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(54) **Title:** EXPEDITED NON-STANDALONE RANDOM ACCESS PROCEDURE FOR 5G

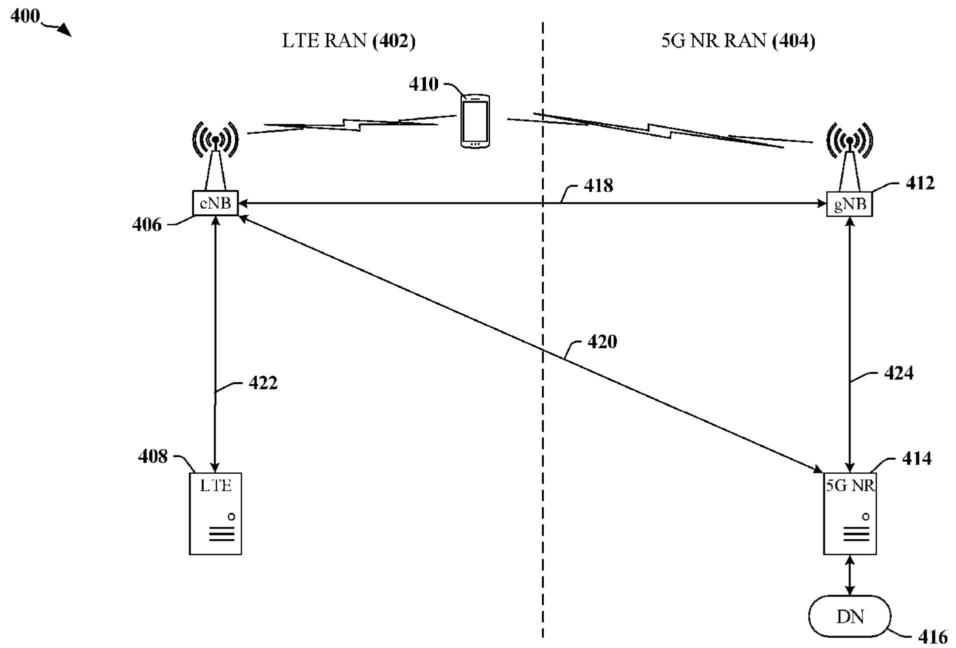

FIG. 4

(57) **Abstract:** Aspects of the disclosure relate to connection reconfiguration failures in wireless communication networks. A method includes receiving a first connection reconfiguration request at the UE while the UE is configured for 5G NR non-standalone operation and while the UE is connected in a first LTE cell, initiating a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request, initiating a first cell reselection procedure to camp in a second LTE cell when the first random access procedure fails, and after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE, adding the first LTE cell to a barred cell list, and refraining from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the barred cell list.

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EXPEDITED NON-STANDALONE RANDOM ACCESS PROCEDURE FOR 5G

TECHNICAL FIELD

[0001] The technology discussed below relates generally to wireless communication systems, and more particularly, to detecting repeated failures of connection reconfiguration procedures.

INTRODUCTION

[0002] Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be accessed by various types of devices adapted to facilitate wireless communications, where multiple devices share the available system resources (e.g., time, frequency, and power).

[0003] As the demand for mobile broadband access continues to increase, research and development continue to advance wireless communication technologies not only to meet the growing demand for mobile broadband access, but to advance and enhance the user experience with mobile communications. For example, the third generation partnership project (3GPP) is an organization that develops and maintains telecommunication standards for fourth generation (4G) long-term evolution (LTE) networks. Recently, the 3GPP has begun the development of a next-generation evolution of LTE called New Radio (NR), which may correspond to a fifth generation (5G) network. As it stands today, 5G NR networks may exhibit a higher degree of flexibility and scalability than LTE, and are envisioned to support very diverse sets of requirements. In some instances, it may be desirable that one or more of the improvements obtained in 5G NR be applicable to other multi-access technologies and the telecommunication standards that employ these technologies. In one example, improvements are needed to address the complexities and overhead associated with operating user equipment (UE) in multiple networks that are operated in accordance with different network technologies or standards.

BRIEF SUMMARY OF SOME EXAMPLES

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

[0005] Various aspects of the disclosure relate to providing methods for detecting repeated failures of connection reconfiguration procedures at a UE in a first anchor network, reselecting a second anchor network and listing the first anchor network in a barred cell list. The barred cell list may cause the UE to avoid connecting to, or camping in the first anchor network. Some aspects relate to UEs that support connections for multiple subscriptions to a network. In one example, a method of wireless communication at a UE is disclosed. The method includes receiving a first connection reconfiguration request at the UE while the UE is configured for 5G NR non-standalone operation and while the UE is connected in a first LTE cell, initiating a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request, initiating a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE, adding the first LTE cell to a first barred cell list, and refraining from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

[0006] In another example, a UE configured for wireless communication is disclosed. The scheduled entity includes a processor, a transceiver communicatively coupled to the processor, and a memory communicatively coupled to the processor. The processor is configured to receive a first connection reconfiguration request at the UE while the UE is configured for 5G NR non-standalone operation and while the UE is connected in a first LTE cell, initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request, initiate a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE, add the first LTE cell to a first barred cell list, and refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

[0007] In another example, a computer-readable medium may be configured to store information including computer executable code. The code may be executed by a processor and may cause the processor to receive a first connection reconfiguration request at the UE while the UE is configured for 5G NR non-standalone operation and while the UE is connected in a first LTE cell, initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request, initiate a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE, add the first LTE cell to a first barred cell list, and refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

[0008] In another example, a UE configured for wireless communication is disclosed. The scheduled entity includes means for receiving signaling from a first LTE cell, including a connection reconfiguration request at the UE while the UE is configured for 5G NR non-standalone operation, means for initiating random access procedures, including a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request, and means for initiating cell reselection procedures, including a first cell reselection procedure to camp in a second LTE cell when the random access procedure failures, and after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE. The UE may be configured to add the first LTE cell to a barred cell list. The UE may refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

[0009] In various examples, the UE may be configured to receive a second connection reconfiguration request at the UE while the UE is connected in the second LTE cell, initiate a second random access procedure in a second 5G NR cell indicated by the connection reconfiguration request, and transmit data through the second 5G NR cell after completing the second random access procedure. The UE may be further configured to initiate a timer after listing the first LTE cell in the first barred cell list, and remove the first LTE cell from the first barred cell list when the timer expires. The first connection reconfiguration request may be received in a radio resource control (RRC) message. The first LTE cell may provide an anchor before the first cell reselection procedure is completed. The second LTE cell may provide the anchor after the first cell reselection procedure is completed. The UE may be further configured to increment a counter when the first random access procedure fails, and initiate the first cell reselection procedure when the counter equals or exceeds a preconfigured threshold value.

[0010] In various examples, the UE is a multi-subscription UE. The first connection reconfiguration request may be directed to a first subscription and the cell reselection procedure may be initiated on behalf of the first subscription. The first barred cell list may be associated with the first subscription. The UE may be further configured to synchronize the first barred cell list with a second barred cell list associated with a second subscription after the first LTE cell is added to the first barred cell list. The first LTE cell may be added to the second barred cell list by synchronizing the first barred cell list with a second barred cell list. The UE may be further configured to initiate a cell reselection procedure on behalf of the second subscription after the first LTE cell is added to the second barred cell list. The cell reselection procedure may be initiated on behalf of the second subscription in response to addition of the first LTE cell to the second barred cell list by synchronizing the first barred cell list with a second barred cell list. The UE may be further configured to receive a first connection reconfiguration request on behalf of the second subscription while the second subscription is camped on the first LTE cell, initiate a first random access procedure in the first 5G NR cell on behalf of the second subscription, and initiate the cell reselection procedure on behalf of the second subscription in response to failure of the first random access procedure. The UE may be further configured to receive a first connection reconfiguration request directed to the second subscription after completion of the cell reselection procedure on behalf of the second subscription, initiate a second random access procedure in the second 5G NR cell on behalf of the second subscription, and transmit data through the second 5G NR cell on behalf of the second subscription.

[0011] These and other aspects of the invention will become more fully understood upon a review of the detailed description, which follows. Other aspects, features, and embodiments of the present invention will become apparent to those of ordinary skill in the art, upon reviewing the following description of specific, exemplary embodiments of the present invention in conjunction with the accompanying figures. While features of the present invention may be discussed relative to certain embodiments and figures below, all embodiments of the present invention can include one or more of the advantageous features discussed herein. In other words, while one or more embodiments may be discussed as having certain advantageous features, one or more of such features may also be used in accordance with the various embodiments of the invention discussed herein. In similar fashion, while exemplary embodiments may be discussed below as device, system, or method embodiments it should be understood that such exemplary embodiments can be implemented in various devices, systems, and methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a schematic illustration of a wireless communication system according to some aspects.

[0013] FIG. 2 is a conceptual illustration of an example of a radio access network according to some aspects.

[0014] FIG. 3 is a schematic illustration of an organization of wireless resources in an air interface utilizing orthogonal frequency divisional multiplexing (OFDM) according to some aspects.

[0015] FIG. 4 illustrates 5G non-standalone network environment in which a UE that is subscribed to a 5G NR core network may be wirelessly connected in an LTE RAN.

[0016] FIG. 5 is a message flow that illustrates an example of SCG failure.

[0017] FIG. 6 is a message flow that illustrates an example of an SCG procedure that has been adapted in accordance with certain aspects of this disclosure.

