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Haynes and Boone, LLP (36340)
IP Section
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Dallas, TX 75219

Date Mailed: 10/17/2016

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Non-Publication Request: No

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Title

UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Application Number	Not assigned
Filing Date	Herewith
First Named Inventor	HUNG LY
Title	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS
Art Unit	Not assigned
Examiner Name	Not assigned
Attorney Docket Number	49606.423PV01 (170060P1)

SIGNATURE of Applicant or Patent Practitioner

Signature	/Gregory P. Webb/	Date (Optional)	September 30, 2016
Name	GREGORY P. WEBB	Registration Number	59,859
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)	QUALCOMM Incorporated		

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SIGNATURE of Applicant for Patent

Signature	RCB Hn	Date	19SEP2012
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UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS

Hung Ly, Hao Xu, Tingfang Ji, Joseph Soriaga

TECHNICAL FIELD

[0001] This application relates to wireless communication systems, and more particularly to uplink (UL) random access and UL-based mobility for 5th Generation (5G) new radio (NR) network.

INTRODUCTION

[0002] Wireless communication systems are widely deployed to provide various types of communications such as voice, data, video, etc. These systems may be multiple-access systems capable of supporting communication with multiple access terminals by sharing available system resources (*e.g.*, bandwidth and transmit power). Examples of such multiple-access systems include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, 3GPP Long Term Evolution (LTE) systems, and orthogonal frequency division multiple access (OFDMA) systems.

[0003] Typically, a wireless communication network comprises several base stations (BSs), wherein each BS communicates with a mobile station or user equipment (UE) using a forward link and each mobile station (or access terminal) communicates with base station(s) using a reverse link. A UE may synchronize to a network for initial cell access by performing a random access procedure, which may include a number of messages (e.g., about 4) exchange between the UE and a BS. Thus, there is a latency in establishing a connection with the network. After the UE establishes a connection with the network, the UE may move from one cell coverage area to another cell coverage area. When the UE moved out of a current serving cell coverage area, a handover process may be performed to enable the UE to continue communication with the network under a different cell coverage area. Typically, UE mobility management is supported through a downlink (DL)-based mobility approach, where the network sends references signals (RSs) and the UE performs cell search and measurements based on the RSs. Cell search and measurements consume power at the UE.

Thus, a more efficient random access procedure and mobility support may benefit wireless communication.

BRIEF SUMMARY OF SOME EXAMPLES

[0004] The following summarizes some aspects of the present disclosure to provide a basic understanding of the discussed technology. This summary is not an extensive overview of all contemplated features of the disclosure, and is intended neither to identify key or critical elements of all aspects of the disclosure nor to delineate the scope of any or all aspects of the disclosure. Its sole purpose is to present some concepts of one or more aspects of the disclosure in summary form as a prelude to the more detailed description that is presented later.

[0005] For example, in an aspect of the disclosure, a method of wireless communication in a network, includes transmitting, by a first wireless communication device, a first signal carrying a random access sequence and a data; and receiving, by the first wireless communication device from a second wireless communication device in response to the first signal, a second signal.

[0006] In an additional aspect of the disclosure, a method of wireless communication in a network, includes receiving, by a first wireless communication device from a second wireless communication device, a first signal carrying a random access sequence and a data; and transmitting, by the first wireless communication device to the second wireless communication device in response to the first signal, a second signal.

[0007] Other aspects, features, and embodiments of the present invention will become apparent to those of ordinary skill in the art, upon reviewing the following description of specific, exemplary embodiments of the present invention in conjunction with the accompanying figures. While features of the present invention may be discussed relative to certain embodiments and figures below, all embodiments of the present invention can include one or more of the advantageous features discussed herein. In other words, while one or more embodiments may be discussed as having certain advantageous features, one or more of such features may also be used in accordance with the various embodiments of the invention discussed herein. In similar fashion, while exemplary embodiments may be discussed below as device, system, or method embodiments it should be understood that such exemplary embodiments can be implemented in various devices, systems, and methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 illustrates a wireless communication network according to embodiments of the present disclosure.

[0009] FIG. 2 illustrates a subframe configuration according to embodiments of the present disclosure.

[0010] FIG. 3 illustrates a user equipment (UE) radio resource control (RRC) state diagram 300 according to embodiments of the present disclosure.

[0011] Fig. 4 illustrates a wireless communication network that implements uplink (UL)-based mobility according to embodiments of the present disclosure.

[0012] FIG. 5 is a block diagram of an exemplary UE according to embodiments of the present disclosure.

[0013] FIG. 6 is a block diagram of an exemplary base station (BS) according to embodiments of the present disclosure.

[0014] FIG. 7 is a protocol diagram of a method of a 4-step random access procedure according to embodiments of the present disclosure.

[0015] FIG. 8 illustrates a subframe that includes a physical random access channel (PRACH) according to the present disclosure.

[0016] FIG. 9 is a protocol diagram of a method of a 2-step random access procedure according to embodiments of the present disclosure.

[0017] FIG. 10 illustrates a subframe that includes an enhanced PRACH (ePRACH) according to the present disclosure.

[0018] FIG. 11 is a protocol diagram of a method of performing UL mobility in a RRC common state according to embodiments of the present disclosure.

[0019] FIG. 12 illustrates a subframe that includes a physical uplink measurement indication channel (PUMICH) according to the present disclosure.

[0020] FIG. 13 is a protocol diagram of a method of performing UL mobility in a RRC dedicated state according to embodiments of the present disclosure.

[0021] FIG. 14 illustrates a subframe including a physical uplink measurement references signal (PUMRS) channel according to the present disclosure.

[0022] FIG. 15 is a flow diagram of a method of performing UL-based mobility and random access according to embodiments of the present disclosure.

[0023] FIG. 16 is a flow diagram of a method of performing UL-based mobility and random access according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0024] The detailed description set forth below, in connection with the appended drawings, is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of the various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well-known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0025] The techniques described herein may be used for various wireless communication networks such as code-division multiple access (CDMA), time-division multiple access (TDMA), frequency-division multiple access (FDMA), orthogonal frequency-division multiple access (OFDMA), single-carrier FDMA (SC-FDMA) and other networks. The terms “network” and “system” 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 (WCDMA) and other variants of CDMA. 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), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDMA, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunication System (UMTS). 3GPP Long Term Evolution (LTE) and LTE-Advanced (LTE-A) are new releases of UMTS that use E-UTRA. UTRA, E-UTRA, UMTS, LTE, LTE-A and GSM are described in documents from an organization named “3rd Generation Partnership Project” (3GPP). CDMA2000 and UMB are described in documents from an organization named “3rd Generation Partnership Project 2” (3GPP2). The techniques described herein may be used for the wireless networks and radio technologies mentioned above as well as other wireless networks and radio technologies, such as a next generation (e.g., 5th Generation (5G)) network.

[0026] The present disclosure describes an improved random access procedure and UL-based mobility. UL-based mobility refers to a network performing UE search and/or measurements based on reference signals transmitted by UEs. In the disclosed embodiments, a UE may simultaneously transmit a random access preamble and data in a single transmission. For random access, the UE may simultaneously transmit a random access preamble and a connection request message (e.g., the data) instead of separately, and thus may reduce random access latency. For UL-based mobility, when the UE is in a RRC common state, the UE may transmit a random access preamble and a UE-identifier (ID) (e.g., the data) that identifies the UE in the network. Upon detecting the random access preamble and the UE-ID, a BS or a transmission/reception (TRP) may transmit an acknowledgement (ACK) to the UE and may include paging information. When the UE is in a RRC dedicated state, the UE may send a UL mobility reference signal and the BS may transmit an ACK to the UE and may include handover information. The disclosed embodiments define an ePRACH and a PUMICH in a UL-centric self-contained subframe for carrying both a random access preamble and data for random access and UL-based mobility, respectively. In addition, the disclosed embodiments defined a PUMRS channel in a UL-centric self-contained subframe for carrying a UL mobility reference signal.

[0027] FIG. 1 illustrates a wireless communication network 100 according to embodiments of the present disclosure. The network 100 may include a number of UEs 102, as well as a number of BSs 104. The BSs 104 may include an Evolve Node B (eNodeB). A BS 104 may be a station that communicates with the UEs 102 and may also be referred to as a base transceiver station, a node B, an access point, and the like.

[0028] The BSs 104 communicate with the UEs 102 as indicated by communication signals 106. A UE 102 may communicate with the BS 104 via an uplink (UL) and a downlink (DL). The downlink (or forward link) refers to the communication link from the BS 104 to the UE 102. The UL (or reverse link) refers to the communication link from the UE 102 to the BS 104. The BSs 104 may also communicate with one another, directly or indirectly, over wired and/or wireless connections, as indicated by communication signals 108.

[0029] The UEs 102 may be dispersed throughout the network 100, as shown, and each UE 102 may be stationary or mobile. The UE 102 may also be referred to as a terminal, a mobile station, a subscriber unit, etc. The UE 102 may be a cellular phone, a smartphone, a personal digital assistant, a wireless modem, a laptop computer, a tablet computer, an IoT device, etc. The network 100 is one example of a network to which various aspects of the disclosure apply.

[0030] Each BS 104 may provide communication coverage for a particular geographic area. In 3GPP, the term “cell” can refer to this particular geographic coverage area of a BS and/or a BS subsystem serving the coverage area, depending on the context in which the term is used. In this regard, a BS 104 may provide communication coverage for a macro cell, a pico cell, a femto cell, and/or other types of cell. A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs with service subscriptions with the network provider. A pico cell may generally cover a relatively smaller geographic area and may allow unrestricted access by UEs with service subscriptions with the network provider. A femto cell may also generally cover a relatively small geographic area (e.g., a home) and, in addition to unrestricted access, may also provide restricted access by UEs having an association with the femto cell (e.g., UEs in a closed subscriber group (CSG), UEs for users in the home, and the like). A BS for a macro cell may be referred to as a macro BS. A BS for a pico cell may be referred to as a pico BS. A BS for a femto cell may be referred to as a femto BS or a home BS.

[0031] In the example shown in FIG. 1, the BSs 104a, 104b and 104c are examples of macro BSs for the coverage areas 110a, 110b and 110c, respectively. The BSs 104d and 104e are examples of pico and/or femto BSs for the coverage areas 110d and 110e, respectively. As will be recognized, a BS 104 may support one or multiple (e.g., two, three, four, and the like) cells.

[0032] The network 100 may also include relay stations. A relay station is a station that receives a transmission of data and/or other information from an upstream station (e.g., a BS, a UE, or the like) and sends a transmission of the data and/or other information to a downstream station (e.g., another UE, another BS, or the like). A relay station may also be a UE that relays transmissions for other UEs. A relay station may also be referred to as a relay BS, a relay UE, a relay, and the like.

[0033] The network 100 may support synchronous or asynchronous operation. For synchronous operation, the BSs 104 may have similar frame timing, and transmissions from different BSs 104 may be approximately aligned in time. For asynchronous operation, the BSs 104 may have different frame timing, and transmissions from different BSs 104 may not be aligned in time.

[0034] In some implementations, the network 100 utilizes orthogonal frequency division multiplexing (OFDM) on the downlink and single-carrier frequency division multiplexing (SC-FDM) on the UL. OFDM and SC-FDM partition the system bandwidth into multiple (K) orthogonal subcarriers, which are also commonly referred to as tones, bins, or the like. Each subcarrier may be modulated with data. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDM. The spacing between adjacent subcarriers may be fixed, and the total number of subcarriers (K) may be dependent on the system bandwidth. For example, K may be equal to 72, 180, 300, 600, 900, and 1200 for a corresponding system bandwidth of 1.4, 3, 5, 10, 15, or 20 megahertz (MHz), respectively. The system bandwidth may also be partitioned into sub-bands. For example, a sub-band may cover 1.08 MHz, and there may be 1, 2, 4, 8 or 16 sub-bands for a corresponding system bandwidth of 1.4, 3, 5, 10, 15, or 20 MHz, respectively.

[0035] In an embodiment, the BSs 104 can assign or schedule transmission resources (e.g., in the form of time-frequency resource blocks) for DL and UL transmissions in the network 100. The communication can be in the form of radio frames. A radio frame may be divided into a plurality of subframes. In a FDD mode, simultaneous UL and DL transmissions may occur in different frequency bands. In a TDD mode, UL and DL transmissions occur at different time periods using the same frequency band. For example, a subset of the subframes in a radio frame may be used for DL transmissions and another subset of the subframes may be used for UL transmissions. The DL and UL subframes can be shared among the BSs 104 and the UEs 102, respectively.

[0036] The DL subframes and the UL subframes can be further divided into several regions. For example, each DL or UL subframe may have pre-defined regions for transmissions of reference signals, control information, and data. Reference signals are pre-determined signals that facilitate the communications between the BSs 104 and the UEs 102. For example, a reference signal can have a particular pilot pattern or structure, where pilot tones may span across an operational bandwidth or frequency band, each positioned at a pre-defined time and a pre-defined frequency. Control information may include resource assignments and protocol controls. Data may include protocol data and/or operational data.

[0037] In an embodiment, the BSs 104 can broadcast system information associated with the network 100. Some examples of system information may include physical layer information such as cell bandwidths and frame configurations, cell access information, and neighbor cell information. A UE 102 can access the network 100 by listening to the broadcast system information and requests connection or channel establishments with a BS 104. For example, the UE 102 can perform a random access procedure to begin communication with the BS 104 and subsequently may perform connection and/or registration procedures to register with the BS 104. After completing the connection and/or the registration, the UE 102 and the BS 104 can enter a normal operation stage, where operational data may be exchanged.

