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(54) Title: RANDOM ACCESS PROCEDURE BASED ON TWO-STEP RANDOM ACCESS CHANNEL PROCEDURE AND FOUR-STEP RANDOM ACCESS CHANNEL PROCEDURE

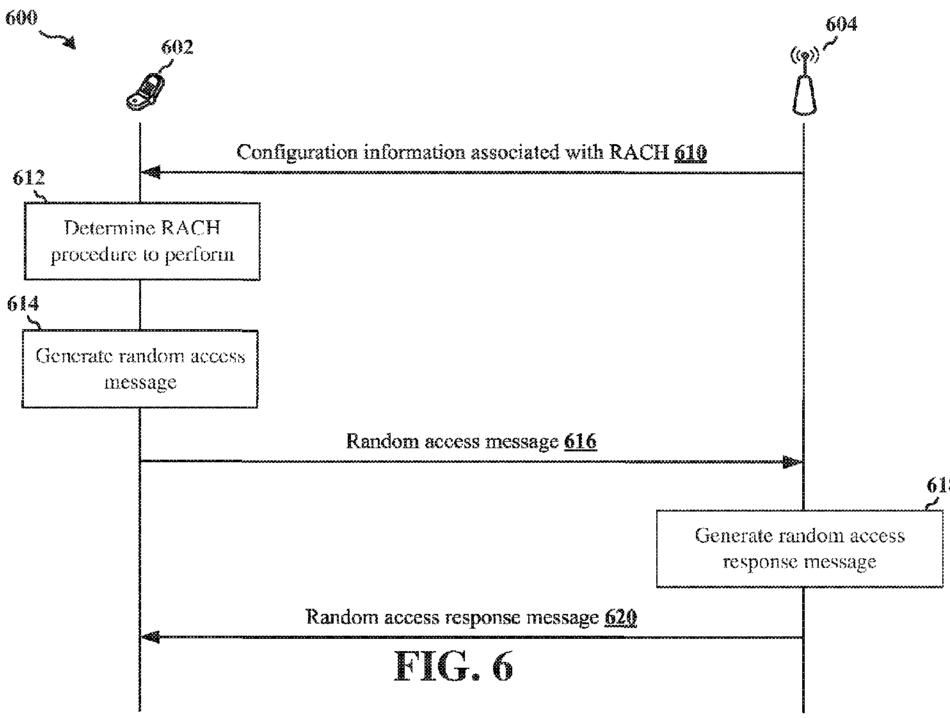

FIG. 6

(57) **Abstract:** Apparatus, methods, and computer-readable media for performing random access procedures based on two-step random access channel procedures and four-step random access channel procedures are disclosed herein. An example method for wireless communication at a User Equipment (UE) includes determining whether to perform a two-step random access channel (RACH) procedure or a four-step RACH procedure. The example method also includes generating a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step RACH procedure or a second random access message including the preamble and a payload when the determining is to perform the two-step RACH procedure. The example method also includes performing a RACH attempt by transmitting, to a base

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station, the random access message.

RANDOM ACCESS PROCEDURE BASED ON TWO-STEP RANDOM ACCESS CHANNEL PROCEDURE AND FOUR-STEP RANDOM ACCESS CHANNEL PROCEDURE

BACKGROUND

Technical Field

[0001] The present disclosure relates generally to communication systems, and more particularly, to a wireless communication system to perform a random access channel procedure.

Introduction

[0002] Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources. Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0003] These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example telecommunication standard is 5G New Radio (NR). 5G/NR is part of a continuous mobile broadband evolution promulgated by Third Generation Partnership Project (3GPP) to meet new requirements associated with latency, reliability, security, scalability (e.g., with Internet of Things (IoT)), and other requirements. 5G/NR includes services associated with enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra reliable low latency communications (URLLC). Some aspects of 5G/NR may be based on the 4G Long Term Evolution (LTE) standard. There exists a need for further improvements in 5G/NR technology. These improvements may also be applicable to other multiaccess technologies and the telecommunication standards that employ these technologies.

SUMMARY

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

[0005] A four-step random access channel (RACH) procedure is a type of random access procedure in which a user equipment (UE) sends an initial message that includes a preamble (referred to herein as "msg1"). A two-step RACH procedure is a type of random access procedure in which the UE sends an initial message that includes a preamble and a payload (referred to herein as a "msgA"). However, including the payload in the initial message associated with the two-step RACH procedure (msgA) results in a relatively larger initial message compared to the initial message associated with the four-step RACH procedure (msg1). As a result, the inclusion of the payload in the initial message associated with the two-step RACH procedure (msgA) may reduce link budget and/or cell coverage.

[0006] The present disclosure provides unique techniques for determining whether to perform a two-step RACH procedure or a four-step RACH procedure when a random access procedure is triggered. For example, the UE may perform one or more downlink measurements to measure channel quality, such as reference signal received power (RSRP) and/or a path loss measurement. Based on the one or more downlink measurements, the UE may determine whether to perform a two-step RACH procedure or to perform a four-step RACH procedure. Additional or alternative aspects include determining whether (or when) to revert to a four-step RACH procedure after initiating a two-step RACH procedure. For example, while performing a two-step RACH procedure, the UE may determine to stop performing the two-step RACH procedure and to initiate a four-step RACH procedure. In additional or alternative aspects, the UE may transition from performing the two-step RACH procedure to performing the four-step RACH procedure.

[0007] In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided for facilitating wireless communication at a UE. An example apparatus determines whether to perform a two-step RACH procedure or a four-step RACH procedure. The example apparatus also generates a random access message based on the determining. The random access message may be a first random access message including a preamble when the determining is to perform the four-step RACH procedure or a second random access message including the preamble and a payload when the determining is to perform the two-step RACH procedure. The example apparatus also performs a RACH attempt by transmitting, to a base station, the random access message.

[0008] In another aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided for facilitating wireless communication at a base station. An example apparatus provides, to a UE, an indication of whether the base station supports a two-step RACH procedure. The example apparatus also receives, from the UE, a random access message based at least in part on the indication. The random access message may be a first random access message including a preamble or a second random access message including the preamble and a payload.

[0009] To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a diagram illustrating an example of a wireless communications system and an access network.

[0011] FIGS. 2A, 2B, 2C, and 2D are diagrams illustrating examples of a first 5G/NR frame, DL channels within a 5G/NR subframe, a second 5G/NR frame, and UL channels within a 5G/NR subframe, respectively.

[0012] FIG. 3 is a diagram illustrating an example of a base station and user equipment (UE) in an access network.

[0013] FIG. 4 is a diagram illustrating a call flow diagram between a UE and a base station implementing a four-step random access channel (RACH) procedure.

[0014] FIG. 5 is a diagram illustrating a call flow diagram between a UE and a base station implementing a two-step RACH procedure.

[0015] FIG. 6 is a diagram illustrating a call flow diagram between a UE and a base station when the UE employs techniques for determining whether to perform a two-step RACH procedure or a four-step RACH procedure, as disclosed herein.

[0016] FIG. 7 is a flowchart of a method of wireless communication for a UE to perform a random access procedure.

[0017] FIG. 8 is a conceptual data flow diagram illustrating the data flow between different means/components in an exemplary apparatus.

[0018] FIG. 9 is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

[0019] FIG. 10 is a flowchart of a method of wireless communication for a base station to perform a random access procedure.

[0020] FIG. 11 is a conceptual data flow diagram illustrating the data flow between different means/components in an exemplary apparatus.

[0021] FIG. 12 is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

DETAILED DESCRIPTION

[0022] 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 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.

[0023] Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0024] By way of example, an element, or any portion of an element, or any combination of elements may be implemented as a "processing system" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, graphics processing units (GPUs), central processing units (CPUs), application processors, digital signal processors (DSPs), reduced instruction set computing (RISC) processors, systems on a chip (SoC), baseband processors, field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software components, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

[0025] Accordingly, in one or more example embodiments, the functions described may be implemented in hardware, software, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), optical disk storage, magnetic disk storage, other magnetic storage devices, combinations of the aforementioned types of computer-readable media, or any other medium that can be used to store computer executable code in the form of instructions or data structures that can be accessed by a computer. As used herein, the term computer-readable medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals and to exclude transmission media. As used herein, "computer-readable medium" and "machine-readable medium" are used interchangeably.

[0026] FIG. 1 is a diagram illustrating an example of a wireless communications system and an access network 100. The wireless communications system (also referred to as a wireless wide area network (WWAN)) includes base stations 102, UEs 104, an Evolved Packet Core (EPC) 160, and a Core Network 190. The base stations 102 may include macrocells (high power cellular base station) and/or small cells (low power cellular base station). The macrocells include base stations. The small cells include femtocells, picocells, and microcells.

[0027] The base stations 102 configured for 4G LTE (collectively referred to as Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN)) may interface with the EPC 160 through backhaul links 132 (e.g., S1 interface). The base stations 102 configured for 5G/NR (collectively referred to as Next Generation RAN (NG-RAN)) may interface with the Core Network 190 through backhaul links 184. In addition to other functions, the base stations 102 may perform one or more of the following functions: transfer of user data, radio channel ciphering and deciphering, integrity protection, header compression, mobility control functions (e.g., handover, dual connectivity), inter-cell interference coordination, connection setup and release, load balancing, distribution for non-access stratum (NAS) messages, NAS node selection, synchronization, radio access network (RAN) sharing, multimedia broadcast multicast service (MBMS), subscriber and equipment trace, RAN information management (RIM), paging, positioning, and delivery of warning messages. The base stations 102 may communicate directly or indirectly (e.g., through the EPC 160 or the Core Network 190) with each other over backhaul links 134 (e.g., X2 interface). The backhaul links 134 may be wired or wireless.

[0028] The base stations 102 may wirelessly communicate with the UEs 104. Each of the base stations 102 may provide communication coverage for a respective geographic coverage area 110. There may be overlapping geographic coverage areas 110. For example, the small cell 102' may have a coverage area 110' that overlaps the coverage area 110 of one or more macro base stations 102. A network that includes both small cell and macrocells may be known as a heterogeneous network. A heterogeneous network may also include Home Evolved Node Bs (eNBs) (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG). The communication links 120 between the base stations 102 and the UEs 104 may include uplink (UL) (also referred to as reverse link) transmissions from a UE 104 to a base station 102 and/or downlink (DL) (also referred to as forward link) transmissions from a base station 102 to a UE 104. The communication links 120 may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links may be through one or more carriers. The base stations 102 / UEs 104 may use spectrum up to Y MHz (e.g., 5, 10, 15, 20, 100, 400, etc. MHz) bandwidth per carrier allocated in a carrier aggregation of up to a total of Yx MHz (x component carriers) used for transmission in each direction. The carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL). The component carriers may include a primary component carrier and one or more secondary component carriers. A primary component carrier may be referred to as a primary cell (PCell) and a secondary component carrier may be referred to as a secondary cell (SCell).

[0029] Certain UEs 104 may communicate with each other using device-to-device (D2D) communication link 158. The D2D communication link 158 may use the DL/UL WWAN spectrum. The D2D communication link 158 may use one or more sidelink channels, such as a physical sidelink broadcast channel (PSBCH), a physical sidelink discovery channel (PSDCH), a physical sidelink shared channel (PSSCH), and a physical sidelink control channel (PSCCH). D2D communication may be through a variety of wireless D2D communications systems, such as for example, FlashLinQ, WiMedia, Bluetooth, ZigBee, Wi-Fi based on the IEEE 802.11 standard, LTE, or NR.

[0030] The wireless communications system may further include a Wi-Fi access point (AP) 150 in communication with Wi-Fi stations (STAs) 152 via communication links 154 in a 5 GHz unlicensed frequency spectrum. When communicating in an unlicensed frequency spectrum, the STAs 152 / AP 150 may perform a clear channel assessment (CCA) prior to communicating in order to determine whether the channel is available.

[0031] The small cell 102' may operate in a licensed and/or an unlicensed frequency spectrum. When operating in an unlicensed frequency spectrum, the small cell 102' may employ NR and use the same 5 GHz unlicensed frequency spectrum as used by the Wi-Fi AP 150. The small cell 102', employing NR in an unlicensed frequency spectrum, may boost coverage to and/or increase capacity of the access network.

[0032] A base station 102, whether a small cell 102' or a large cell (e.g., macro base station), may include an eNB, gNodeB (gNB), or another type of base station. Some base stations, such as gNB 180 may operate in a traditional sub 6 GHz spectrum, in millimeter wave (mmW) frequencies, and/or near mmW frequencies in communication with the UE 104. When the gNB 180 operates in mmW or near mmW frequencies, the gNB 180 may be referred to as an mmW base station. Extremely high frequency (EHF) is part of the RF in the electromagnetic spectrum. EHF has a range of 30 GHz to 300 GHz and a wavelength between 1 millimeter and 10 millimeters. Radio waves in the band may be referred to as a millimeter wave. Near mmW may extend down to a frequency of 3 GHz with a wavelength of 100 millimeters. The super high frequency (SHF) band extends between 3 GHz and 30 GHz, also referred to as centimeter wave. Communications using the mmW / near mmW radio frequency band (e.g., 3 GHz – 300 GHz) has extremely high path loss and a short range. The mmW base station 180 may utilize beamforming 182 with the UE 104 to compensate for the extremely high path loss and short range.

[0033] The base station 180 may transmit a beamformed signal to the UE 104 in one or more transmit directions 182'. The UE 104 may receive the beamformed signal from the base station 180 in one or more receive directions 182''. The UE 104 may also transmit a beamformed signal to the base station 180 in one or more transmit directions. The base station 180 may receive the beamformed signal from the UE 104 in one or more receive directions. The base station 180 / UE 104 may perform beam training to determine the best receive and transmit directions for each of the base station 180 / UE 104. The transmit and receive directions for the base station 180 may or may not be the same. The transmit and receive directions for the UE 104 may or may not be the same.

[0034] The EPC 160 may include a Mobility Management Entity (MME) 162, other MMEs 164, a Serving Gateway 166, a Multimedia Broadcast Multicast Service (MBMS) Gateway 168, a Broadcast Multicast Service Center (BM-SC) 170, and a Packet

Data Network (PDN) Gateway 172. The MME 162 may be in communication with a Home Subscriber Server (HSS) 174. The MME 162 is the control node that processes the signaling between the UEs 104 and the EPC 160. Generally, the MME 162 provides bearer and connection management. All user Internet protocol (IP) packets are transferred through the Serving Gateway 166, which itself is connected to the PDN Gateway 172. The PDN Gateway 172 provides UE IP address allocation as well as other functions. The PDN Gateway 172 and the BM-SC 170 are connected to the IP Services 176. The IP Services 176 may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a PS Streaming Service, and/or other IP services. The BM-SC 170 may provide functions for MBMS user service provisioning and delivery. The BM-SC 170 may serve as an entry point for content provider MBMS transmission, may be used to authorize and initiate MBMS Bearer Services within a public land mobile network (PLMN), and may be used to schedule MBMS transmissions. The MBMS Gateway 168 may be used to distribute MBMS traffic to the base stations 102 belonging to a Multicast Broadcast Single Frequency Network (MBSFN) area broadcasting a particular service, and may be responsible for session management (start/stop) and for collecting eMBMS related charging information.

[0035] The Core Network 190 may include a Access and Mobility Management Function (AMF) 192, other AMFs 193, a Session Management Function (SMF) 194, and a User Plane Function (UPF) 195. The AMF 192 may be in communication with a Unified Data Management (UDM) 196. The AMF 192 is the control node that processes the signaling between the UEs 104 and the Core Network 190. Generally, the AMF 192 provides QoS flow and session management. All user Internet protocol (IP) packets are transferred through the UPF 195. The UPF 195 provides UE IP address allocation as well as other functions. The UPF 195 is connected to the IP Services 197. The IP Services 197 may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a PS Streaming Service, and/or other IP services.

[0036] The base station may also be referred to as a gNB, Node B, evolved Node B (eNB), an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), a transmit reception point (TRP), or some other suitable terminology. The base station 102 provides an access point to the EPC 160 or the Core Network 190 for a UE 104.

Examples of UEs 104 include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, a tablet, a smart device, a wearable device, a vehicle, an electric meter, a gas pump, a large or small kitchen appliance, a healthcare device, an implant, a sensor/actuator, a display, or any other similar functioning device. Some of the UEs 104 may be referred to as IoT devices (e.g., parking meter, gas pump, toaster, vehicles, heart monitor, etc.). The UE 104 may also be referred to as a station, a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology.

[0037] Referring again to FIG. 1, in certain aspects, the UE 104 may be configured to manage one or more aspects of wireless communication via a random access procedure. For example, the UE 104 of FIG. 1 includes a random access channel procedure component 198 configured to determine whether to perform a two-step RACH procedure or a four-step RACH procedure, generate a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step RACH procedure or a second random access message including the preamble and a payload when the determining is to perform the two-step RACH procedure, and perform a RACH attempt by transmitting, to a base station, the random access message.

[0038] Referring still to FIG. 1, in certain aspects, the base station 102/180 may be configured to manage one or more aspects of wireless communication via a random access procedure. For example, the base station 102/180 of FIG. 1 includes a random access channel procedure component 199 configured to provide, to UE 104, an indication of whether the base station supports a two-step RACH procedure, and receive, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload.

