RLC
MAC
PHY
RRC
RLC
MAC
PHY
RRC
RLC
MAC
PHY
NAS
RRC
PDCP
RLC
MAC
PHY

FIG. 5

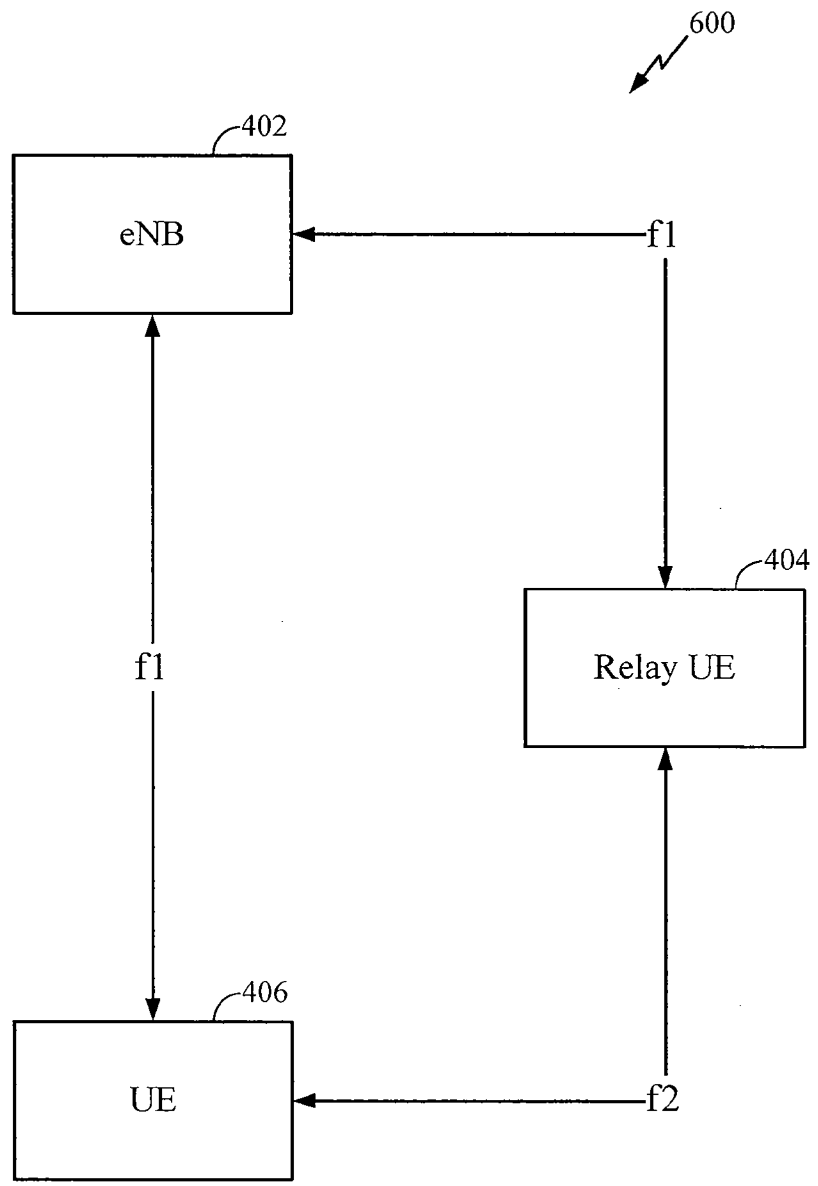


FIG. 6

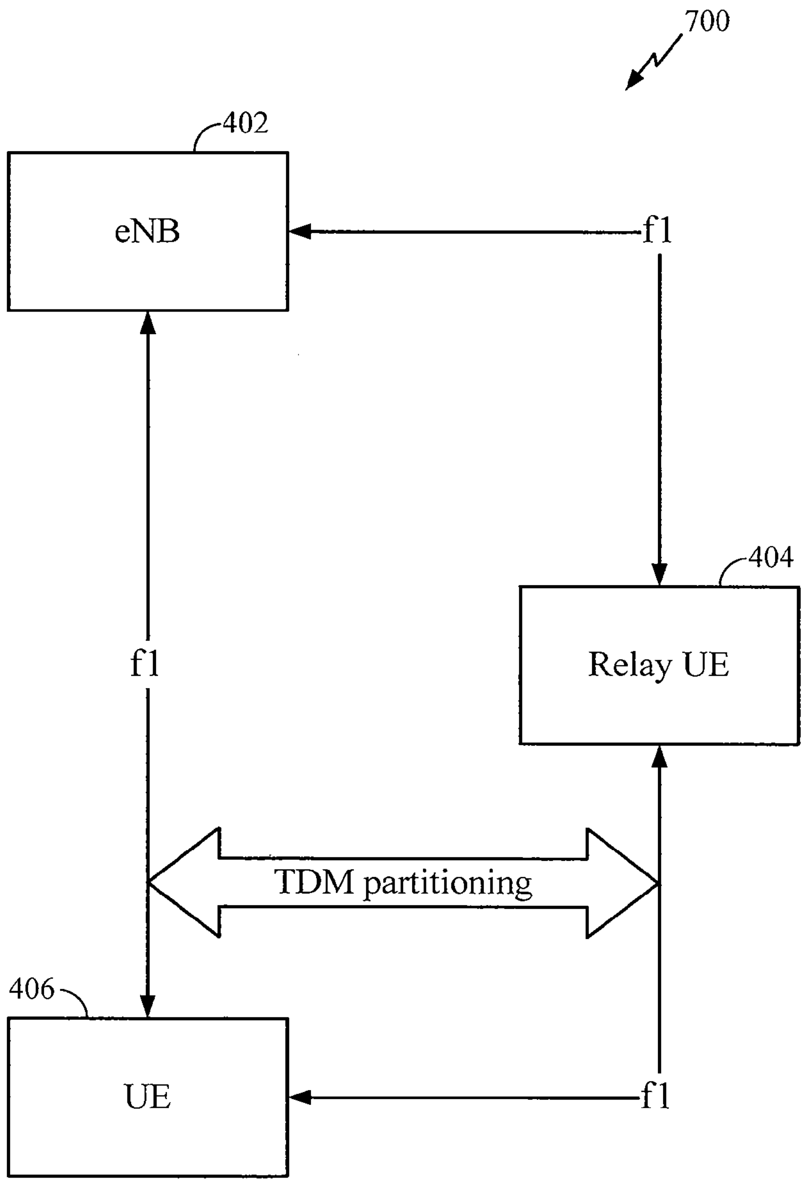


FIG. 7

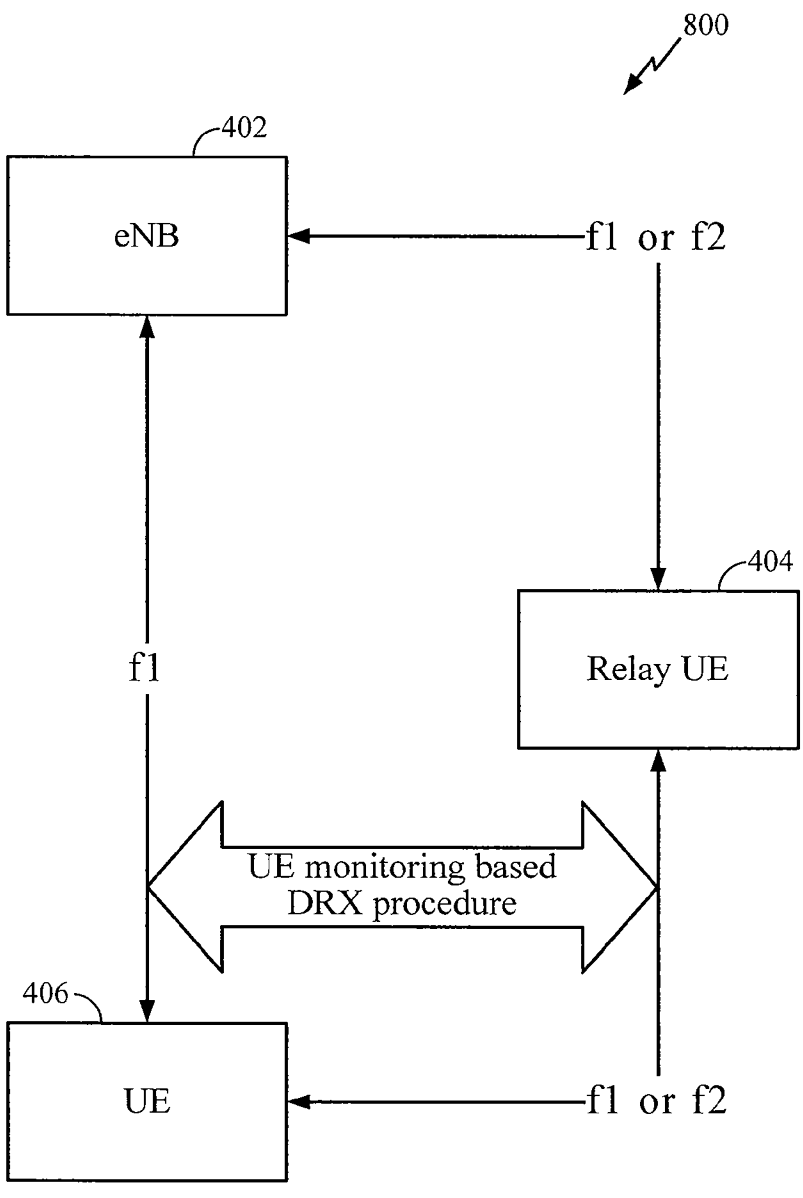

800
402
eNB
f1 or f2
404
Relay UE
f1
UE monitoring based
DRX procedure
406
UE
f1 or f2