[0038] FIG. 2 illustrates a subframe configuration 200 according to embodiments of the present disclosure. The configuration 200 may be employed by the BSs 104 and the UEs 102 for transmission. In FIG. 2, the x-axis represents time in some constant units and the y-axis represents frequency in some constant units. The configuration 200 shows two self-contained subframes 210 and 220. The subframes 210 and 220 can be configured for UL transmission or DL transmission. As an example, the subframe 210 is configured for UL transmission and the subframe 220 is configured for DL transmission. Thus, the subframe 210 may be referred to as a UL-centric subframe and the subframe 220 may be referred to as a DL-centric subframe. The subframe 210 includes a DL control portion 212 for carrying DL control, a UL data portion 214 for carrying UL data, and a UL control portion 216 for carrying UL control. The subframe 220 includes a DL control portion 222 for carrying DL control, a DL data portion 224 for carrying DL data, and a UL control portion 226 for carrying UL control. As shown, the subframe 210 further includes s a guard band 218 between the DL control portion 212 and the UL data portion 214. The subframe 220 further includes s a guard band 228 between the DL data portion 224 and the UL control portion 226. The guard bands 218 and 228 allow for switching between transmit and receive.

[0039] FIG. 3 illustrates a UE RRC state diagram 300 according to embodiments of the present disclosure. The RRC state diagram 300 shows the RRC states of the UE 102 after completing an initial radio access network (RAN) or cell access. As shown, the UE 102 may transitions between a RRC dedicated state 310, a RRC common state 320, a reachable idle state 330, and a power saving state 340. In the RRC dedicated state 310, the UE 102 context is known to the RAN. The UE 102 may be assigned with air interface resources (e.g., physical resources). The UE 102 may transmit and receive any data. The UE 102 may transition from the RRC dedicated state 310 to the RRC common state 320 due to inactivity.

[0040] In the RRC common state 320, the UE 102 context is known to the RAN. The UE 102 has no assigned air interface resources. The UE 102 may transmit and receive a small amount of data. The UE 102 may transition from the RRC common state 320 to the RRC dedicated state 310 when a nominal amount of data reception or transmission occurs. The UE 102 may transition to from the RRC common state 320 to the reachable idle state 330 due to inactivity. When the UE 102 is in the RRC dedicated state 310 or the RRC common state 320, the UE 102 is in a connected mode.

[0041] In the reachable idle state 330, the context of the UE 102 is not known to the RAN. The UE 102 has no assigned air interface resources. The UE 102 may transmit and receive a small amount of data. The UE 102 may transition from the reachable idle state 330 to the RRC dedicated state 310 when a nominal amount of data reception or transmission occurs. The UE 102 may transition from the reachable idle state 330 to the power saving state 340 when a reachability timer expires.

[0042] In the power saving state 340, the context of the UE 102 is not known to the RAN. The UE 102 has no assigned air interface resources. The UE 102 has no data transmission or reception. The UE 102 may transition from the power saving state 340 to the reachability idle state 330 upon any data transmission or reception. When the UE 102 is in the reachability idle state 330 or the power saving state 340, the UE 102 is in an idle mode.

[0043] Fig. 4 illustrates a wireless communication network 400 that implements UL-based mobility according to embodiments of the present disclosure. FIG. 4 illustrates one transmission/reception point (TRP) 404 and one UE 402 for purposes of simplicity of discussion, though it will be recognized that embodiments of the present disclosure may scale to many more UEs 402 and/or TRPs 404. The TRP 404 may be substantially similar to the BSs 104, but may include remote radio heads for wireless signal transmission and reception and may communicate with a central unit for baseband processing. The UEs 402 may be substantially similar to the UEs 102. The UE 402 and the TRP 404 may communicate with each other at any suitable frequencies.

[0044] The network 400 includes a plurality of zones 410. A zone 410 is a collection of tightly synchronized cells. As shown, the zone 410a includes the zone 410b where the TRP 404 is located and a cluster of cells 412 serving the UE 402. To support UL-based intra-zone mobility, for example, within the zone 410a, the UE 402 may send UL mobility RSs for mobility tracking at the network side. For example, the TRP 404 may perform UE search and measurements based on the RSs sent by the UE 402. The TRP 404 may acknowledge the UL mobility RSs and signal paging indicator, as described in greater detail herein. The network 400 may autonomously selects a serving cell 412 (e.g., a TRP) or cells 412 (e.g., TRPs) to send the acknowledgement (ACK). Thus, intra-zone mobility may be transparent to the UE 402. For inter-zone mobility, for example, from the zone 410a to the zone 410b, the UE 402 may perform handover when a pre-determined condition is satisfied.

[0045] UL-based mobility provides several benefits. For example, power consumption may be reliably tradeoff at a UE. The handshake at the physical layer (e.g., layer 1 (L1)) may be more efficient, and thus may provide UEs and the network with channel information in a shorter amount of time than DL-based mobility. In addition, UL-based mobility may provide better mobility tracking since the network may have more antennas than UEs. UL-based mobility may benefit high mobility or poor channel conditions. For example, UL-based mobility may reduce UE power consumption, improve paging miss and call set up delay, improve network resource utilization efficiency, and reduce handover failure rate.

[0046] FIG. 5 is a block diagram of an exemplary UE 500 according to embodiments of the present disclosure. The UE 500 may be a UE 102 as discussed above. As shown, the UE 500 may include a processor 502, a memory 504, a random access (RACH) and UL mobility processing module 508, a transceiver 610 including a modem subsystem 612 and a RF unit 614, and an antenna 616. These elements may be in direct or indirect communication with each other, for example via one or more buses.

[0047] The processor 502 may include a central processing unit (CPU), a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a controller, a field programmable gate array (FPGA) device, another hardware device, a firmware device, or any combination thereof configured to perform the operations described herein. The processor 502 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.

[0048] The memory 504 may include a cache memory (e.g., a cache memory of the processor 502), random access memory (RAM), magnetoresistive RAM (MRAM), read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read only memory (EPROM), electrically erasable programmable read only memory (EEPROM), flash memory, solid state memory device, hard disk drives, other forms of volatile and non-volatile memory, or a combination of different types of memory. In an embodiment, the memory 504 includes a non-transitory computer-readable medium. The memory 504 may store instructions 506. The instructions 506 may include instructions that, when executed by the processor 502, cause the processor 502 to perform the operations described herein with reference to the UEs 102 in connection with embodiments of the present disclosure. Instructions 506 may also be referred to as code. The terms “instructions” and “code” should be interpreted broadly to include any type of computer-readable statement(s). For example, the terms “instructions” and “code” may refer to one or more programs, routines, sub-routines, functions, procedures, etc. “Instructions” and “code” may include a single computer-readable statement or many computer-readable statements.

[0049] The RACH and UL mobility processing module 508 may be used for various aspects of the present disclosure. For example, the RACH and UL mobility processing module 508 is configured to perform RACH and facilitate UL mobility, as described in greater detail herein.

[0050] As shown, the transceiver 510 may include the modem subsystem 512 and the RF unit 514. The transceiver 510 can be configured to communicate bi-directionally with other devices, such as the BSs 104. The modem subsystem 512 may be configured to modulate and/or encode the data from the memory 504 and/or the RACH and UL mobility processing module 508 according to a modulation and coding scheme (MCS), e.g., a low-density parity check (LDPC) coding scheme, a turbo coding scheme, a convolutional coding scheme, a digital beamforming scheme, etc. The RF unit 514 may be configured to process (e.g., perform analog to digital conversion or digital to analog conversion, etc.) modulated/encoded data from the modem subsystem 512 (on outbound transmissions) or of transmissions originating from another source such as a UE 102 or a BS 104. Although shown as integrated together in transceiver 510, the modem subsystem 512 and the RF unit 514 may be separate devices that are coupled together at the UE 102 to enable the UE 102 to communicate with other devices.

[0051] The RF unit 514 may provide the modulated and/or processed data, e.g. data packets (or, more generally, data messages that may contain one or more data packets and other information), to the antenna 516 for transmission to one or more other devices. The antenna 516 may further receive data messages transmitted from other devices. This may include, for example, transmission and reception of signals associated with RACH and UL mobility according to embodiments of the present disclosure. The antenna 516 may provide the received data messages for processing and/or demodulation at the transceiver 510. Although FIG. 5 illustrates antenna 516 as a single antenna, antenna 516 may include multiple antennas of similar or different designs in order to sustain multiple transmission links. The RF unit 514 may configure the antenna 516.

[0052] FIG. 6 is a block diagram of an exemplary BS 600 according to embodiments of the present disclosure. The BS 600 may be a BS 104 as discussed above. As shown, the BS 600 may include a processor 602, a memory 604, a RACH and UL mobility processing module 608, a transceiver 610 including a modem subsystem 612 and a RF unit 614, and an antenna 616. These elements may be in direct or indirect communication with each other, for example via one or more buses.

[0053] The processor 602 may have various features as a specific-type processor. For example, these may include a CPU, a DSP, an ASIC, a controller, a FPGA device, another hardware device, a firmware device, or any combination thereof configured to perform the operations described herein. The processor 602 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.

[0054] The memory 604 may include a cache memory (e.g., a cache memory of the processor 602), RAM, MRAM, ROM, PROM, EPROM, EEPROM, flash memory, a solid state memory device, one or more hard disk drives, memristor-based arrays, other forms of volatile and non-volatile memory, or a combination of different types of memory. In some embodiments, the memory 604 may include a non-transitory computer-readable medium. The memory 604 may store instructions 606. The instructions 606 may include instructions that, when executed by the processor 602, cause the processor 602 to perform operations described herein. Instructions 606 may also be referred to as code, which may be interpreted broadly to include any type of computer-readable statement(s) as discussed above with respect to FIG. 5.

[0055] The RACH and UL mobility processing module 608 may be used for various aspects of the present disclosure. For example, the RACH and UL mobility processing module 608 may perform RACH and support UL mobility, as described in greater detail herein.

[0056] As shown, the transceiver 610 may include the modem subsystem 612 and the RF unit 614. The transceiver 610 can be configured to communicate bi-directionally with other devices, such as the UEs 102 and/or another core network element. The modem subsystem 612 may be configured to modulate and/or encode data according to a MCS, e.g., a LDPC coding scheme, a turbo coding scheme, a convolutional coding scheme, a digital beamforming scheme, etc. The RF unit 614 may be configured to process (e.g., perform analog to digital conversion or digital to analog conversion, etc.) modulated/encoded data from the modem subsystem 612 (on outbound transmissions) or of transmissions originating from another source such as a UE 102. Although shown as integrated together in transceiver 610, the modem subsystem 612 and the RF unit 614 may be separate devices that are coupled together at the BS 104 to enable the BS 104 to communicate with other devices.

[0057] The RF unit 614 may provide the modulated and/or processed data, e.g. data packets (or, more generally, data messages that may contain one or more data packets and other information), to the antenna 616 for transmission to one or more other devices. This may include, for example, transmission of information to complete attachment to a network and communication with a camped UE 102 according to embodiments of the present disclosure. The antenna 616 may further receive data messages transmitted from other devices and provide the received data messages for processing and/or demodulation at the transceiver 610. Although FIG. 6 illustrates antenna 616 as a single antenna, antenna 616 may include multiple antennas of similar or different designs in order to sustain multiple transmission links.

[0058] FIG. 7 is a protocol diagram of a method 700 of a 4-step random access procedure according to embodiments of the present disclosure. Steps of the method 700 can be executed by computing devices (e.g., a processor, processing circuit, and/or other suitable component) of wireless communication devices, such as the BSs 104 and 600, the TRP 404, and the UEs 102, 402, and 500. The method 700 is suitable for use in any RRC states as described in the

UE RRC state diagram 300. The method 700 can be better understood with reference to FIG. 4. The method 700 may employ similar mechanisms as in the network 400. As illustrated, the method 700 includes a number of enumerated steps, but embodiments of the method 700 may include additional steps before, after, and in between the enumerated steps. In some embodiments, one or more of the enumerated steps may be omitted or performed in a different order. The method 700 illustrates two TRPs 404a and 404b and one UE 402 for purposes of simplicity of discussion, though it will be recognized that embodiments of the present disclosure may scale to many more UEs 402 and/or TRPs 404.

[0059] At step 710, the UE 402 transmits a message 1 (MSG1), which may be referred to as a random access preamble. The UE 402 may transmit the MSG1 in a physical random access channel (PRACH). The random access preamble may be a Zadoff-Chu sequence, a gold sequence, a m-sequence or any suitable orthogonal sequence and may include cyclic shifts. In some embodiments, the MSG1 may also reach the TRP 404b as shown by the arrows in the dashed oval.

[0060] At step 720, upon detecting the MSG1, the TRP 404a transmits a message 2 (MSG2), which may be referred to as a random access response (RAR). The TRP 404a may transmit allocation information for the MSG2 in a physical downlink control channel (PDCCH) and the MSG2 in a physical downlink shared channel (PDSCH). The MSG2 may include a detected random access preamble identifier (ID), timing advance (TA) information, a UL grant, a temporary cell-radio network temporary identifier (C-RNTI), and a backoff indicator. In some embodiments, the TRP 404b may also detect the MSG1 and may respond with a MSG2 as shown by the dashed arrow.

[0061] At step 730, the UE 402 transmits a message 3 (MSG3) based on the MSG2. The UE 402 may transmit the MSG3 in a physical uplink shared channel (PUSCH). The MSG3 may include a RRC connection request, a tracking area update, and a scheduling request.

[0062] At step 740, the TRP 404a transmits a message 4 (MSG4). The TRP 404a may transmit allocation information for the MSG4 in a PDCCH and the MSG4 in a PDSCH. The MSG4 includes a contention resolution. The PRACH and the PUSCH are sent in a UL-centric subframe (e.g., the subframe 210), as described in greater detail herein. The PRACH and the PUSCH may have the same numerology (e.g., a tone spacing of 15 kHz) or different numerologies.