[0039] FIG. 2A is a diagram 200 illustrating an example of a first subframe within a 5G/NR frame structure. FIG. 2B is a diagram 230 illustrating an example of DL channels within a 5G/NR subframe. FIG. 2C is a diagram 250 illustrating an example of a second subframe within a 5G/NR frame structure. FIG. 2D is a diagram 280 illustrating an example of UL channels within a 5G/NR subframe. The 5G/NR frame structure may be FDD in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for either DL or UL, or may be TDD in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for both DL and UL. In the examples provided by FIGS. 2A, 2C, the 5G/NR frame structure is assumed to be TDD, with subframe 4 being configured with slot format 28 (with mostly DL), where D is DL, U is UL, and X is flexible for use between DL/UL, and subframe 3 being configured with slot format 34 (with mostly UL). While subframes 3, 4 are shown with slot formats 34, 28, respectively, any particular subframe may be configured with any of the various available slot formats 0-61. Slot formats 0, 1 are all DL, UL, respectively. Other slot formats 2-61 include a mix of DL, UL, and flexible symbols. UEs are configured with the slot format (dynamically through DL control information (DCI), or semi-statically/statically through radio resource control (RRC) signaling) through a received slot format indicator (SFI). Note that the description *infra* applies also to a 5G/NR frame structure that is TDD.

[0040] Other wireless communication technologies may have a different frame structure and/or different channels. A frame (10 ms) may be divided into 10 equally sized subframes (1 ms). Each subframe may include one or more time slots. Subframes may also include mini-slots, which may include 7, 4, or 2 symbols. Each slot may include 7 or 14 symbols, depending on the slot configuration. For slot configuration 0, each slot may include 14 symbols, and for slot configuration 1, each slot may include 7 symbols. The symbols on DL may be cyclic prefix (CP) OFDM (CP-OFDM) symbols. The symbols on UL may be CP-OFDM symbols (for high throughput scenarios) or discrete Fourier transform (DFT) spread OFDM (DFT-s-OFDM) symbols (also referred to as single carrier frequency-division multiple access (SC-FDMA) symbols) (for power limited scenarios; limited to a single stream transmission). The number of slots within a subframe is based on the slot configuration and the numerology. For slot configuration 0, different numerologies μ 0 to 5 allow for 1, 2, 4, 8, 16, and 32 slots, respectively, per subframe. For slot configuration 1, different numerologies 0 to 2 allow for 2, 4, and 8 slots, respectively, per subframe. Accordingly, for slot configuration 0 and numerology μ, there are 14 symbols/slot and 2^{μ} slots/subframe. The subcarrier spacing and symbol length/duration are a function of the numerology. The subcarrier spacing may be equal to $2^{\mu} * 15\ kKz$, where μ is the numerology 0 to 5. As such, the numerology μ=0 has a subcarrier spacing of 15 kHz and the numerology μ=5 has a subcarrier spacing of 480 kHz. The symbol length/duration is inversely related to the subcarrier spacing. FIGS. 2A to 2D provide an example of slot configuration 0 with 14 symbols per slot and numerology μ=0 with 1 slot per subframe. The subcarrier spacing is 15 kHz and symbol duration is approximately 66.7 μs.

[0041] A resource grid may be used to represent the frame structure. Each time slot includes a resource block (RB) (also referred to as physical RBs (PRBs)) that extends 12 consecutive subcarriers. The resource grid is divided into multiple resource elements (REs). The number of bits carried by each RE depends on the modulation scheme.

[0042] As illustrated in FIG. 2A, some of the REs carry reference (pilot) signals (RS) for the UE. The RS may include demodulation RS (DM-RS) (indicated as R_x for one particular configuration, where 100x is the port number, but other DM-RS configurations are possible) and channel state information reference signals (CSI-RS) for channel estimation at the UE. The RS may also include beam measurement RS (BRS), beam refinement RS (BRRS), and phase tracking RS (PT-RS).

[0043] FIG. 2B illustrates an example of various DL channels within a subframe of a frame. The physical downlink control channel (PDCCH) carries DCI within one or more control channel elements (CCEs), each CCE including nine RE groups (REGs), each REG including four consecutive REs in an OFDM symbol. A primary synchronization signal (PSS) may be within symbol 2 of particular subframes of a frame. The PSS is used by a UE 104 to determine subframe/symbol timing and a physical layer identity. A secondary synchronization signal (SSS) may be within symbol 4 of particular subframes of a frame. The SSS is used by a UE to determine a physical layer cell identity group number and radio frame timing. Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a physical cell identifier (PCI). Based on the PCI, the UE can determine the locations of the aforementioned DM-RS. The physical broadcast channel (PBCH), which carries a master information block (MIB), may be logically grouped with the PSS and SSS to form a synchronization signal (SS)/PBCH block. The MIB provides a number of RBs in the system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and paging messages.

[0044] As illustrated in FIG. 2C, some of the REs carry DM-RS (indicated as R for one particular configuration, but other DM-RS configurations are possible) for channel estimation at the base station. The UE may transmit DM-RS for the physical uplink control channel (PUCCH) and DM-RS for the physical uplink shared channel (PUSCH). The PUSCH DM-RS may be transmitted in the first one or two symbols of the PUSCH. The PUCCH DM-RS may be transmitted in different configurations depending on whether short or long PUCCHs are transmitted and depending on the particular PUCCH format used. Although not shown, the UE may transmit sounding reference signals (SRS). The SRS may be used by a base station for channel quality estimation to enable frequency-dependent scheduling on the UL.

[0045] FIG. 2D illustrates an example of various UL channels within a subframe of a frame. The PUCCH may be located as indicated in one configuration. The PUCCH carries uplink control information (UCI), such as scheduling requests, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and HARQ ACK/NACK feedback. The PUSCH carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

[0046] FIG. 3 is a block diagram of a base station 310 in communication with a UE 350 in an access network. In the DL, IP packets from the EPC 160 may be provided to a controller/processor 375. The controller/processor 375 implements layer 3 and layer 2 functionality. Layer 3 includes a radio resource control (RRC) layer, and layer 2 includes a service data adaptation protocol (SDAP) layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a medium access control (MAC) layer. The controller/processor 375 provides RRC layer functionality associated with broadcasting of system information (e.g., MIB, SIBs), RRC connection control (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), inter radio access technology (RAT) mobility, and measurement configuration for UE measurement reporting; PDCP layer functionality associated with header compression / decompression, security (ciphering, deciphering, integrity protection, integrity verification), and handover support functions; RLC layer functionality associated with the transfer of upper layer packet data units (PDUs), error correction through ARQ, concatenation, segmentation, and reassembly of RLC service data units (SDUs), re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto transport blocks (TBs), demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[0047] The transmit (TX) processor 316 and the receive (RX) processor 370 implement layer 1 functionality associated with various signal processing functions. Layer 1, which includes a physical (PHY) layer, may include error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, interleaving, rate matching, mapping onto physical channels, modulation/demodulation of physical channels, and MIMO antenna processing. The TX processor 316 handles mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols may then be split into parallel streams. Each stream may then be mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator 374 may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE 350. Each spatial stream may then be provided to a different antenna 320 via a separate transmitter 318TX. Each transmitter 318TX may modulate an RF carrier with a respective spatial stream for transmission.

[0048] At the UE 350, each receiver 354RX receives a signal through its respective antenna 352. Each receiver 354RX recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor 356. The TX processor 368 and the RX processor 356 implement layer 1 functionality associated with various signal processing functions. The RX processor 356 may perform spatial processing on the information to recover any spatial streams destined for the UE 350. If multiple spatial streams are destined for the UE 350, they may be combined by the RX processor 356 into a single OFDM symbol stream. The RX processor 356 then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the base station 310. These soft decisions may be based on channel estimates computed by the channel estimator 358. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the base station 310 on the physical channel. The data and control signals are then provided to the controller/processor 359, which implements layer 3 and layer 2 functionality.

[0049] The controller/processor 359 can be associated with a memory 360 that stores program codes and data. The memory 360 may be referred to as a computer-readable medium. In the UL, the controller/processor 359 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, and control signal processing to recover IP packets from the EPC 160. The controller/processor 359 is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0050] Similar to the functionality described in connection with the DL transmission by the base station 310, the controller/processor 359 provides RRC layer functionality associated with system information (e.g., MIB, SIBs) acquisition, RRC connections, and measurement reporting; PDCP layer functionality associated with header compression / decompression, and security (ciphering, deciphering, integrity protection, integrity verification); RLC layer functionality associated with the transfer of upper layer PDUs, error correction through ARQ, concatenation, segmentation, and reassembly of RLC SDUs, re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto TBs, demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[0051] Channel estimates derived by a channel estimator 358 from a reference signal or feedback transmitted by the base station 310 may be used by the TX processor 368 to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor 368 may be provided to different antenna 352 via separate transmitters 354TX. Each transmitter 354TX may modulate an RF carrier with a respective spatial stream for transmission.

[0052] The UL transmission is processed at the base station 310 in a manner similar to that described in connection with the receiver function at the UE 350. Each receiver 318RX receives a signal through its respective antenna 320. Each receiver 318RX recovers information modulated onto an RF carrier and provides the information to a RX processor 370.

[0053] The controller/processor 375 can be associated with a memory 376 that stores program codes and data. The memory 376 may be referred to as a computer-readable medium. In the UL, the controller/processor 375 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover IP packets from the UE 350. IP packets from the controller/processor 375 may be provided to the EPC 160. The controller/processor 375 is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0054] A wireless communication system may include a base station and a UE. The base station may provide a cell, on which the UE may operate. In order to communicate in the wireless communication system, the base station and the UE may acquire a timing advance for uplink signals. The base station and the UE may acquire timing synchronization (e.g., uplink timing synchronization) through a random access procedure. For example, the UE may initiate the random access procedure for initial access to the cell provided by the base station, RRC connection reestablishment, handover from another base station to the base station, reacquisition of timing synchronization, transition from an RRC Inactive state, SCell timing alignment, request for Other System Information (SI), and/or beam failure recovery.

[0055] In certain aspects, the random access procedure may be a four-step random access channel (RACH) procedure in which the UE and the base station exchange four messages. In certain aspects, the random access procedure may be a two-step RACH procedure in which the UE and the base station exchange two messages.

[0056] FIG. 4 is a diagram illustrating a call flow diagram 400 between a UE 402 and a base station 404 implementing a four-step RACH procedure 410. Aspects of the UE 402 may be described with respect to the UE 104 of FIG. 1 and/or the UE 350 of FIG. 3. Aspects of the base station 404 may be described with respect to the base station 102 of FIG. 1, the gNB 180 of FIG. 1, and/or the base station 310 of FIG. 3.

[0057] In the illustrated example of FIG. 4, the four-step RACH procedure 410 includes the exchange of four messages. Specifically, the UE 402 may initiate the message exchange of the four-step RACH procedure 410 by sending, to the base station 404, a first four-step RACH message 412 including only a preamble. The base station 404 then sends, to the UE 402, a second four-step RACH response message 414 including a random access response (RAR). In certain aspects, the second four-step RACH response message 414 may include an identifier of the RACH preamble, a time advance (TA), an uplink grant for the UE 402 to transmit data, cell radio network temporary identifier (C-RNTI), and/or a back-off indicator. The UE 402 then sends a third four-step RACH message 416 to the base station 404. In certain aspects, the third four-step RACH message 416 may include a radio resource control (RRC) connection request, an RRC connection re-establishment request, or an RRC connection resume request, depending on the trigger for the UE 402 initiating the random access procedure. The base station 404 then completes the four-step RACH procedure 410 by sending a fourth four-step RACH response message 418 to the UE 402. In certain aspects, the fourth four-step RACH response message 418 includes timing advancement information, contention resolution information, and/or RRC connection setup information. In certain aspects, the first four-step RACH message 412 may be referred to as "msg1," the second four-step RACH response message 414 may be referred to as "msg2," the third four-step RACH message 416 may be referred to as "msg3," and the fourth four-step RACH response message 418 may be referred to as "msg4."

[0058] Although not shown, it should be appreciated that in certain aspects, the UE 402 may re-transmit a RACH message. For example, in certain aspects, after transmitting the msg1 412, the UE 402 may re-transmit (e.g., periodically, a-periodically, and/or as a one-time event) the msg1 412 until the msg2 414 is received from the base station 404 and/or a timer expires. In other examples, the RACH response message received by the UE 402 may indicate that the base station 404 was unable to process (e.g., decode) at least a portion of the RACH message. In certain such examples, the UE 402 may then re-transmit the corresponding RACH message.

[0059] FIG. 5 is a diagram illustrating a call flow diagram 500 between a UE 502 and a base station 504 implementing a two-step RACH procedure 510. Aspects of the UE 502 may be described with respect to the UE 104 of FIG. 1, the UE 350 of FIG. 3, and/or the UE 402 of FIG. 4. Aspects of the base station 504 may be described with respect to the base station 102 of FIG. 1, the gNB 180 of FIG. 1, the base station 310 of FIG. 3, and/or the base station 404 of FIG. 4.

[0060] In the illustrated example of FIG. 5, the two-step RACH procedure 510 includes the exchange of two messages. Specifically, the UE 502 may initiate the message exchange of the two-step RACH procedure 510 by sending a first two-step RACH message 512 to the base station 504 and, responsive to the first two-step RACH message 512, the base station 504 may complete the message exchange of the two-step RACH procedure 510 by sending a second two-step RACH message 514 to the UE 502. In certain aspects, the first two-step RACH message 512 may be referred to as "msgA" and the second two-step RACH response message 514 may be referred to as "msgB."

[0061] In certain aspects, to initiate the two-step RACH procedure 510, the UE 502 may generate the msgA 512. For the two-step RACH procedure 510, the UE 502 may generate the msgA 512 to include at least a preamble 512a (e.g., a PRACH preamble) and a payload 512b. In certain aspects, the preamble 512a corresponds to the msg1 412 and the payload 512b corresponds to the msg3 416 of the four-step RACH procedure 410 of FIG. 4.

[0062] The UE 502 may be identified by the base station 504 according to an identifier (ID) of the UE 502, such as a radio network temporary identifier (RNTI) (e.g., a random access (RA) RNTI, a temporary RNTI, etc.). The msgA 512 may be the first transmission by the UE 502 to the base station 504 and, therefore, the base station 504 may benefit from a mechanism for indicating the ID of the UE 502 to the base station 504 in the msgA 512, particularly because the msgA 512 may include data from the UE 502 in the payload 512b. Accordingly, the UE 502 may indicate an ID of the UE 502 using one or more (or a combination of) approaches for including information in the msgA 512.

[0063] In response to receiving the msgA 512, the base station 504 may generate the msgB 514. The base station 504 may generate the msgB 514 to include control information in a PDCCH and data in a PDSCH. The base station 504 may send the msgB 514 to the UE 502 to complete the two-step RACH procedure 510. In certain aspects, information included in the msgB 514 may correspond to the msg2 414 and the msg4 418 of the four-step RACH procedure 410 of FIG. 4. The UE 502 may receive the msgB 514, and the UE 502 may acquire timing synchronization based on the msgB 514.

[0064] Although not shown, it should be appreciated that in certain aspects, the UE 502 may re-transmit a RACH message. For example, in certain aspects, after transmitting the msgA 512, the UE 502 may re-transmit (e.g., periodically, a-periodically, and/or as a one-time event) the msgA 512 until the msgB 514 is received from the base station 504 and/or a timer expires. In other examples, the RACH response message received by the UE 502 may indicate that the base station 504 was unable to process (e.g., decode) at least a portion of the RACH message. In certain such examples, the UE 502 may then re-transmit the corresponding RACH message. For example, the base station 504 may transmit a RACH response message indicating that the base station 504 was unable to decode the payload 512b of the msgA 512.

[0065] It should be appreciated that while the two-step RACH procedure 510 of FIG. 5 differs in some aspects from the four-step RACH procedure 410 of FIG. 4, some aspects may be common across the RACH procedures 410, 510. For example, sequences associated with a physical RACH (PRACH) and sequences associated with DMRS used for the four-step RACH procedure 410 may also be used for the two-step RACH procedure 510. Further, a TX chain used for a PUSCH in the four-step RACH procedure 410 may also be used for the two-step RACH procedure 510.

[0066] While performing a two-step RACH procedure includes exchanging fewer messages than when performing a four-step RACH procedure, the increased size of the first two-step RACH message (e.g., the msgA 512 of FIG. 5) compared to the size of the first four-step RACH message (e.g., the msg1 412 of FIG. 4) may reduce link budget and, thus, adversely impact cell coverage. Thus, techniques disclosed herein enable the UE to determine whether to perform a two-step RACH procedure or a four-step RACH procedure. In certain aspects, the UE may additionally or alternatively determine when to terminate performing the two-step RACH procedure and to initiate performing the four-step RACH procedure. In certain aspects, the UE may additionally or alternatively determine when to transition from performing the two-step RACH procedure to the four-step RACH procedure.

[0067] FIG. 6 is a diagram illustrating a call flow diagram 600 between a UE 602 and a base station 604 when the UE 602 employs techniques for determining whether to perform a two-step RACH procedure or a four-step RACH procedure, as disclosed herein. Aspects of the UE 602 may be described with respect to the UE 104 of FIG. 1, the UE 350 of FIG. 3, the UE 402 of FIG. 4, and/or the UE 502 of FIG. 5. Aspects of the base station 604 may be described with respect to the base station 102 of FIG. 1, the gNB 180 of FIG. 1, the base station 310 of FIG. 3, the base station 404 of FIG. 4, and/or the base station 504 of FIG. 5.

[0068] The base station 604 may periodically send (e.g., broadcast) information associated with operating on the cell provided by the base station 604. As described with respect to FIG. 2B, *supra*, the base station 604 may send a MIB and one or more SIBs. In the illustrated example of FIG. 6, the base station 604 transmits configuration information 610 associated with performing a RACH procedure. In certain aspects, the base station 604 may transmit the configuration information 610 via system information while the UE 602 is operating in a connected mode, operating in an idle mode, or operating in an inactive mode. In certain aspects, the base station 604 may transmit the configuration information 610 via dedicated signaling while the UE 602 is operating in a connected mode.