FIG. 8

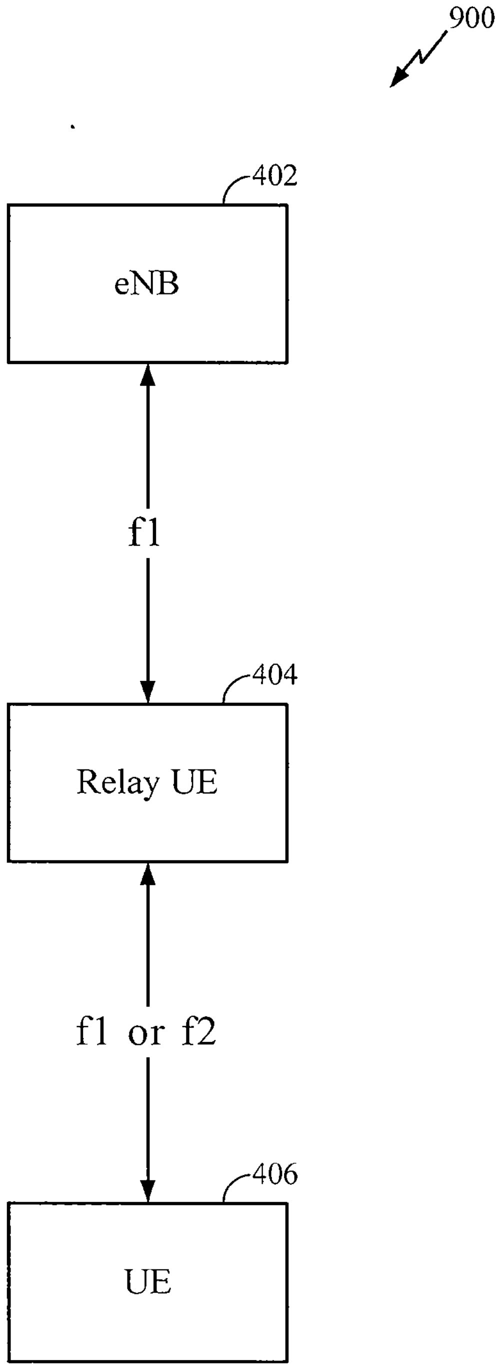
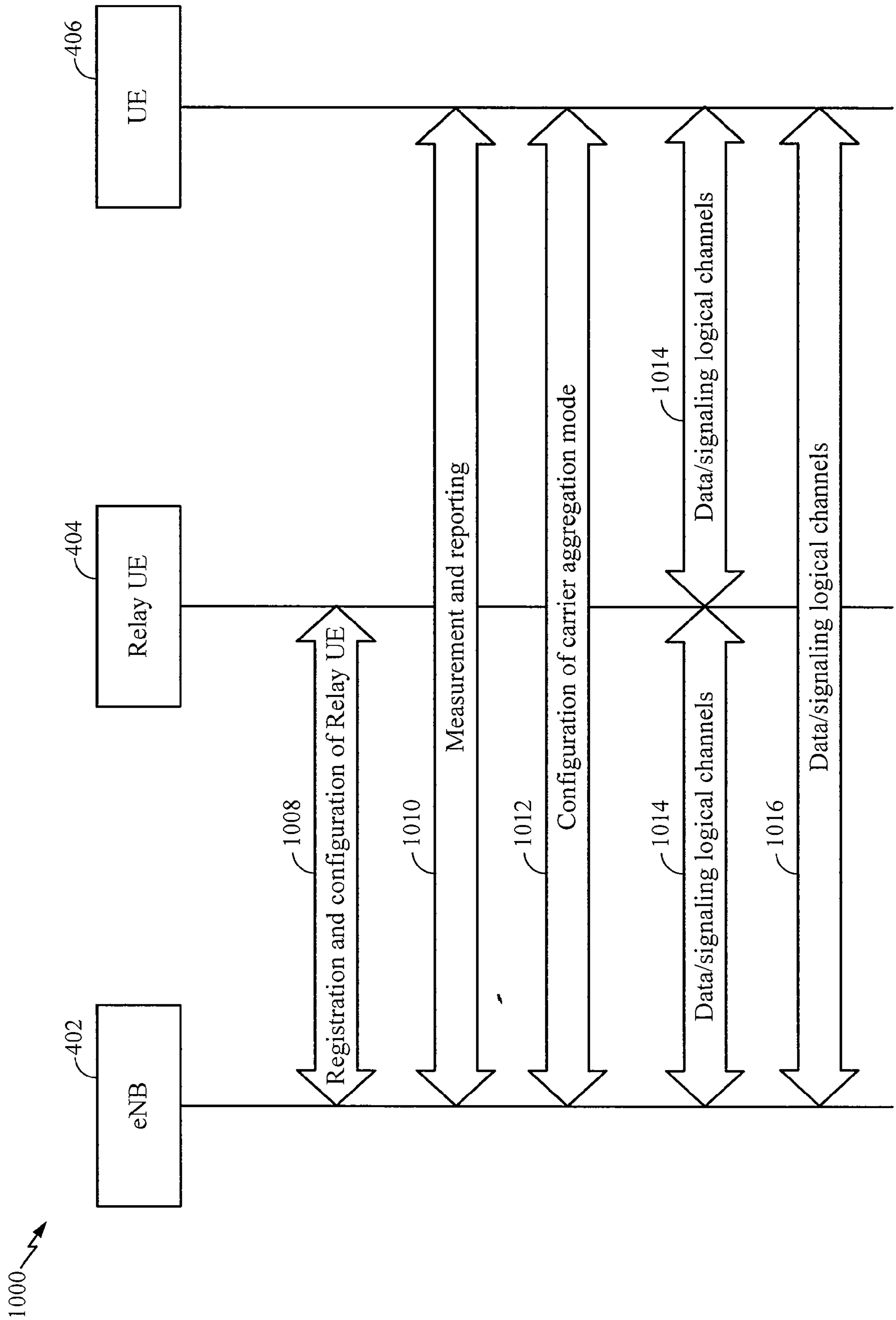


FIG. 9



1000
eNB
402
Relay UE
404
UE
406
1008
Registration and configuration of Relay UE
1010
Measurement and reporting
1012
Configuration of carrier aggregation mode
1014
Data/signaling logical channels
1014
Data/signaling logical channels
1016
Data/signaling logical channels