[0063] FIG. 8 illustrates a subframe 800 that includes a PRACH 850 according to the present disclosure. The subframe 800 is employed by the UE 402 when implementing the 4-step random access procedure described in the method 700. In FIG. 8, the x-axis represents time in some constant units and the y-axis represents frequency in some constant units. The subframe 800 is a UL-centric subframe and has a similar structure as the subframe 210. The subframe 800 may carry a DL common burst, a UL regular burst, and a UL common burst in a DL control portion 212, a UL data portion 214, and a UL control portion 216. As shown, the subframe 800 carriers the PRACH 850 in the UL data portion 214. In some embodiments, the position of the PRACH 850 may be configurable. For example, the PRACH 850 may be in both the UL data portion 214 and the UL control portion 216. In addition, the PRACH 850 may span more than one subframe 800.

[0064] FIG. 9 is a protocol diagram of a method 900 of performing a 2-step random access according to embodiments of the present disclosure. Steps of the method 900 can be executed by computing devices (e.g., a processor, processing circuit, and/or other suitable component) of wireless communication devices, such as the BSs 104 and 600, the TRP 404, and the UEs 102, 402, and 500. The method 900 is suitable for use when a UE is in a RRC common state (e.g., the RRC common state 320). The method 900 can be better understood with reference to FIG. 4. The method 900 may employ similar mechanisms as in the network 400. As illustrated, the method 900 includes a number of enumerated steps, but embodiments of the method 900 may include additional steps before, after, and in between the enumerated steps. In some embodiments, one or more of the enumerated steps may be omitted or performed in a different order. The method 900 illustrates two TRPs 404a and 404b and one UE 402 for purposes of simplicity of discussion, though it will be recognized that embodiments of the present disclosure may scale to many more UEs 402 and/or TRPs 404.

[0065] At step 910, the UE 402 transmits an enhanced message 1 (eMSG1), which includes the MSG1 and the MSG2 of the method 700. The UE 402 may transmit the eMSG1 in an enhanced physical random access channel (ePRACH). The ePRACH includes PUSCHs and a PRACH, as described in greater detail herein. The eMSG1 may include a random access preamble, a RRC connection request, a tracking area update, a scheduling request, and a UE identifier (UE-ID). For example, the PRACH is transmitted in the PRACH of the ePRACH and the remaining eMSG1 is transmitted in the PUSCHs of the ePRACH. In some embodiments, the eMSG1 may also reach the TRP 404b as shown by the arrows in the dashed oval.

[0066] At step 920, upon detecting the eMSG1, the TRP 404a transmits an enhanced message 2 (eMSG2), which includes the MSG3 and MSG4 of the method 700. The TRP 404a may transmit allocation information for the eMSG2 in a PDCCH and the eMSG2 in a PDSCH. The eMSG2 may include a detected random access preamble ID, TA information, a C-RNTI, a backoff indicator, and a contention resolution. In some embodiments, the TRP 404b may also detect the eMSG1 and may respond with an eMSG2 as shown by the dashed arrow.

[0067] As shown, the method 900 requires two steps instead of four steps as in the method 700. Thus, the method 900 may reduce latency for random access. The method 900 is suitable for small-cell deployments or in unlicensed bands.

[0068] FIG. 10 illustrates a subframe 1000 that includes an ePRACH 1050 according to the present disclosure. The subframe 1000 is employed by the UE 402 when implementing the 4-step random access procedure described in the method 900. In FIG. 10, the x-axis represents time in some constant units and the y-axis represents frequency in some constant units. The subframe 1000 is a UL-centric subframe and has a similar structure as the subframe 210. The subframe 1000 may carry a DL common burst, a UL regular burst, and a UL common burst in a DL control portion 212, a UL data portion 214, and a UL control portion 216. As shown, the subframe 1000 carries the ePRACH 1050 in the UL data portion 214.

[0069] The ePRACH 1050 includes a plurality of PUSCHs 1052, a PRACH 1054, and a guard band 1056 at the end of the ePRACH 1050. For example, the PRACH 1054 carries a random access preamble of an eMSG1 and the PUSCHs 1052 carry remaining portions of the eMSG1. Each of the PUSCHs 1052 and the PRACH 1054 includes a cyclic prefix (CP) portion 1058. Each of the PUSCHs 1052 and the PRACH 1054 may span a duration of one symbol. For example, each of the PUSCHs 1052 and the PRACH 1054 may be configured to have a tone spacing of about 15 kHz with about 256 tones, a symbol duration of about 66.67 microseconds (μs), and a CP duration of about 10 μs.

[0070] In an embodiment, the PRACH 1054 may be used as a reference signal for demodulation at the TRP 404. In an embodiment, the PRACH 1054 is configured to be about the center of the ePRACH 1050 to provide better performance. Thus, the random access preamble may also be referred to as a random access mid-amble.The PUSCHs 1052 and the PRACH 1054 may have the same numerology or different numerologies. For example, a network may broadcast the configuration or numerology of the ePRACH 1050. In an embodiment, the tone spacing of the PRACH 1054 are configured such that the PRACH 1054 may accommodate a selected random access preamble length. For example, a random access preamble length may be selected by dimensioning cyclic shifts based on channel conditions. Although the PUSCHs 1052 and PRACH 1054 are shown as time-division multiplexed, the PUSCHs 1052 and the PRACH 1054 may be frequency-division multiplexed.

[0071] FIG. 11 is a protocol diagram of a method 1100 of performing UL mobility in a RRC common state (e.g., the RRC common state 220) according to embodiments of the present disclosure. Steps of the method 1100 can be executed by computing devices (e.g., a processor, processing circuit, and/or other suitable component) of wireless communication devices, such as the BSs 104 and 600, the TRP 404, and the UEs 102, 402, and 500. The method 1100 can be better understood with reference to FIG. 4. The method 1100 may employ similar mechanisms as in the network 400. As illustrated, the method 1100 includes a number of enumerated steps, but embodiments of the method 1100 may include additional steps before, after, and in between the enumerated steps. In some embodiments, one or more of the enumerated steps may be omitted or performed in a different order. The method 1100 illustrates two TRPs 404a and 404b and one UE 402 for purposes of simplicity of discussion, though it will be recognized that embodiments of the present disclosure may scale to many more UEs 402 and/or TRPs 404.

[0072] For example, the UE 402 has obtained a UE-ID after establishing a connection with the network and is in a RRC common state. At step 1110, the UE 402 transmits a RRC common state UL mobility signal including a UE-ID of the UE 402 and a random access preamble. The random access preamble may be similar to the random access preamble in the methods 700 and 900. When the UE 402 is in the RRC common state, the context (e.g., the UE-ID) of the UE 402 is saved in the network, but the UE 402 is not assigned with any air interface resource. Thus, UE 402 transmits the random access preamble to access the network and the UE-ID identifies the sender of the random access preamble as the UE 402. The UE 402 may transmit the UL mobility signal in a PUMICH. The PUMICH includes PUSCHs and a PRACH, as described in greater detail herein. For example, the random access preamble is transmitted in the PRACH and the UE-ID is transmitted in the PUSCHs. In some embodiments, the RRC common state UL mobility signal may also reach the TRP 404b as shown by the arrows in the dashed oval.

[0073] At step 1120, upon detecting the UE-ID and the random access preamble, the TRP 404a transmits a UL mobility response signal including a PUMICH ACK and a paging indicator to the UE 402. The TRP 404a may transmit the UL mobility response signal in a physical keep alive channel (PKACH). The PUMICH ACK may have a length of one bit. For example, a bit-value of 1 indicates an acknowledgement (ACK) of a successful reception of the PUMICH and a bit-value of 0 indicates a not-ACK (NACK) that the PUMICH is received with error. When the UE 402 fails to receive an ACK, the UE 402 may perform power control, for example, to increase the transmit power, for a next UL mobility signal transmission. In an embodiment, when the UE 402 is in the RRC common state, the UE 402 may transmit the UL mobility signal periodically, for example, at every 1.28 second (sec) and the TRP 404a may transmit a paging indicator along with the PUMICH ACK. Thus, the transmission of PUMICH facilitates UL mobility management and UE paging indicator polling.

[0074] FIG. 12 illustrates a subframe 1200 that includes a PUMICH 1250 according to the present disclosure. The subframe 1200 is employed by the UE 402 when implementing the UL mobility procedure described in the method 1100. In FIG. 12, the x-axis represents time in some constant units and the y-axis represents frequency in some constant units. The subframe 1200 is similar to the subframe 1000, but includes the PUMICH 1250 instead of the ePRACH 1050. As shown, the subframe 1200 carries the PUMICH 1250 in a UL data portion 214. The position of the PUMICH 1250 within the subframe 1250 may be configurable. For example, a network may broadcast the configuration of the PUMICH 1250. The PUMICH 1250 has a similar structure as the ePRACH 1050. For example, the PRACH 1054 carries the random access preamble of the RRC common state UL mobility signal and the PUSCHs 1058 carry the UE-ID of the RRC common state UL mobility signal of the method 1100.

[0075] FIG. 13 is a protocol diagram of a method 1300 of performing UL mobility in a RRC dedicated state (e.g., the RRC dedicated state 310) according to embodiments of the present disclosure. Steps of the method 1300 can be executed by computing devices (e.g., a processor, processing circuit, and/or other suitable component) of wireless communication devices, such as the BSs 104 and 600, the TRP 404, and the UEs 102, 402, and 500. The method 1300 can be better understood with reference to FIG. 3. The method 1300 may employ similar mechanisms as in the network 400. As illustrated, the method 1300 includes a number of enumerated steps, but embodiments of the method 1300 may include additional steps before, after, and in between the enumerated steps. In some embodiments, one or more of the enumerated steps may be omitted or performed in a different order. The method 1300 illustrates two TRPs 404a and 404b and one UE 402 for purposes of simplicity of discussion, though it will be recognized that embodiments of the present disclosure may scale to many more UEs 402 and/or TRPs 404.

[0076] For example, the UE 402 has obtained a UE-ID after establishing a connection with the network and is in a RRC dedicated state. At step 1310, the UE 402 transmits a UL mobility RS in a PUMRS channel, as described in greater detail herein. In an embodiment, the UL mobility RS includes a sounding reference signal (SRS) with an extended CP. The extended CP may enable the UL mobility RS to reach multiple TRPs. In some embodiments, the UE 402 may transmit the UL mobility RS in one or more transmit antenna ports that are the same or different from the regular SRS transmissions for sounding measurements. In some embodiments, the UL mobility RS may also reach the TRP 404b as shown by the arrows in the dashed oval.

[0077] At step 1320, the TRP 404a transmits a RRC dedicated UL mobility response signal in a PKACH. The network may perform mobility management based on the UL mobility RS. For example, the network may measure the receive signal strength of the UL mobility RS and tracks the mobility of the UE 404 based on the receive signal strength. In some embodiments, the network may determine to hand the UE 404 control over to another cell when the signal strength received from a current serving cell (e.g., the TRP 404a) is weak. Thus, the RRC dedicated UL mobility signal may include information associated with handover.

[0078] FIG. 14 illustrates a subframe 1400 including a PUMRS channel 1450 according to the present disclosure. The subframe 1400 is employed by the UE 402 when implementing the UL mobility procedure described in the method 1300. In FIG. 14, the x-axis represents time in some constant units and the y-axis represents frequency in some constant units. The subframe 1400 has a similar structure as the subframes 210, 800, 1000, and 1200 and includes the PUMRS channel 1450. As shown, the subframe 1400 carries PUMRS channel 1450 in a UL data portion 214. The position of the PUMRS channel 1450 within the UL data portion 214 may be configurable. For example, a network may broadcast the configuration of the PUMRS channel 1450. In an embodiment, the PUMRS channel 1450 spans a time duration of one symbol. For example, the PUMRS channel 1450 carries the UL mobility RS of the method 1300.

[0079] In an embodiment, the UL-based mobility mechanisms described in the methods 1100 and 1300 and the 2-step random access mechanisms described in the method 900 are suitable for use in small-cell areas, for example, with a cell radius of less than about 1.5 kilometers (km). The network 400 may employ two sets of random access preamble sequences with cyclic shifts, one set for random access procedure and the other set for UL mobility. In an embodiment, each set may include 64 Zadoff-Chu sequences, gold sequences, m-sequences, or any suitable orthogonal sequences. The following table illustrates an example configuration for the PRACH 1054 and the PUSCHs 1052 of the ePRACH 1050 or the PUMICH 1250 with a bandwidth of 3.84 MHz:

Channel	SCS (kHz)	Symbol duration (us)	CP (us)	Number of tones	Number of symbols
PRACH	15	66.67	10	256	1

PUSCH	15	66.67	10	256	4

Table 1 – Example Configuration for PRACH and PUSCH in ePRACH or PUMICH

[0080] A UE may transmit a random access preamble over multiple subframes (e.g., the subframes) based on link budget. The UE may transmit the random access preamble based on one numerology and the data based on another numerology when transmitting the eMSG1 or the RRC common state UL mobility signal. A BS or a TRP may utilize the random access preamble as a demodulation references signal to demodulate the data or the PUSCH.

[0081] In an embodiment, the random access procedure described above may be suitable for use is in large-cell deployment. The PRACH may be configured similar to the LTE PRACH in terms of random access preamble sequences (e.g., Zadoff-Chu with cyclic shifts), dimensioning of cyclic shifts such that delay spread and/or Doppler shift have minimal impacts on the RACH sequence cross-correlation. For example, the CP length may be dimensioned and a RACH sequence may be repeated to support different cell range requirements. The following table shows example PRACH formats and configurations:

Format	BW (MHz)	SCS (kHz)	CP (us)	SEQ (us)	Guard (us)	Duration (ms)	Cell radius (km)
0	1.08	1.25	103.1	800	96.9	1	14.5
1	1.08	1.25	684.4	800	515.6	2	77.3
2	1.08	1.25	203.1	1600	196.9	2	29.5
3	1.08	1.25	684.4	1600	715.6	3	107.3

Table 2 – Example PRACH Format

[0082] FIG. 15 is a flow diagram of a method 1500 of performing UL-based mobility and random access according to embodiments of the present disclosure. Steps of the method 1500 can be executed by a computing device (e.g., a processor, processing circuit, and/or other suitable component) of a wireless communication device, such as the UEs 402 and 500. The method 1500 may employ similar mechanisms as in the methods 900, 1100, and 1300. The method 1500 can be better understood with reference to FIG. 3. As illustrated, the method 1500 includes a number of enumerated steps, but embodiments of the method 1500 may include additional steps before, after, and in between the enumerated steps. In some embodiments, one or more of the enumerated steps may be omitted or performed in a different order.