[0069] In some aspects, the configuration information 610 may indicate whether the base station 604 supports a two-step RACH procedure. In some aspects, the configuration information 610 may indicate that the base station 604 supports the two-step RACH procedure for one or more UE access classes. In some aspects, the configuration information 610 may include one or more parameter(s) associated with performing the two-step RACH procedure. For example, the configuration information 610 may include one or more of a payload size, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, and/or a second random access message transmittal count threshold.

[0070] In certain aspects, the payload size parameter may be associated with, for example, the payload 512b of FIG. 5. In certain aspects, the payload size parameter may include a set of payload sizes. In certain such examples, each payload size included in the set of payload sizes may correspond to a set of one or more preambles. In certain examples, the set of one or more preamble may be disjointed preambles. In certain aspects, the Reference Signal Received Power (RSRP) threshold may be associated with a minimum RSRP measurement at which the UE 602 may perform the two-step RACH procedure. In certain aspects, the path loss threshold may be associated with a maximum path loss measurement at which the UE 602 may perform the two-step RACH procedure. In certain aspects, the fallback timer setting may indicate whether the UE 602 is configured to enable a fallback timer while performing a two-step RACH procedure. In certain aspects, the first random access message transmittal count threshold is associated with a maximum quantity of first random access message transmittals that the UE 602 may perform. As disclosed herein, a first random access message is a random access message that includes only a preamble (e.g., the msg1 412 of the four-step RACH procedure 410 of FIG. 4). Thus, the first random access message transmittal count threshold indicates a maximum quantity of transmissions and/or re-transmissions of the msg1 412 that the UE 602 may perform. In certain aspects, the second random access message transmittal count threshold is associated with a maximum quantity of second random access message transmittals that the UE 602 may perform. As disclosed herein, a second random access message may be a random access message that includes a preamble and a payload (e.g., the msgA 512 of the two-step RACH procedure 510 of FIG. 5). Thus, the second random access message transmittal count threshold indicates a maximum quantity of transmissions and/or re-transmissions of the msgA 512 that the UE 602 may perform.

[0071] The UE 602 may receive and decode the configuration information 610 and may subsequently perform a RACH attempt based at least in part on the configuration information 610. For example, at 612, the UE 602 determines whether to perform a two-step RACH procedure (e.g., the two-step RACH procedure 510 of FIG. 5) or a four-step RACH procedure (e.g., the four-step RACH procedure 410 of FIG. 4) based at least in part on the configuration information 610, including the one or more parameters. For example, if the configuration information 610 indicates that the base station 604 does not support the two-step RACH procedure, then the UE 602 determines to perform the four-step RACH procedure. In certain aspects, the configuration information 610 may indicate that the base station 604 supports the two-step RACH procedure for one or more UE access classes. In certain such examples, if an access class associated with the UE 602 is not indicated by the configuration information 610, the UE 602 determines to perform the four-step RACH procedure.

[0072] However, if the configuration information 610 indicates that the base station 604 supports the two-step RACH procedure (and/or if the access class associated with the UE is indicated as being supported by the base station 604 for performing the two-step RACH procedure), then the UE 602 may perform a second check to determine whether an estimated link quality between the UE 602 and the base station 604 is satisfactory to perform the two-step RACH procedure. As described above, due to the larger size of the msgA compared to the size of the msg1 (e.g., when the msgA includes a preamble and a payload compared to the msg1 that includes only a preamble), an increased link budget is needed to perform the two-step RACH procedure compared to the four-step RACH procedure. To that end, in certain aspects, after determining that the base station 604 supports the two-step RACH procedure (and/or the base station 604 supports the two-step RACH procedure for the access class associated with the UE 602), the UE 602 may perform one or more downlink measurements to measure channel quality, such as reference signal received power (RSRP) and/or a path loss measurement. For example, the UE 602 may measure a reference signal and compare the reference signal measurement to an associated parameter and/or threshold provided in the configuration information 610. In certain aspects, the reference signal is comprised in a Synchronization Signal Block (SSB). In certain aspects, the reference signal comprises a channel state information reference signal (CSI-RS). In certain aspects, the UE 602 may select the reference signal based on a predetermined rule. For example, the UE 602 may select the reference signal for which an RSRP measurement is available. In certain aspects, the UE 602 selects the reference signal from among a plurality of reference signals received by the UE 02 and based on respective reference signal measurements. For example, the UE 602 may select the reference signal associated with the highest RSRP measurement, the lowest path loss measurement, etc.

[0073] In certain aspects, after selecting the reference signal and measuring the selected reference signal, the UE 602 compares the reference signal measurement to a threshold associated with the reference signal measurement. In certain aspects, the threshold associated with the reference signal measurement is provided by the base station 604 via the configuration information 610 (e.g., one or more parameter(s)). Based on the comparison (e.g., whether the reference signal measurement satisfies the associated threshold), the UE 602 may determine whether to perform the two-step RACH procedure or the four-step RACH procedure.

[0074] For example, if the reference signal measurement is an RSRP measurement, the UE 602 may compare the RSRP measurement of the reference signal to the RSRP threshold provided in the configuration information 610. In certain such examples, if the UE 602 determines that the RSRP measurement of the reference signal satisfies the RSRP threshold (e.g., the RSRP measurement of the reference signal is greater than or equal to the RSRP threshold), the UE 602 determines to perform the two-step RACH procedure. Otherwise, if the UE 602 determines that the RSRP measurement of the reference signal does not satisfy the RSRP threshold (e.g., the RSRP measurement of the reference signal is less than the RSRP threshold), the UE 602 determines to perform the four-step RACH procedure.

[0075] In some examples, the reference signal measurement is a path loss measurement and the UE 602 may compare the path loss measurement of the reference signal to the path loss threshold provided in the configuration information 610. In certain such examples, if the UE 602 determines that the path loss measurement of the reference signal satisfies the path loss threshold (e.g., the path loss measurement of the reference signal is less than or equal to the path loss threshold), the UE 602 determines to perform the two-step RACH procedure. Otherwise, if the UE 602 determines that the path loss measurement of the reference signal does not satisfy the path loss threshold (e.g., the path loss measurement of the reference signal is greater than the path loss threshold), the UE 602 determines to perform the four-step RACH procedure.

[0076] At 614, the UE 602 generates a random access message based on the determined RACH procedure. For example, after determining to perform the four-step RACH procedure, the UE 602 may generate a first random access message including only a preamble (e.g., the msg1 412). Otherwise, if the UE 602 determines to perform the two-step RACH procedure, the UE 602 may generate a second random access message including the preamble and the payload (e.g., the msgA 512 including the preamble 512a and the payload 512b). The UE 602 then attempts to perform the determined RACH procedure by transmitting the generated random access message 616 to the base station 604.

[0077] In certain aspects, after transmitting the generated random access message 616 to the base station 604, the UE 602 increments a transmittal count associated with the random access message 616. For example, if the random access message 616 is the msg1 412 including only a preamble, the UE 602 increments a first random access message transmittal count that corresponds to the quantity of transmissions and/or re-transmissions of the first random access message (e.g., the msg1 412). Otherwise, if the random access message 616 is the msgA 512 including the preamble 512a and the payload 512b, the UE 602 increments a second random access message transmittal count that corresponds to the quantity of transmissions and/or re-transmissions of the second random access message (e.g., the msgA 512).

[0078] At 618, the base station 604 generates a random access response message based at least in part on the random access message 616 received from the UE 602. For example, if the random access message 616 is the msg1 412 including only the preamble, the base station 604 may determine that the UE 602 is performing the four-step RACH procedure and may generate the msg2 414 (e.g., of the four-step RACH procedure 410 of FIG. 4) including, for example, an identifier of the RACH preamble, a time advance (TA), an uplink grant for the UE 602 to transmit data, cell radio network temporary identifier (C-RNTI), and/or a back-off indicator.

Otherwise, if the random access message 616 is the msgA 512 including the preamble 512a and the payload 512b, the base station 604 may determine that the UE 602 is performing the two-step RACH procedure and may generate the msgB 514 (e.g., of the two-step RACH procedure 510 of FIG. 5) including, for example, an uplink grant for the UE 602 to transmit data, control information in a PDCCH, and/or data in a PDSCH. The base station 604 may then transmit the random access response message 620 (e.g., the msg2 414 or the msgB 514) to the UE 602.

[0079] In certain aspects, the UE 602 uses RNTI to receive a response message associated with the two-step RACH procedure (e.g., the msgB 514) or to receive a response message associated with the four-step RACH procedure (e.g., the msg2 414). In certain aspects, the UE uses, while operating in an idle mode or an inactive mode, a random access RNTI (RA-RNTI) to receive a response message associated with the two-step RACH procedure (e.g., the msgB 514) or to receive a response message associated with the four-step RACH procedure (e.g., the msg2 414). In certain aspects, the UE 602 uses a cell RNTI (C-RNTI) to receive a response message associated with a two-step RACH procedure while the UE is operating in a connected mode.

[0080] In certain aspects, the UE 602 may detect a re-transmission triggering event. In certain aspects, a re-transmission triggering event may include not receiving a response message from the base station in response to the random access message (e.g., no msg2 414 or msgB 514 is received). In certain aspects, a re-transmission triggering event may include receiving a response message including information indicating a failure by the base station 604 to process (e.g., decode) at least a portion of the random access message (e.g., the payload 512b of the msgA 512).

[0081] In certain aspects, in response to detecting a re-transmission triggering event, the UE 602 may re-transmit the random access message. In certain aspects, in response to detecting a re-transmission triggering event, the UE 602 may determine to stop the current RACH procedure and initiate a new RACH procedure. In certain aspects, in response to detecting a re-transmission triggering event, the UE 602 may determine to transition from the current RACH procedure to another RACH procedure. In certain aspects, in response to detecting a re-transmission triggering event, the UE 602 may stop performing all RACH procedures (until the UE 602 is able to next perform the one or more downlink measurements).

[0082] In certain aspects, after detecting a re-transmission triggering event, the UE 602 determines how to proceed based on the current RACH procedure being performed and/or based on one or more parameters included in the configuration information 610. For example, in certain aspects, the one or more parameters may include the fallback timer setting indicative of whether a fallback timer is configured for the UE 602 and/or on a random access message transmittal count threshold.

[0083] In certain aspects, the fallback timer setting may indicate that the fallback timer is not configured for the UE 602. In certain such aspects, the UE 602 may determine that the UE 602 has not received a response message. The UE 602 may then determine how to proceed based on a transmittal count associated with the random access message. For example, when performing the two-step RACH procedure, the UE 602 may compare the msgA transmittal count (e.g., the second random access message transmittal count) to the msgA transmittal count threshold (e.g., the second random access message transmittal count threshold provided via the configuration information 610). Otherwise, if the UE 602 is performing the four-step RACH procedure, the UE 602 may compare the msg1 transmittal count (e.g., the first random access message transmittal count) to the msg1 transmittal count threshold (e.g., the first random access message transmittal count threshold provided via the configuration information 610). In certain aspects, if the UE 602 determines that the random access message transmittal count does not satisfy the respective random access message transmittal count threshold (e.g., the msgA transmittal count is greater than the msgA transmittal count threshold or the msg1 transmittal count is greater than the msg1 transmittal count threshold), the UE 602 stops performing RACH procedures and notifies the upper layer (e.g., the PHY layer). Otherwise, if the UE 602 determines that the random access message transmittal count satisfies the respective random access message transmittal count threshold (e.g., the msgA transmittal count is less than or equal to the msgA transmittal count threshold or the msg1 transmittal count is less than or equal to the msg1 transmittal count threshold), the UE 602 may return to 612 to determine whether to perform the two-step RACH procedure or the four-step RACH procedure (e.g., based on whether a reference signal measurement satisfies a threshold associated with the reference signal measurement).

[0084] In certain aspects, if the fallback timer setting indicates that the fallback timer is configured for the UE 602, the UE 602 may default to attempting to performing the two-step RACH procedure. For example, after initiating the fallback timer, the UE 602 may repeat transmissions of the msgA for reference signals with reference signal measurements that satisfy the associated threshold until the UE 602 receives a msgB (e.g., the two-step RACH procedure was successfully completed), the fallback timer expires, or the msgA transmittal count does not satisfy the msgA transmittal count threshold (e.g., the second random access message transmittal count is greater than the second random access message transmittal count threshold). In certain examples, if the UE 602 determines that the fallback timer expired or the msgA transmittal count does not satisfy the msgA transmittal count threshold, the UE 602 may stop performing the two-step RACH procedure and initiate the four-step RACH procedure (e.g., may transmit the msg1 412 of the four-step RACH procedure 410 including only the preamble).

[0085] In certain aspects, the UE 602 may transition from performing the two-step RACH procedure to the four-step RACH procedure based on, for example, the response message received from the base station 604. For example, the base station 604 may receive the msgA 512 including the preamble 512a and the payload 512b from the UE 602. While processing the msgA 512, the base station 604 may successfully decode the preamble 512a of the msgA 512 but fail to decode the payload 512b of the msgA 512. In certain aspects, the payload 512b may include an identifier associated with the UE 604. The base station 604 may then send a response message that is the same as the second four-step RACH response message 414 (e.g., the msg2). In certain examples, the msg2 414 includes an uplink grant for the UE 602. In certain such examples, in response to receiving the msg2 414 from the base station 604, the UE 602 transmits the third four-step RACH message 416 (e.g., the msg3) to the base station 604 using the uplink grant and waits for the fourth four-step RACH response message 418 (e.g., the msg4) from the base station 604. In certain such examples, the RACH attempt is successful if the UE 602 is able to decode the msg4 418 and the msg4 418 includes the UE identifier. However, if the UE 602 is unable to decode the msg4 418 and/or the msg4 418 does not include the UE identifier, the RACH attempt may be considered as unsuccessful. In certain such aspects, the UE 602 then returns to 612 to determine whether to perform a two-step RACH procedure or a four-step RACH procedure.

[0086] FIG. 7 is a flowchart 700 of a method of wireless communication. The method may be performed by a UE, such as the UE 104 of FIG. 1, the UE 350 of FIG. 3, the UE 402 of FIG. 4, the UE 502 of FIG. 5, the UE 602 of FIG. 6, the UE 1150 of FIG. 11, and/or the apparatus 802/802' of FIGS. 8 and 9, respectively. One or more of the illustrated operations may be omitted, transposed, or contemporaneous. In FIG. 7, optional aspects are illustrated with a dashed line. The method provides for improved communication between a UE and a network and enables a UE to determine when to perform a two-step RACH procedure and when to perform a four-step RACH procedure. Thus, aspects may improve the efficiency of the UE accessing the network for data transmissions.

[0087] At 702, the UE may receive configuration information associated with a RACH procedure. For example, the configuration information may indicate whether the network supports a two-step RACH procedure. In certain aspects, the configuration information may indicate one or more UE access classes for which the network supports the two-step RACH procedure. The configuration information may additionally or alternatively include one or more parameter(s) associated with the two-step RACH procedure, such as a payload size (and/or a set of payload sizes), a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold (e.g., a msg1 transmittal count threshold), and/or a second random access message transmittal count threshold (e.g., a msgA transmittal count threshold). In certain aspects, the UE may receive the configuration information, including the one or more parameter(s), via system information while the UE is operating in a connected mode, operating in an idle mode, or operating in an inactive mode. In certain aspects, the UE may receive the configuration information, including the one or more parameter(s), via dedicated signaling while the UE is operating in a connected mode.

[0088] At 704, the UE may measure a reference signal. In certain aspects, the reference signal is comprised in a Synchronization Signal Block (SSB). In certain aspects, the reference signal comprises a channel state information reference signal (CSI-RS). In certain aspects, the UE may select the reference signal based on a predetermined rule. In certain aspects, the UE may select the reference signal from among a plurality of reference signals received by the UE and based on respective reference signal measurements.

[0089] At 706, the UE may compare the reference signal measurement to at least one parameter. In certain aspects, the UE may compare the reference signal measurement to a threshold associated with the at least one parameter. For example, if the reference signal measurement is an RSRP measurement, the UE may compare the RSPR measurement to the RSRP threshold. In certain aspects, if the reference signal measurement is a path loss measurement, the UE may compare the path loss measurement to the path loss threshold.

[0090] At 708, the UE determines whether to perform a two-step RACH procedure or a four-step RACH procedure. In certain aspects, the UE determines which RACH procedure to perform based on the comparison of the reference signal measurement to the threshold associated with the at least one parameter. For example, the UE may determine to perform the two-step RACH procedure when the reference signal measurement satisfies the threshold associated with the at least one parameter. In other examples, the UE may determine to perform the four-step RACH procedure when the reference signal measurement does not satisfy the threshold associated with the at least one parameter.

[0091] At 710, the UE generates a random access message based on the determined RACH procedure. In certain aspects, the UE may generate a first random access message including only a preamble (e.g., the msg1) when the UE determines to perform the four-step RACH procedure. In other examples, the UE may generate a second random access message including the preamble and a payload (e.g., the msgA) when the UE determines to perform the two-step RACH procedure.

[0092] At 712, the UE transmits the random access message, for example, to the base station.

[0093] At 714, the UE may increment a transmittal count associated with the random access message. For example, in response to transmitting the first random access message (e.g., the msg1), the UE increments a first random access message transmittal count. In other examples, in response to transmitting the second random access message (e.g., the msgA), the UE increments a second random access message transmittal count.

[0094] At 716, the UE may determine whether to perform another RACH procedure attempt. In certain aspects, the UE may determine to repeat a transmission of the random access message. For example, the UE may determine to repeat a transmission of the random access message in response to detecting a re-transmission triggering event in which the UE has not received a response message, for example, from the base station. In certain such examples, the UE may determine to repeat the transmission of the random access message when the random access message transmittal count satisfies the corresponding random access message transmittal count threshold and the fallback timer is not configured for the UE. However, if the UE determines that the fallback timer is not configured for the UE and the random access message transmit count does not satisfy the corresponding random access message transmittal count threshold, the UE may determine to terminate performing any RACH procedures.