[0018] FIG. 7 illustrates an example of a multi-subscription UE.

[0019] FIG. 8 is a message flow that illustrates a first example of the use of a shared Barred Cell List maintained in a dual-subscription UE in accordance with certain aspects of this disclosure.

[0020] FIG. 9 is a message flow that illustrates a second example of the use of a shared Barred Cell List maintained in a dual-subscription UE in accordance with certain aspects of this disclosure.

[0021] FIG. 10 is a block diagram conceptually illustrating an example of a hardware implementation for a scheduling entity according to some aspects.

[0022] FIG. 11 is a block diagram conceptually illustrating an example of a hardware implementation for a scheduled entity according to some aspects.

[0023] FIG. 12 is a flow chart illustrating an example of a process for generating and communicating a PHR according to some aspects.

DETAILED DESCRIPTION

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

[0025] While aspects and embodiments are described in this application by illustration to some examples, those skilled in the art will understand that additional implementations and use cases may come about in many different arrangements and scenarios. Innovations described herein may be implemented across many differing platform types, devices, systems, shapes, sizes, packaging arrangements. For example, embodiments and/or uses may come about via integrated chip embodiments and other non-module-component based devices (e.g., end-user devices, vehicles, communication devices, computing devices, industrial equipment, retail/purchasing devices, medical devices, AI-enabled devices, etc.). While some examples may or may not be specifically directed to use cases or applications, a wide assortment of applicability of described innovations may occur. Implementations may range a spectrum from chip-level or modular components to non-modular, non-chip-level implementations and further to aggregate, distributed, or OEM devices or systems incorporating one or more aspects of the described innovations. In some practical settings, devices incorporating described aspects and features may also necessarily include additional components and features for implementation and practice of claimed and described embodiments. For example, transmission and reception of wireless signals necessarily includes a number of components for analog and digital purposes (e.g., hardware components including antenna, RF-chains, power amplifiers, modulators, buffer, processor(s), interleaver, adders/summers, etc.). It is intended that innovations described herein may be practiced in a wide variety of devices, chip-level components, systems, distributed arrangements, end-user devices, etc. of varying sizes, shapes and constitution.

[0026] The various concepts presented throughout this disclosure may be implemented across a broad variety of telecommunication systems, network architectures, and communication standards. Referring now to FIG. 1, as an illustrative example without limitation, various aspects of the present disclosure are illustrated with reference to a wireless communication system 100. The wireless communication system 100 includes three interacting domains: a core network 102, a radio access network (RAN) 104, and a user equipment (UE) 106. By virtue of the wireless communication system 100, the UE 106 may be enabled to carry out data communication with an external data network 110, such as (but not limited to) the Internet.

[0027] The RAN 104 may implement any suitable wireless communication technology or technologies to provide radio access to the UE 106. As one example, the RAN 104 may operate according to 3rd Generation Partnership Project (3GPP) New Radio (NR) specifications, often referred to as 5G. As another example, the RAN 104 may operate under a hybrid of 5G NR and Evolved Universal Terrestrial Radio Access Network (eUTRAN) standards, often referred to as LTE. The 3GPP refers to this hybrid RAN as a next-generation RAN, or NG-RAN. A base station 108 configured for 5G NR may interface with a core network 102 through a backhaul link 120. In addition to other functions, the base station 108 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, RAN sharing, multimedia broadcast multicast service (MBMS), subscriber and equipment trace, RAN information management (RIM), paging, positioning, and delivery of warning messages. Of course, many other examples may be utilized within the scope of the present disclosure.

[0028] As illustrated, the RAN 104 includes a plurality of base stations 108. Broadly, a base station is a network element in a radio access network responsible for radio transmission and reception in one or more cells to or from a UE. In different technologies, standards, or contexts, a base station may variously be referred to by those skilled in the art as a base transceiver station (BTS), a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), an access point (AP), a Node B (NB), an eNode B (eNB), a gNode B (gNB), or some other suitable terminology.

[0029] The radio access network 104 is further illustrated supporting wireless communication for multiple mobile apparatuses. A mobile apparatus may be referred to as user equipment (UE) in 3GPP standards, but may also be referred to by those skilled in the art as a mobile station (MS), 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 (AT), a mobile terminal, a wireless terminal, a remote terminal, a handset, a terminal, a user agent, a mobile client, a client, or some other suitable terminology. A UE may be an apparatus that provides a user with access to network services.

[0030] Within the present document, a "mobile" apparatus need not necessarily have a capability to move, and may be stationary. The term mobile apparatus or mobile device broadly refers to a diverse array of devices and technologies. UEs may include a number of hardware structural components sized, shaped, and arranged to help in communication; such components can include antennas, antenna arrays, RF chains, amplifiers, one or more processors, etc. electrically coupled to each other. For example, some non-limiting examples of a mobile apparatus include a mobile, a cellular (cell) phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal computer (PC), a notebook, a netbook, a smartbook, a tablet, a personal digital assistant (PDA), and a broad array of embedded systems, e.g., corresponding to an "Internet of things" (IoT). A mobile apparatus may additionally be an automotive or other transportation vehicle, a remote sensor or actuator, a robot or robotics device, a satellite radio, a global positioning system (GPS) device, an object tracking device, a drone, a multi-copter, a quad-copter, a remote control device, a consumer and/or wearable device, such as eyewear, a wearable camera, a virtual reality device, a smart watch, a health or fitness tracker, a digital audio player (e.g., MP3 player), a camera, a game console, etc. A mobile apparatus may additionally be a digital home or smart home device such as a home audio, video, and/or multimedia device, an appliance, a vending machine, intelligent lighting, a home security system, a smart meter, etc. A mobile apparatus may additionally be a smart energy device, a security device, a solar panel or solar array, a municipal infrastructure device controlling electric power (e.g., a smart grid), lighting, water, etc.; an industrial automation and enterprise device; a logistics controller; agricultural equipment; military defense equipment, vehicles, aircraft, ships, and weaponry, etc. Still further, a mobile apparatus may provide for connected medicine or telemedicine support, e.g., health care at a distance. Telehealth devices may include telehealth monitoring devices and telehealth administration devices, whose communication may be given preferential treatment or prioritized access over other types of information, e.g., in terms of prioritized access for transport of critical service data, and/or relevant QoS for transport of critical service data.

[0031] Wireless communication between a RAN 104 and a UE 106 may be described as utilizing an air interface. Transmissions over the air interface from a base station (e.g., base station 108) to one or more UEs (e.g., UE 106) may be referred to as downlink (DL) transmission. In accordance with certain aspects of the present disclosure, the term downlink may refer to a point-to-multipoint transmission originating at a scheduling entity (described further below; e.g., base station 108). Another way to describe this scheme may be to use the term broadcast channel multiplexing. Transmissions from a UE (e.g., UE 106) to a base station (e.g., base station 108) may be referred to as uplink (UL) transmissions. In accordance with further aspects of the present disclosure, the term uplink may refer to a point-to-point transmission originating at a scheduled entity (described further below; e.g., UE 106).

[0032] In some examples, access to the air interface may be scheduled, wherein a scheduling entity (e.g., a base station 108) allocates resources for communication among some or all devices and equipment within its service area or cell. Within the present disclosure, as discussed further below, the scheduling entity may be responsible for scheduling, assigning, reconfiguring, and releasing resources for one or more scheduled entities. That is, for scheduled communication, UEs 106, which may be scheduled entities, may utilize resources allocated by the scheduling entity 108.

[0033] Base stations 108 are not the only entities that may function as scheduling entities. That is, in some examples, a UE may function as a scheduling entity, scheduling resources for one or more scheduled entities (e.g., one or more other UEs).

[0034] As illustrated in FIG. 1, a scheduling entity 108 may broadcast downlink traffic 112 to one or more scheduled entities 106. Broadly, the scheduling entity 108 is a node or device responsible for scheduling traffic in a wireless communication network, including the downlink traffic 112 and, in some examples, uplink traffic 116 from one or more scheduled entities 106 to the scheduling entity 108. On the other hand, the scheduled entity 106 is a node or device that receives downlink control information 114, including but not limited to scheduling information (e.g., a grant), synchronization or timing information, or other control information from another entity in the wireless communication network such as the scheduling entity 108.

[0035] In general, base stations 108 may include a backhaul interface for communication with a backhaul portion 120 of the wireless communication system. The backhaul 120 may provide a link between a base station 108 and the core network 102. Further, in some examples, a backhaul network may provide interconnection between the respective base stations 108. Various types of backhaul interfaces may be employed, such as a direct physical connection, a virtual network, or the like using any suitable transport network.

[0036] The core network 102 may be a part of the wireless communication system 100, and may be independent of the radio access technology used in the RAN 104. In some examples, the core network 102 may be configured according to 5G standards (e.g., 5GC). In other examples, the core network 102 may be configured according to a 4G evolved packet core (EPC), or any other suitable standard or configuration. When the RAN 104 is operated as a 5G NR network and the core network 102 is configured according to 5G standards, a UE connected to the RAN 104 may be operated in a standalone mode that may be referred to as a 5G NR SA mode, or 5G SA mode. When the RAN 104 is operated as a 5G NR network and the core network 102 is configured as a 4G EPC, a UE connected to the RAN 104 may be operated in a non-standalone mode that may be referred to as a 5G NR NSA mode, or 5G NSA mode. In 5G NSA mode, a UE 106 that is configured for 5G NSA operation can access 5G NR network services while relying on an anchor in the 4G LTE RAN and core network.