[0083] At step 1510, the method 1500 includes transmitting a first signal carrying a random access preamble and data, for example, by a UE. At step 1520, the method includes receiving a second signal in response to the first signal. In an embodiment of random access, the first signal carries the eMSG1 as described in the method 900, where the data may include at least one of a connection request, tracking area updated information, a scheduling request, or a UE-ID of the UE. The second signal may include at least one of a random access preamble ID of the random access preamble, timing advance information, backoff information, or a contention resolution.

[0084] In an embodiment UL-based mobility, the first signal carries the RRC common state UL mobility signal as described in the method 1100, where the data carries a UE-ID of the UE. The second signal may include at least one of an acknowledgement for the first signal or paging information.

[0085] FIG. 16 is a flow diagram of a method 1600 of performing UL-based mobility and random access according to embodiments of the present disclosure. Steps of the method 1600 can be executed by a computing device (e.g., a processor, processing circuit, and/or other suitable component) of a wireless communication device, such as the TRPs 404 and the BS 600. The method 1600 may employ similar mechanisms as in the methods 900, 1100, and 1300. The method 1600 can be better understood with reference to FIG. 3. As illustrated, the method 1600 includes a number of enumerated steps, but embodiments of the method 1600 may include additional steps before, after, and in between the enumerated steps. In some embodiments, one or more of the enumerated steps may be omitted or performed in a different order.

[0086] At step 1610, the method 1600 includes receiving a first signal carrying a random access preamble and data, for example, by a TRP. At step 1620, the method includes transmitting a second signal in response to the first signal. In an embodiment of random access, the first signal carries the eMSG1 as described in the method 900, where the data may include at least one of a connection request, tracking area updated information, a scheduling request, or a UE-ID of the UE. The second signal may include at least one of a random access preamble ID of the random access preamble, timing advance information, backoff information, or a contention resolution.

[0087] In an embodiment UL-based mobility, the first signal carries the RRC common state UL mobility signal as described in the method 1100, where the data carries a UE-ID of the UE. The second signal may include at least one of an acknowledgement for the first signal or paging information.

[0088] 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.

[0089] The various illustrative blocks and modules described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any 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, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

[0090] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described above can be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations. Also, as used herein, including in the claims, "or" as used in a list of items (for example, a list of items prefaced by a phrase such as "at least one of" or "one or more of") indicates an inclusive list such that, for example, a list of [at least one of A, B, or C] means A or B or C or AB or AC or BC or ABC (i.e., A and B and C).

[0091] As those of some skill in this art will by now appreciate and depending on the particular application at hand, many modifications, substitutions and variations can be made in and to the materials, apparatus, configurations and methods of use of the devices of the present disclosure without departing from the spirit and scope thereof. In light of this, the scope of the present disclosure should not be limited to that of the particular embodiments illustrated and described herein, as they are merely by way of some examples thereof, but rather, should be fully commensurate with that of the claims appended hereafter and their functional equivalents.

WHAT IS CLAIMED IS:

1. A method of wireless communication in a network, comprising:

transmitting, by a first wireless communication device, a first signal carrying a random access sequence and a data; and

receiving, by the first wireless communication device from a second wireless communication device in response to the first signal, a second signal.

2. The method of claim 1, wherein the transmitting the first signal includes:

multiplexing the random access sequence and the data to produce a multiplexed signal; and

transmitting the multiplexed signal in a uplink (UL)-centric subframe.

3. The method of claim 2, wherein the multiplexing is a time-division multiplexing (TDM).

4. The method of claim 3, wherein the random access sequence is transmitted in a central time duration of a UL data portion of the subframe.

5. The method of claim 2, wherein the multiplexing is a frequency-division multiplexing (FDM).

6. The method of claim 1, wherein the data includes at least one of a connection request, tracking area updated information, a scheduling request, or an identifier (ID) that identifies the first wireless communication device in the network, and wherein the second signal includes at least one of a random access sequence ID of the random access sequence, timing advance information, backoff information, or a contention resolution.

7. The method of claim 1, wherein the first signal is a UL-based mobility signal, wherein the data includes an identifier (ID) that identifies the first wireless communication device in the network, and wherein the second signal includes at least one of an acknowledgement for the first signal or paging information.

8. The method of claim 1, further comprising:

transmitting, by the first wireless communication device, a UL-based mobility reference signal; and

receiving, by the first wireless communication device from the second wireless communication device, a third signal.

9. The method claim 8, wherein the third signal includes paging information and UL-based mobility reference signal acknowledgment.

10. A method of wireless communication in a network, comprising:

receiving, by a first wireless communication device from a second wireless communication device, a first signal carrying a random access sequence and a data; and

transmitting, by the first wireless communication device to the second wireless communication device in response to the first signal, a second signal.

11. The method of claim 10, further comprising transmitting, by the first wireless communication device, at least a random access configuration or a UL-based mobility configuration, wherein the first signal is received according to the random access configuration or the UL-based mobility configuration.

12. The method of claim 11, wherein the random access configuration indicates a physical random access channel including a first random access portion and a first data portion, wherein the UL-based mobility configuration indicates a physical UL measurement indication channel including a second random access portion and a second data portion, wherein the random access sequence is received in the first random access portion or the second random access portion, and wherein the data is received in the first data portion or the second data portion.

13. The method of claim 10, wherein the data includes at least one of a connection request, tracking area updated information, a scheduling request, or an identifier (ID) that identifies the second wireless communication device in the network, and wherein the second signal includes at least one of a random access sequence ID of the random access sequence, timing advance information, backoff information, or a contention resolution.

14. The method of claim 10, wherein the first signal is a UL-based mobility signal, wherein the data includes an identifier (ID) that identifies the second wireless communication device in the network, and wherein the second signal includes at least one of an acknowledgement for the first signal or paging information.

15. The method of claim 10, further comprising:

receiving, by the first wireless communication device from the second wireless communication device, a UL-based mobility reference signal; and

performing, by the first wireless communication device, mobility management associated with the second wireless communication device based on the first signal.

16. The method of claim 15, further comprising transmitting, by the first wireless communication device to the second wireless communication device, a third signal indicating handover information for the second wireless communication device based on the first signal.

ABSTRACT

Wireless communications systems and methods related to random access and uplink (UL)-based mobility. A first wireless communication device transmits a first signal carrying a random access sequence and a data. The first wireless communication device receives a second signal from a second wireless communication device in response to the first signal. For random access, the data in the first signal includes at least one of an identifier of the first wireless communication device or a connection request, and the second signal includes at least one of timing advance information or a contention resolution. For UL-based mobility, the data in the first signal includes at least an identifier of the first wireless communication device, and the second signal includes at least an acknowledgement for the first signal or paging information associated with the first wireless communication device.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS
First Named Inventor/Applicant Name:	Hung Ly
Filer:	Gregory Webb/Monique Le Sadahiro
Attorney Docket Number:	49606.423PV01 (170060P1)

Filed as Large Entity

Filing Fees for **Provisional**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
PROVISIONAL APPLICATION FILING	1005	1	260	260
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
	Total in USD ($)			**260**

Electronic Acknowledgement Receipt	
EFS ID:	27096876
Application Number:	62402956
International Application Number:	
Confirmation Number:	3748
Title of Invention:	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS
First Named Inventor/Applicant Name:	Hung Ly
Customer Number:	101306
Filer:	Gregory Webb/Monique Le Sadahiro
Filer Authorized By:	Gregory Webb
Attorney Docket Number:	49606.423PV01 (170060P1)
Receipt Date:	30-SEP-2016
Filing Date:	
Time Stamp:	20:43:31
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$260
RAM confirmation Number	100316INTEFSW20442400
Deposit Account	081394
Authorized User	Monique Le Sadahiro

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Provisional Cover Sheet (SB16)	49606_423PV01_ProvTransmittal.pdf	625625 45f6374c17617661832dfa3ffdb67054bd62c44b	no	3

Warnings:

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Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Application Data Sheet	49606_423PV01_ADS.pdf	504068 65d7d79c9860524339c64dc3231c374b3d368983	no	9

Warnings:

Information:

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Drawings-only black and white line drawings	49606_423PV01_Drawings.pdf	1218356 510e5d4b7d8c00b1428ff71ff44bf6ccf21a9c9a	no	16

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Power of Attorney	49606_423PV01_POA.pdf	1144486 77fec4e054e8d760145c1683007ee033b965efbf	no	2

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
5		49606_423PV01_Specification.pdf	580405 58a29add19a5a467964090a4224dfb5b4176f219	yes	26

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	22
Claims	23	25

	Abstract		26		26
Warnings:					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	30347 6975dcd7dad0afefecb468787af22c433cb423fc	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4103287		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/16 (03-13)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EFS

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
HUNG	LY	SAN DIEGO, CA
HAO	XU	SAN DIEGO, CA
TINGFANG	JI	SAN DIEGO, CA
JOSEPH BINAMIRA	SORIAGA	SAN DIEGO, CA

Additional inventors are being named on the ________ separately numbered sheets attached hereto.

TITLE OF THE INVENTION (500 characters max):

UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☑ The address corresponding to Customer Number: 101306

OR

☐ Firm or Individual Name

Address

City	State	Zip
Country	Telephone	Email

ENCLOSED APPLICATION PARTS (*check all that apply*)

☑ Application Data Sheet. See 37 CFR 1.76.

☐ CD(s), Number of CDs ________

☑ Drawing(s) *Number of Sheets* 16

☐ Other (specify) ________

☑ Specification (e.g., description of the invention) *Number of Pages* 26

Fees Due: Filing Fee of $260 ($130 for small entity) ($65 for micro entity). If the specification and drawings exceed 100 sheets of paper, an application size fee is also due, which is $400 ($200 for small entity) ($100 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

METHOD OF PAYMENT OF THE FILING FEE AND APPLICATION SIZE FEE FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.

☐ A check or money order made payable to the *Director of the United States Patent and Trademark Office* is enclosed to cover the filing fee and application size fee (if applicable).

TOTAL FEE AMOUNT ($) 260.00

☑ Payment by credit card. Form PTO-2038 is attached.

☑ The Director is hereby authorized to charge the filing fee and application size fee (if applicable) or credit any overpayment to Deposit Account Number: 08-1394.

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 2 of 2

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

- [✓] No.
- [ ] Yes, the invention was made by an agency of the U.S. Government. The U.S. Government agency name is: ______
- [ ] Yes, the invention was made under a contract with an agency of the U.S. Government. The name of the U.S. Government agency and Government contract number are: ______

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

SIGNATURE /Gregory P. Webb/ DATE September 30, 2016

TYPED OR PRINTED NAME GREGORY P. WEBB REGISTRATION NO. 59,859
(*if appropriate*)

TELEPHONE (214) 651-5000 DOCKET NUMBER 49606.423PV01 (170060P1)

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	

Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Hung		Ly	

Residence Information (Select One) ◉ US Residency ◯ Non US Residency ◯ Active US Military Service

City	San Diego	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	5775 Morehouse Drive		
Address 2			
City	San Diego	State/Province	CA
Postal Code	92121	Country i	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Hao		Xu	

Residence Information (Select One) ◉ US Residency ◯ Non US Residency ◯ Active US Military Service

City	San Diego	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	5775 Morehouse Drive		
Address 2			
City	San Diego	State/Province	CA
Postal Code	92121	Country i	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Tingfang		Ji	

Residence Information (Select One) ◉ US Residency ◯ Non US Residency ◯ Active US Military Service

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

City	San Diego	**State/Province**	CA	**Country of Residence**	US

Mailing Address of Inventor:

Address 1	5775 Morehouse Drive		
Address 2			
City	San Diego	**State/Province**	CA
Postal Code	92121	**Country**	US

Inventor 4

Legal Name

Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**
	Joseph	Binamira	Soriaga	

Residence Information (Select One) (●) US Residency ( ) Non US Residency ( ) Active US Military Service

City	San Diego	**State/Province**	CA	**Country of Residence**	US

Mailing Address of Inventor:

Address 1	5775 Morehouse Drive		
Address 2			
City	San Diego	**State/Province**	CA
Postal Code	92121	**Country**	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	101306
Email Address	ipdocketing@haynesboone.com

Application Information:

Title of the Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS		
Attorney Docket Number	49606.423PV01 (170060P1)	**Small Entity Status Claimed**	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	16	**Suggested Figure for Publication (if any)**	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	101306		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h) (1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

- (●) Assignee
- ( ) Legal Representative under 35 U.S.C. 117
- ( ) Joint Inventor
- ( ) Person to whom the inventor is obligated to assign.
- ( ) Person who shows sufficient proprietary interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	QUALCOMM Incorporated		
Mailing Address Information For Applicant:			
Address 1	5775 Morehouse Drive		
Address 2			
City	San Diego	**State/Province**	CA
Country	US	Postal Code	92121-1714
Phone Number	858-658-4351	Fax Number	
Email Address	patent.docketing.us@qualcomm.com		

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Gregory P. Webb/			Date (YYYY-MM-DD)	2016-09-30
First Name	GREGORY P.	Last Name	WEBB	Registration Number	59,859

Additional Signature may be generated within this form by selecting the Add button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	49606.423PV01 (170060P1)
	Application Number	
Title of Invention	UPLINK (UL) RANDOM ACCESS CHANNEL (RACH) AND MOBILITY SIGNALS	

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The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