[0095] In certain aspects in which the fallback timer is configured for the UE, the UE may determine to repeat the transmission of the second random access message until a successful response message is received (e.g., the msgB), the second random access message transmittal count does not satisfy the second random access message transmittal count threshold (e.g., is less than a msgA threshold count value), or the fallback timer expired. In certain such examples in which the UE determines that the second random access message transmittal count does not satisfy the second random access message transmittal count threshold (e.g., the maximum msgA count has been reached) or the fallback timer expired, the UE stops performing the two-step RACH procedure and initiates performing the four-step RACH procedure. In certain examples, the UE continues performing the four-step RACH procedure until the four-step RACH procedure is successfully completed or the first random access message transmittal count does not satisfy the first random access message transmittal count threshold (e.g., the maximum msgA count has been reached).

[0096] In certain aspects in which the UE is performing the two-step RACH procedure and receives a response message including information indicating that the base station was unsuccessful in processing (e.g., decoding) at least a portion of the msgA (e.g., was unable to decode the payload 512b of the msgA 512), the UE may transition to performing the four-step RACH procedure by generating and transmitting a third random access message including the payload (e.g., the msg3 416 of the four-step RACH procedure 410).

[0097] FIG. 8 is a conceptual data flow diagram 800 illustrating the data flow between different means/components in an exemplary apparatus 802. The apparatus may be the UE 104. The apparatus includes a reception component 804 configured to receive downlink communication from a base station 850 and a transmission component 806 configured to transmit uplink communication to the base station 850. The apparatus includes a determination component 808 configured to a determination component configured to determine whether to perform a two-step RACH procedure or a four-step RACH procedure.

[0098] The apparatus comprises a generation component 810 configured to generate a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step RACH procedure or a second random access message including the preamble and a payload when the determining is to perform the four-step RACH procedure.

[0099] The apparatus comprises a RACH component 812 configured to perform a RACH attempt by transmitting, to a base station, the random access message.

[00100] The apparatus may comprise an indication component 814 configured to receive, from the base station, an indication that indicates whether the base station supports a two-step RACH procedure, wherein the UE determines whether to generate the first random access message or the second random access message based on the indication.

[00101] The apparatus may comprise a parameter component 816 configured to receive, from the base station, at least one parameter associated with the two-step RACH procedure, the at least one parameter including one or more of a payload size (and/or a set of payload sizes), a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold. The determination component 808 may determine whether to generate the first random access message or the second random access message based on the at least one parameter.

[00102] The apparatus may comprise a measurement component 818 configured to measure a reference signal and a comparison component 820 configured to compare a measurement of the reference signal to the at least one parameter. The determination component 808 may be configured to determine to generate the second random access message when the measurement of the reference signal satisfies a threshold associated with the at least one parameter. In another example, the determination component 808 may be configured to determine to generate the first random access message when the measurement of the at least one reference signal does not satisfy a threshold associated with the at least one parameter.

[00103] The random access message may be the second random access message including the preamble and the payload, and the apparatus may include an increment component 822 configured to increment a second random access message transmittal count after the transmitting of the second random access message. The apparatus may further comprise a count component 824 configured to determine whether the second random access message transmittal count satisfies a second random access message transmittal count threshold if a response message is not received from the base station and a repeat component 826 configured to determine whether to repeat transmission of the second random access message or to perform the four-step RACH procedure by generating the first random access message based on whether the second random access message transmittal count satisfies the second random access message transmittal count threshold.

[00104] The apparatus may comprise a response component 828 configured to receive, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and information indicating a failure to decode the payload of the second random access message. The RACH component 812 may be configured to transmit, to the base station, a third random access message comprising the payload based on the uplink grant, the third random access message associated with the four-step RACH procedure. The determination component 808 may be configured to determine whether to perform another RACH attempt using the two-step RACH procedure or the four-step RACH procedure when no response to the third random access message is received or when

the UE receives a response to the third random access message indicating another failure to decode the payload.

[00105] The apparatus may include additional components that perform each of the blocks of the algorithm in the aforementioned flowcharts of FIGS. 6 and 7. As such, each block in the aforementioned flowcharts of FIGS. 6 and 7 may be performed by a component and the apparatus may include one or more of those components. The components may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by a processor configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by a processor, or some combination thereof.

[00106] FIG. 9 is a diagram 900 illustrating an example of a hardware implementation for an apparatus 802' employing a processing system 914. The processing system 914 may be implemented with a bus architecture, represented generally by the bus 924. The bus 924 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 914 and the overall design constraints. The bus 924 links together various circuits including one or more processors and/or hardware components, represented by the processor 904, the components 804, 806, 808, 810, 812, 814, 816, 818, 820, 822, 824, 826, 828, and the computer-readable medium / memory 906. The bus 924 may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further.

[00107] The processing system 914 may be coupled to a transceiver 910. The transceiver 910 is coupled to one or more antennas 920. The transceiver 910 provides a means for communicating with various other apparatus over a transmission medium. The transceiver 910 receives a signal from the one or more antennas 920, extracts information from the received signal, and provides the extracted information to the processing system 914, specifically the reception component 804. In addition, the transceiver 910 receives information from the processing system 914, specifically the transmission component 806, and based on the received information, generates a signal to be applied to the one or more antennas 920. The processing system 914 includes a processor 904 coupled to a computer-readable medium / memory 906. The processor 904 is responsible for general processing, including the execution of

software stored on the computer-readable medium / memory 906. The software, when executed by the processor 904, causes the processing system 914 to perform the various functions described *supra* for any particular apparatus. The computer-readable medium / memory 906 may also be used for storing data that is manipulated by the processor 904 when executing software. The processing system 914 further includes at least one of the components 804, 806, 808, 810, 812, 814, 816, 818, 820, 822, 824, 826, 828. The components may be software components running in the processor 904, resident/stored in the computer readable medium / memory 906, one or more hardware components coupled to the processor 904, or some combination thereof. The processing system 914 may be a component of the UE 350 and may include the memory 360 and/or at least one of the TX processor 368, the RX processor 356, and the controller/processor 359.

[00108] In one configuration, the apparatus 802/802' for wireless communication includes means for determining whether to perform a two-step random access channel (RACH) procedure or a four-step RACH procedure; means for generating a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step RACH procedure or a second random access message including the preamble and a payload when the determining is to perform the four-step RACH procedure; means for performing a RACH attempt by transmitting, to a base station, the random access message; means for receiving, from the base station, an indication that indicates whether the base station supports a two-step RACH procedure, wherein the UE determines whether to generate the first random access message or the second random access message based on the indication; means for receiving, from the base station, at least one parameter associated with the two-step RACH procedure, the at least one parameter including one or more of a payload size, a set of payload sizes, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold; means for measuring a reference signal; means for comparing a measurement of the reference signal to the at least one parameter; means for determining to generate the second random access message when the measurement of the reference signal satisfies a threshold associated with the at least one parameter; means for determining to generate the first random access message when the measurement of the at least one reference signal does not satisfy a threshold associated with the at least one parameter; means for incrementing a second random access message transmittal count after the transmitting of the second random access message; means for determining whether the second random access message transmittal count satisfies a second random access message transmittal count threshold if a response message is not received from the base station; means for determining whether to repeat transmission of the second random access message or to perform the four-step RACH procedure by generating the first random access message based on whether the second random access message transmittal count satisfies the second random access message transmittal count threshold; means for receiving, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and information indicating a failure to decode the payload of the second random access message; means for transmitting, to the base station, a third random access message comprising the payload based on the uplink grant, the third random access message associated with the four-step RACH procedure; and means for determining whether to perform another RACH attempt using the two-step RACH procedure or the four-step RACH procedure when no response to the third random access message is received or when the UE receives a response to the third random access message indicating another failure to decode the payload. The aforementioned means may be one or more of the aforementioned components of the apparatus 802 and/or the processing system 914 of the apparatus 802' configured to perform the functions recited by the aforementioned means. As described *supra*, the processing system 914 may include the TX Processor 368, the RX Processor 356, and the controller/processor 359. As such, in one configuration, the aforementioned means may be the TX Processor 368, the RX Processor 356, and the controller/processor 359 configured to perform the functions recited by the aforementioned means.

[00109] FIG. 10 is a flowchart 1000 of a method of wireless communication. The method may be performed by a base station, such as the base station 102/180 of FIG. 1, the base station 310 of FIG. 3, the base station 404 of FIG. 4, the base station 504 of FIG. 5, the base station 604 of FIG. 6, the base station 850 of FIG. 8, and/or the

apparatus 1102/1102' of FIGS. 11 and 12, respectively. One or more of the illustrated operations may be omitted, transposed, or contemporaneous. In FIG. 10, optional aspects are illustrated with a dashed line. The method provides for improved communication between a UE and a network. Aspects may improve the efficiency of performing uplink synchronization between the UE and the network.

[00110] At 1002, the base station provides an indication of whether the base station supports a two-step RACH procedure. As discussed above, certain base stations may support two-step RACH while others might not. By providing the indication of whether the base station supports a two-step RACH procedure, the base station can guide the UE in selecting a way to initiate random access with the base station. In certain aspects, the base station may support two-step RACH on a UE access class basis. In certain such examples, the indication provided by the base station may identify the one or more UE access classes for which the base station supports the two-step RACH procedure.

[00111] At 1004, the base station may transmit at least one parameter associated with the two-step RACH procedure, for example, to the UE. For example, the base station may transmit one or more parameter(s) including a payload size (and/or a set of payload sizes), a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold (e.g., a msg1 transmittal count threshold), and/or a second random access message transmittal count threshold (e.g., a msgA transmittal count threshold). In certain aspects, the base station transmits the indication of whether the base station supports the two-step RACH procedure and/or the one or more parameter(s) via system information. In certain aspects, the base station transmits the indication of whether the base station supports the two-step RACH procedure and/or the one or more parameter(s) via dedicated signaling to the UE operating in a connected mode.

[00112] At 1006, the base station receives a random access message based at least in part on the indication of whether the base station supports the two-step RACH procedure. In certain aspects, the random access message is a first random access message including only a preamble (e.g., a msg1). In certain aspects, the random access message is a second random access message including the preamble and a payload (e.g., a msgA).

[00113] At 1008, the base station may generate a response message in response to receiving the random access message. In certain aspects, the response message includes an uplink grant. In certain aspects, the base station attempts to process (e.g., decode) the random access message and may generate the response message based on the success or failure of the processing. For example, if the random access message is the second random access message including the preamble and the payload, the base station may attempt to decode the payload. In certain such examples, if the base station successfully decodes the payload, the base station generates the response message to also include timing advancement information, contention resolution information, and/or radio resource control (RRC) connection setup information. In certain other examples, if the base station is unable to decode the payload, the base station generates the response message to also include information indicating the failure to decode the payload.

[00114] At 1010, the base station transmits the response message to the UE.

[00115] In certain aspects, the base station may also receive a third random access message including the payload. For example, the base station may receive the third random access message in response to the response message including the information indicating the failure to decode the payload. In certain such examples, the base station may then generate and transmit the fourth four-step RACH response message 418 (e.g., the msg4).

[00116] FIG. 11 is a conceptual data flow diagram 1100 illustrating the data flow between different means/components in an exemplary apparatus 1102. The apparatus may be the base station 102/180. The apparatus includes a reception component 1104 configured to receive uplink communication from UE(s) 1150 and a transmission component 1106 configured to transmit downlink communication to the UE 1150. The apparatus comprises an indication component 1108 configured to provide to a UE, an indication of whether the base station supports a two-step RACH procedure. The apparatus comprises a RACH message component 1110 configured to receive, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload.

[00117] The apparatus may include a parameter component 1112 configured to transmit, to the UE, at least one parameter associated with the two-step RACH procedure, the at least one parameter including one or more of a payload size (and/or a set of payload sizes), a RSRP threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold.

[00118] The apparatus may comprise a response component 1114 configured to generate a random access response message in response to receiving the random access message, the random access response message including an uplink grant; and

[00119] The transmission component 1106 may be configured to transmit, to the UE, the random access response message.

[00120] The random access message may be the second random access message, and the apparatus may further comprise a decode component 1116 configured to attempt to decode the payload of the second random access message and a provision component 1118 configured to provide, in the random access response message, timing advancement information, contention resolution information, and/or RRC connection setup information, in response to the base station successfully decoding the payload.

[00121] The apparatus may include a failure component 1120 configured to provide, in the random access response message, information indicating a failure to decode the payload of the second random access message, in response to the base station unsuccessfully decoding the payload. The RACH message component 1110 may be configured to receive, from the UE, a third random access message including the payload based at least in part on the information indicating the failure to decode the payload.

[00122] The apparatus may include additional components that perform each of the blocks of the algorithm in the aforementioned flowcharts of FIGS. 6 and 10. As such, each block in the aforementioned flowcharts of FIGS. 6 and 10 may be performed by a component and the apparatus may include one or more of those components. The components may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by a processor configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by a processor, or some combination thereof.

[00123] FIG. 12 is a diagram 1200 illustrating an example of a hardware implementation for an apparatus 1102' employing a processing system 1214. The processing system 1214 may be implemented with a bus architecture, represented generally by the bus 1224. The bus 1224 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 1214 and the overall design constraints. The bus 1224 links together various circuits including one or more processors and/or hardware components, represented by the processor 1204, the components 1104, 1106, 1108, 1110, 1112, 1114, 1116, 1118, 1120, and the computer-readable medium / memory 1206. The bus 1224 may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further.

[00124] The processing system 1214 may be coupled to a transceiver 1210. The transceiver 1210 is coupled to one or more antennas 1220. The transceiver 1210 provides a means for communicating with various other apparatus over a transmission medium. The transceiver 1210 receives a signal from the one or more antennas 1220, extracts information from the received signal, and provides the extracted information to the processing system 1214, specifically the reception component 1104. In addition, the transceiver 1210 receives information from the processing system 1214, specifically the transmission component 1106, and based on the received information, generates a signal to be applied to the one or more antennas 1220. The processing system 1214 includes a processor 1204 coupled to a computer-readable medium / memory 1206. The processor 1204 is responsible for general processing, including the execution of software stored on the computer-readable medium / memory 1206. The software, when executed by the processor 1204, causes the processing system 1214 to perform the various functions described *supra* for any particular apparatus. The computer-readable medium / memory 1206 may also be used for storing data that is manipulated by the processor 1204 when executing software. The processing system 1214 further includes at least one of the components 1104, 1106, 1108, 1110, 1112, 1114, 1116, 1118, 1120. The components may be software components running in the processor 1204, resident/stored in the computer readable medium / memory 1206, one or more hardware components coupled to the processor 1204, or some combination thereof. The processing system 1214 may be a component of the base

station 310 and may include the memory 376 and/or at least one of the TX processor 316, the RX processor 370, and the controller/processor 375.

[00125] In one configuration, the apparatus 1102/1102' for wireless communication includes means for providing to a UE, an indication of whether the base station supports a two-step RACH procedure; means for receiving, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload; means for transmitting, to the UE, at least one parameter associated with the two-step RACH procedure, the at least one parameter including one or more of a payload size, a set of payload sizes, a RSRP threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold; means for generating a random access response message in response to receiving the random access message, the random access response message including an uplink grant; means for transmitting, to the UE, the random access response message; means for attempting to decode the payload of the second random access message; means for providing, in the random access response message, timing advancement information, contention resolution information, or RRC connection setup information, in response to the base station successfully decoding the payload; means for providing, in the random access response message, information indicating a failure to decode the payload of the second random access message, in response to the base station unsuccessfully decoding the payload; and means for receiving, from the UE, a third random access message including the payload based at least in part on the information indicating the failure to decode the payload. The aforementioned means may be one or more of the aforementioned components of the apparatus 1102 and/or the processing system 1214 of the apparatus 1102' configured to perform the functions recited by the aforementioned means. As described *supra*, the processing system 1214 may include the TX Processor 316, the RX Processor 370, and the controller/processor 375. As such, in one configuration, the aforementioned means may be the TX Processor 316, the RX Processor 370, and the controller/processor 375 configured to perform the functions recited by the aforementioned means.

[00126] Further disclosure is included in the Appendix.