[0037] Referring now to FIG. 2, by way of example and without limitation, a schematic illustration of a RAN 200 is provided. In some examples, the RAN 200 may be the same as the RAN 104 described above and illustrated in FIG. 1. The geographic area covered by the RAN 200 may be divided into cellular regions (cells) that can be uniquely identified by a user equipment (UE) based on an identification broadcasted from one access point or base station. FIG. 2 illustrates macrocells 202, 204, and 206, and a small cell 208, each of which may include one or more sectors (not shown). A sector is a sub-area of a cell. All sectors within one cell are served by the same base station. A radio link within a sector can be identified by a single logical identification belonging to that sector. In a cell that is divided into sectors, the multiple sectors within a cell can be formed by groups of antennas with each antenna responsible for communication with UEs in a portion of the cell.

[0038] In FIG. 2, two base stations 210 and 212 are shown in cells 202 and 204; and a third base station 214 is shown controlling a remote radio head (RRH) 216 in cell 206. That is, a base station can have an integrated antenna or can be connected to an antenna or RRH by feeder cables. In the illustrated example, the cells 202, 204, and 126 may be referred to as macrocells, as the base stations 210, 212, and 214 support cells having a large size. Further, a base station 218 is shown in the small cell 208 (e.g., a microcell, picocell, femtocell, home base station, home Node B, home eNode B, etc.) which may overlap with one or more macrocells. In this example, the cell 208 may be referred to as a small cell, as the base station 218 supports a cell having a relatively small size. Cell sizing can be done according to system design as well as component constraints.

[0039] It is to be understood that the radio access network 200 may include any number of wireless base stations and cells. Further, a relay node may be deployed to extend the size or coverage area of a given cell. The base stations 210, 212, 214, 218 provide wireless access points to a core network for any number of mobile apparatuses. In some examples, the base stations 210, 212, 214, and/or 218 may be the same as the base station/scheduling entity 108 described above and illustrated in FIG. 1.

[0040] FIG. 2 further includes a quadcopter or drone 220, which may be configured to function as a base station. That is, in some examples, a cell may not necessarily be stationary, and the geographic area of the cell may move according to the location of a mobile base station such as the quadcopter 220.

[0041] Within the RAN 200, the cells may include UEs that may be in communication with one or more sectors of each cell. Further, each base station 210, 212, 214, 218, and 220 may be configured to provide an access point to a core network 102 (see FIG. 1) for all the UEs in the respective cells. For example, UEs 222 and 224 may be in communication with base station 210; UEs 226 and 228 may be in communication with base station 212; UEs 230 and 232 may be in communication with base station 214 by way of RRH 216; UE 234 may be in communication with base station 218; and UE 236 may be in communication with mobile base station 220. In some examples, the UEs 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, and/or 242 may be the same as the UE/scheduled entity 106 described above and illustrated in FIG. 1.

[0042] In some examples, a mobile network node (e.g., quadcopter 220) may be configured to function as a UE. For example, the quadcopter 220 may operate within cell 202 by communicating with base station 210.

[0043] In a further aspect of the RAN 200, sidelink signals may be used between UEs without necessarily relying on scheduling or control information from a base station. For example, two or more UEs (e.g., UEs 226 and 228) may communicate with each other using peer to peer (P2P) or sidelink signals 227 without relaying that communication through a base station (e.g., base station 212). In a further example, UE 238 is illustrated communicating with UEs 240 and 242. Here, the UE 238 may function as a scheduling entity or a primary sidelink device, and UEs 240 and 242 may function as a scheduled entity or a non-primary (e.g., secondary) sidelink device. In still another example, a UE may function as a scheduling entity in a device-to-device (D2D), peer-to-peer (P2P), or vehicle-to-vehicle (V2V) network, and/or in a mesh network. In a mesh network example, UEs 240 and 242 may optionally communicate directly with one another in addition to communicating with the scheduling entity 238. Thus, in a wireless communication system with scheduled access to time–frequency resources and having a cellular configuration, a P2P configuration, or a mesh configuration, a scheduling entity and one or more scheduled entities may communicate utilizing the scheduled resources.

[0044] In the radio access network 200, the ability for a UE to communicate while moving, independent of its location, is referred to as mobility. The various physical channels between the UE and the radio access network are generally set up, maintained, and released under the control of an access and mobility management function that is part of the core network 102 of FIG. 1. The AMF may include a security context management function (SCMF) that manages the security context for both the control plane and the user plane functionality, and a security anchor function (SEAF) that performs authentication.

[0045] In various aspects of the disclosure, a radio access network 200 may utilize DL-based mobility or UL-based mobility to enable mobility and handovers (i.e., the transfer of a UE's connection from one radio channel to another). In a network configured for DL-based mobility, during a call with a scheduling entity, or at any other time, a UE may monitor various parameters of the signal from its serving cell as well as various parameters of neighboring cells. Depending on the quality of these parameters, the UE may maintain communication with one or more of the neighboring cells. During this time, if the UE moves from one cell to another, or if signal quality from a neighboring cell exceeds that from the serving cell for a given amount of time, the UE may undertake a handoff or handover from the serving cell to the neighboring (target) cell. For example, UE 224 (illustrated as a vehicle, although any suitable form of UE may be used) may move from the geographic area corresponding to its serving cell 202 to the geographic area corresponding to a neighbor cell 206. When the signal strength or quality from the neighbor cell 206 exceeds that of its serving cell 202 for a given amount of time, the UE 224 may transmit a reporting message to its serving base station 210 indicating this condition. In response, the UE 224 may receive a handover command, and the UE may undergo a handover to the cell 206.

[0046] In a network configured for UL-based mobility, UL reference signals from each UE may be utilized by the network to select a serving cell for each UE. In some examples, the base stations 210, 212, and 214/216 may broadcast unified synchronization signals (e.g., unified Primary Synchronization Signals (PSSs), unified Secondary Synchronization Signals (SSSs) and unified Physical Broadcast Channels (PBCH)). The UEs 222, 224, 226, 228, 230, and 232 may receive the unified synchronization signals, derive the carrier frequency and slot timing from the synchronization signals, and in response to deriving timing, transmit an uplink pilot or reference signal. The uplink pilot signal transmitted by a UE (e.g., UE 224) may be concurrently received by two or more cells (e.g., base stations 210 and 214/216) within the radio access network 200. Each of the cells may measure a strength of the pilot signal, and the radio access network (e.g., one or more of the base stations 210 and 214/216 and/or a central node within the core network) may determine a serving cell for the UE 224. As the UE 224 moves through the radio access network 200, the network may continue to monitor the uplink pilot signal transmitted by the UE 224. When the signal strength or quality of the pilot signal measured by a neighboring cell exceeds that of the signal strength or quality measured by the serving cell, the network 200 may handover the UE 224 from the serving cell to the neighboring cell, with or without informing the UE 224.

[0047] Although the synchronization signal transmitted by the base stations 210, 212, and 214/216 may be unified, the synchronization signal may not identify a particular cell, but rather may identify a zone of multiple cells operating on the same frequency and/or with the same timing. The use of zones in 5G networks or other next generation communication networks enables the uplink-based mobility framework and improves the efficiency of both the UE and the network, since the number of mobility messages that need to be exchanged between the UE and the network may be reduced.

[0048] The air interface in the radio access network 200 may utilize one or more duplexing algorithms. Duplex refers to a point-to-point communication link where both endpoints can communicate with one another in both directions. Full duplex means both endpoints can simultaneously communicate with one another. Half duplex means only one endpoint can send information to the other at a time. In a wireless link, a full duplex channel generally relies on physical isolation of a transmitter and receiver, and suitable interference cancellation technologies. Full duplex emulation is frequently implemented for wireless links by utilizing frequency division duplex (FDD) or time division duplex (TDD). In FDD, transmissions in different directions operate at different carrier frequencies. In TDD, transmissions in different directions on a given channel are separated from one another using time division multiplexing. That is, at some times the channel is dedicated for transmissions in one direction, while at other times the channel is dedicated for transmissions in the other direction, where the direction may change very rapidly, e.g., several times per slot.

[0049] Various aspects of the present disclosure will be described with reference to an OFDM waveform 300, schematically illustrated in FIG. 3. It should be understood by those of ordinary skill in the art that the various aspects of the present disclosure may be applied to a DFT-s-OFDMA waveform in substantially the same way as described herein below. That is, while some examples of the present disclosure may focus on an OFDM link for clarity, it should be understood that the same principles may be applied as well to DFT-s-OFDMA waveforms.

[0050] Within the present disclosure, a frame refers to a duration of 10 ms for wireless transmissions, with each frame consisting of 10 subframes of 1 ms each. On a given carrier, there may be one set of frames in the UL, and another set of frames in the DL. Referring now to FIG. 3, an expanded view of an exemplary DL subframe 302 is illustrated, showing an OFDM resource grid 304. However, as those skilled in the art will readily appreciate, the PHY transmission structure for any particular application may vary from the example described here, depending on any number of factors. Here, time is in the horizontal direction with units of OFDM symbols; and frequency is in the vertical direction with units of subcarriers or tones.