FIG. 10

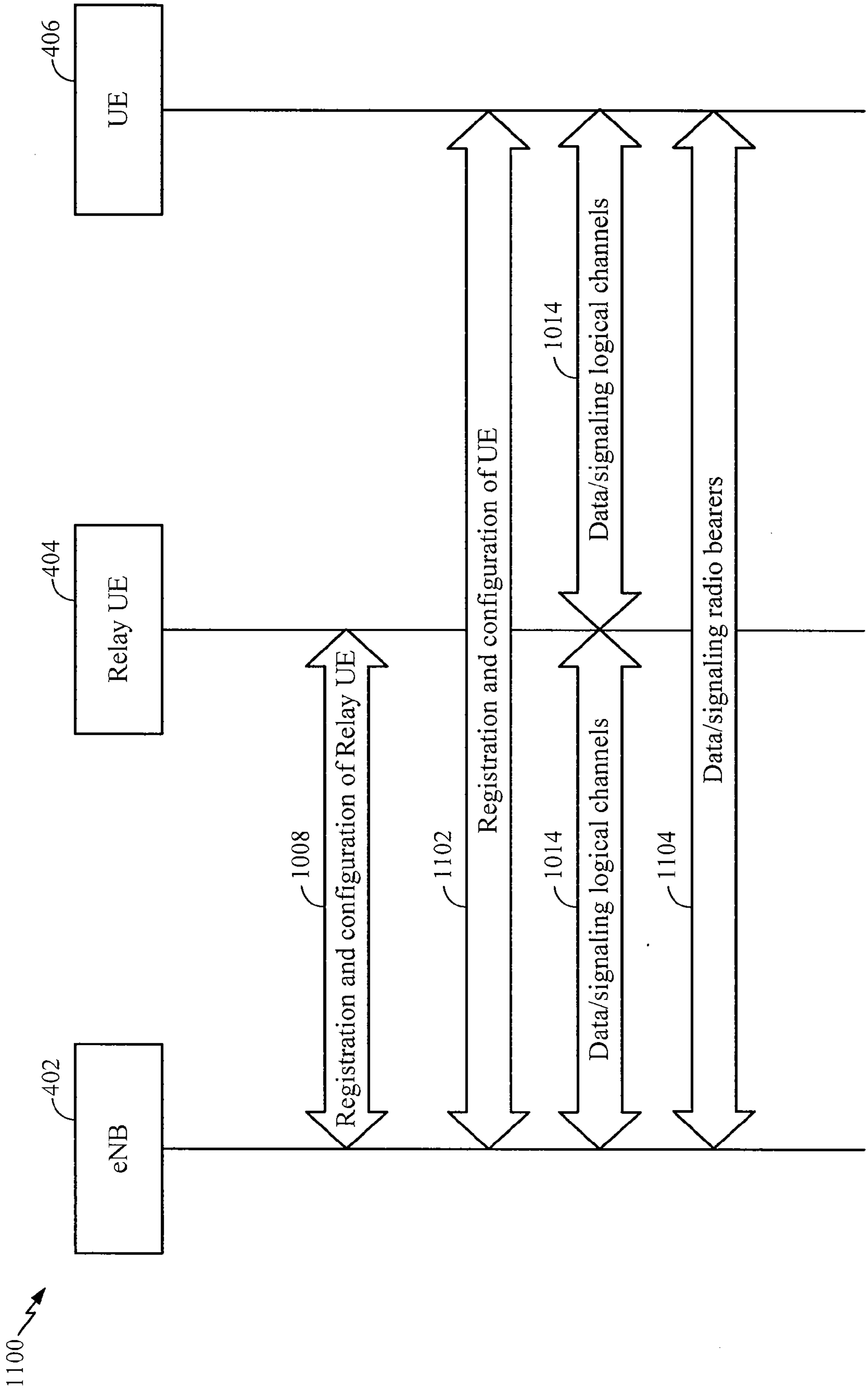

1100
402
eNB
404
Relay UE
406
UE
1008
Registration and configuration of Relay UE
1102
Registration and configuration of UE
1014
Data/signaling logical channels
1014
Data/signaling logical channels
1104
Data/signaling radio bearers

FIG. 11

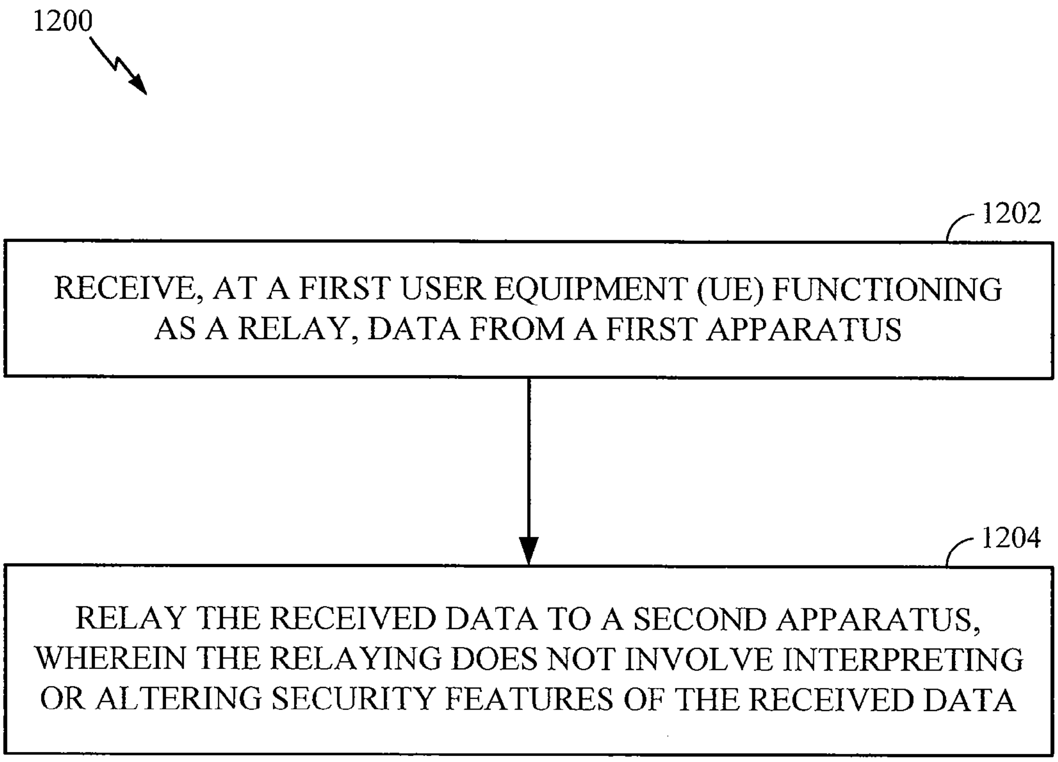

1200
1202
RECEIVE, AT A FIRST USER EQUIPMENT (UE) FUNCTIONING AS A RELAY, DATA FROM A FIRST APPARATUS
1204
RELAY THE RECEIVED DATA TO A SECOND APPARATUS, WHEREIN THE RELAYING DOES NOT INVOLVE INTERPRETING OR ALTERING SECURITY FEATURES OF THE RECEIVED DATA

FIG. 12

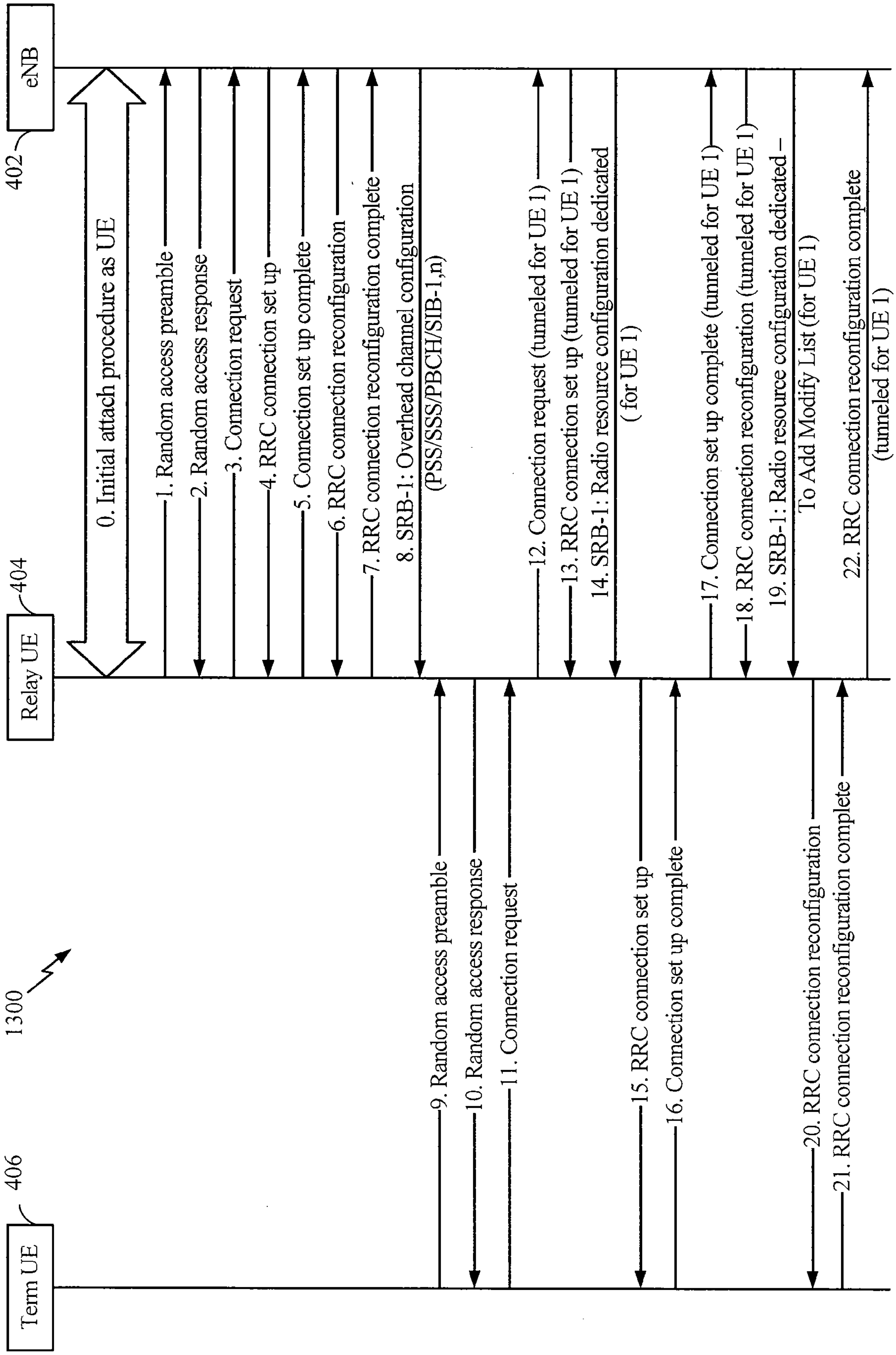

1300
402
eNB
404
Relay UE
406
Term UE
0. Initial attach procedure as UE
1. Random access preamble
2. Random access response
3. Connection request
4. RRC connection set up
5. Connection set up complete
6. RRC connection reconfiguration
7. RRC connection reconfiguration complete
8. SRB-1: Overhead channel configuration (PSS/SSS/PBCH/SIB-1,n)
9. Random access preamble
10. Random access response
11. Connection request
12. Connection request (tunneled for UE 1)
13. RRC connection set up (tunneled for UE 1)
14. SRB-1: Radio resource configuration dedicated (for UE 1)
15. RRC connection set up
16. Connection set up complete
17. Connection set up complete (tunneled for UE 1)
18. RRC connection reconfiguration (tunneled for UE 1)
19. SRB-1: Radio resource configuration dedicated – To Add Modify List (for UE 1)
20. RRC connection reconfiguration
21. RRC connection reconfiguration complete
22. RRC connection reconfiguration complete (tunneled for UE 1)