[00127] It is understood that the specific order or hierarchy of blocks in the processes / flowcharts disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of blocks in the processes / flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[00128] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "device," and the like may not be a substitute for the word "means." As such, no

claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

Random Access Procedure Based on Two-Step RACH and Four-Step RACH (Random Access Channel)

Introduction

- Two-step RACH is a type of random access procedure in which a first message (sometimes referred to as “msgA”) sent by a user equipment (UE) includes both a preamble and a payload
  - The first message in the existing four-step RACH includes only a preamble
- The inclusion of payload in msgA could reduce link budget and hence cell coverage
  - UE needs to decide whether to perform two-step RACH vs four-step RACH when random access procedure is triggered
  - Even during a two-step RACH procedure, UE may need to fall back to four-step RACH if link condition degrades
- Proposals disclosed herein provide example conditions in which UE may perform two-step RACH

Proposal

- Network advertises whether it supports two-step RACH via system information
- If network supports two-step RACH, network also advertises parameters associated with two-step RACH, which include (but not limited to):
  - Payload size of the msgA
  - RSRP (Reference Signal Received Power) threshold for two-step RACH (denoted 2step_RSRP), or path loss threshold for two-step RACH (denoted 2step_PL) (see page 4 of appendix)
  - (optional) fallback timer
  - Maximum number of msgA transmissions (denoted max_msgA_count)
  - Maximum number of preamble transmissions (denoted max_preamble_count)
- Network signals the above parameters to UE
  - Via system information for UEs in RRC (Radio Resource Control) Idle or RRC Inactive mode
  - By dedicated signaling (RRC config) for UEs in RRC Connected mode

Page 4 of Appendix

Example conditions for selecting two-step RACH

- Due to larger msgA, two-step RACH may require more link budget than four-step RACH
- UE hence can make this decision based on estimated link quality
  - Option 1. Network configures a threshold on RSRP of DL reference signal
    - If measured RSRP is higher than the configured threshold (2step_RSRP), then UE can consider two-step RACH feasible
  - Option 2. Network configures a threshold on path loss
    - If measured path loss is less than UE's maximum PRACH (Physical RACH) Tx (Transmit) power - target receiving power at base station - path loss threshold (2step_PL), then UE can consider two-step RACH feasible

Proposal

- Option A. if fallback timer is configured
  - UE starts a random access procedure by performing two-step RACH first
  - If at least one of the eligible reference signals (RS) meets a condition described on page 4 of the Appendix
    - UE chooses one of those qualifying RSs (similar to a four-step RACH procedure)
      - Eligible RSs for two-step RACH can be either SSB (Synchronization Signal Block) or CSI-RS (Channel State Information - Reference Signal) configured by network (e.g. for UE in RRC Connected mode). Selection of qualifying RSs can be based on either a preset rule or up to UE implementation
    - UE then performs one attempt of two-step RACH based on the RS selected in the previous step
      - Each RS for RACH procedure is associated with its own set of RACH occasions (which are used for msgA transmission), and this association is configured by network (similar to the four-step RACH procedure)
      - If UE successfully receives a response from network (aka msgB), the random access procedure is successfully completed; Otherwise,

        - if the max_msgA_count has reached its maximum (configured by network), UE may stop using two-step RACH and perform regular four-step RACH instead;

        - Otherwise, if the fallback timer is still running, UE may make another attempt of two-step RACH. If the fallback timer has expired, UE may stop performing two-step RACH and perform regular four-step RACH
  - Otherwise, i.e. there is no qualifying RS
    - UE may wait until the next RSRP measurement report from PHY (Physical) layer and then repeat the above steps, as long as the fallback timer is still running. Otherwise, when the fallback time expires, UE may stop performing two-step RACH and perform regular four-step RACH. UE keeps making four-step RACH attempts until either the RACH procedure is successfully completed or it reaches the maximum number of attempts configured for four-step RACH.

Proposal

- Option B. if fallback timer is not configured
  - Before UE makes each RACH attempt, it first decides whether to perform two-step or four-step RACH. It does that by first checking whether a condition described on page 4 of the appendix is met
    - If there is at least one such RS, UE performs one attempt of two-step RACH based on the selected RS
      - If UE successfully receives a response from network (aka msgB), the random access procedure is successfully completed; Otherwise,

        - if the number of two-step RACH performed has reached max_msgA_count, UE may terminate the random access procedure and notify the upper layer;

        - Otherwise, UE may make another attempt by repeating the above steps. The next attempt could be either two-step or four-step RACH, depend on whether there is any RS with RSRP above the threshold 2step_RSRP
    - Otherwise, i.e. there is no qualifying RS
      - UE performs one attempt of regular four-step RACH as specified in the current specification
      - If this attempt of four-step RACH is successfully completed, UE terminates the random access procedure. Otherwise, i.e. this attempt of four-step RACH has failed

        - If the number of four-step RACH performed has reached max_preamble_count, UE may terminate the random access procedure and notify the upper layer;

        - Otherwise, UE makes a new RACH attempt by repeating the above steps (i.e. check RSRP and then decide whether to perform 2-step or 4-step RACH)

Proposal - additional details

- In either procedure (e.g., Option A or Option B) described in the previous pages of the appendix, UE may fallback from a two-step RACH to four-step RACH, for the following reason(s)
  - If NW (Network) can successfully decode preamble of msgA but fails to decode the payload (which contains the UE ID), NW can send back a RAR (Random Access Response) but cannot confirm for the UE ID in the response
  - In this case, the RAR would be the same as the one in a regular four-step RACH
  - Therefore, instead of considering the two-step RACH failed, UE can proceed with the remaining steps of a regular four-step RACH, e.g.,
    - UE transmits a msg3 using the UL (Uplink) grant received in the RAR and then wait for msg4
    - This RACH attempt is considered successfully completed if UE can decode msg4 and the msg4 includes UE's UE ID
    - If msg4 is not correct or not received, the RACH attempt is considered failed. UE makes another attempt as described in the previous procedure

CLAIMS

WHAT IS CLAIMED IS:

1. A method of wireless communication at a User Equipment (UE), comprising:

determining whether to perform a two-step random access procedure or a four-step random access procedure;

generating a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step random access procedure or a second random access message including the preamble and a payload when the determining is to perform the two-step random access procedure; and

performing a random access attempt by transmitting, to a base station, the random access message.

2. The method of claim 1, further comprising:

receiving, from the base station, an indication that indicates whether the base station supports a two-step random access procedure, wherein the UE determines whether to generate the first random access message or the second random access message based on the indication.

3. The method of claim 2, wherein the indication indicates that the base station supports the two-step random access procedure on an access class basis, and wherein the UE determines whether to generate the first random access message or the second random access message based on an access class associated with the UE.

4. The method of claim 1, further comprising:

receiving, from the base station, at least one parameter associated with the two-step random access procedure, the at least one parameter including one or more of a payload size, a set of payload sizes, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold, wherein the UE determines whether to generate the first random access message or the second random access message based on the at least one parameter.

5. The method of claim 4, wherein the UE receives the at least one parameter via system information.

6. The method of claim 4, wherein the UE receives the at least one parameter via dedicated signaling while the UE is operating in a connected mode.

7. The method of claim 4, further comprising:

measuring a reference signal;

comparing a measurement of the reference signal to the at least one parameter; and

determining to generate the second random access message when the measurement of the reference signal satisfies a threshold associated with the at least one parameter.

8. The method of claim 7, wherein the reference signal is comprised in a Synchronization Signal Block (SSB).

9. The method of claim 7, wherein the reference signal comprises a channel state information reference signal.

10. The method of claim 7, wherein the UE selects the reference signal based on a predetermined rule.

11. The method of claim 7, wherein the UE selects the reference signal from among a plurality of reference signals received by the UE and based on respective reference signal measurements.

12. The method of claim 7, wherein the measurement of the reference signal comprises a Reference Signal Received Power (RSRP) of the reference signal, and the

UE generates the second random access message including the preamble and the payload when the RSRP of the reference signal satisfies the RSRP threshold.

13. The method of claim 7, wherein the measurement of the reference signal comprises a path loss measurement associated with the reference signal, and the UE generates the second random access message including the preamble and the payload when the path loss measurement satisfies the path loss threshold.

14. The method of claim 4, further comprising:

measuring at least one reference signal;

comparing a measurement of the at least one reference signal to the at least one parameter; and

determining to generate the first random access message when the measurement of the at least one reference signal does not satisfy a threshold associated with the at least one parameter.

15. The method of claim 1, wherein the random access message is the second random access message including the preamble and the payload, and further comprising:

incrementing a second random access message transmittal count after the transmitting of the second random access message;

determining whether the second random access message transmittal count satisfies a second random access message transmittal count threshold if a response message is not received from the base station; and

determining whether to repeat transmission of the second random access message or to perform the four-step random access procedure by generating the first random access message based on whether the second random access message transmittal count satisfies the second random access message transmittal count threshold.

16. The method of claim 15, wherein the determining of whether to repeat the transmission of the second random access message or to perform the four-step random access procedure is further based on whether a fallback timer is configured for the UE.

17. The method of claim 16, wherein if the second random access message transmittal count is greater than the second random access message transmittal count threshold, the UE:

performs the four-step random access procedure by generating the first random access message when the fallback timer is configured for the UE, and

determines whether to terminate performing any random access procedure when the fallback timer is not configured for the UE.

18. The method of claim 16, wherein if the second random access message transmittal count is less than the second random access message transmittal count threshold, the UE:

repeats the transmission of the second random access message until the fallback timer expires, if the fallback timer is configured for the UE, and

determines whether to repeat the transmission of the second random access message or to perform the four-step random access procedure by generating the first random access message based on a reference signal measurement, if the fallback timer is not configured for the UE.

19. The method of claim 1, further comprising:

receiving, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and information indicating a failure to decode the payload of the second random access message; and

transmitting, to the base station, a third random access message comprising the payload based on the uplink grant, the third random access message associated with the four-step random access procedure.

20. The method of claim 19, further comprising:

determining whether to perform another random access attempt using the two-step random access procedure or the four-step random access procedure when no response to the third random access message is received or when the UE receives a response to the third random access message indicating another failure to decode the payload.

21. The method of claim 1, further comprising:

receiving, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and an identifier associated with the UE.

22. The method of claim 1, wherein the UE uses a radio network temporary identifier (RNTI) to receive a response message associated with a two-step random access procedure or a four-step random access procedure.

23. The method of claim 1, wherein the UE uses, while operating in an idle mode or an inactive mode, a random access radio network temporary identifier (RA-RNTI) to receive a response message associated with a two-step random access procedure or a four-step random access procedure.

24. The method of claim 23, wherein the UE uses a cell radio network temporary identifier (C-RNTI) to receive a response message associated with a two-step random access procedure while the UE is operating in a connected mode.

25. A method of wireless communication at a base station, comprising:

providing to a User Equipment (UE), an indication of whether the base station supports a two-step random access procedure; and

receiving, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload.

26. The method of claim 25, further comprising:

transmitting, to the UE, at least one parameter associated with the two-step random access procedure, the at least one parameter including one or more of a payload size, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold.

27. The method of claim 26, wherein the base station transmits the at least one parameter via system information.

28. The method of claim 26, wherein the base station transmits the at least one parameter via dedicated signaling to the UE operating in a connected mode.

29. The method of claim 25, further comprising:

generating a random access response message in response to receiving the random access message, the random access response message including an uplink grant; and

transmitting, to the UE, the random access response message.

30. The method of claim 29, wherein the random access message is the second random access message, and further comprising:

attempting to decode the payload of the second random access message; and

in response to the base station successfully decoding the payload, providing, in the random access response message, timing advancement information, contention resolution information, or RRC connection setup information.

31. The method of claim 30, further comprising:

in response to the base station unsuccessfully decoding the payload, providing, in the random access response message, information indicating a failure to decode the payload of the second random access message; and

receiving, from the UE, a third random access message including the payload based at least in part on the information indicating the failure to decode the payload.

32. An apparatus for wireless communication at a User Equipment (UE), comprising:

means for determining whether to perform a two-step random access procedure or a four-step random access procedure;

means for generating a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step random access procedure or a second random access message including the preamble and a payload when the determining is to perform the two-step random access procedure; and

means for performing a random access attempt by transmitting, to a base station, the random access message.

33. The apparatus of claim 32, further comprising:

means for receiving, from the base station, an indication that indicates whether the base station supports a two-step random access procedure, wherein the UE determines whether to generate the first random access message or the second random access message based on the indication.

34. The apparatus of claim 33, wherein the indication indicates that the base station supports the two-step random access procedure on an access class basis, and wherein the UE determines whether to generate the first random access message or the second random access message based on an access class associated with the UE.

35. The apparatus of claim 32, further comprising:

means for receiving, from the base station, at least one parameter associated with the two-step random access procedure, the at least one parameter including one or more of a payload size, a set of payload sizes, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold,

wherein the UE determines whether to generate the first random access message or the second random access message based on the at least one parameter.

36. The apparatus of claim 35, further comprising:

means for measuring a reference signal;

means for comparing a measurement of the reference signal to the at least one parameter; and

means for determining to generate the second random access message when the measurement of the reference signal satisfies a threshold associated with the at least one parameter.

37. The apparatus of claim 35, further comprising:

means for measuring at least one reference signal;

means for comparing a measurement of the at least one reference signal to the at least one parameter; and

means for determining to generate the first random access message when the measurement of the at least one reference signal does not satisfy a threshold associated with the at least one parameter.

38. The apparatus of claim 32, wherein the random access message is the second random access message including the preamble and the payload, and further comprising:

means for incrementing a second random access message transmittal count after the transmitting of the second random access message;

means for determining whether the second random access message transmittal count satisfies a second random access message transmittal count threshold if a response message is not received from the base station; and

means for determining whether to repeat transmission of the second random access message or to perform the four-step random access procedure by generating the first random access message based on whether the second random access message transmittal count satisfies the second random access message transmittal count threshold.

39. The apparatus of claim 32, further comprising:

means for receiving, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and information indicating a failure to decode the payload of the second random access message; and

means for transmitting, to the base station, a third random access message comprising the payload based on the uplink grant, the third random access message associated with the four-step random access procedure.

40. The apparatus of claim 39, further comprising:

means for determining whether to perform another random access attempt using the two-step random access procedure or the four-step random access procedure when no response to the third random access message is received or when the UE receives a response to the third random access message indicating another failure to decode the payload.

41. The apparatus of claim 32, further comprising:

means for receiving, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and an identifier associated with the UE.

42. An apparatus for wireless communication at a base station, comprising:

means for providing to a User Equipment (UE), an indication of whether the base station supports a two-step random access procedure; and

means for receiving, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload.

43. The apparatus of claim 42, further comprising:

means for transmitting, to the UE, at least one parameter associated with the two-step random access procedure, the at least one parameter including one or more of a payload size, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold.

44. The apparatus of claim 42, further comprising:

means for generating a random access response message in response to receiving the random access message, the random access response message including an uplink grant; and

means for transmitting, to the UE, the random access response message.

45. The apparatus of claim 44, wherein the random access message is the second random access message, and further comprising:

means for attempting to decode the payload of the second random access message; and

means for providing, in the random access response message, timing advancement information, contention resolution information, or RRC connection setup information, in response to the base station successfully decoding the payload.

46. The apparatus of claim 45, further comprising:

means for providing, in the random access response message, information indicating a failure to decode the payload of the second random access message, in response to the base station unsuccessfully decoding the payload; and

means for receiving, from the UE, a third random access message including the payload based at least in part on the information indicating the failure to decode the payload.

47. An apparatus for wireless communication at a User Equipment (UE), comprising:

a memory; and

at least one processor coupled to the memory and configured to:

determine whether to perform a two-step random access procedure or a four-step random access procedure;

generate a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step random access procedure or a second random access message including the preamble and a payload when the determining is to perform the four-step random access procedure; and

perform a random access attempt by transmitting, to a base station, the random access message.

48. The apparatus of claim 47, wherein the at least one processor is further configured to:

receive, from the base station, an indication that indicates whether the base station supports a two-step random access procedure, wherein the UE determines whether to generate the first random access message or the second random access message based on the indication.

49. The apparatus of claim 47, wherein the at least one processor is further configured to:

receive, from the base station, at least one parameter associated with the two-step random access procedure, the at least one parameter including one or more of a payload size, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold,

wherein the UE determines whether to generate the first random access message or the second random access message based on the at least one parameter.

50. The apparatus of claim 49, wherein the at least one processor is further configured to:

measure a reference signal;

compare a measurement of the reference signal to the at least one parameter; and

determine to generate the second random access message when the measurement of the reference signal satisfies a threshold associated with the at least one parameter.

51. The apparatus of claim 49, wherein the at least one processor is further configured to:

measure at least one reference signal;

compare a measurement of the at least one reference signal to the at least one parameter; and

determine to generate the first random access message when the measurement of the at least one reference signal does not satisfy a threshold associated with the at least one parameter.

52. The apparatus of claim 47, wherein the random access message is the second random access message including the preamble and the payload, and wherein the at least one processor is further configured to:

increment a second random access message transmittal count after the transmitting of the second random access message;

determine whether the second random access message transmittal count satisfies a second random access message transmittal count threshold if a response message is not received from the base station; and

determine whether to repeat transmission of the second random access message or to perform the four-step random access procedure by generating the first random access message based on whether the second random access message transmittal count satisfies the second random access message transmittal count threshold.

53. The apparatus of claim 47, wherein the at least one processor is further configured to:

receive, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and information indicating a failure to decode the payload of the second random access message; and

transmit, to the base station, a third random access message comprising the payload based on the uplink grant, the third random access message associated with the four-step random access procedure.

54. The apparatus of claim 53, wherein the at least one processor is further configured to:

determine whether to perform another random access attempt using the two-step random access procedure or the four-step random access procedure when no response to the third random access message is received or when the UE receives a response to the third random access message indicating another failure to decode the payload.

55. The apparatus of claim 47, wherein the at least one processor is further configured to:

receive, from the base station, a random access response message in response to the transmission of the second random access message including the preamble and the payload, the random access response message including an uplink grant and an identifier associated with the UE.

56. An apparatus for wireless communication at a base station, comprising:

a memory; and

at least one processor coupled to the memory and configured to:

provide to a User Equipment (UE), an indication of whether the base station supports a two-step random access procedure; and

receive, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload.

57. The apparatus of claim 56, wherein the at least one processor is further configured to:

transmit, to the UE, at least one parameter associated with the two-step random access procedure, the at least one parameter including one or more of a payload size, a Reference Signal Received Power (RSRP) threshold, a path loss threshold, a fallback timer setting, a first random access message transmittal count threshold, or a second random access message transmittal count threshold.

58. The apparatus of claim 56, wherein the at least one processor is further configured to:

generate a random access response message in response to receiving the random access message, the random access response message including an uplink grant; and

transmit, to the UE, the random access response message.