[0051] The resource grid 304 may be used to schematically represent time–frequency resources for a given antenna port. That is, in a MIMO implementation with multiple antenna ports available, a corresponding multiple number of resource grids 304 may be available for communication. The resource grid 304 is divided into multiple resource elements (REs) 306. An RE, which is 1 subcarrier × 1 symbol, is the smallest discrete part of the time–frequency grid, and contains a single complex value representing data from a physical channel or signal. Depending on the modulation utilized in a particular implementation, each RE may represent one or more bits of information. In some examples, a block of REs may be referred to as a physical resource block (PRB) or a resource block (RB) 308, which contains any suitable number of consecutive subcarriers in the frequency domain. In one example, an RB may include 12 subcarriers, a number independent of the numerology used. In some examples, depending on the numerology, an RB may include any suitable number of consecutive OFDM symbols in the time domain. Within the present disclosure, it is assumed that a single RB such as the RB

308 entirely corresponds to a single direction of communication (either transmission or reception for a given device).

[0052] A UE generally utilizes only a subset of the resource grid 304. An RB may be the smallest unit of resources that can be allocated to a UE. Thus, the more RBs scheduled for a UE, and the higher the modulation scheme chosen for the air interface, the higher the data rate for the UE.

[0053] In this illustration, the RB 308 is shown as occupying less than the entire bandwidth of the subframe 302, with some subcarriers illustrated above and below the RB 308. In a given implementation, the subframe 302 may have a bandwidth corresponding to any number of one or more RBs 308. Further, in this illustration, the RB 308 is shown as occupying less than the entire duration of the subframe 302, although this is merely one possible example.

[0054] Each 1 ms subframe 302 may consist of one or multiple adjacent slots. In the example shown in FIG. 3, one subframe 302 includes four slots 310, as an illustrative example. In some examples, a slot may be defined according to a specified number of OFDM symbols with a given cyclic prefix (CP) length. For example, a slot may include 7 or 14 OFDM symbols with a nominal CP. Additional examples may include mini-slots having a shorter duration (e.g., one or two OFDM symbols). These mini-slots may in some cases be transmitted occupying resources scheduled for ongoing slot transmissions for the same or for different UEs.

[0055] An expanded view of one of the slots 310 illustrates the slot 310 including a control region 312 and a data region 314. In general, the control region 312 may carry control channels (e.g., PDCCH), and the data region 314 may carry data channels (e.g., PDSCH or PUSCH). Of course, a slot may contain all DL, all UL, or at least one DL portion and at least one UL portion. The structure illustrated in FIG. 3 is merely exemplary in nature, and different slot structures may be utilized, and may include one or more of each of the control region(s) and data region(s).

[0056] Although not illustrated in FIG. 3, the various REs 306 within an RB 308 may be scheduled to carry one or more physical channels, including control channels, shared channels, data channels, etc. Other REs 306 within the RB 308 may also carry pilots or reference signals, including but not limited to a demodulation reference signal (DMRS) a control reference signal (CRS), or a sounding reference signal (SRS). These pilots or reference signals may provide for a receiving device to perform channel estimation of the corresponding channel, which may enable coherent demodulation/detection of the control and/or data channels within the RB 308.

[0057] In a DL transmission, the transmitting device (e.g., the scheduling entity 108) may allocate one or more REs 306 (e.g., within a control region 312) to carry DL control information 114 including one or more DL control channels that generally carry information originating from higher layers, such as a physical broadcast channel (PBCH), a physical downlink control channel (PDCCH), etc., to one or more scheduled entities 106. In addition, DL REs may be allocated to carry DL physical signals that generally do not carry information originating from higher layers. These DL physical signals may include a primary synchronization signal (PSS); a secondary synchronization signal (SSS); a demodulation reference signal (DM-RS); a phase-tracking reference signal (PT-RS); a channel-state information reference signal (CSI-RS); etc.

[0058] The synchronization signals PSS and SSS (collectively referred to as SS), and in some examples, the PBCH, may be transmitted in an SS block (SSB) that includes 4 consecutive OFDM symbols, numbered via a time index in increasing order from 0 to 3. In the frequency domain, the SSB may extend over 240 contiguous subcarriers, with the subcarriers being numbered via a frequency index in increasing order from 0 to 239. Of course, the present disclosure is not limited to this specific SSB configuration. Other nonlimiting examples may utilize greater or fewer than two synchronization signals; may include one or more supplemental channels in addition to the PBCH; may omit a PBCH; and/or may utilize nonconsecutive symbols for an SSB, within the scope of the present disclosure.

[0059] The PDCCH may carry downlink control information (DCI) for one or more UEs supported by one or more serving cells, including but not limited to power control commands, scheduling information, a grant, and/or an assignment of REs for DL and UL transmissions.

[0060] In an UL transmission, the transmitting device (e.g., the scheduled entity 106) may utilize one or more REs 306 to carry UL control information 118 originating from higher layers via one or more UL control channels, such as a physical uplink control channel (PUCCH), a physical random access channel (PRACH), etc., to the scheduling entity 108. Further, UL REs may carry UL physical signals that generally do not carry information originating from higher layers, such as demodulation reference signals (DM-RS), phase-tracking reference signals (PT-RS), sounding reference signals (SRS), etc. In some examples, the control information 118 may include a scheduling request (SR), i.e., a request for the scheduling entity 108 to schedule uplink transmissions. Here, in response to the SR transmitted on the control channel 118, the scheduling entity 108 may transmit downlink control information 114 that may schedule resources for uplink packet transmissions. UL control information may also include hybrid automatic repeat request (HARQ) feedback such as an acknowledgment (ACK) or negative acknowledgment (NACK), channel state information (CSI), or any other suitable UL control information. HARQ is a technique well-known to those of ordinary skill in the art, wherein the integrity of packet transmissions may be checked at the receiving side for accuracy, e.g., utilizing any suitable integrity checking mechanism, such as a checksum or a cyclic redundancy check (CRC). If the integrity of the transmission confirmed, an ACK may be transmitted, whereas if not confirmed, a NACK may be transmitted. In response to a NACK, the transmitting device may send a HARQ retransmission, which may implement chase combining, incremental redundancy, etc.

[0061] In addition to control information, one or more REs 306 (e.g., within the data region 314) may be allocated for user data or traffic data. Such traffic may be carried on one or more traffic channels, such as, for a DL transmission, a physical downlink shared channel (PDSCH); or for an UL transmission, a physical uplink shared channel (PUSCH).

[0062] In order for a UE to gain initial access to a cell, the RAN may provide system information (SI) characterizing the cell. This system information may be provided utilizing minimum system information (MSI), and other system information (OSI). The MSI may be periodically broadcast over the cell to provide the most basic information required for initial cell access, and for acquiring any OSI that may be broadcast periodically or sent on-demand. In some examples, the MSI may be provided over two different downlink channels. For example, the PBCH may carry a master information block (MIB), and the PDSCH may carry a system information block type 1 (SIB1). In the art, SIB1 may be referred to as the remaining minimum system information (RMSI).

[0063] OSI may include any SI that is not broadcast in the MSI. In some examples, the PDSCH may carry a plurality of SIBs, not limited to SIB1, discussed above. Here, the OSI may be provided in these SIBs, e.g., SIB2 and above.

[0064] The channels or carriers described above and illustrated in FIGs. 1 and 3 are not necessarily all the channels or carriers that may be utilized between a scheduling entity 108 and scheduled entities 106, and those of ordinary skill in the art will recognize that other channels or carriers may be utilized in addition to those illustrated, such as other traffic, control, and feedback channels.

[0065] These physical channels described above are generally multiplexed and mapped to transport channels for handling at the medium access control (MAC) layer. Transport channels carry blocks of information called transport blocks (TB). The transport block size (TBS), which may correspond to a number of bits of information, may be a controlled parameter, based on the modulation and coding scheme (MCS) and the number of RBs in a given transmission.

[0066] A UE that is subscribed to an operator network may establish a connection with the network through a registration process. In one example, the UE may register with a 5G NR core network using information maintained by a universal subscriber identity module (USIM) application provided on a universal Integrated Circuit Card (UICC). The combination of the USIM and UICC may be referred to herein as a subscriber identity module (SIM). In some implementations, the SIM maintains information associated with or provided by a network operator, including information that identifies the UE, a subscription to the network, an international mobile subscriber identity (IMSI), security authentication and ciphering information, and a list of the services accessible by the UE. A UE may be assigned or acquire multiple network subscriptions. For instance, the UE may hold subscriptions to two or more different network. In some instances, the UE may hold multiple subscriptions to a single network, where the UE is provisioned with multiple SIMs and where each SIM identifies the UE as a subscriber of the network. In these instances, each SIM may identify a different subscription associated with the UE or user of the UE. The UE may establish connections with one or more subscribed networks based on subscription information maintained by one or more SIMs.

[0067] In 5G NSA mode, a 5G NR is enabled or assisted by LTE infrastructure. In some implementations, a UE configured for 5G NSA mode can be connected in an LTE network and may access certain LTE RAN and core network components, and/or an added 5G NR component carrier. FIG. 4 illustrates an example of a 5G NSA network environment 400 in which a UE 410 that is subscribed to a 5G NR core network 414 may be wirelessly connected in an LTE RAN 402 operated by an LTE core network 408. In this example, the LTE RAN 402 is a member of a Master Cell Group (MCG) when the UE 410 connects to an eNB 406 in the LTE RAN 402. The MCG operates as an anchor cell group for the UE 410, such that the UE 410 may perform its initial registration through the eNB 406. The anchor cell group may add the 5G NR RAN 404 operated by the 5G NR core network 414 in a Secondary Cell Group (SCG). Control and user traffic may be exchanged by the UE 410 and the 5G NR core network 414 through the MCG and through the LTE RAN 402. In one example, the UE 410 may communicate with the 5G NR core network 414 and/or a gNB 412 in the SCG through the eNB 406 and one or more connections 418, 420, 422, 424 configured for control or user plane communication. The 5G NR core network 414 may provide packet switched (PS) data services that enable the UE 410 to communicate over a data network (DN 416) such as the Internet.