FIG. 13

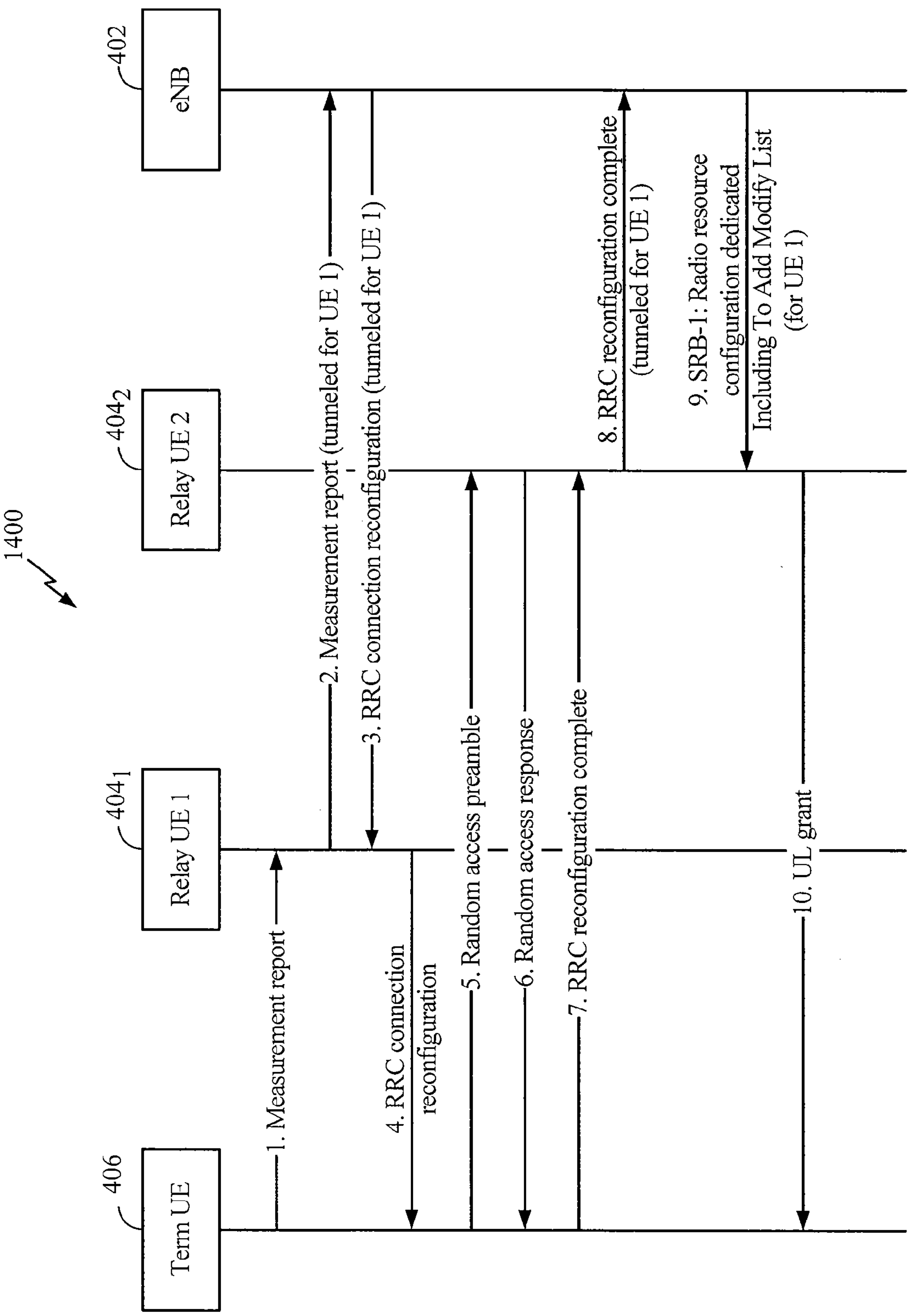

1400
402
eNB
404_2
Relay UE 2
404_1
Relay UE 1
406
Term UE
1. Measurement report
2. Measurement report (tunneled for UE 1)
3. RRC connection reconfiguration (tunneled for UE 1)
4. RRC connection reconfiguration
5. Random access preamble
6. Random access response
7. RRC reconfiguration complete
8. RRC reconfiguration complete (tunneled for UE 1)
9. SRB-1: Radio resource configuration dedicated Including To Add Modify List (for UE 1)
10. UL grant

FIG. 14

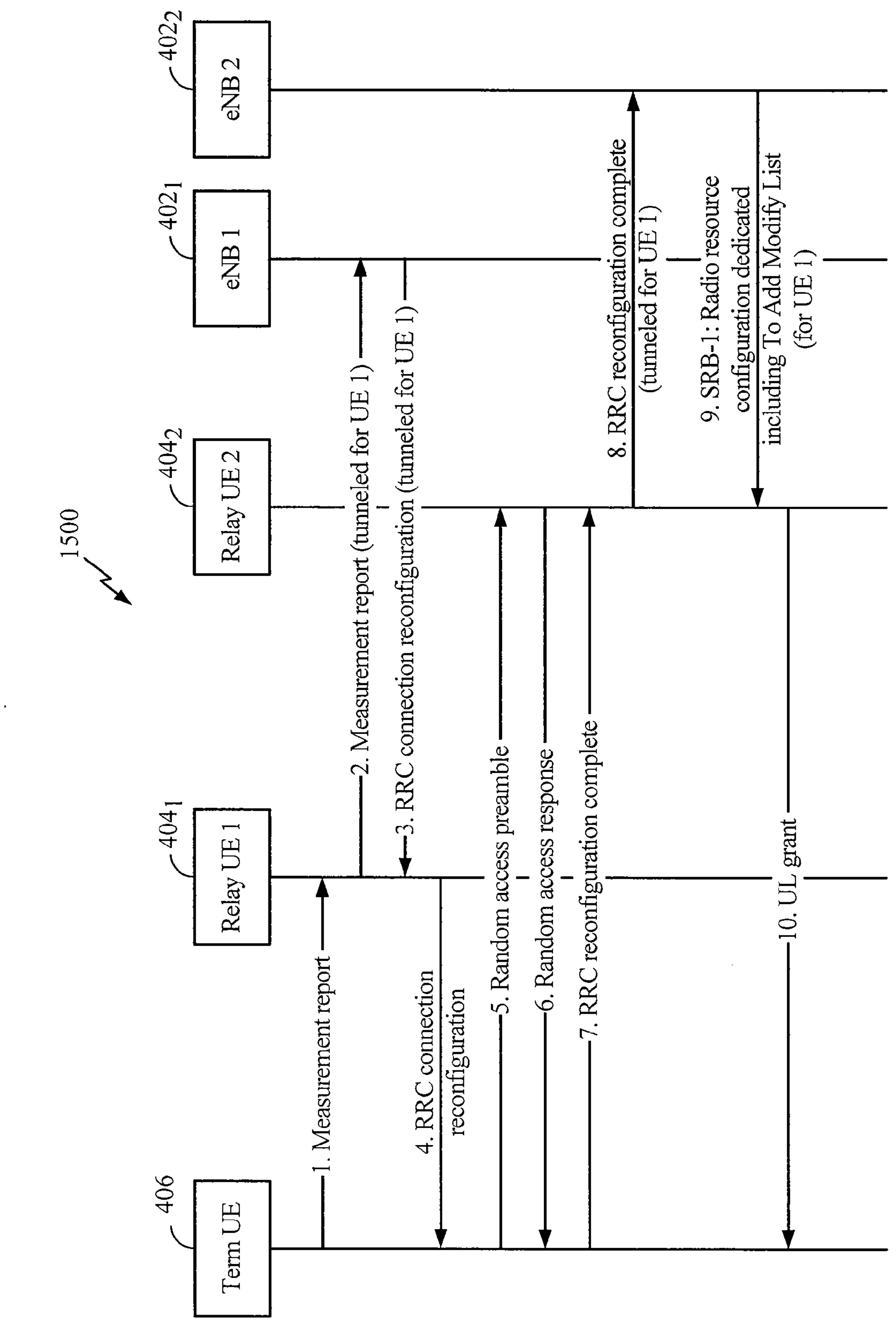

1500
406
Term UE
404₁
Relay UE 1
404₂
Relay UE 2
402₁
eNB 1
402₂
eNB 2
1. Measurement report
2. Measurement report (tunneled for UE 1)
3. RRC connection reconfiguration (tunneled for UE 1)
4. RRC connection reconfiguration
5. Random access preamble
6. Random access response
7. RRC reconfiguration complete
8. RRC reconfiguration complete (tunneled for UE 1)
9. SRB-1: Radio resource configuration dedicated including To Add Modify List (for UE 1)
10. UL grant