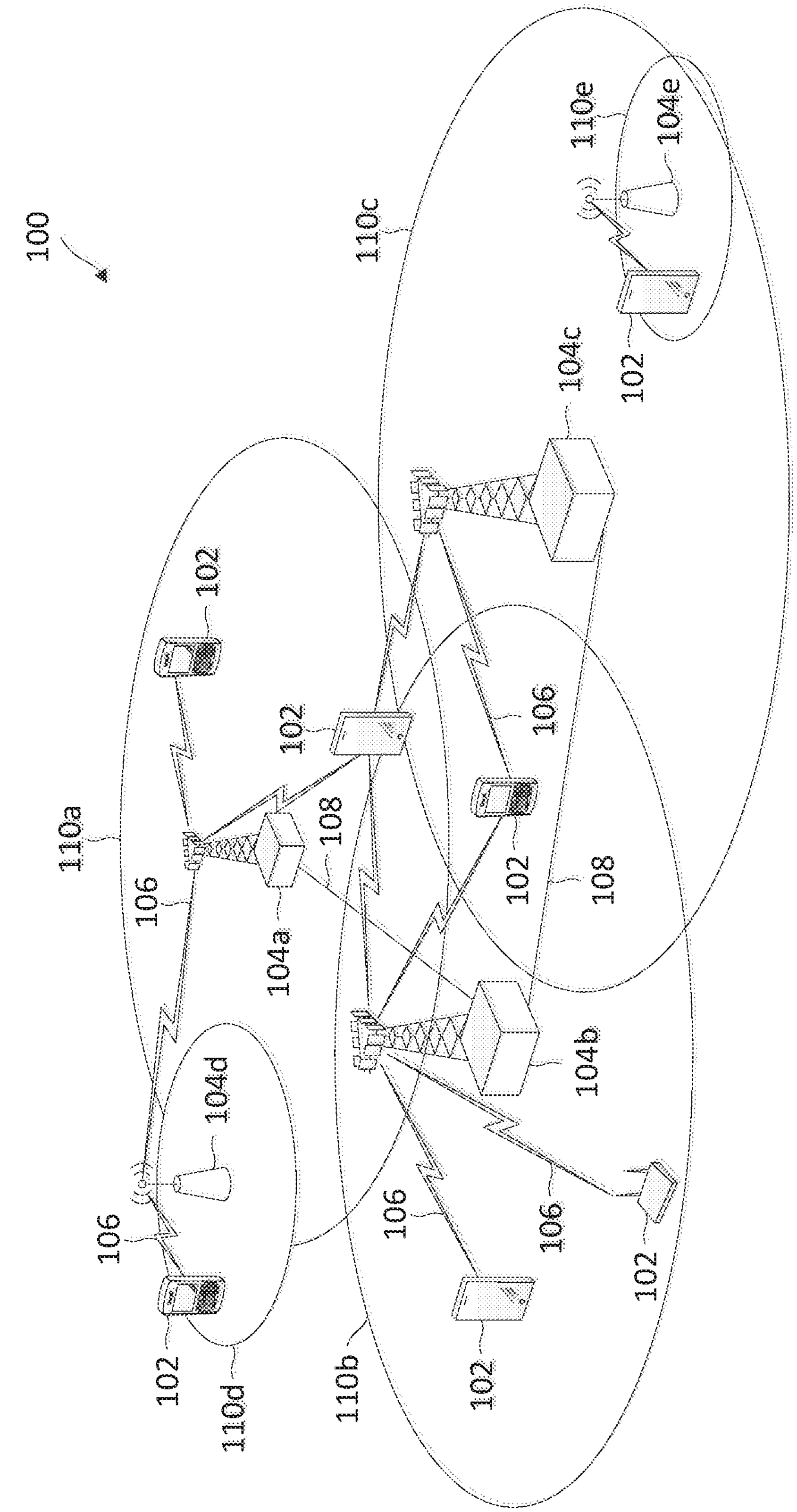

100
110a
110b
110c
110d
110e
104a
104b
104c
104d
104e
102
102
102
102
102
102
102
102
106
106
106
106
106
108
108

FIG. 1

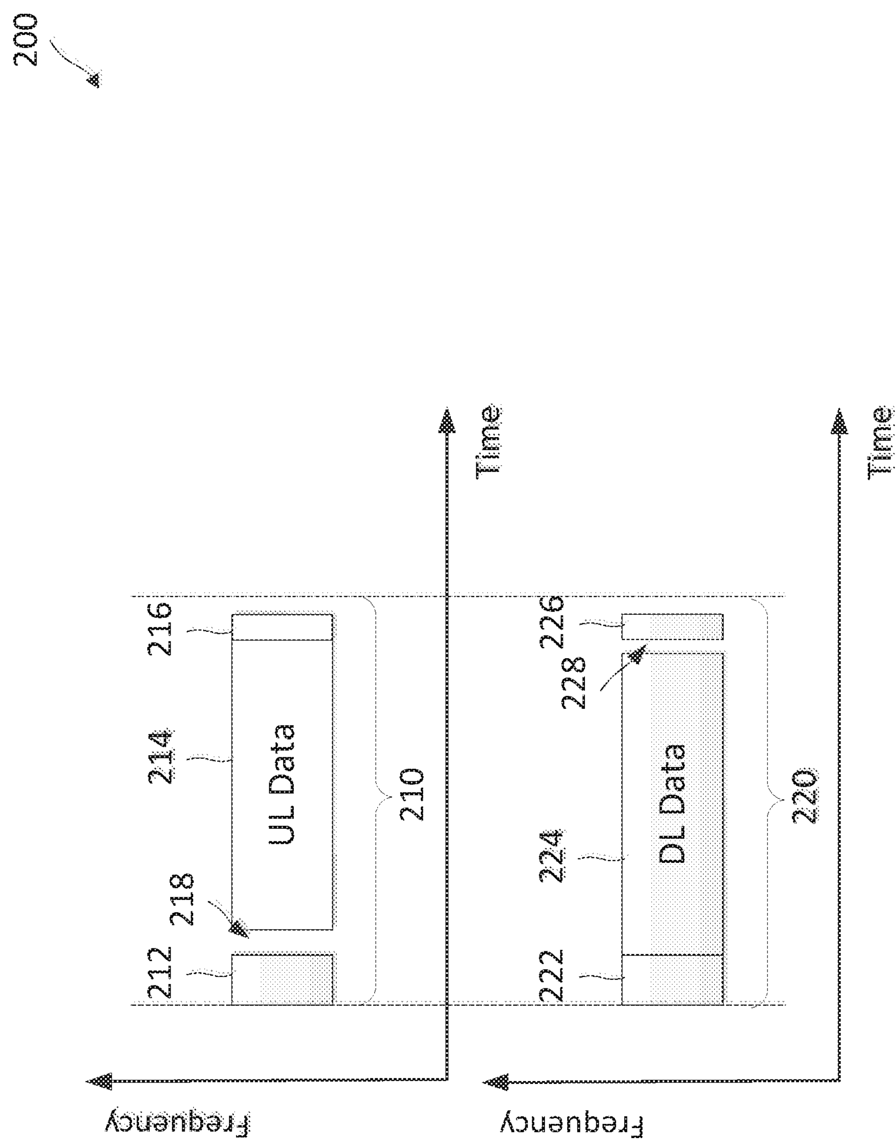
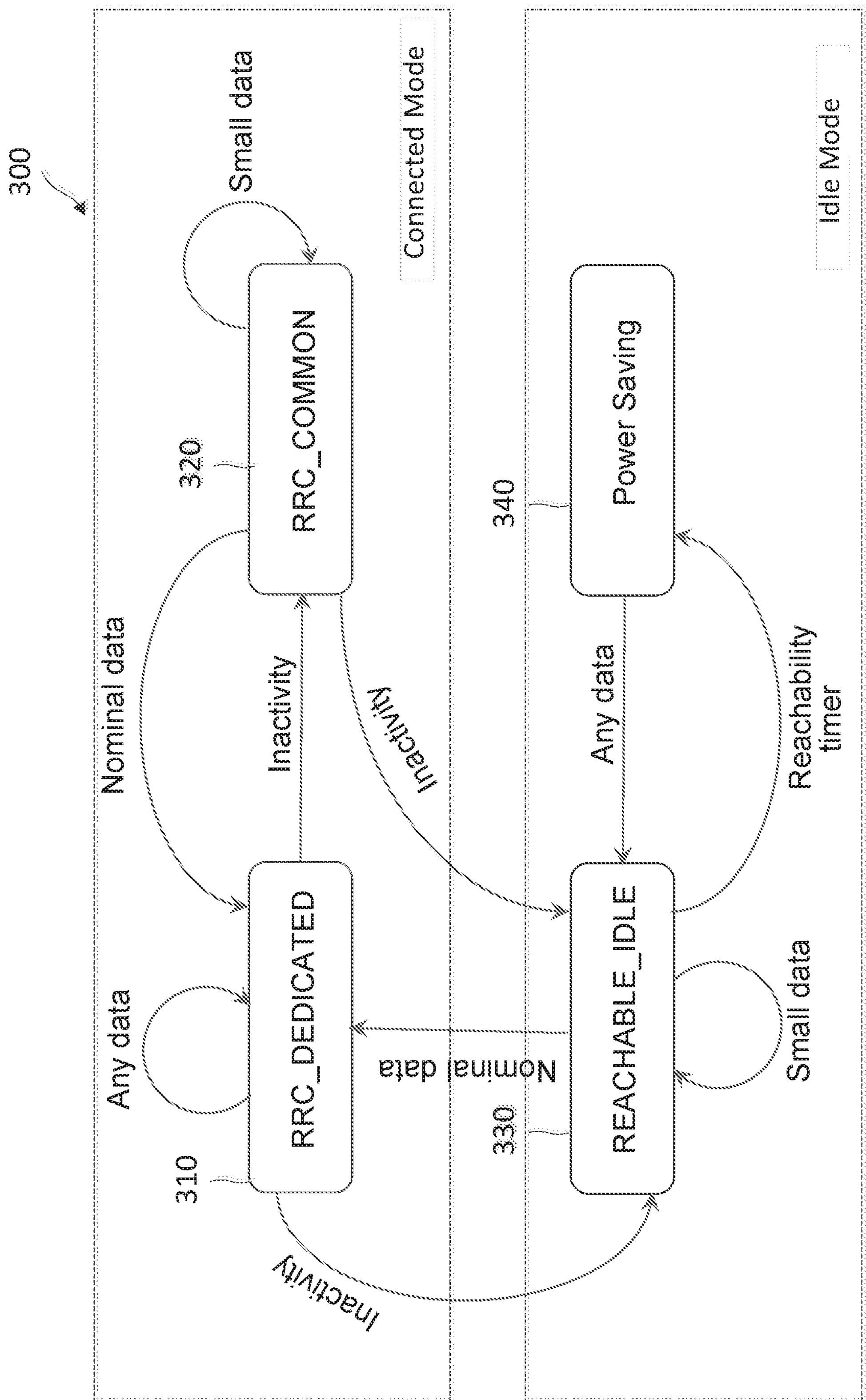

200
UL Data
DL Data
212
214
216
218
210
222
224
226
228
220
Frequency
Time
Frequency
Time

FIG. 2



300
Connected Mode
Small data
RRC_COMMON
320
Nominal data
Inactivity
Inactivity
RRC_DEDICATED
310
Any data
Nominal data
Inactivity
Idle Mode
Power Saving
340
Any data
Reachability timer
REACHABLE_IDLE
330
Small data