[0068] In one example, a connection can be established between the UE 410 and the 5G NR core network 414 using an LTE radio resource control (RRC) Connection Reconfiguration procedure performed after the UE 410 has established a connection with the eNB 406 in the LTE RAN 402. RRC protocols are used for connection establishment, reconfiguration and release, system information broadcast, radio bearer establishment, and for other purposes. RRC protocols can configure the user plane and the control plane based on network conditions. Other protocols may be used to manage the operation of the UE 410 in the LTE RAN 402. For example, a Tracking Area Update (TAU) message may be sent to inform the network of changes in location. A Tracking Area (TA) may be defined for the UE 410. In some instances, the network defines multiple TAs, and the UE 410 may be configured with a subset of the TAs in which it can move without updating the network. The UE 410 may send a TAU message when the UE 410 is no longer present in one of the configured subset of TAs.

[0069] In some implementations of 5G NSA, SCG failures may occur and may cause loss of connection between the UE 410 and the 5G NR core network 414. In one example, an SCG failure may occur during a random access procedure (RACH procedure). The UE 410 may send a RACH request when attempting to attach or be synchronized with the network. For example, the UE 410 may send a RACH request during initial access, during an RRC connection reestablishment procedure, handover between cells, for scheduling purposes, after loss synchronization with the network, or for other purposes related to synchronization.

[0070] An SCG failure may occur when the UE experiences poor signal-to-noise (SNR) due to severe interference in the SCG NR cell, for example. In some implementations, reductions in transmitter power after completion of SCG setup and other reasons can result in significant decreases in Reference Signal Receive Power (RSRP) and SNR.

The deterioration in SNR can prevent the UE 410 from obtaining services such as PS data service through the 5G NR network. RSRP may be calculated as the average power of REs that carry cell-specific reference signals.

[0071] FIG. 5 shows a message flow 500 that illustrates an example of SCG failure in a conventional system. In this example, A 5G NR capable UE 502 is operating in NSA mode and may be able to detect signals associated with multiple RANs, including signals transmitted in LTE cells 504, 508 and 5G cells 506, 510. LTE cells 504, 508 support NSA. UE 502 is initially connected to, or camped on LTE cell 504 and may be in a PS data transfer mode 512, in which UE 502 may be transmitting and/or receiving data through an LTE network.

[0072] LTE cell 504 may add 5G Cell 506 as a secondary node using an SCG procedure 514 in which the LTE cell 504 sends a request to 5G Cell 506 and receives an acknowledgement indicating that 5G Cell 506 agrees to be added to the SCG. The request may include information regarding the capabilities of the UE 502 and measurements of the 5G Cell 506 obtained by the UE 502. Upon adding 5G Cell 506 to the SCG, RRC connection reconfiguration 516 is performed. LTE cell 504 sends an RRC connection reconfiguration request 518 to UE 502, where the RRC connection reconfiguration request 518 identifies 5G Cell 506 and provides information regarding 5G Cell 506 and details of the requested reconfiguration. UE 502 sends an RRC connection reconfiguration complete response message 520 to LTE cell 504 if able to perform the reconfiguration.

[0073] UE 502 may use the information in the RRC connection reconfiguration request to initiate a RACH procedure 522 to connect to 5G Cell 506, which is now in the SCG. In one example, the RRC connection reconfiguration request 518 identifies reference signals transmitted by to 5G Cell 506. In the illustrated example, UE 502 measures an SNR that is unacceptable, below a threshold configured or defined for minimum SNR and/or unable to support PS data transfer 526. UE 502 may send an SCG failure message 524 to LTE cell 504. In conventional systems, the UE 502 takes no further action 530 and may continue in a connected state in LTE cell 504 or camped on LTE cell 504. LTE cell 504 responds to the SCG failure message 524 by resending the RRC connection reconfiguration request to UE 502, thereby repeating the connection reconfiguration loop 528. UE 502 may perform many iterations of the connection reconfiguration loop 528. Iterations of the connection reconfiguration loop 528 that result in consistent failure can have a detrimental effect on power usage of the UE 502, processing time, and/or the ability of the UE 502 to sustain a PS data stream.

[0074] In one aspect of this disclosure, a UE may be configured to limit the number of iterations of a connection reconfiguration loop that result in consistent failure. The UE may be configured to maintain a list of cells that are consistently or repeatedly involved in unsuccessful connection reconfiguration procedures. The list of cells may be referred to as a "Barred Cell List" herein. and may be used to record cells that have been identified in a failed RACH procedure, including cells that failed a random access procedure following RRC connection reconfiguration requests. In one example, the UE may add a cell to the Barred Cell List after a number of failures of the UE to connect to the cell during a random access procedure.

[0075] FIG. 6 is a message flow 600 illustrating an example of an SCG procedure that has been adapted or configured in accordance with certain aspects of this disclosure. In this example, A 5G NR capable UE 602 is operating in NSA mode and may be able to detect signals associated with one or more LTE RANs and one or more 5G NR RANS, including signals transmitted in LTE cells 604, 608 and in 5G cells 606, 610. LTE cells 604, 608 support NSA. UE 602 is initially connected to, or camped on LTE cell 604, which serves as the anchor cell. UE 602 may be in a PS data transfer mode 612, in which UE 602 is transmitting and/or receiving data through an LTE network.

[0076] LTE cell 604 may add 5G cell 606 as a secondary node using an SCG procedure 614 in which the LTE cell 604 sends a request to 5G cell 606 and receives an acknowledgement indicating that 5G cell 606 agrees to be added to the SCG. The request may include information regarding the capabilities of the UE 602 and measurements of the 5G cell 606 obtained by the UE 602. Upon adding 5G cell 606 to the SCG, RRC connection reconfiguration 616 is performed. In one example, LTE cell 604 sends an RRC connection reconfiguration request to UE 602, where the RRC connection reconfiguration request identifies 5G cell 606. The RRC connection reconfiguration request may provide information regarding 5G cell 606 and details of the requested reconfiguration. UE 602 sends an RRC connection reconfiguration complete response message to LTE cell 604 if able to perform the reconfiguration.

[0077] UE 602 may use the information in the RRC connection reconfiguration request to initiate a RACH procedure 618 to connect to 5G cell 606, which is now in the SCG. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by to 5G cell 606. In the illustrated example, UE 602 measures an SNR that is unacceptable and/or below a threshold configured or defined for minimum SNR and/or unable to support PS data transfer. UE 602 may send an SCG failure message 620 to LTE cell 604.

[0078] In one aspect, UE 602 may respond to the failed SCG procedure by incrementing a loop counter 622 used to track the number of iterations of the connection reconfiguration procedure that resulted in SCG failure. In some implementations, the number of successive failures is counted by the loop counter, and the loop counter is reset after a successful SCG procedure. In some implementations, the loop counter is incremented after each SCG failure and decremented after each successful SCG procedure unless the loop counter is already in a reset state and/or has a zero-value.

[0079] UE 602 may check 624 the loop counter. UE 602 may take no further action 628 and may continue in a connected state in LTE cell 604 or camped on LTE cell 604, provided the loop counter has not exceeded a threshold maximum loop value. When the UE 602 takes no further action 628, LTE cell 604 can be expected to resend the RRC connection reconfiguration request to UE 602, and repeat the connection reconfiguration loop 626. When the loop counter has exceeded the threshold maximum loop value, UE 602 may add 630 LTE cell 604 to the Barred Cell List.

[0080] In some implementations, UE 602 may initiate a timer 632 that determines the period of time LTE cell 604 remains on the Barred Cell List. For example, LTE cell 604 may be removed from the Barred Cell List after the timer expires. After initiating the timer, UE 602 may perform a cell reselection procedure 634. Cell reselection enables the UE 602 to disconnect from a current cell and camp or connect to a different cell in the anchor cell group. UE 602 may be camped on a cell after completing a cell selection and/or reselection process and may be monitoring system information and optionally paging information. The UE 602 is not allowed to camp on certain cells, which may be referred to as “Barred Cells” and which may include the entries in the Barred Cell List.

[0081] In the illustrated example, UE 602 uses the cell reselection procedure 634 to disconnect from LTE cell 604 and connect to LTE cell 608. Cell reselection is typically used to ensure that the UE is connected to the cell with optimum radio configuration and conditions. In the case of SCG procedure failure, reselecting to LTE cell 608 may result in reduced interference and/or improved RSRP and SNR in a 5G cell 606 or 610. Reselecting to LTE cell 608 may also result in limited iterations of a persistently failing connection reconfiguration loop 626.