FIG. 15

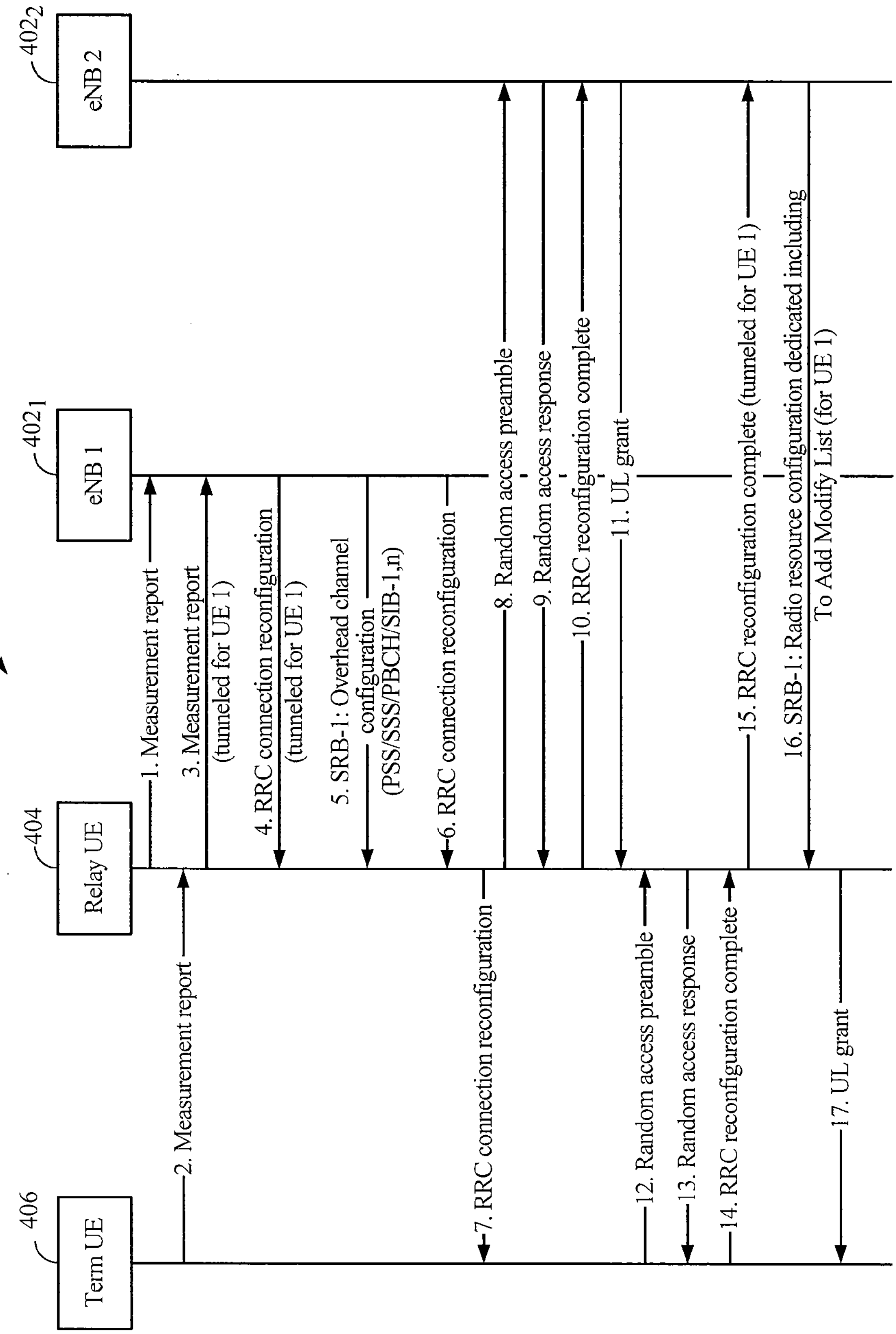

1600
402₂
eNB 2
402₁
eNB 1
404
Relay UE
406
Term UE
1. Measurement report
2. Measurement report
3. Measurement report (tunneled for UE 1)
4. RRC connection reconfiguration (tunneled for UE 1)
5. SRB-1: Overhead channel configuration (PSS/SSS/PBCH/SIB-1,n)
6. RRC connection reconfiguration
7. RRC connection reconfiguration
8. Random access preamble
9. Random access response
10. RRC reconfiguration complete
11. UL grant
12. Random access preamble
13. Random access response
14. RRC reconfiguration complete
15. RRC reconfiguration complete (tunneled for UE 1)
16. SRB-1: Radio resource configuration dedicated including To Add Modify List (for UE 1)
17. UL grant

FIG. 16

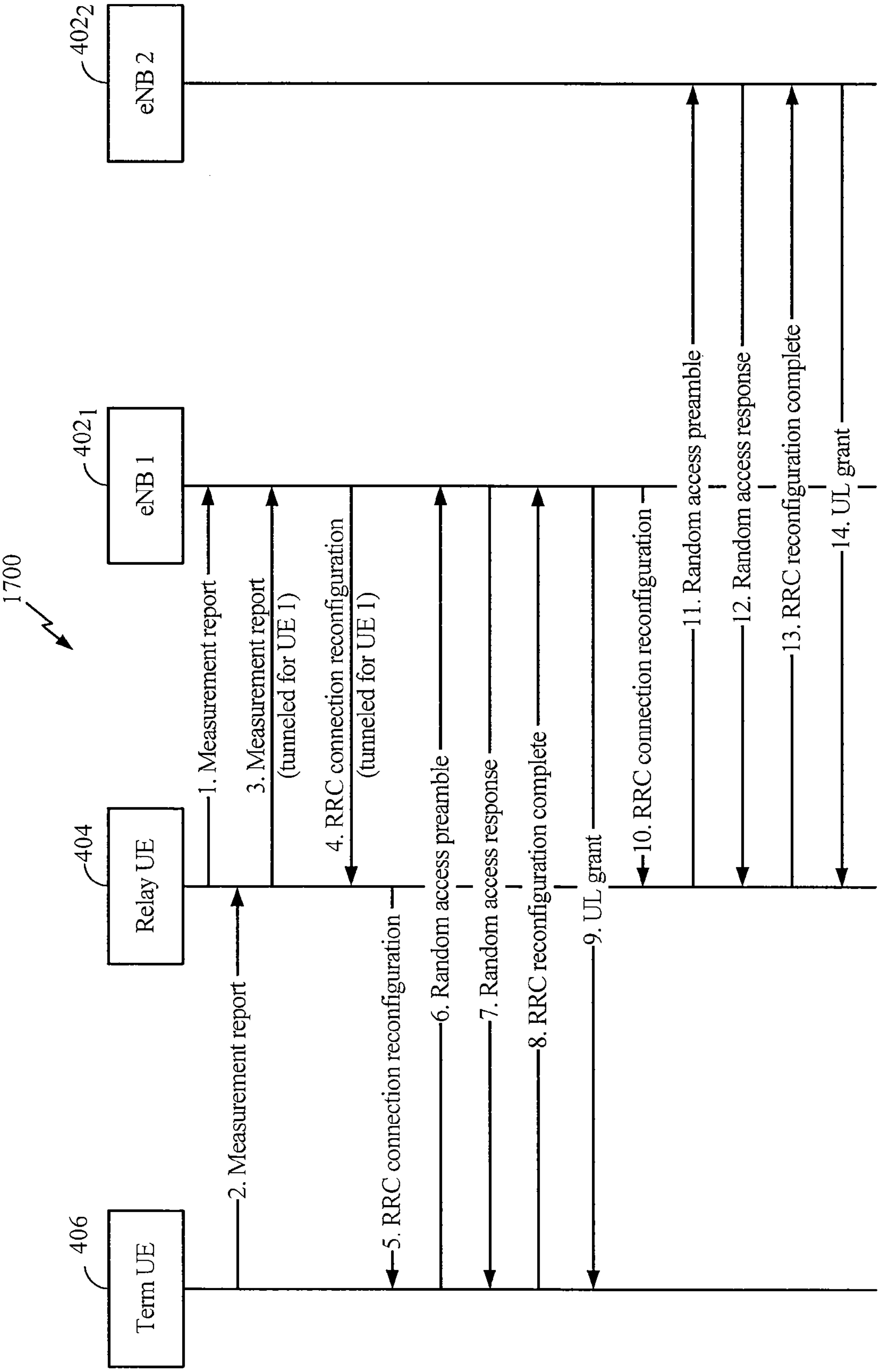

1700
402₂
eNB 2
402₁
eNB 1
404
Relay UE
406
Term UE
1. Measurement report
2. Measurement report
3. Measurement report (tunneled for UE 1)
4. RRC connection reconfiguration (tunneled for UE 1)
5. RRC connection reconfiguration
6. Random access preamble
7. Random access response
8. RRC reconfiguration complete
9. UL grant
10. RRC connection reconfiguration
11. Random access preamble
12. Random access response
13. RRC reconfiguration complete
14. UL grant