59. The apparatus of claim 58, wherein the random access message is the second random access message, and wherein the at least one processor is further configured to:

attempt to decode the payload of the second random access message; and

provide, in the random access response message, timing advancement information, contention resolution information, or RRC connection setup information, in response to the base station successfully decoding the payload.

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

provide, in the random access response message, information indicating a failure to decode the payload of the second random access message, in response to the base station unsuccessfully decoding the payload; and

receive, from the UE, a third random access message including the payload based at least in part on the information indicating the failure to decode the payload.

61. A computer-readable medium storing computer executable code for wireless communication at a User Equipment (UE), the code when executed by a processor cause the processor to:

determine whether to perform a two-step random access procedure or a four-step random access procedure;

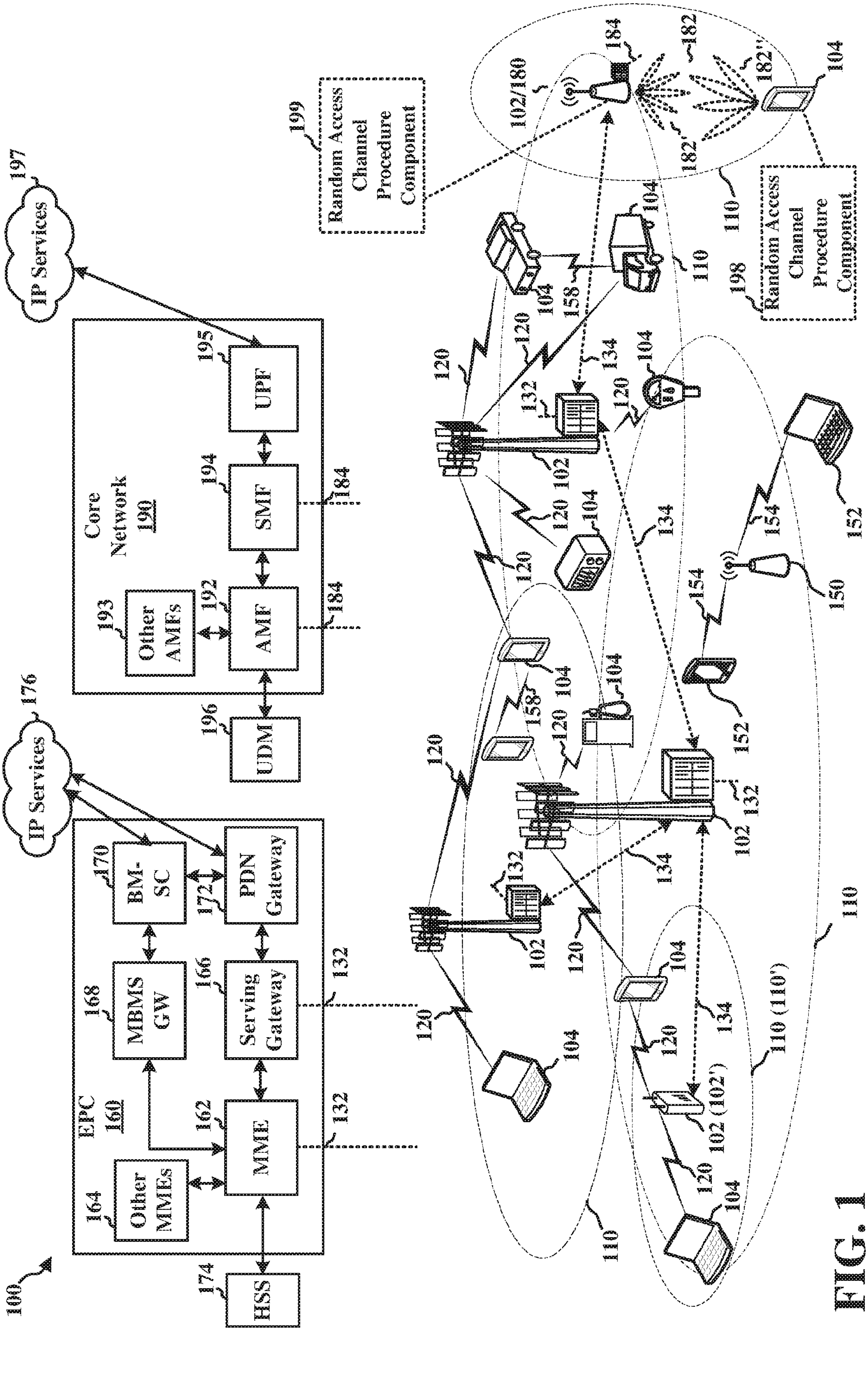
generate a random access message based on the determining, wherein the random access message is one of a first random access message including a preamble when the determining is to perform the four-step random access procedure or a second random access message including the preamble and a payload when the determining is to perform the two-step random access procedure; and

perform a random access attempt by transmitting, to a base station, the random access message.

62. A computer-readable medium storing computer executable code for wireless communication at a base station, the code when executed by a processor cause the processor to:

provide to a User Equipment (UE), an indication of whether the base station supports a two-step random access procedure; and

receive, from the UE, a random access message based at least in part on the indication, wherein the random access message is one of either a first random access message including a preamble or a second random access message including the preamble and a payload.


100
HSS
174
Other MMEs
164
MME
162
EPC
160
MBMS GW
168
Serving Gateway
166
BM-SC
170
PDN Gateway
172
IP Services
176
UDM
196
Other AMFs
193
AMF
192
SMF
194
UPF
195
Core Network
190
IP Services
197
Random Access Channel Procedure Component
199
Random Access Channel Procedure Component
198
102/180
184
182
182'
182''
102 (102')
110 (110')
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104
110
120
132
134
150
152
154
158

FIG. 1

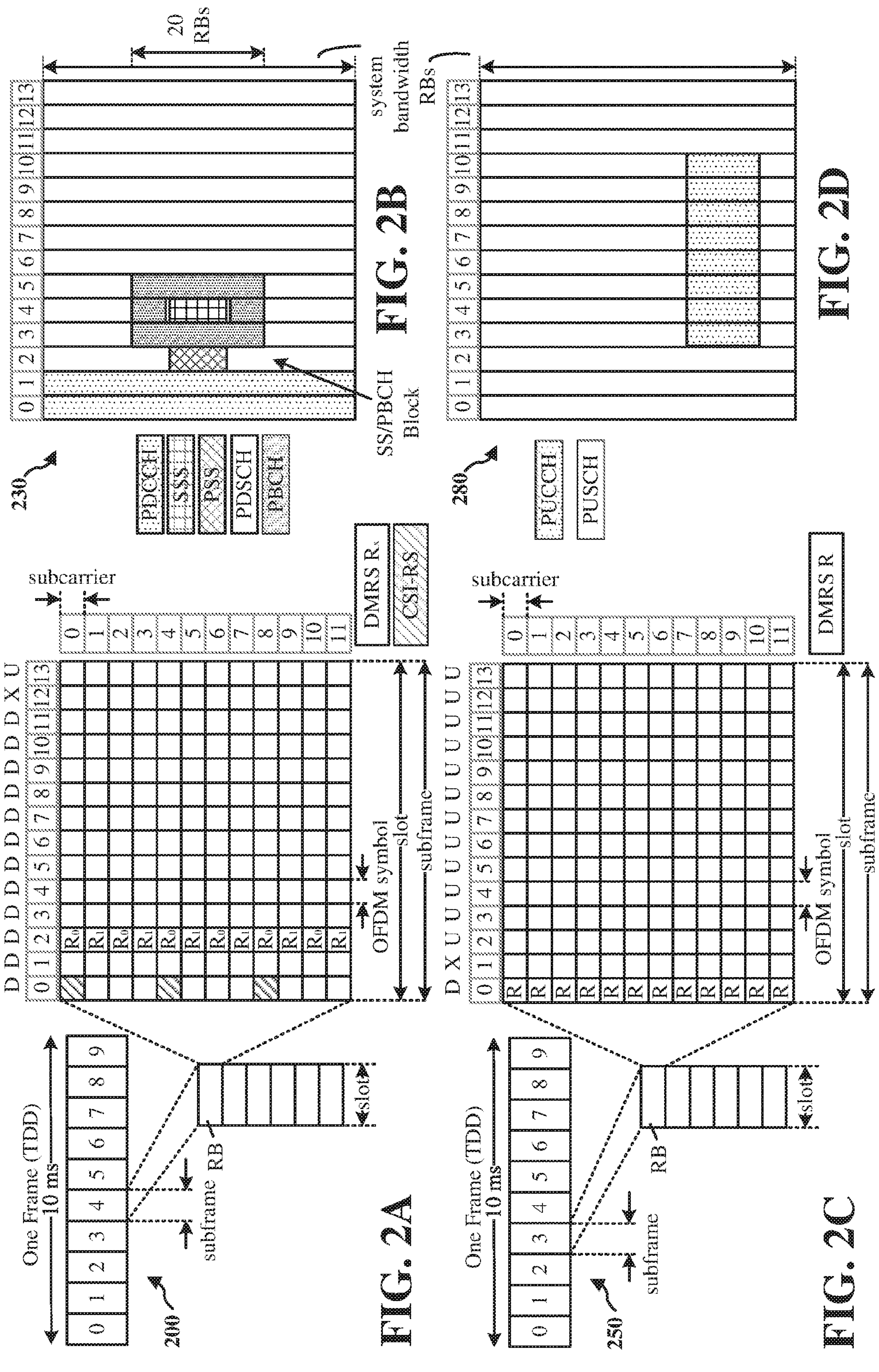

FIG. 2A

FIG. 2B

FIG. 2C

FIG. 2D

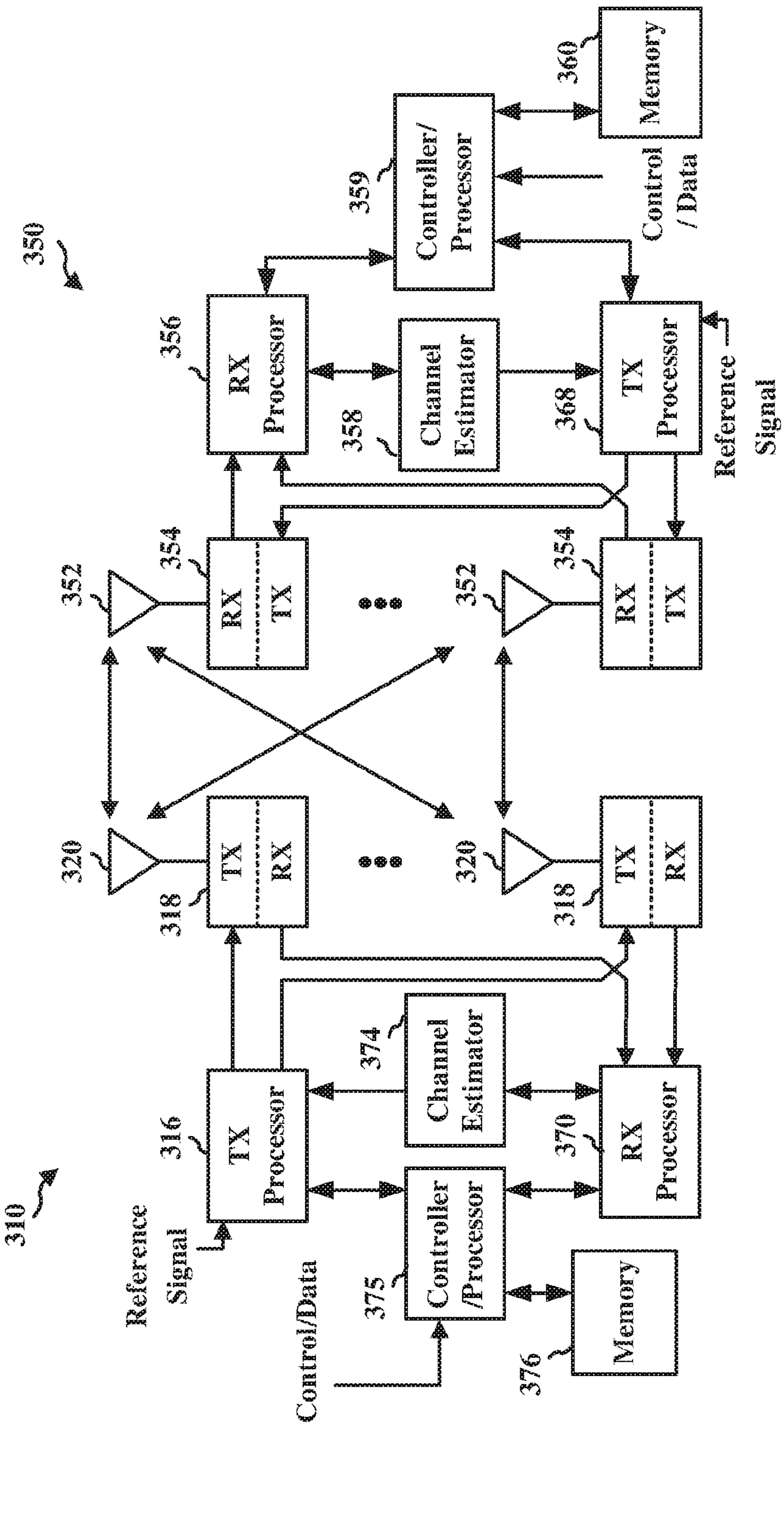
350
310
Reference Signal
316
TX Processor
Control/Data
375
Controller /Processor
376
Memory
374
Channel Estimator
370
RX Processor
318
TX
RX
320
352
354
RX
TX
356
RX Processor
358
Channel Estimator
368
TX Processor
Reference Signal
359
Controller/ Processor
360
Memory
Control / Data