[0082] After the cell reselection procedure 634 has been completed, the UE 602 may enter a PS data transfer state 636, in which UE 602 is using LTE cell 608 to transmit and/or receive data through the LTE network. LTE cell 608 may add a 5G cell 606 or 610 as a secondary node. In the illustrated example, LTE cell 608 may add 5G cell 610 as a secondary node using an SCG procedure 638 in which the LTE cell 604 sends a request to 5G cell 610 and receives an acknowledgement indicating that 5G cell 610 agrees to be added to the SCG. The request may include information regarding the capabilities of the UE 602 and measurements of the 5G cell 610 obtained by the UE 602. Upon adding 5G cell 610 to the SCG, RRC connection reconfiguration 640 is performed. In one example, LTE cell 608 sends an RRC connection reconfiguration request to UE 602, where the RRC connection reconfiguration request identifies 5G cell 610. The RRC connection reconfiguration request may provide information regarding 5G cell 610 and details of the requested reconfiguration. UE 602 sends an RRC connection reconfiguration complete response message to LTE cell 608 if able to perform the reconfiguration.

[0083] UE 602 may use the information in the RRC connection reconfiguration request to initiate a RACH procedure 642 to connect to 5G cell 610. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by to 5G cell 610. In the illustrated example, UE 602 measures an SNR that is acceptable and the UE 602 enters a PS data transfer 644 while connected to 5G cell 610. The use of the cell reselection procedure 634 permits UE 602 to maintain 5G NR capabilities and avoid further failures on LTE cell 604.

[0084] According to certain aspects of the disclosure, the Barred Cell List generated for a first subscription of a multi-subscription UE may be shared for the use of another subscription of the UE. FIG. 7 is a block diagram 700 illustrating an example of a multi-subscription UE 702. In this example, the UE 702 may be adapted or configured to support two subscriptions 708a and 708b, where the subscriptions are identified or otherwise correspond to SIMs 718a, 718b installed in the UE 702. A subscription manager 710 may be provided to manage the subscriptions 708a, 708b associated with the SIMs 718a and 718b. The subscription manager 710 may be implemented in a combination of hardware circuits and software/firmware modules or other logic elements, and the operation of the subscription manager 710 may be controlled by a processing circuit 714.

[0085] The UE 702 may support a variety of operational modes when multiple SIMs 718a, 718b are installed in the UE 702. For example, in dual SIM dual stand-by (DSDS) mode, the UE 702 may initially be in standby mode for two different subscriptions. After establishing a call through one operator network 720 or 722, the UE 702 may cause the connection between the UE 702 and the other operator network 722 or 720 to enter an inactive state. In one example, DSDS mode may be used when the UE 702 is equipped with a transceiver 712 that has fewer available receive (Rx) chains 716a and/or transmit (Tx) chains 716b than the number of desired active connections. In another example, the UE 702 may have idled one or more other transceivers or one or more Rx chains 716a and/or Tx chains 716b of the transceiver 712 in order to conserve power. In dual SIM dual active (DSDA) mode, the UE 702 may be concurrently connected to one or more operator networks 720 and/or 722. A UE 702 that is DSDA-enabled may be capable of switching between two simultaneously active calls and/or connecting two active calls at the UE 702.

[0086] The UE 702 may have one or more transceivers 712 and/or RF front-end interfaces 724a, 724b, with a corresponding number of Rx chains 716a and associated RF font-end interfaces 724a, 724b. The RF front-end interfaces 724a, 724b may include RF amplifiers, antennas and other RF circuitry and components. The UE 702 may establish a wireless connection using an Rx chain 716a and a Tx chain 716b and associated RF front-end interfaces 724a, 724b.

[0087] The UE 702 may be configured to receive services provided by one or more operator networks 720, 722. In one example, the UE 702 may obtain services from a first operator network 720 through a first base station 704 and may obtain services from a second operator network 722 through a second base station 706. The UE 702 may obtain services from a single operator network 720 or 722 on behalf of two different subscriptions 708a and 708b. Each operator network 720 and 722 may provide voice services, data services or some combination of voice and data services through one or more RANs operated by the same or different network operators.

[0088] In one example, the subscription manager 710 may be adapted to control or configure access to a shared Rx chain 716a, a shared Tx chain 716b, and/or another RF component or RF front-end interface 724a, 724b, such as an antenna. In another example, the subscription manager 710 may cooperate or otherwise interact with the processing circuit 714 and/or sharing logic 726 to control access to a shared Rx chain 716a, a shared Tx chain 716b, and/or other RF front-end interface 724a, 724b. The sharing logic

726 may include switches, timers, gates, state machines and other logic. The sharing logic 726 may respond to control signals provided by the subscription manager 710 and/or processing circuit 714 to control access to the shared Rx chain 716a, shared Tx chain 716b, and/or other RF front-end interface 724a, 724b.

[0089] The SIMs 718a and 718b can be used to identify and authenticate subscribed users of the various services offered by network operators. In one example, each SIM 718a, 718b may store an international mobile subscriber identity (IMSI) and related keys that can uniquely identify and authenticate a subscribed user of the UE 702. Each SIM 718a, 718b may enable access to subscribed services available to the user through the operator networks 720 and/or 722. Each subscription 708a or 708b may be associated with a telephone number or another network identifier, and the two subscriptions 708a and 708b typically include different telephone numbers or identifiers. In one example, the UE 702 may be a mobile telephone device equipped with two or more SIMs 718a, 718b that enable the establishment of traffic calls on one or more voice and/or data services provided by the operator networks 720, 722. The UE 702 may be adapted or configured to maintain two or more concurrently active calls according to a configured or selected mode of operation.

[0090] FIG. 8 is a message flow 800 illustrating a first example of the use of a shared Barred Cell List in relation to an SCG procedure at a dual-subscription UE 802, which may be configured or adapted in accordance with certain aspects of this disclosure. In the first example, an addition of a cell to the Barred Cell List by a first subscription 812_1 may automatically cause a second subscription 812_2 to trigger a cell reselection process to camp on a different cell if currently camped on the cell added to the Barred Cell List. A UE 802 may refrain from initiating a cell reselection procedure for either subscription 812_1, 812_2 while the target cell for reselection is listed in the Barred Cell List.

[0091] In the illustrated example, 5G NR capable UE 802 is operating in NSA mode on two subscriptions 812_1, 812_2. For the purposes of this disclosure, an action taken by the UE 802 on behalf of one of the subscriptions 812_1, 812_2 may be referred to herein as an action taken by the corresponding subscription 812_1, 812_2. Actions taken by the UE 802 on behalf of one of the subscriptions 812_1, 812_2 include transmissions on behalf of the corresponding subscription 812_1, 812_2. Additionally, and for the purposes of this disclosure, an action affecting the UE 802 when operating on behalf of one of the subscriptions 812_1, 812_2 may be referred to herein as an action affecting the corresponding subscription 812_1, 812_2. Actions affecting the UE 802 when operating on behalf of one of the subscriptions 812_1, 812_2 include reception of messages directed to the corresponding subscription 812_1, 812_2.

[0092] The UE 802 may be operated in DSDS mode or DSDA mode and may be registered with the same home network operator. The UE 802 may be able to detect signals associated with one or more LTE RANs and one or more 5G NR RANS, including signals transmitted in LTE cells 804, 808 and in 5G NR cells 806, 810. LTE cells 804, 808 support NSA. The first subscription 812_1 is initially connected to, or camped on LTE cell 804, which serves as the anchor cell for first subscription 812_1. In the illustrated example, the second subscription 812_1 may participate in one or more procedures 814 that result in the second subscription 812_2 being in a connected state, or camped on LTE cell 804, which then serves as the anchor cell for second subscription 812_2. The procedures 814 may include TAU, attachment and/or other procedures.

[0093] LTE cell 804 may add 5G Cell 806 as a secondary node using an SCG procedure 816 in which the LTE cell 804 sends a request to 5G Cell 806 and receives an acknowledgement indicating that 5G Cell 806 agrees to be added to the SCG. The request may include information regarding the capabilities of the first subscription 812_1 and measurements of the 5G Cell 806 obtained by the first subscription 812_1. Upon adding 5G Cell 806 to the SCG, RRC connection reconfiguration 818 is performed. In one example, LTE cell 804 sends an RRC connection reconfiguration request to the first subscription 812_1, where the RRC connection reconfiguration request identifies 5G Cell 806. The RRC connection reconfiguration request may provide information regarding 5G Cell 806 and details of the requested reconfiguration. The first subscription 812_1 sends an RRC connection reconfiguration complete response message to LTE cell 804 if able to perform the reconfiguration.

[0094] The first subscription 812_1 may use information received in the RRC connection reconfiguration request to initiate a RACH procedure 820 in order to connect to 5G Cell 806, which is in the SCG. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by 5G Cell 806. In the illustrated example, the first subscription 812_1 measures an SNR that is unacceptable and/or below a threshold configured or defined for minimum SNR and/or unable to support PS data transfer. The first subscription 812_1 may send an SCG failure message 822 to LTE cell 804.

[0095] The first subscription 812_1 may take a loop decision 824. The loop decision may be taken in accordance with the example disclosed with respect to FIG. 6. For example, the first subscription 812_1 may respond to the failed SCG procedure by incrementing a loop counter used to track the number of iterations of the requested connection reconfiguration procedure that resulted in SCG failure. The first subscription 812_1 may check the loop counter and may continue in a camped or connected state in LTE cell 804 when the loop counter has not exceeded a threshold maximum value. The first subscription 812_1 may add LTE cell 804 to the Barred Cell List 826 when the loop counter exceeds the threshold maximum value. In some instances, the first subscription 812_1 may initiate a timer that determines the period of time LTE cell 804 remains on the Barred Cell List. For example, LTE cell 804 may be removed from the Barred Cell List after the timer expires. After initiating the timer, the first subscription 812_1 may perform a cell reselection procedure 828. In the illustrated example, the first subscription 812_1 uses the cell reselection procedure 828 to disconnect from LTE cell 804 and connect to LTE cell 808. The first subscription 812_1 may be in camped or connected state in LTE cell 808 after the cell reselection procedure 828 has been completed.