FIG. 17

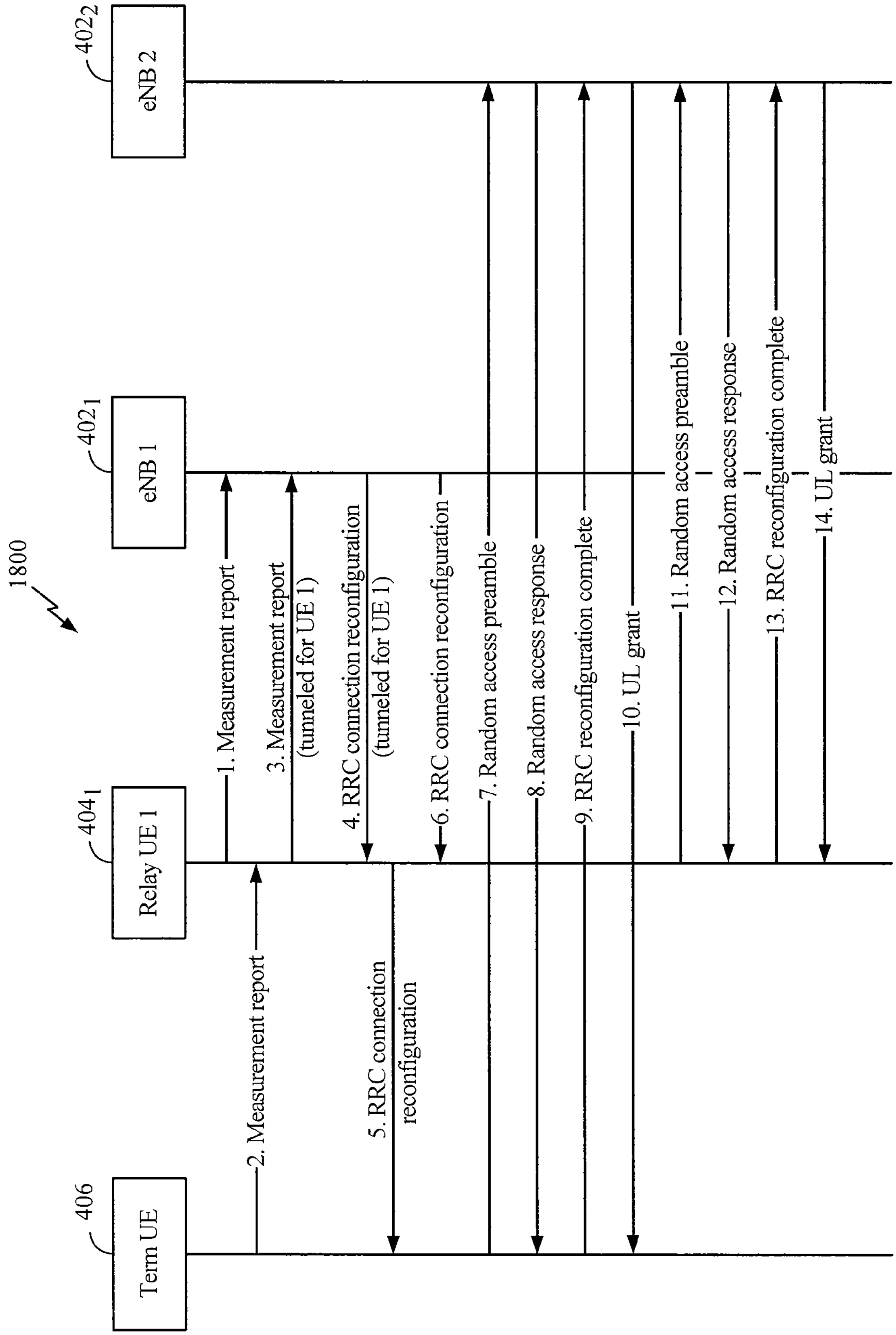

1800
402₂
eNB 2
402₁
eNB 1
404₁
Relay UE 1
406
Term UE
1. Measurement report
2. Measurement report
3. Measurement report (tunneled for UE 1)
4. RRC connection reconfiguration (tunneled for UE 1)
5. RRC connection reconfiguration
6. RRC connection reconfiguration
7. Random access preamble
8. Random access response
9. RRC reconfiguration complete
10. UL grant
11. Random access preamble
12. Random access response
13. RRC reconfiguration complete
14. UL grant

FIG. 18

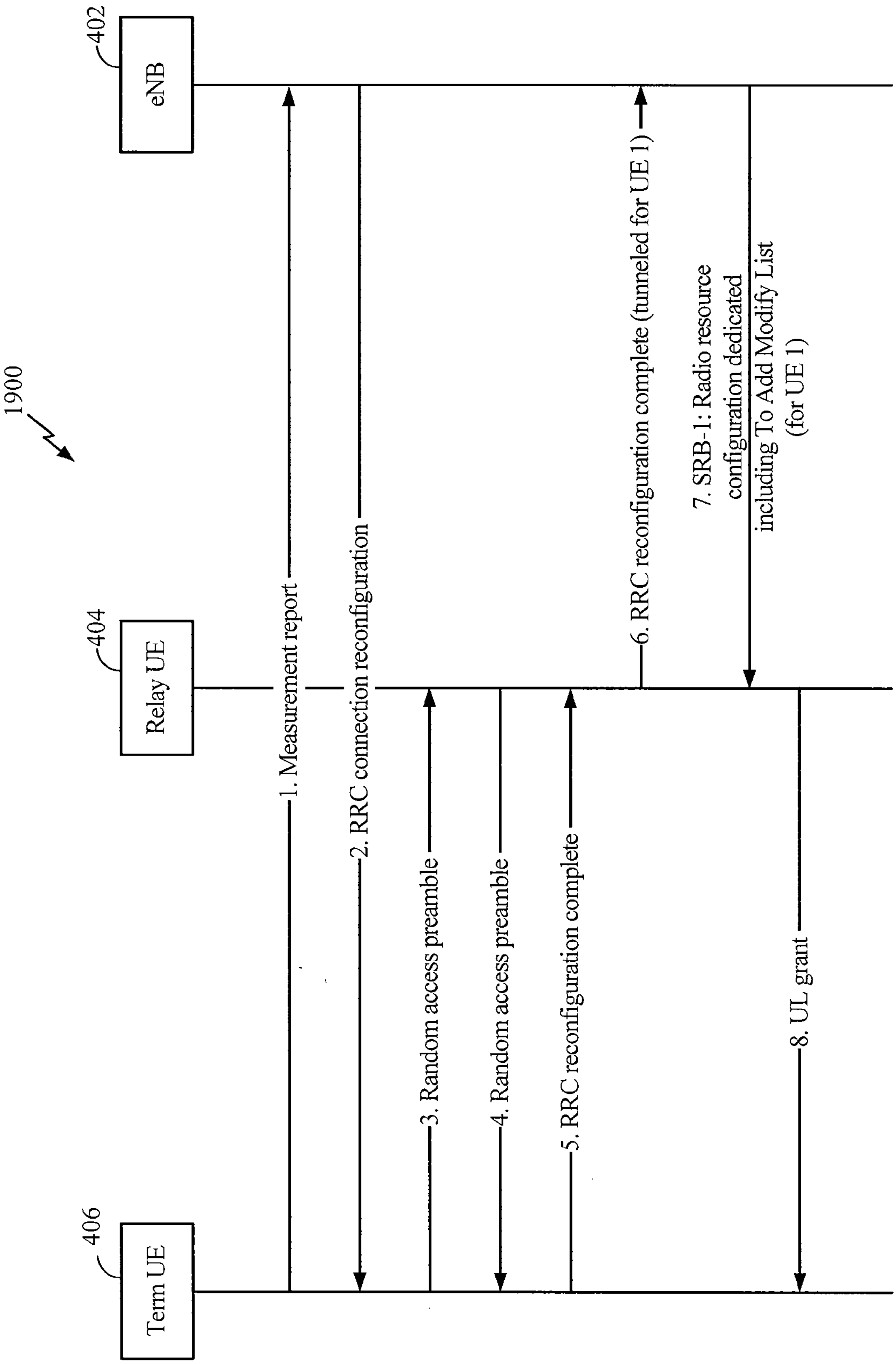

1900
402
eNB
404
Relay UE
406
Term UE
1. Measurement report
2. RRC connection reconfiguration
3. Random access preamble
4. Random access preamble
5. RRC reconfiguration complete
6. RRC reconfiguration complete (tunneled for UE 1)
7. SRB-1: Radio resource configuration dedicated including To Add Modify List (for UE 1)
8. UL grant