FIG. 3

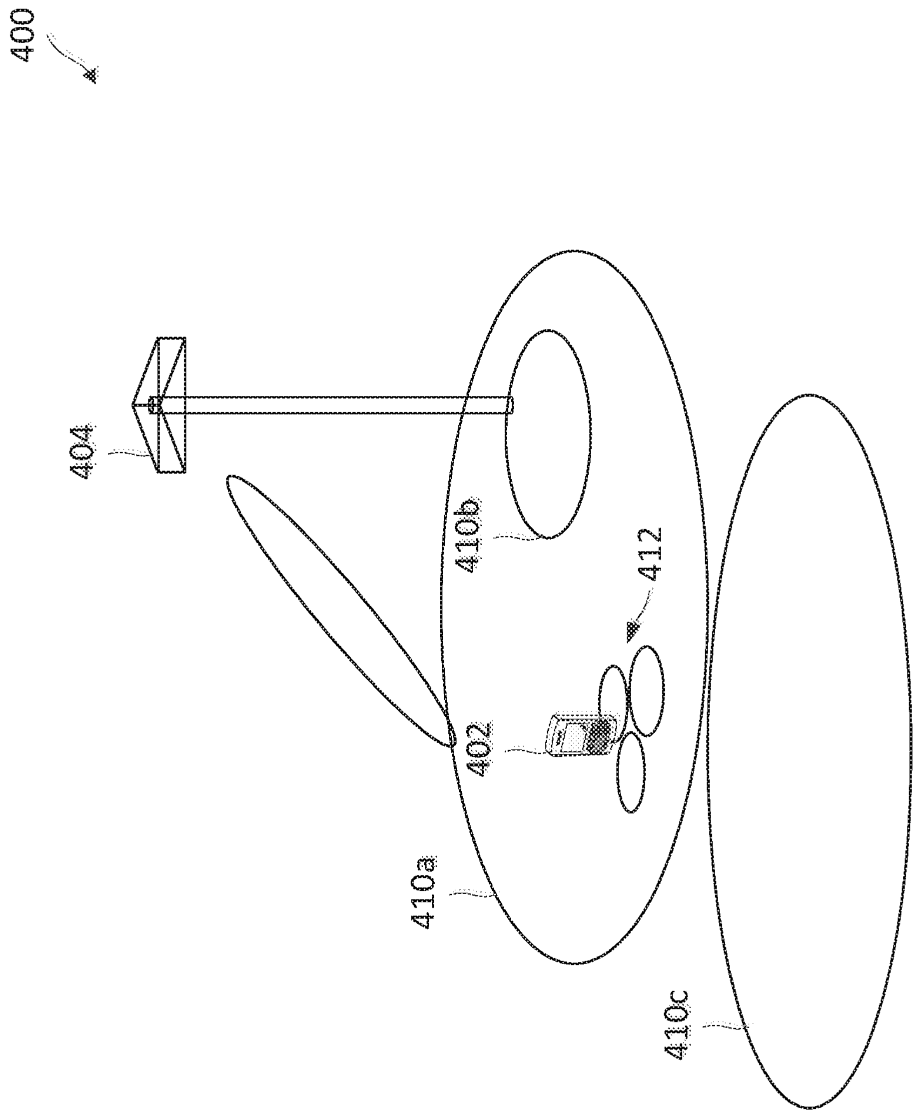


FIG. 4

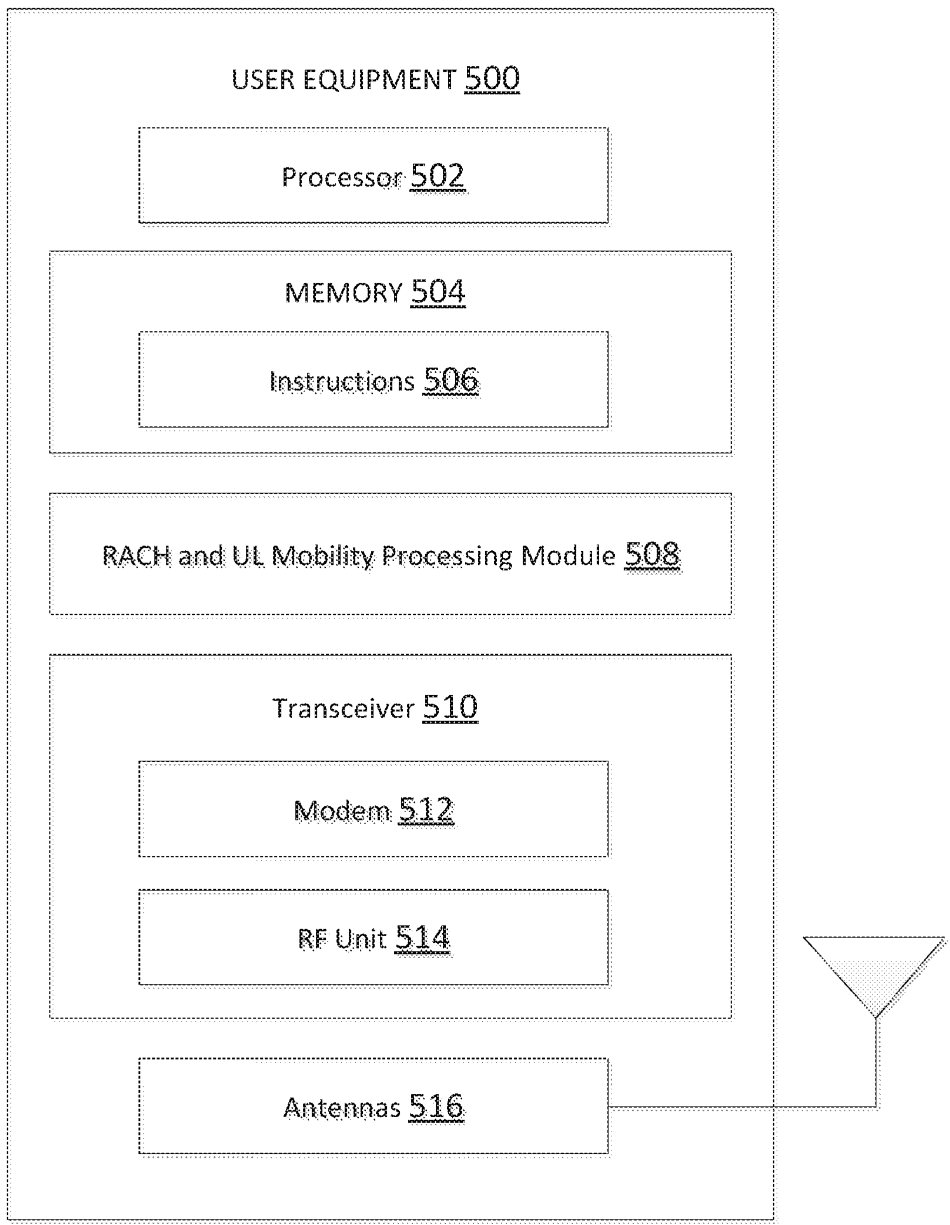

USER EQUIPMENT 500
Processor 502
MEMORY 504
Instructions 506
RACH and UL Mobility Processing Module 508
Transceiver 510
Modem 512
RF Unit 514
Antennas 516

FIG. 5

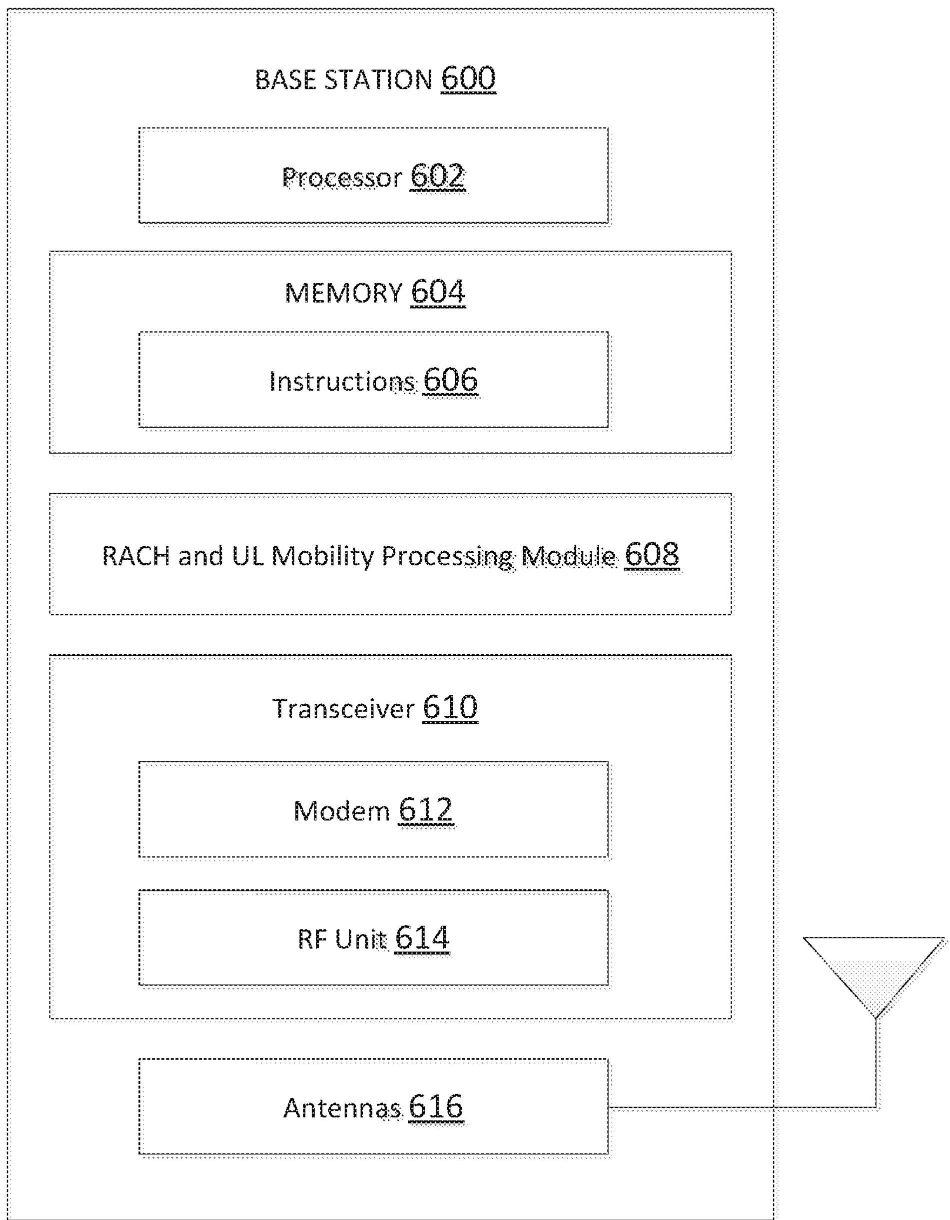

BASE STATION 600
Processor 602
MEMORY 604
Instructions 606
RACH and UL Mobility Processing Module 608
Transceiver 610
Modem 612
RF Unit 614
Antennas 616

FIG. 6

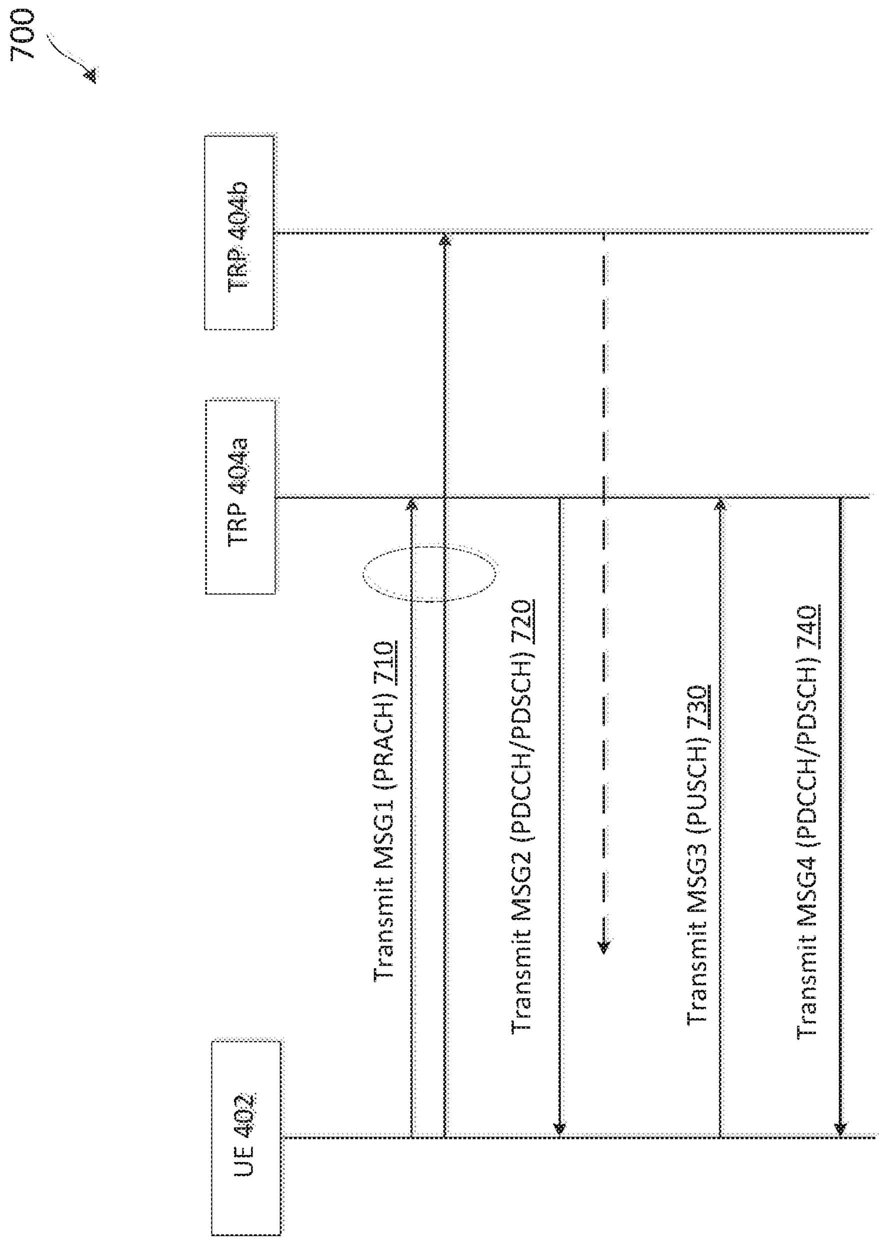

700
UE 402
TRP 404a
TRP 404b
Transmit MSG1 (PRACH) 710
Transmit MSG2 (PDCCH/PDSCH) 720
Transmit MSG3 (PUSCH) 730
Transmit MSG4 (PDCCH/PDSCH) 740