[0096] According to certain aspects of the disclosure, the Barred Cell List updated by the first subscription 812_1 may be synchronized with a Barred Cell List maintained by the second subscription 812_2. In one example, the first subscription 812_1 may send a request 830 to the second subscription 812_2, where the request is configured to cause the subscriptions 812_1, 812_2 to exchange updates including additions to the respective Barred Cell Lists, deletions from the respective Barred Cell Lists, status of timers associated with entries in the Barred Cell Lists, and/or restarts of timers associated with entries in the Barred Cell Lists. In another example, the Barred Cell Lists of the subscriptions 812_1, 812_2 may be synchronized automatically by the UE 802 without proactive action by one of the subscriptions 812_1, 812_2. In another example, the Barred Cell Lists of the subscriptions 812_1, 812_2 may be synchronized periodically based on a system timer or scheduler within the UE 802.

[0097] According to certain aspects of the disclosure, an update to the Barred Cell List by the first subscription 812_1 may cause the second subscription 812_2 to perform a cell reselection procedure 832 after synchronization of the Barred Cell Lists. For example, the second subscription 812_2 may be in a camped or connected state in LTE cell 804 when the first subscription 812_1 adds LTE cell 804 to its Barred Cell List. When the addition of LTE cell 804 is propagated to the Barred Cell List of the second subscription 812_2, the second subscription 812_2 may automatically perform the cell reselection procedure 832. In the illustrated example, the second subscription 812_2 uses the cell reselection procedure 832 to disconnect from LTE cell 804 and connect to, or camp on LTE cell 808.

[0098] The second subscription 812_2 may be in a PS data transfer state 834 after the cell reselection procedure 832 has been completed. In the PS data transfer state 834, the second subscription 812_2 is using LTE cell 808 to transmit and/or receive data through the LTE network. LTE cell 808 may add 5G Cell 810 as a secondary node using an SCG procedure 836 in which the LTE 808 sends a request to 5G Cell 810 and receives an acknowledgement indicating that 5G Cell 810 agrees to be added to the SCG. The request may include information regarding the capabilities of the second subscription 812_2 and measurements of the 5G Cell 810 obtained by the second subscription 812_2. Upon adding 5G Cell 810 to the SCG, an RRC connection reconfiguration 838 is performed. In one example, LTE cell 808 sends an RRC connection reconfiguration request to the second subscription 812_2, where the RRC connection reconfiguration request identifies 5G Cell 810. The RRC connection reconfiguration request may provide information regarding 5G Cell 810 and details of the requested reconfiguration. The second subscription 812_2 sends an RRC connection reconfiguration complete response message to LTE cell 808 if able to perform the reconfiguration.

[0099] The second subscription 812_2 may use the information in the RRC connection reconfiguration request to initiate a RACH procedure 840 to connect to 5G Cell 810. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by to 5G Cell 810. In the illustrated example, the second subscription 812_2 measures an SNR that is acceptable and the second subscription 812_2 enters a PS data transfer 842 while connected to 5G cell 810.

[0100] The use of automatic cell reselection procedure 832 by the second subscription 812_2 after updates to the Barred Cell List of the first subscription 812_1 permits the second subscription 812_2 to maintain 5G NR capabilities and avoid potential failures on LTE cell 804. In one example, the use of automatic cell reselection procedure 832 by the second subscription 812_2 after updates to the Barred Cell List of the first subscription 812_1 allows the second subscription 812_2 to preserve power and time resources by refraining from engaging in RRC connection reconfigurations that resulted in failure for the first subscription 812_1 and that would likely result in failure for the second subscription 812_2.

[0101] FIG. 9 is a message flow 900 illustrating a second example of the use of a shared Barred Cell List in relation to an SCG procedure at a dual-subscription UE 902, which may be configured or adapted in accordance with certain aspects of this disclosure. In the second example, an addition of a cell to the Barred Cell List by a first subscription 912_1 may cause a second subscription 912_2 that is currently camped on the cell added to the Barred Cell List to trigger a cell reselection process after an SCG failure without waiting for a preconfigured threshold number of attempts at RRC connection reconfiguration to be reached.

[0102] In the illustrated example, 5G NR capable UE 902 is operating in NSA mode for two subscriptions 912_1, 912_2. For the purposes of this disclosure, an action taken by the UE 902 on behalf of one of the subscriptions 912_1, 912_2 may be referred to herein as an action taken by the corresponding subscription 912_1, 912_2. Actions taken by the UE 902 on behalf of one of the subscriptions 912_1, 912_2 include transmissions on behalf of the corresponding subscription 912_1, 912_2. Additionally, and for the purposes of this disclosure, an action affecting the UE 902 when operating on behalf of one of the subscriptions 912_1, 912_2 may be referred to herein as an action affecting the corresponding subscription 912_1, 912_2. Actions affecting the UE 902 when operating on behalf of one of the subscriptions 912_1, 912_2 include reception of messages directed to the corresponding subscription 912_1, 912_2.

[0103] The UE 902 may be operated in DSDS mode or DSDA mode and may be registered with the same home network operator. The UE 902 may be able to detect signals associated with one or more LTE RANs and one or more 5G NR RANS, including signals transmitted in LTE cells 904, 908 and in 5G cells 906, 910. LTE cells 904, 908 support NSA. The first subscription 912_1 is initially connected to, or camped on LTE cell 904, which serves as the anchor cell for first subscription 912_1. In the illustrated example, the second subscription 912_1 may participate in one or more procedures 914 that result in the second subscription 912_2 being in a connected state, or camped on LTE cell 904, which then serves as the anchor cell for second subscription 912_2. The procedures 914 may include TAU, attachment and/or other procedures.

[0104] LTE cell 904 may add 5G cell 906 as a secondary node using an SCG procedure 916 in which the LTE cell 904 sends a request to 5G cell 906 and receives an acknowledgement indicating that 5G cell 906 agrees to be added to the SCG. The request may include information regarding the capabilities of the first subscription 912_1 and measurements of the 5G cell 906 obtained by the first subscription 912_1. Upon adding 5G cell 906 to the SCG, RRC connection reconfiguration 918 is performed. In one example, LTE cell 904 sends an RRC connection reconfiguration request to the first subscription 912_1, where the RRC connection reconfiguration request identifies 5G cell 906. The RRC connection reconfiguration request may provide information regarding 5G cell 906 and details of the requested reconfiguration. The first subscription 912_1 sends an RRC connection reconfiguration complete response message to LTE cell 904 if able to perform the reconfiguration.

[0105] The first subscription 912_1 may use information received in the RRC connection reconfiguration request to initiate a RACH procedure 920 to connect to 5G cell 906, which is in the SCG. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by 5G cell 906. In the illustrated example, the first subscription 912_1 measures an SNR that is unacceptable and/or below a threshold configured or defined for minimum SNR and/or unable to support PS data transfer. The first subscription 912_1 may send an SCG failure message 922 to LTE cell 904.

[0106] The first subscription 912_1 may take a loop decision in accordance with the example disclosed with respect to FIG. 6. For example, the first subscription 912_1 may respond to the failed SCG procedure by incrementing a loop counter used to track the number of iterations of the requested connection reconfiguration procedure that resulted in SCG failure. The first subscription 912_1 may check the loop counter and may continue in a camped or connected state in LTE cell 904 when the loop counter has not exceeded a threshold maximum value. The first subscription 912_1 may add LTE cell 904 to the Barred Cell List 924 when the loop counter exceeds the threshold maximum value. In some instances, the first subscription 912_1 may initiate a timer that determines the period of time LTE cell 904 remains on the Barred Cell List. For example, LTE cell 904 may be removed from the Barred Cell List after the timer expires. After initiating the timer, The first subscription 912_1 may perform a cell reselection procedure 926. In the illustrated example, the first subscription 912_1 uses the cell reselection procedure 926 to disconnect from LTE cell 904 and connect to LTE cell 908. The first subscription 912_1 may be in camped or connected state in LTE cell 908 after the cell reselection procedure 926 has been completed.

[0107] According to certain aspects of the disclosure, the Barred Cell List updated by the first subscription 912_1 may be synchronized with a Barred Cell List maintained by the second subscription 912_2. In one example, the first subscription 912_1 may send a request 928 to the second subscription 912_2 that is configured to cause the subscriptions 912_1, 912_2 to exchange updates including additions to the respective Barred Cell Lists, deletions from the respective Barred Cell Lists, status of timers associated with entries in the Barred Cell Lists, and/or restarts of timers associated with entries in the Barred Cell Lists. In another example, the Barred Cell Lists of the subscriptions 912_1, 912_2 may be synchronized automatically by the UE 902 without proactive action by one of the subscriptions 912_1, 912_2. In another example, the Barred Cell Lists of the subscriptions 912_1, 912_2 may be synchronized periodically based on a system timer or scheduler within the UE 902.

[0108] According to certain aspects of the disclosure, an update to the Barred Cell List by the first subscription 912_1 may cause a sync flag 930 to be set for the second subscription 912_2, indicating that an update to its Barred Cell List has occurred and/or that LTE cell 904 has been added to the Barred Cell List. In one example, the sync flag may be set when the second subscription 912_2 is camped on LTE cell 904.