FIG. 3

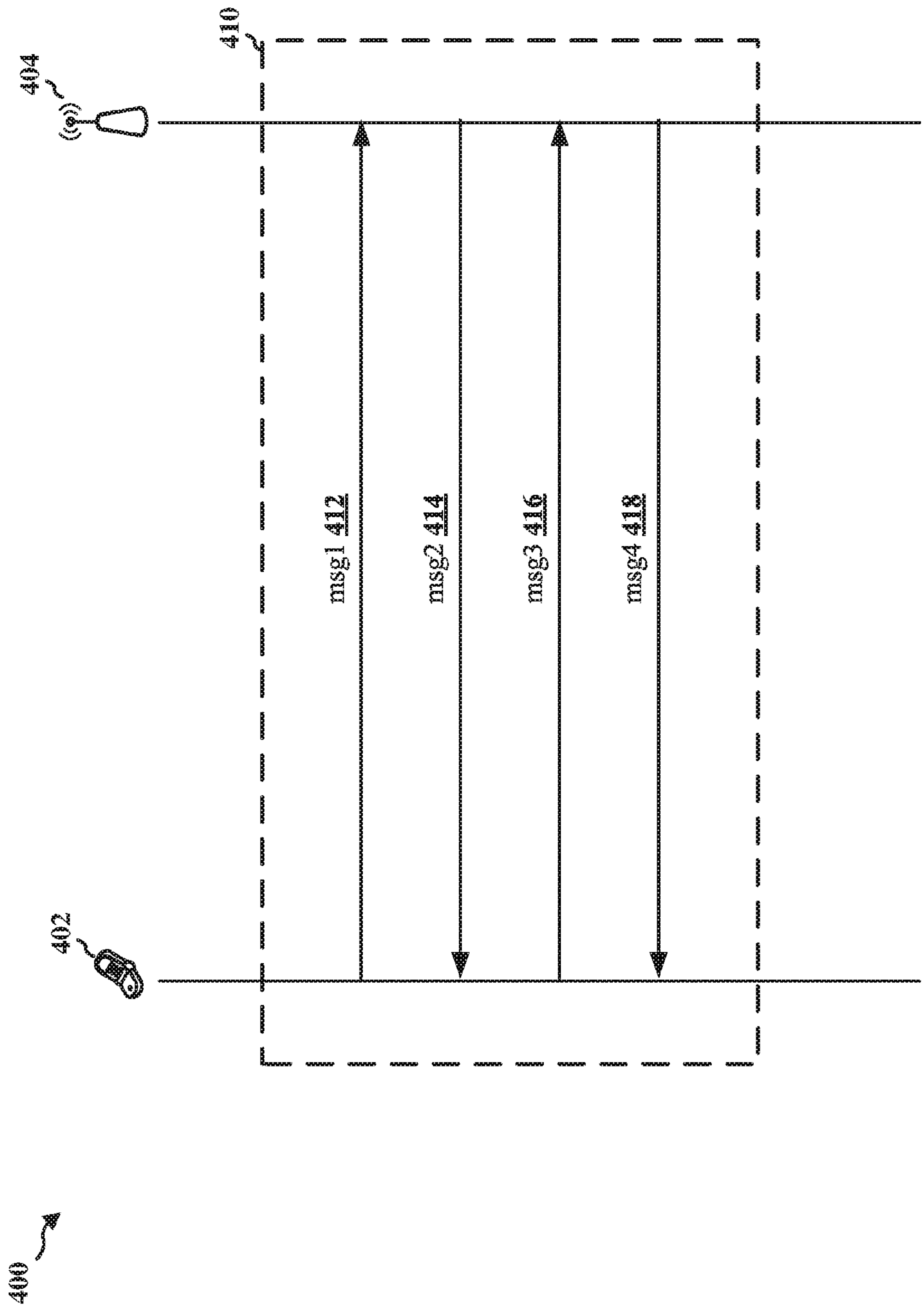

FIG. 4

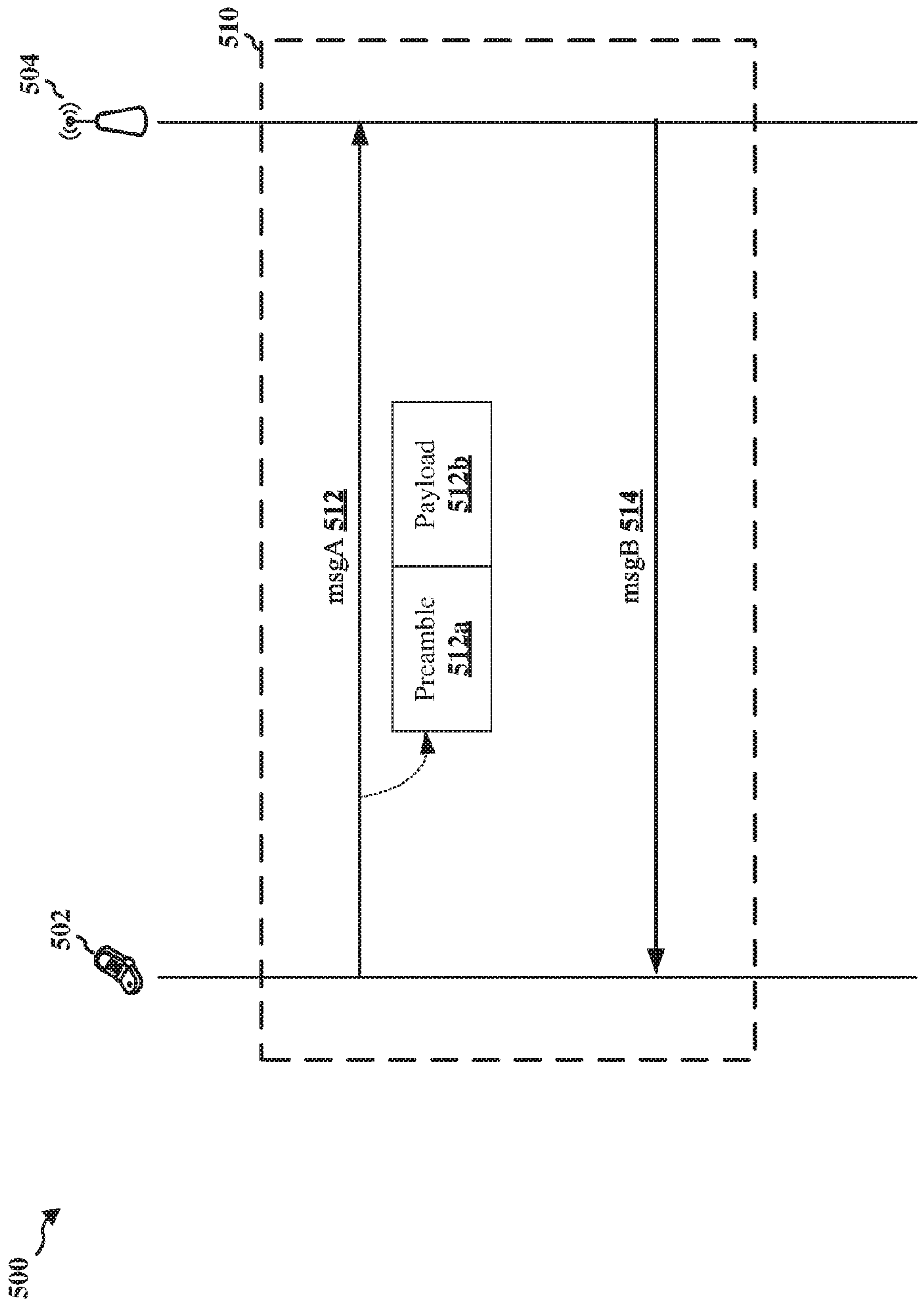

FIG. 5

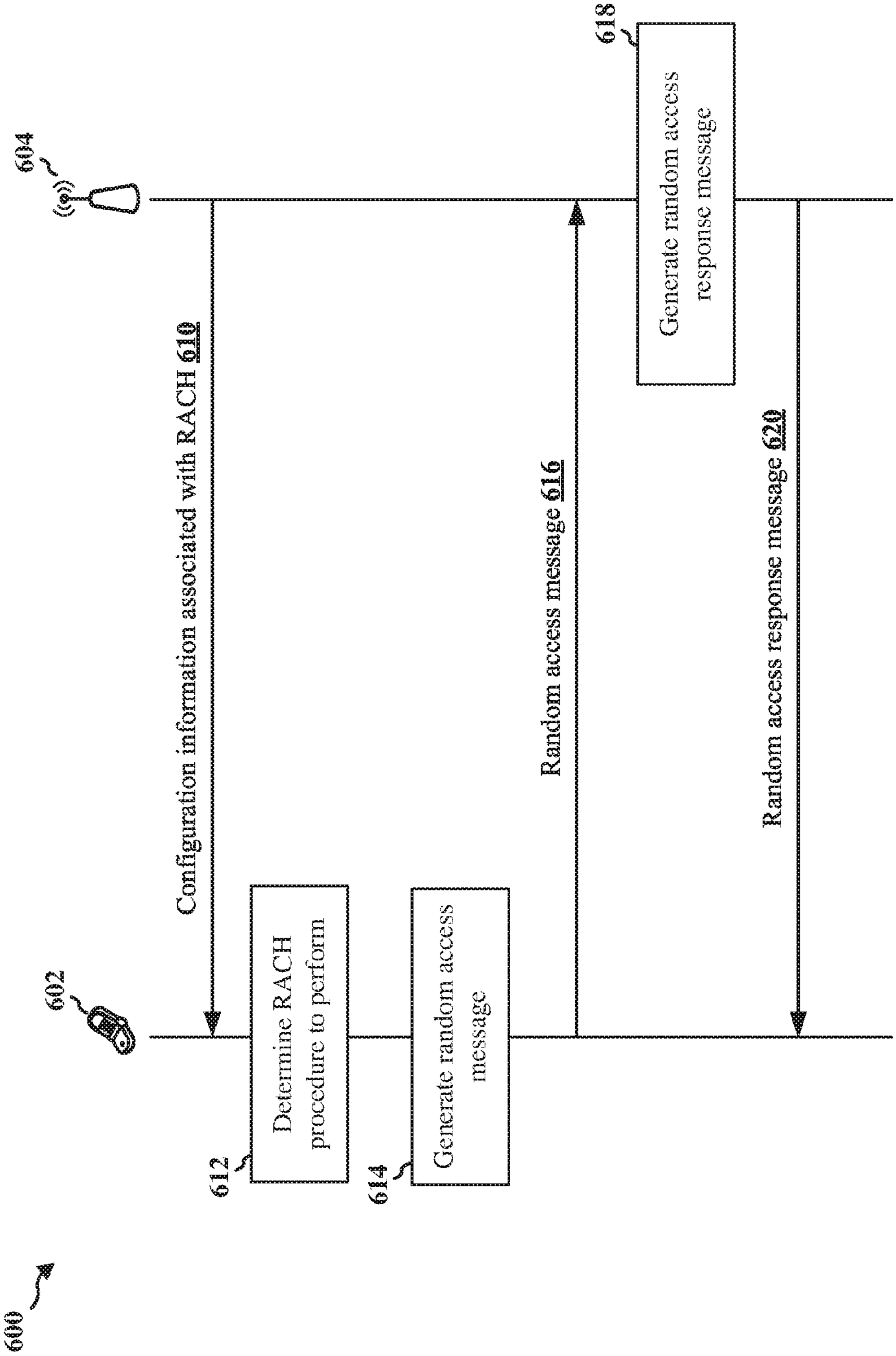
600
602
604
Configuration information associated with RACH 610
612
Determine RACH procedure to perform
614
Generate random access message
Random access message 616
618
Generate random access response message
Random access response message 620

FIG. 6

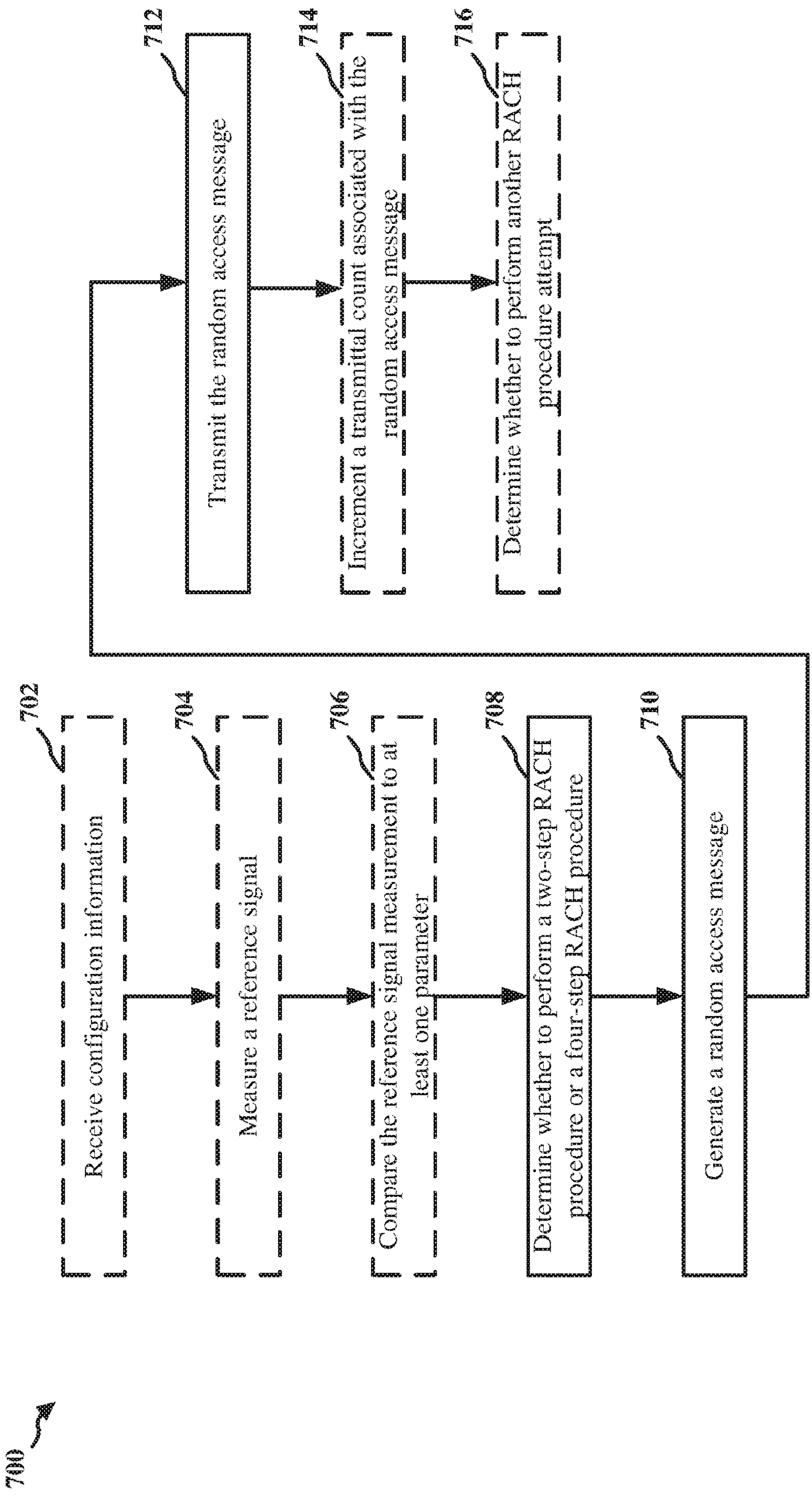
700
702
Receive configuration information
704
Measure a reference signal
706
Compare the reference signal measurement to at least one parameter
708
Determine whether to perform a two-step RACH procedure or a four-step RACH procedure
710
Generate a random access message
712
Transmit the random access message
714
Increment a transmittal count associated with the random access message
716
Determine whether to perform another RACH procedure attempt

FIG. 7

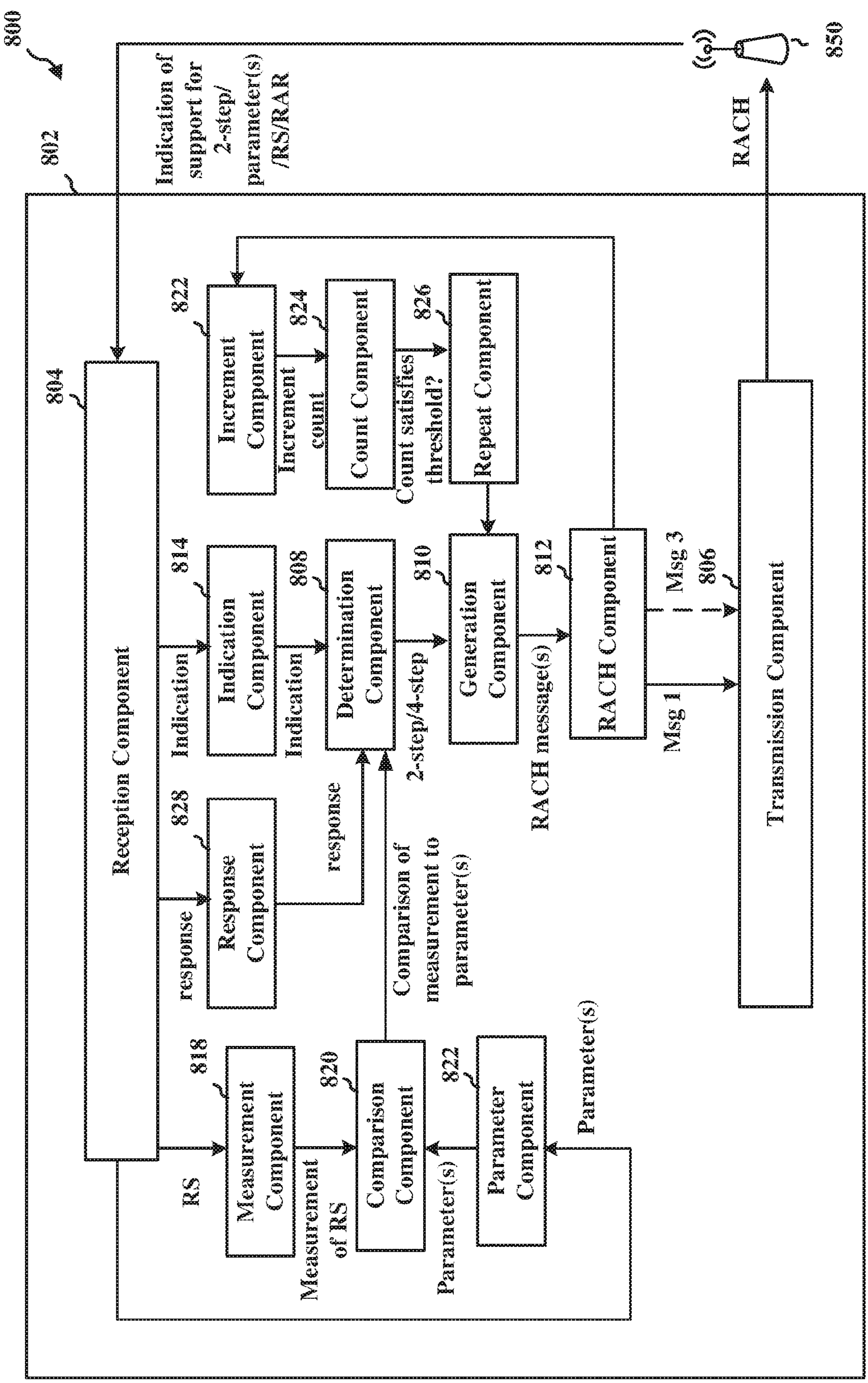
800
802
Indication of support for 2-step/ parameter(s) /RS/RAR
850
RACH
804
Reception Component
822
Increment Component
Increment count
824
Count Component
Count satisfies threshold?
826
Repeat Component
814
Indication
Indication Component
Indication
808
Determination Component
2-step/4-step
810
Generation Component
RACH message(s)
812
RACH Component
Msg 3
Msg 1
806
Transmission Component
828
response
Response Component
response
Comparison of measurement to parameter(s)
818
RS
Measurement Component
Measurement of RS
820
Comparison Component
Parameter(s)
822
Parameter Component
Parameter(s)