FIG. 19

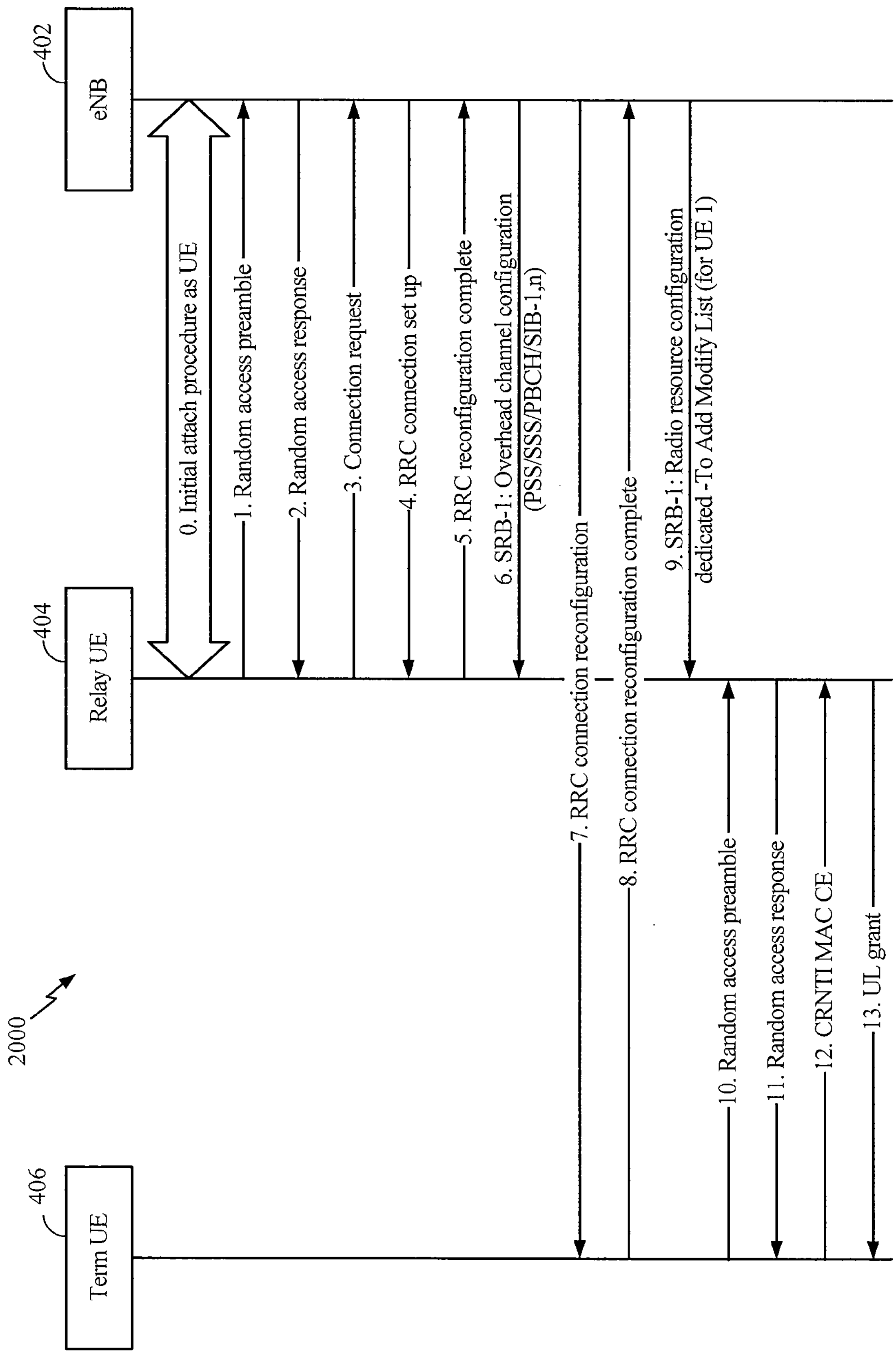

2000
eNB
402
Relay UE
404
Term UE
406
0. Initial attach procedure as UE
1. Random access preamble
2. Random access response
3. Connection request
4. RRC connection set up
5. RRC reconfiguration complete
6. SRB-1: Overhead channel configuration (PSS/SSS/PBCH/SIB-1,n)
7. RRC connection reconfiguration
8. RRC connection reconfiguration complete
9. SRB-1: Radio resource configuration dedicated -To Add Modify List (for UE 1)
10. Random access preamble
11. Random access response
12. CRNTI MAC CE
13. UL grant

FIG. 20

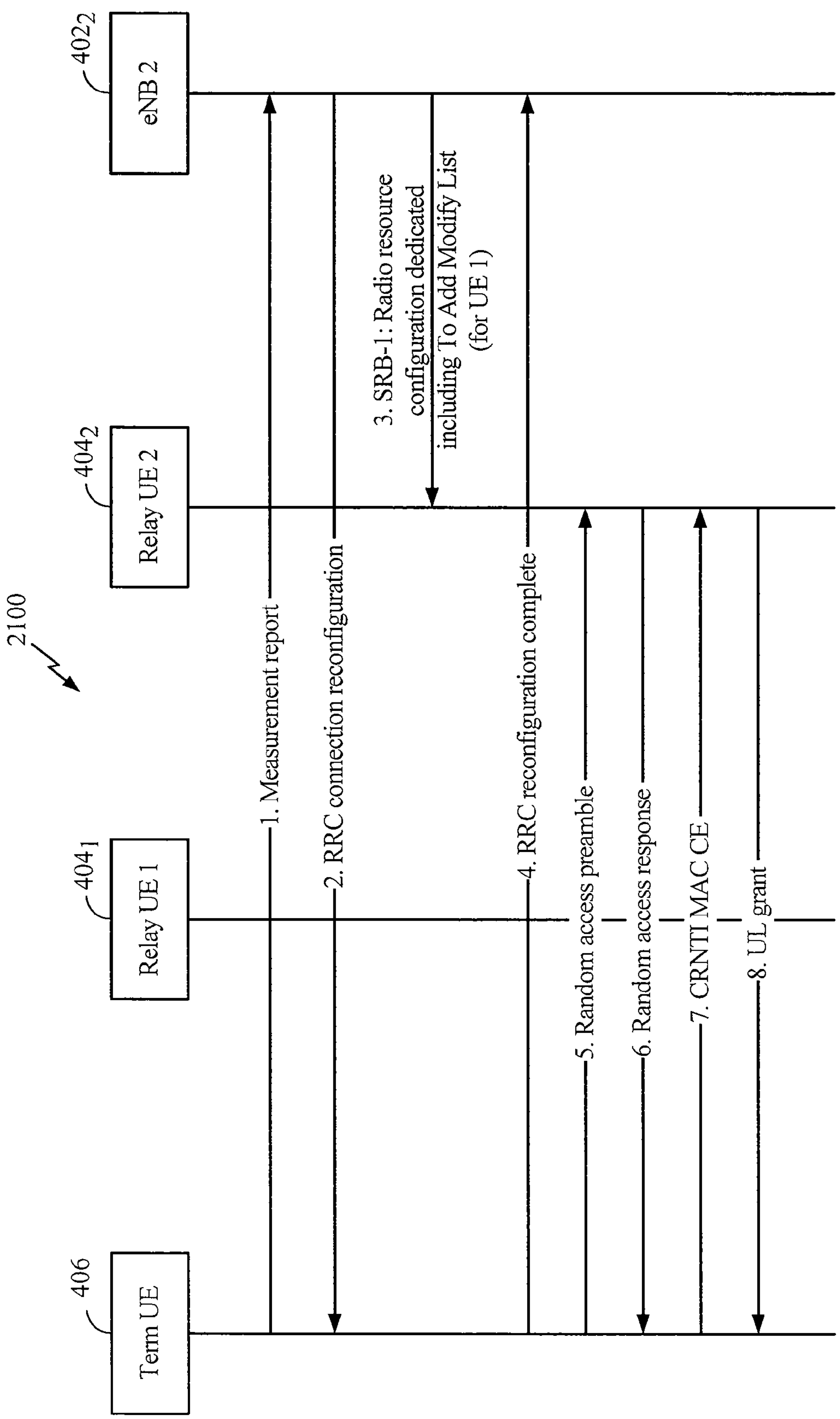

2100
402_2
eNB 2
404_2
Relay UE 2
404_1
Relay UE 1
406
Term UE
1. Measurement report
2. RRC connection reconfiguration
3. SRB-1: Radio resource configuration dedicated including To Add Modify List (for UE 1)
4. RRC reconfiguration complete
5. Random access preamble
6. Random access response
7. CRNTI MAC CE
8. UL grant