FIG. 7

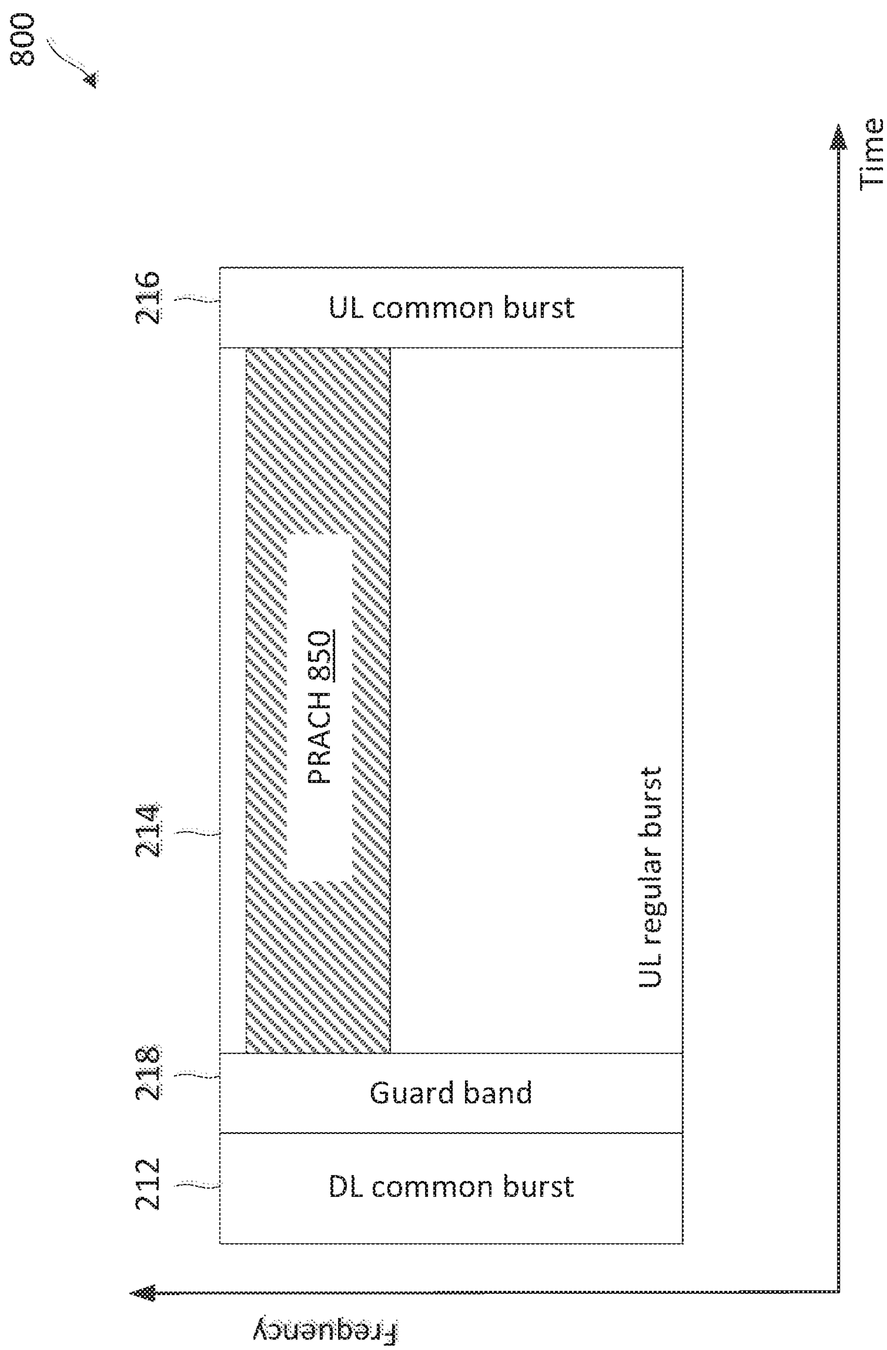

800
Time
216
UL common burst
214
PRACH 850
UL regular burst
218
Guard band
212
DL common burst
Frequency

FIG. 8

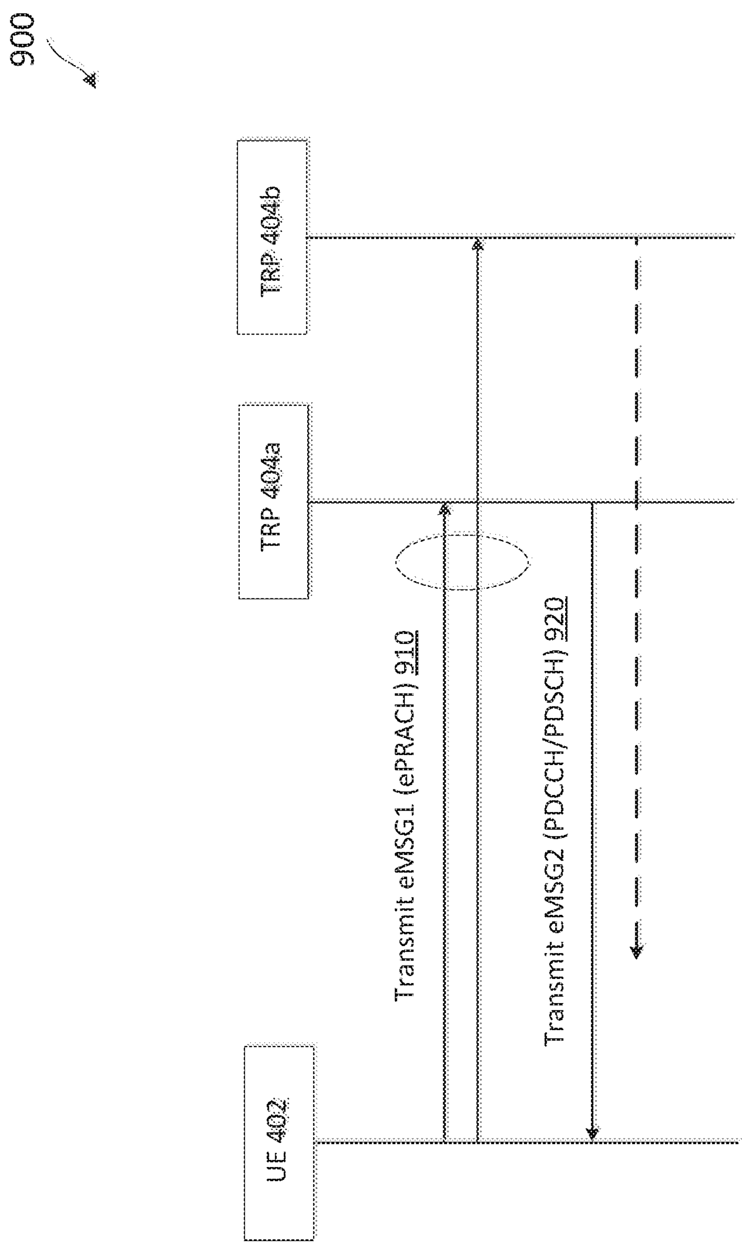

900
UE 402
TRP 404a
TRP 404b
Transmit eMSG1 (ePRACH) 910
Transmit eMSG2 (PDCCH/PDSCH) 920

FIG. 9

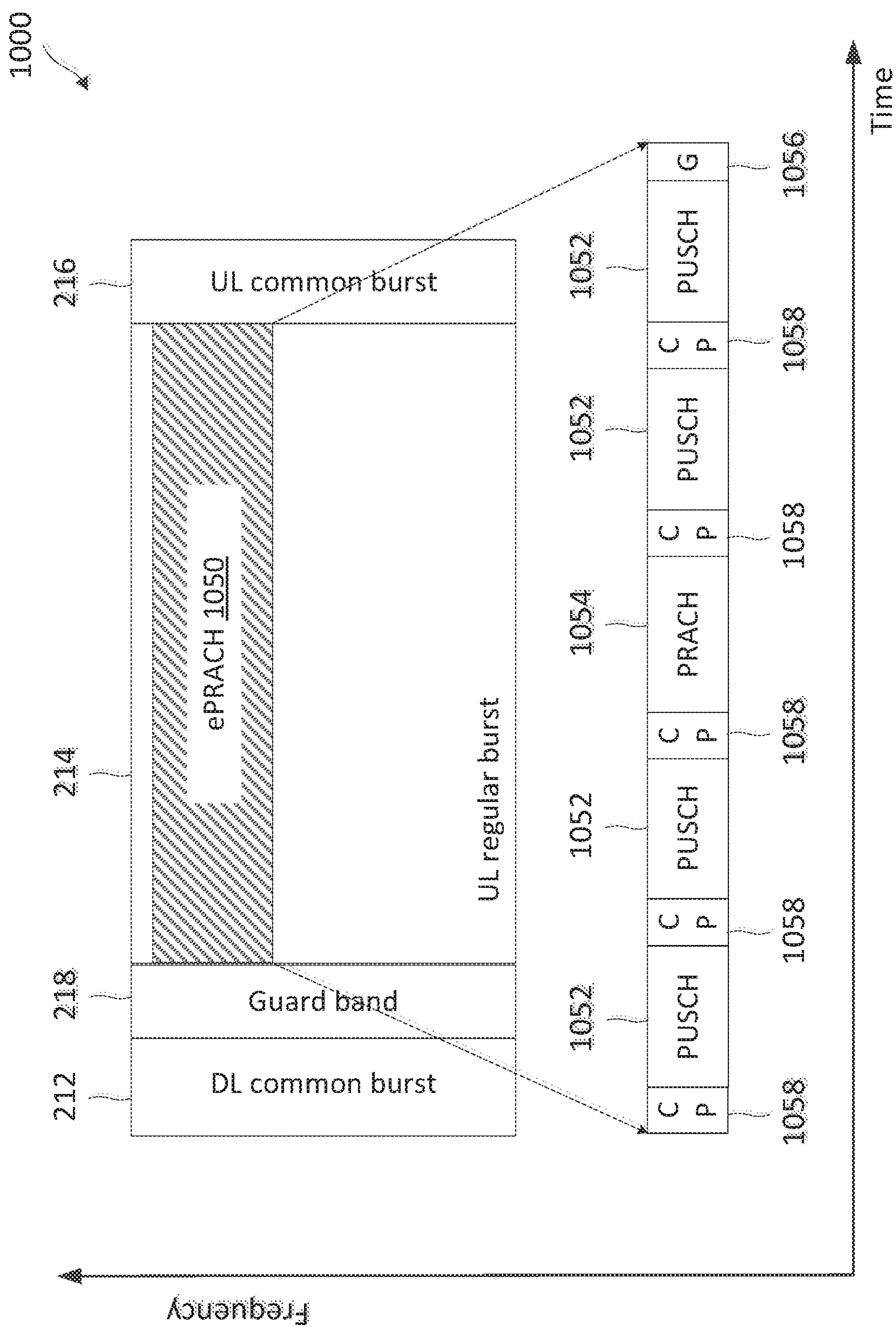

1000
216
UL common burst
214
ePRACH 1050
UL regular burst
218
Guard band
212
DL common burst
1052
1054
PUSCH
C P
PRACH
G
1056
1058
Time
Frequency

FIG. 10

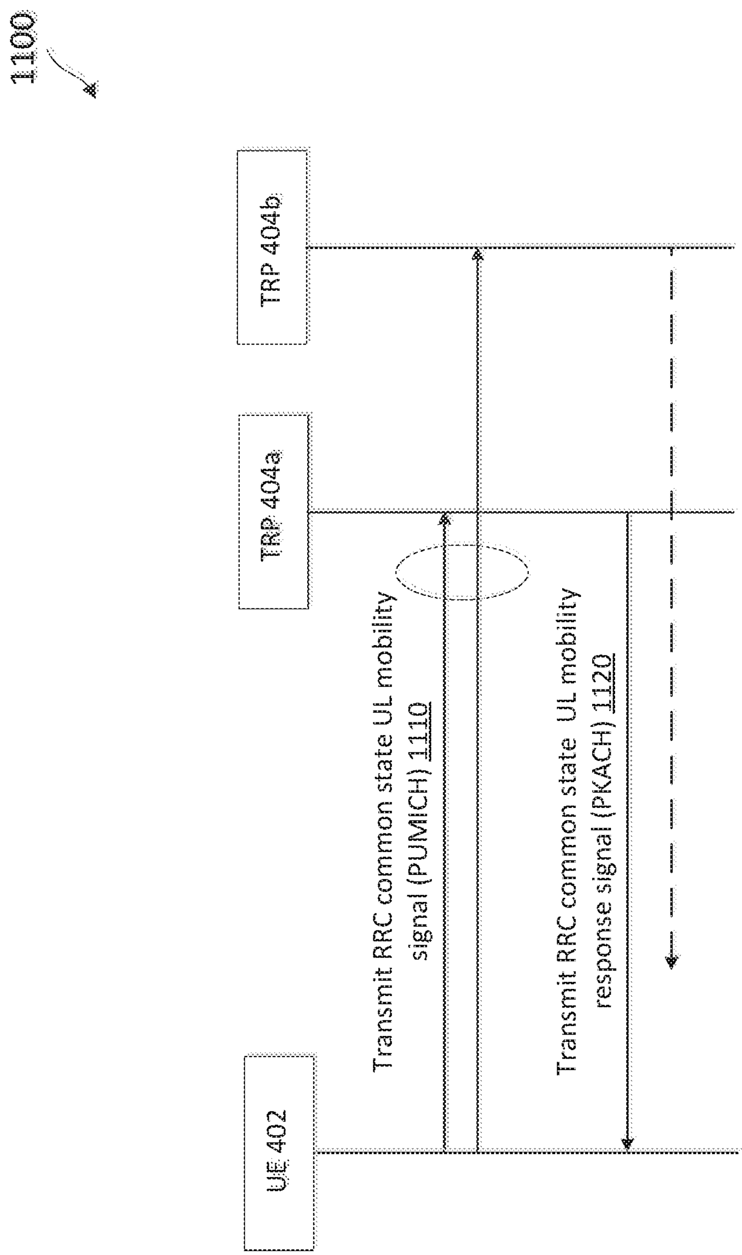

1100
TRP 404b
TRP 404a
UE 402
Transmit RRC common state UL mobility signal (PUMICH) 1110
Transmit RRC common state UL mobility response signal (PKACH) 1120