FIG. 8

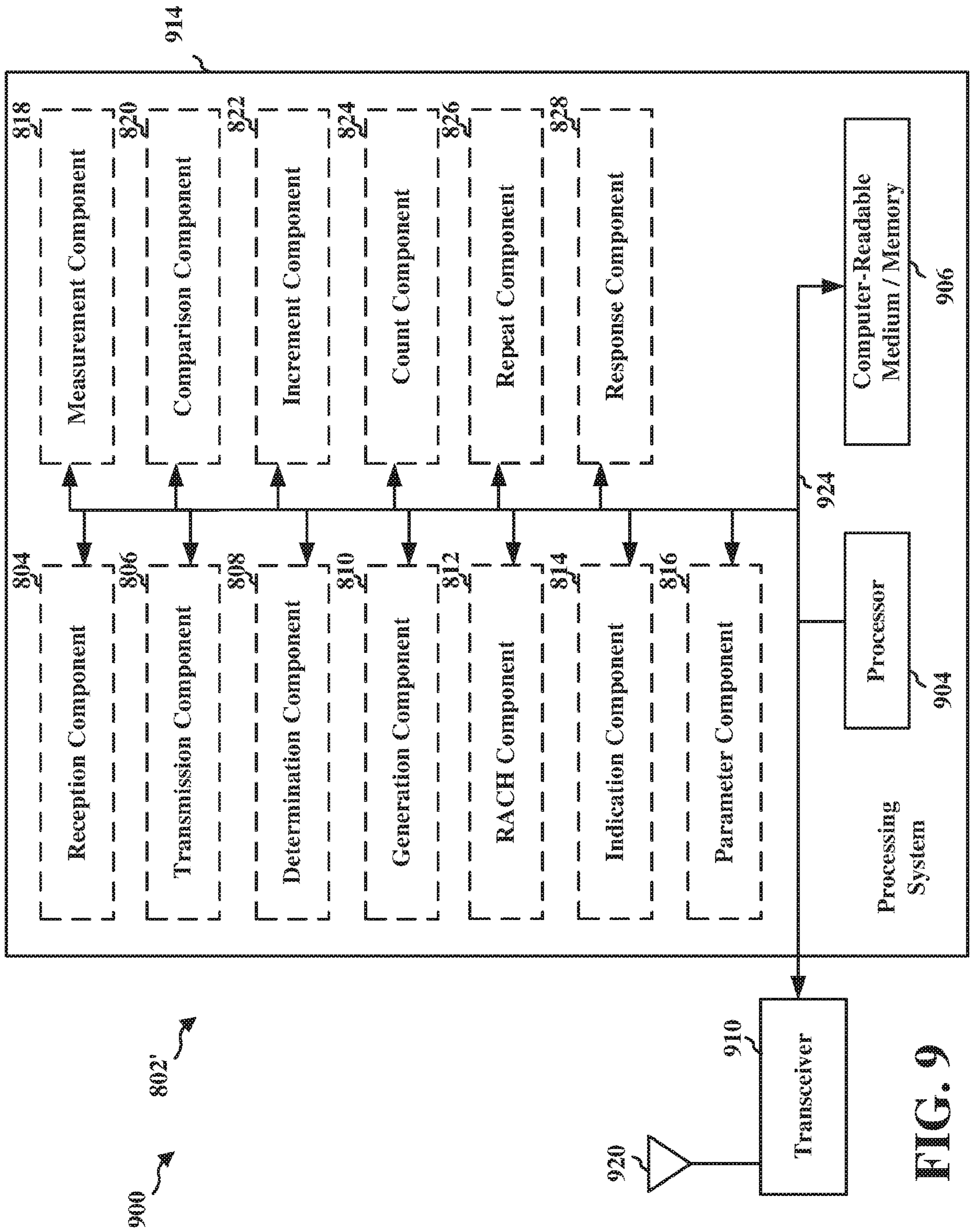
914
818
Measurement Component
820
Comparison Component
822
Increment Component
824
Count Component
826
Repeat Component
828
Response Component
Computer-Readable Medium / Memory
906
924
804
Reception Component
806
Transmission Component
808
Determination Component
810
Generation Component
812
RACH Component
814
Indication Component
816
Parameter Component
Processor
904
Processing System
802'
900
910
Transceiver
920

FIG. 9

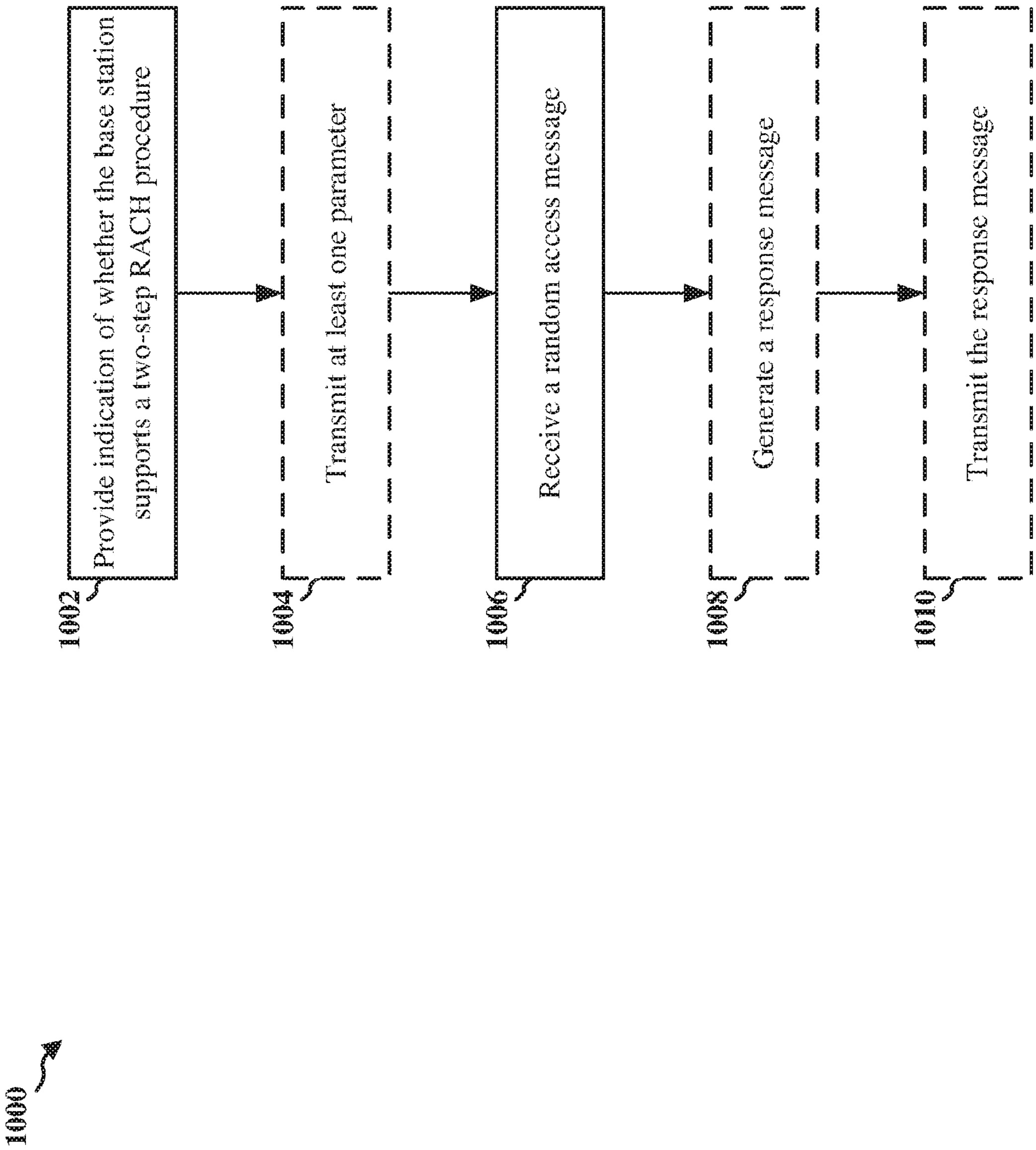
1000
1002
Provide indication of whether the base station supports a two-step RACH procedure
1004
Transmit at least one parameter
1006
Receive a random access message
1008
Generate a response message
1010
Transmit the response message

FIG. 10

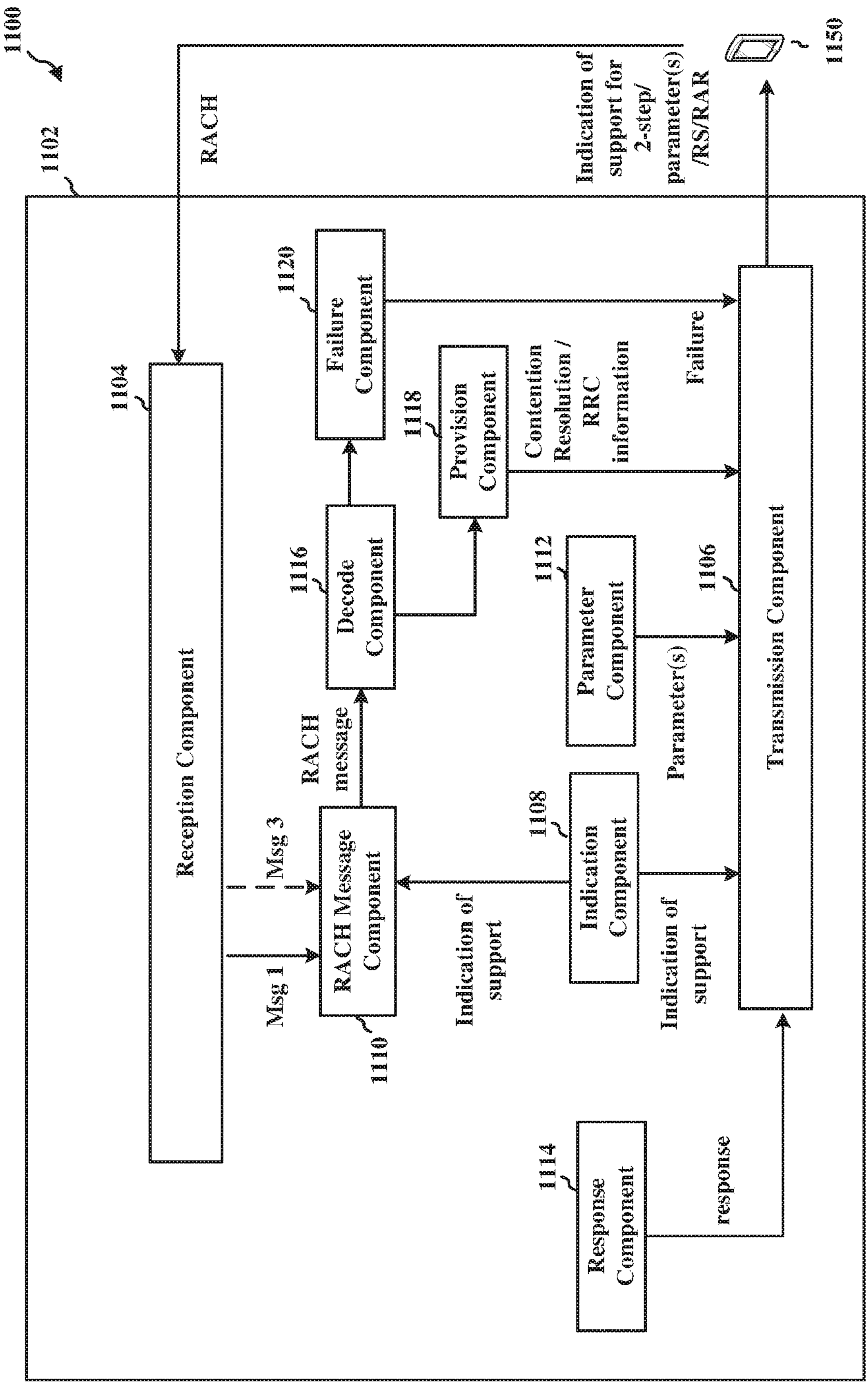
1100
1102
RACH
Indication of support for 2-step/ parameter(s) /RS/RAR
1150
1104
Reception Component
Msg 1
Msg 3
RACH Message Component
1110
RACH message
1116
Decode Component
1120
Failure Component
1118
Provision Component
Contention Resolution / RRC information
Failure
Indication of support
1108
Indication Component
Indication of support
1112
Parameter Component
Parameter(s)
1106
Transmission Component
1114
Response Component
response

FIG. 11

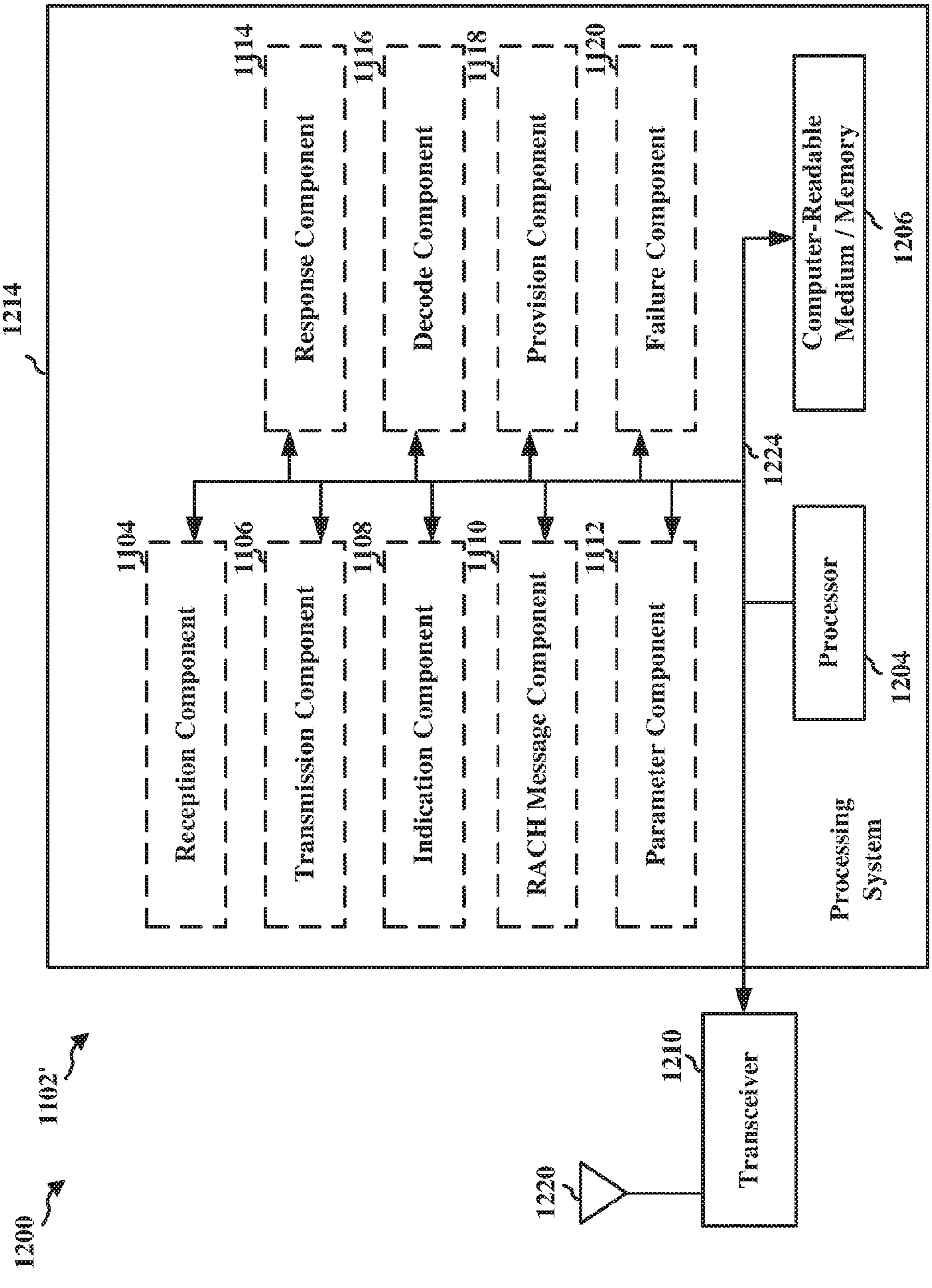
1200
1102'
1214
Reception Component
1104
Transmission Component
1106
Indication Component
1108
RACH Message Component
1110
Parameter Component
1112
Response Component
1114
Decode Component
1116
Provision Component
1118
Failure Component
1120
1224
Processor
1204
Computer-Readable Medium / Memory
1206
Processing System
Transceiver
1210
1220

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/074028

A. CLASSIFICATION OF SUBJECT MATTER

H04W 74/08(2009.01)i；H04W 74/00(2009.01)n

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

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

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

CNPAT;CNKI;WPI;EPODOC;3GPP: two, four, step, random, access, procedure, RACH, message, determining, preamble, payload, RSRP, RNTI, indicate, UE, base station, reference, signal, threshold

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2018110075 A1 (QUALCOMM INCORPORATED) 19 April 2018 (2018-04-19) claims 1-22, description, paragraphs [0049], [0092]-[0108]	1-62
Y	US 2018110074 A1 (QUALCOMM INCORPORATED) 19 April 2018 (2018-04-19) claims 1-11, description, paragraphs [0052]-[0056]	1-62
A	US 2017251499 A1 (QUALCOMM INCORPORATED) 31 August 2017 (2017-08-31) the whole document	1-62
A	WO 2018127226 A1 (CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY) 12 July 2018 (2018-07-12) the whole document	1-62
A	US 2018220452 A1 (INTEL CORPORATION) 02 August 2018 (2018-08-02) the whole document	1-62

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 2019	**28 October 2019**

Name and mailing address of the ISA/CN

National Intellectual Property Administration, PRC
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Facsimile No. **(86-10)62019451**

Authorized officer

YU, Xiaoxi

Telephone No. **86-(10)-53961578**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/074028

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2018110075	A1	19 April 2018	WO	2018075534	A1	26 April 2018
				CN	109845387	A	04 June 2019
				EP	3530060	A1	28 August 2019
US	2018110074	A1	19 April 2018	CN	109863814	A	07 June 2019
				BR	112019007577	A2	02 July 2019
				KR	20190065297	A	11 June 2019
				WO	2018075256	A1	26 April 2018
				EP	3530059	A1	28 August 2019
US	2017251499	A1	31 August 2017	WO	2017147550	A1	31 August 2017
				KR	20180117620	A	29 October 2018
				BR	112018069522	A2	22 January 2019
				EP	3420746	A1	02 January 2019
				TW	201735580	A	01 October 2017
				WO	2017147549	A1	31 August 2017
				US	2017251456	A1	31 August 2017
				EP	3420757	A1	02 January 2019
				KR	20180119576	A	02 November 2018
				JP	2019510407	A	11 April 2019
				AU	2017222683	A1	09 August 2018
				CN	108702645	A	23 October 2018
				CN	108702698	A	23 October 2018
WO	2018127226	A1	12 July 2018	CN	108271275	A	10 July 2018
US	2018220452	A1	02 August 2018	EP	3329729	A1	06 June 2018
				CN	107852757	A	27 March 2018
				WO	2017019119	A1	02 February 2017
				KR	20180034606	A	04 April 2018