FIG. 21

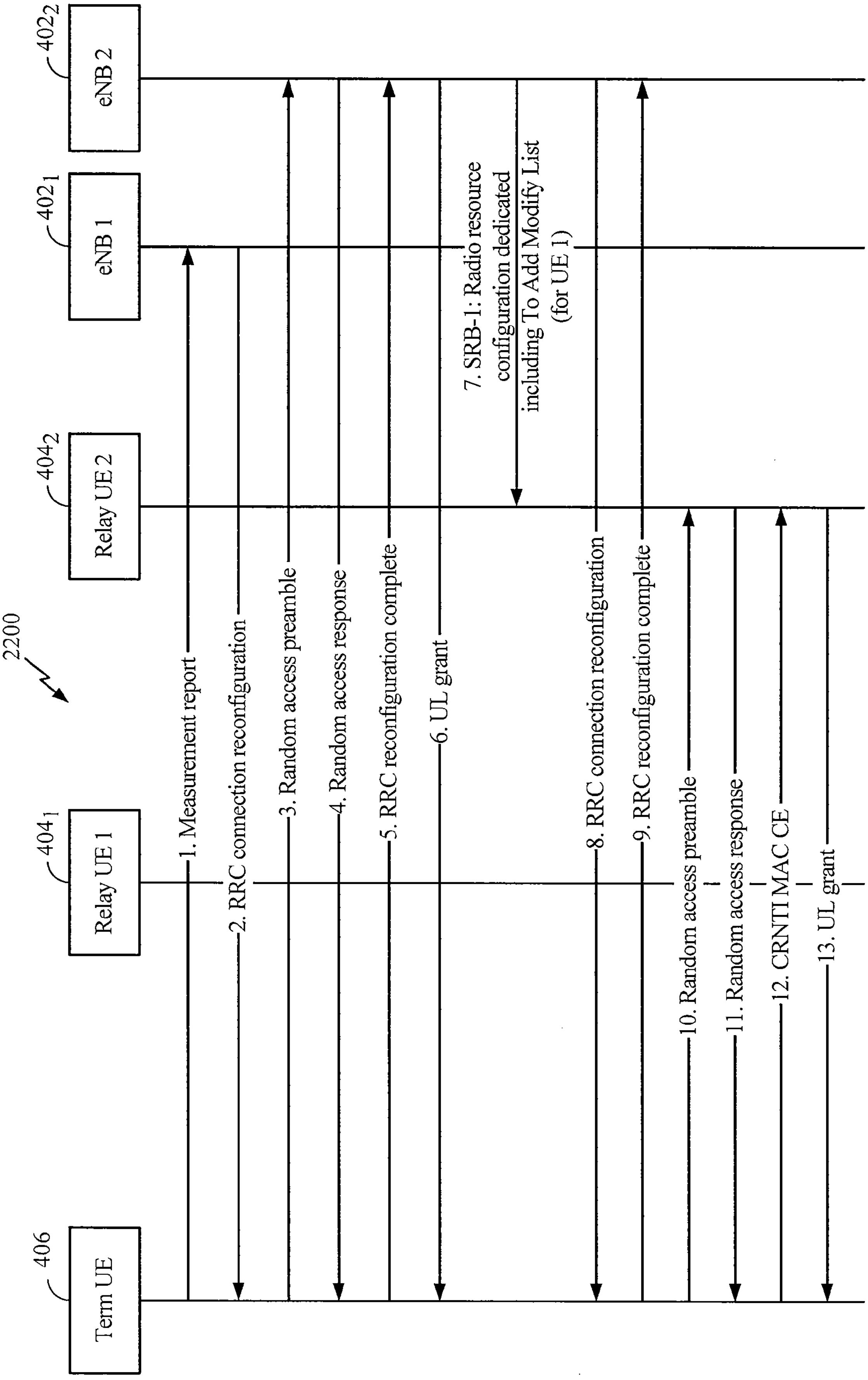

2200
Term UE
406
Relay UE 1
404_1
Relay UE 2
404_2
eNB 1
402_1
eNB 2
402_2
1. Measurement report
2. RRC connection reconfiguration
3. Random access preamble
4. Random access response
5. RRC reconfiguration complete
6. UL grant
7. SRB-1: Radio resource configuration dedicated including To Add Modify List (for UE 1)
8. RRC connection reconfiguration
9. RRC reconfiguration complete
10. Random access preamble
11. Random access response
12. CRNTI MAC CE
13. UL grant

FIG. 22

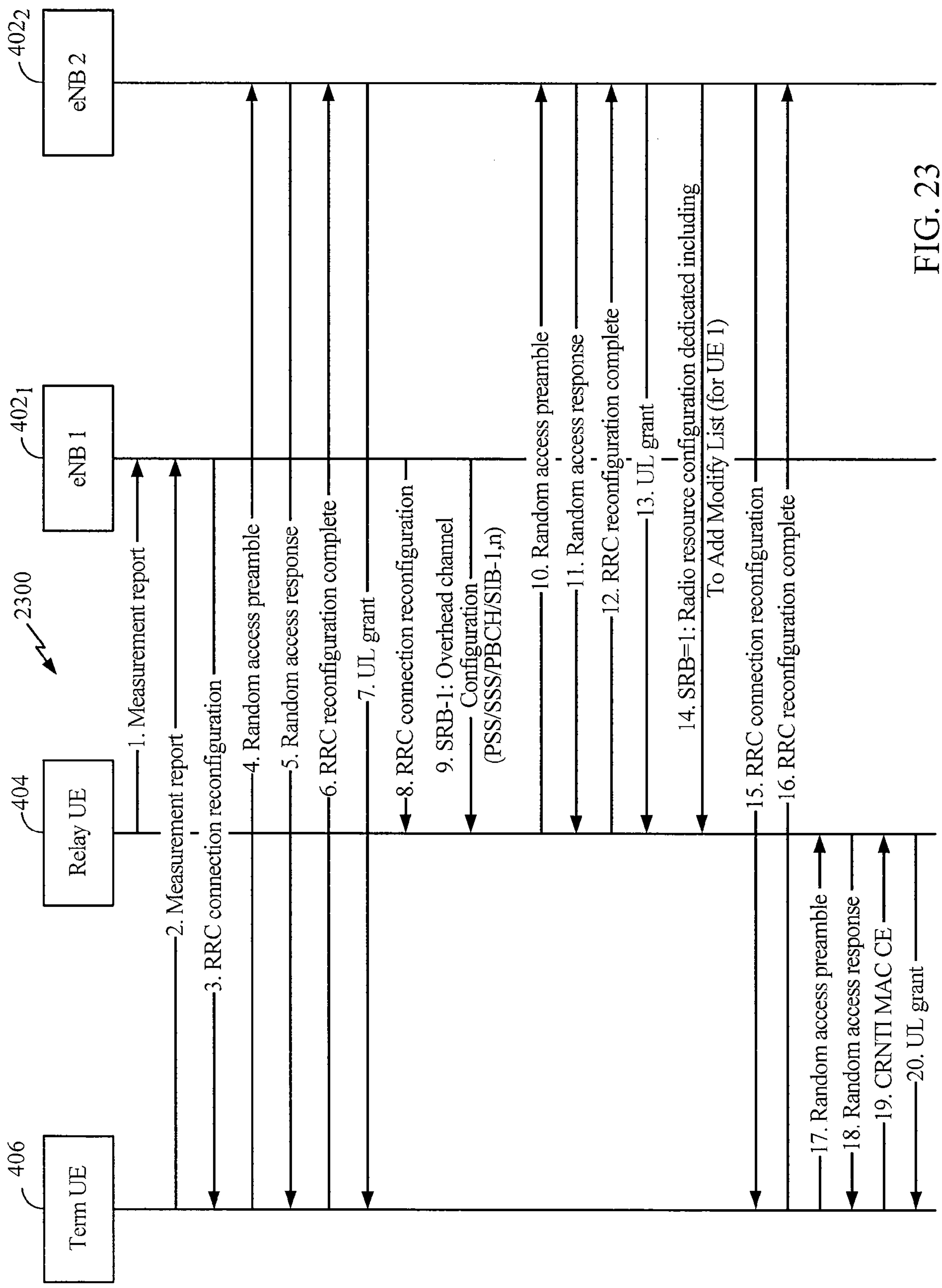

2300
406
Term UE
404
Relay UE
402₁
eNB 1
402₂
eNB 2
1. Measurement report
2. Measurement report
3. RRC connection reconfiguration
4. Random access preamble
5. Random access response
6. RRC reconfiguration complete
7. UL grant
8. RRC connection reconfiguration
9. SRB-1: Overhead channel Configuration (PSS/SSS/PBCH/SIB-1,n)
10. Random access preamble
11. Random access response
12. RRC reconfiguration complete
13. UL grant
14. SRB=1: Radio resource configuration dedicated including To Add Modify List (for UE 1)
15. RRC connection reconfiguration
16. RRC reconfiguration complete
17. Random access preamble
18. Random access response
19. CRNTI MAC CE
20. UL grant

FIG. 23

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/046516

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W88/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/175214 A1 (SFAR SANA [US] ET AL) 9 July 2009 (2009-07-09)	1-7, 18-25, 35-42, 52-58
A	paragraph [0217]	8-17, 26-34, 43-51, 59-68
A	WO 2010/056162 A1 (ERICSSON TELEFON AB L M [SE]; LARSSON PETER [SE]; FRENGER PAAL [SE]; B) 20 May 2010 (2010-05-20) page 1, line 8 - line 16	1-68
A	EP 1 734 774 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 20 December 2006 (2006-12-20) paragraph [0009]	1-68

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 October 2012	16/10/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Emander, Andreas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/046516

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009175214 A1	09-07-2009	CN 101965741 A	02-02-2011
		EP 2232908 A2	29-09-2010
		JP 2011509052 A	17-03-2011
		KR 20100095650 A	31-08-2010
		KR 20100109984 A	11-10-2010
		US 2009175214 A1	09-07-2009
		WO 2009088937 A2	16-07-2009
WO 2010056162 A1	20-05-2010	EP 2359624 A1	24-08-2011
		US 2011217921 A1	08-09-2011
		WO 2010056162 A1	20-05-2010
EP 1734774 A1	20-12-2006	EP 1734774 A1	20-12-2006
		KR 20060129807 A	18-12-2006
		US 2006281404 A1	14-12-2006