FIG. 11

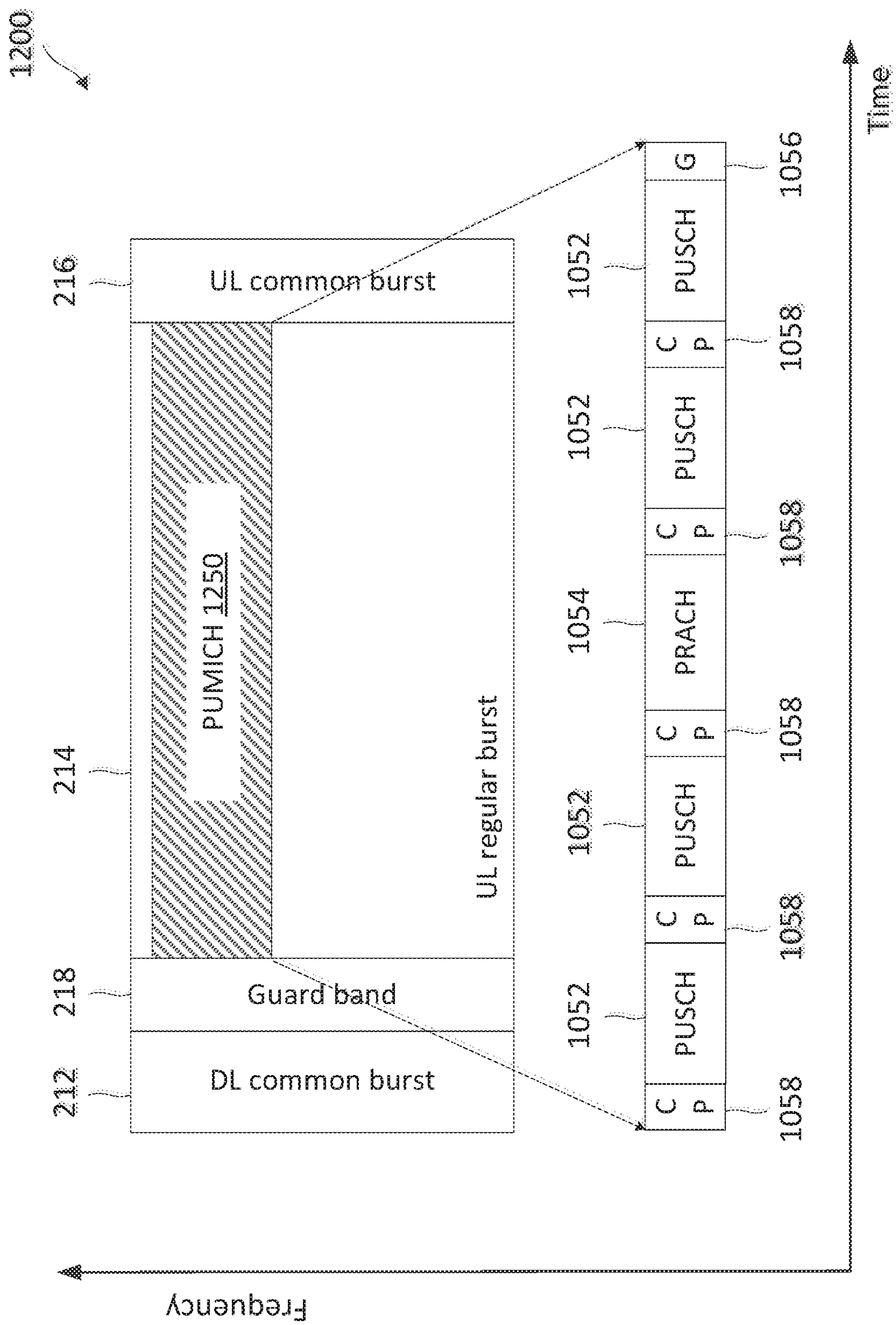

1200
UL common burst
PUMICH 1250
UL regular burst
Guard band
DL common burst
216
214
218
212
1052
1054
1056
1058
PUSCH
PRACH
C P
G
Time
Frequency

FIG. 12

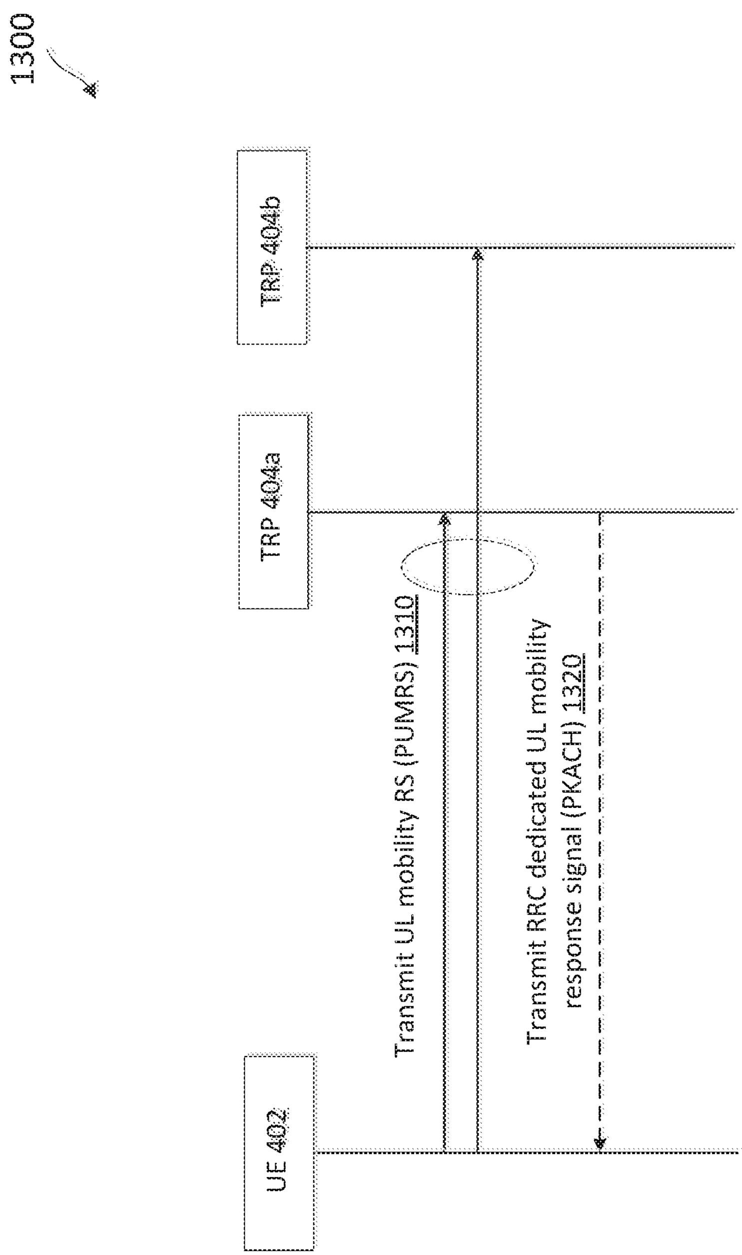

1300
TRP 404b
TRP 404a
UE 402
Transmit UL mobility RS (PUMRS) 1310
Transmit RRC dedicated UL mobility response signal (PKACH) 1320

FIG. 13

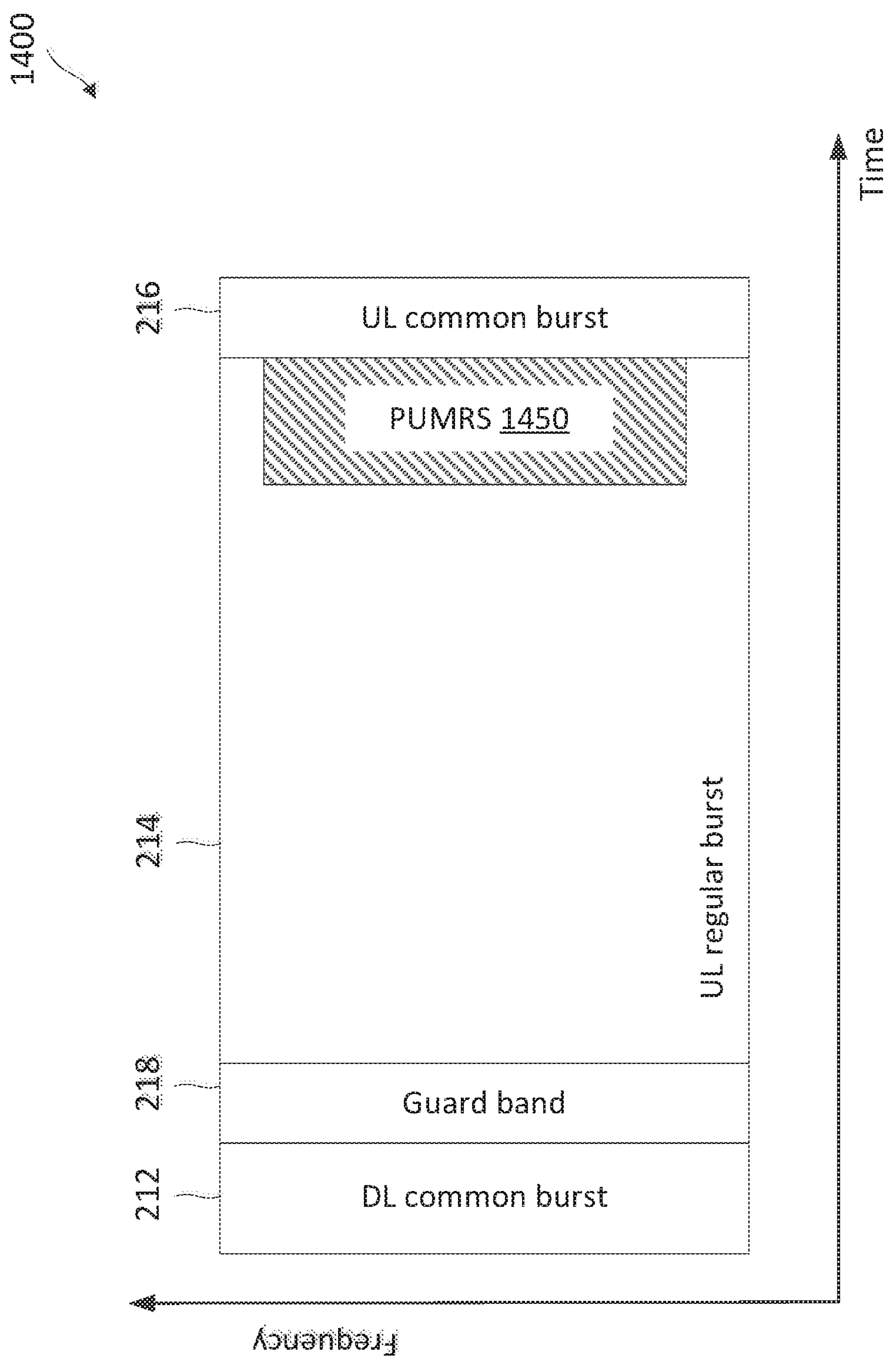

1400
Time
216
UL common burst
PUMRS 1450
214
UL regular burst
218
Guard band
212
DL common burst
Frequency

FIG. 14

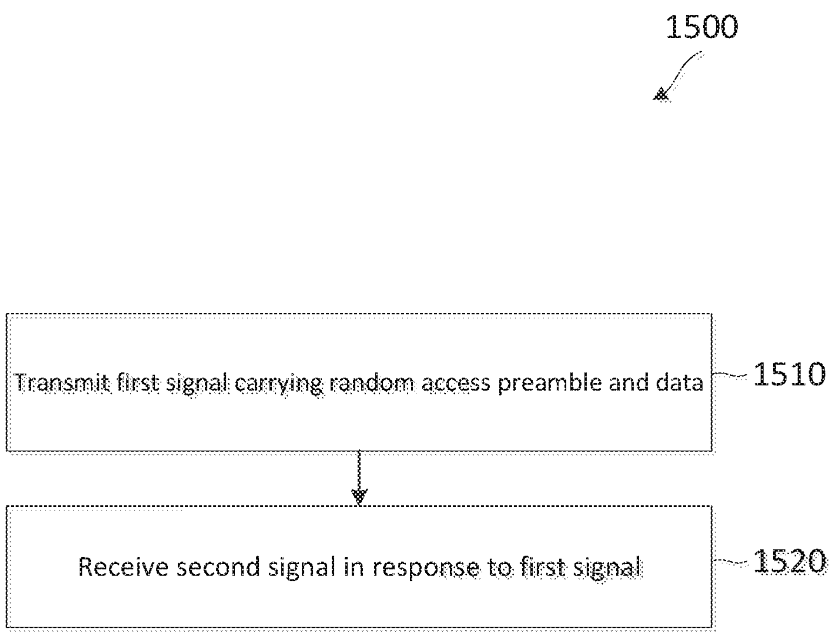

1500
Transmit first signal carrying random access preamble and data
1510
Receive second signal in response to first signal
1520

FIG. 15

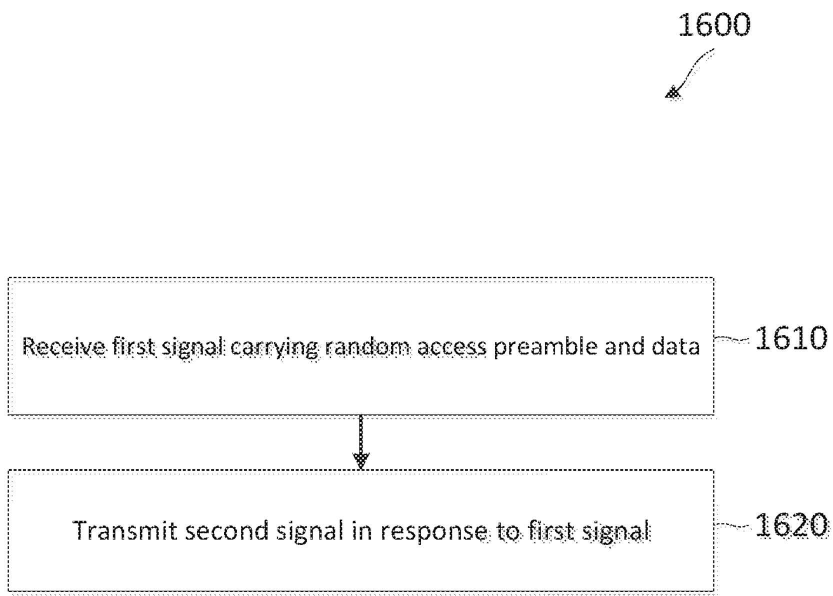

1600
Receive first signal carrying random access preamble and data
1610
Transmit second signal in response to first signal
1620

FIG. 16