[0109] At some point in time, the second subscription 912_2, may engage in an RRC connection reconfiguration 932. In one example, LTE cell 904 sends an RRC connection reconfiguration request to the second subscription 912_2, where the RRC connection reconfiguration request identifies 5G cell 906. The RRC connection reconfiguration request may provide information regarding 5G cell 906 and details of the requested reconfiguration. The second subscription 912_2 sends an RRC connection reconfiguration complete response message to LTE cell 904 if able to perform the reconfiguration.

[0110] The second subscription 912_2 may use information received in the RRC connection reconfiguration request to initiate a RACH procedure 934 to connect to 5G cell 906, which is in the SCG. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by to 5G cell 906. In the illustrated example, the second subscription 912_2 measures an SNR that is unacceptable and/or below a threshold configured or defined for minimum SNR and/or unable to support PS data transfer. The second subscription 912_2 may send an SCG failure message 936 to LTE cell 904.

[0111] The Barred Cell List sync flag may cause the second subscription 912_2 to modify its decision making after SCG failure. For example, the second subscription 912_2 may be configured to take a loop decision in accordance with the example disclosed with respect to FIG. 6 in the absence of an active Barred Cell List sync flag, where the second subscription 912_2 may continue in a camped or connected state in LTE cell 904 when the loop counter has not exceeded a threshold maximum value. When the Barred Cell List sync flag is active, the second subscription 912_2 may expedite reselection by disregarding the threshold maximum value and initiate a cell reselection procedure 938 after the SCG failure.

[0112] In the illustrated example, the second subscription 912_2 uses the cell reselection procedure 938 to disconnect from LTE cell 904 and connect to, or camp on LTE cell 908. The second subscription 912_2 may be in a PS data transfer state 940 after the cell reselection procedure 938 has been completed. In the PS data transfer state 940, the second subscription 912_2 is using LTE cell 908 to transmit and/or receive data through the LTE network. LTE cell 908 may add 5G cell 910 as a secondary node using an SCG procedure 942 in which the LTE cell 908 sends a request to 5G cell 910 and receives an acknowledgement indicating that 5G cell 910 agrees to be added to the SCG. The request may include information regarding the capabilities of the second subscription 912_2 and measurements of the 5G cell 910 obtained by the second subscription 912_2. Upon adding 5G cell 910 to the SCG, an RRC connection reconfiguration 944 is performed. In one example, LTE cell 908 sends an RRC connection reconfiguration request to the second subscription 912_2, where the RRC connection reconfiguration request identifies 5G cell 910. The RRC connection reconfiguration request may provide information regarding 5G cell 910 and details of the requested reconfiguration. The second subscription 912_2 sends an RRC connection reconfiguration complete response message to LTE cell 908 if able to perform the reconfiguration.

[0113] The second subscription 912_2 may use information in the RRC connection reconfiguration request to initiate a RACH procedure 946 to connect to 5G cell 910. In one example, the RRC connection reconfiguration request identifies reference signals transmitted by to 5G cell 910. In the illustrated example, the second subscription 912_2 measures an SNR that is acceptable and the second subscription 912_2 enters a PS data transfer 948 while connected to 5G cell 910.

[0114] The use of expedited cell reselection procedure 938 by the second subscription 912_2 after updates to the Barred Cell List of the first subscription 912_1 permits the second subscription 912_2 to maintain 5G NR capabilities and avoid potential failures on LTE cell 904. In one example, the use of expedited cell reselection procedure 938 by the second subscription 912_2 after updates to the Barred Cell List of the first subscription 912_1 allows the second subscription 912_2 to preserve power and time resources by refraining from engaging in more than one RRC connection reconfiguration procedure that results in failure for the second subscription 912_2 and where a repetition of the procedure would likely result in failure based on results of the same procedure performed by the first subscription 912_1. In some instances, the second subscription 912_2 can preserve power and time resources by waiting until an RRC connection reconfiguration is requested before taking action after updates to the Barred Cell List by the first subscription 912_1.

[0115] FIG. 10 is a block diagram illustrating an example of a hardware implementation for a scheduling entity 1000 employing a processing system 1014. For example, the scheduling entity 1000 may be a user equipment (UE) as illustrated in any one or more of FIGs. 1, 2, 4, 5 and/or 6. In another example, the scheduling entity 1000 may be a base station as illustrated in any one or more of FIGs. 1, 2 and/or 4-9.

[0116] The scheduling entity 1000 may be implemented with a processing system 1014 that includes one or more processors 1004. Examples of processors 1004 include microprocessors, microcontrollers, digital signal processors (DSPs), 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. In various examples, the scheduling entity 1000 may be configured to perform any one or more of the functions described herein. That is, the processor 1004, as utilized in a scheduling entity 1000, may be used to implement any one or more of the processes described below. The processor 1004 may in some instances be implemented via a baseband or modem chip and in other implementations, the processor 1004 may itself comprise a number of devices distinct and different from a baseband or modem chip (e.g., in such scenarios various devices may work in concert to achieve embodiments discussed herein). And as mentioned above, various hardware arrangements and components outside of a baseband modem processor can be used in implementations, including RF-chains, power amplifiers, modulators, buffers, interleavers, adders/summers, etc.

[0117] In this example, the processing system 1014 may be implemented with a bus architecture, represented generally by the bus 1002. The bus 1002 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 1014 and the overall design constraints. The bus 1002 communicatively couples together various circuits including one or more processors (represented generally by the processor 1004), a memory 1005, and computer-readable media (represented generally by the computer-readable medium 1006). The bus 1002 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. A bus interface 1008 provides an interface between the bus 1002 and a transceiver 1010. The transceiver 1010 provides a communication interface or means for communicating with various other apparatus over a transmission medium. Depending upon the nature of the apparatus, a user interface 1012 (e.g., keypad, display, speaker, microphone, joystick) may also be provided. Of course, such a user interface 1012 is optional, and may be omitted in some examples, such as a base station.

[0118] The processor 1004 is responsible for managing the bus 1002 and general processing, including the execution of software stored on the computer-readable medium 1006. The software, when executed by the processor 1004, causes the processing system 1014 to perform the various functions described below for any particular apparatus. The computer-readable medium 1006 and the memory 1005 may also be used for storing data that is manipulated by the processor 1004 when executing software.

[0119] One or more processors 1004 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 modules, 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. The software may reside on a computer-readable medium 1006.

[0120] The computer-readable medium 1006 may be a non-transitory computer-readable medium. A non-transitory computer-readable medium includes, by way of example, a magnetic storage device (e.g., hard disk, floppy disk, magnetic strip), an optical disk (e.g., a compact disc (CD) or a digital versatile disc (DVD)), a smart card, a flash memory device (e.g., a card, a stick, or a key drive), a random access memory (RAM), a read only memory (ROM), a programmable ROM (PROM), an erasable PROM (EPROM), an electrically erasable PROM (EEPROM), a register, a removable disk, and any other suitable medium for storing software and/or instructions that may be accessed and read by a computer. The computer-readable medium may also include, by way of example, a carrier wave, a transmission line, and any other suitable medium for transmitting software and/or instructions that may be accessed and read by a computer. The computer-readable medium 1006 may reside in the processing system 1014, external to the processing system 1014, or distributed across multiple entities including the processing system 1014. The computer-readable medium 1006 may be embodied in a computer program product. By way of example, a computer program product may include a computer-readable medium in packaging materials. Those skilled in the art will recognize how best to implement the described functionality presented throughout this disclosure depending on the particular application and the overall design constraints imposed on the overall system.

[0121] In some aspects of the disclosure, the processor 1004 may include circuitry configured for various functions. For example, the processor 1004 may include resource assignment and scheduling circuitry 1042, configured to generate, schedule, and modify a resource assignment or grant of time–frequency resources (e.g., a set of one or more resource elements). For example, the resource assignment and scheduling circuitry 1042 may schedule time–frequency resources within a plurality of time division duplex (TDD) and/or frequency division duplex (FDD) subframes, slots, and/or mini-slots to carry user data traffic and/or control information to and/or from multiple UEs.

[0122] In some examples, the resource assignment and scheduling circuitry 1042 may be configured to allocate/schedule downlink resources for the transmission of one or more messages. The resource assignment and scheduling circuitry 1042 may further be configured to allocate/schedule uplink resources for a UE to communicate information to the scheduling entity 1000. The uplink resources may be a dynamically scheduled via an uplink grant, semi-statically scheduled, or semi-persistently scheduled. The resource assignment and scheduling circuitry 1042 may further be configured to execute resource assignment and scheduling software 1052 stored in the computer-readable medium 1006 to implement one or more of the functions described herein.

[0123] The processor 1004 may further include communication and processing circuitry 1044 configured to communicate with a UE. In some examples, the communication and processing circuitry 1044 may include one or more hardware components that provide the physical structure that performs processes related to wireless communication (e.g., signal reception and/or signal transmission) and signal processing (e.g., processing a received signal and/or processing a signal for transmission). In some examples, the communication and processing circuitry 1044 may be configured to generate and transmit one or more messages via the transceiver 1010, including RRC messages for example. In addition, the communication and processing circuitry 1044 may be configured to receive and process messages via the transceiver 1010. The communication and processing circuitry 1044 may further be configured to execute communication and processing software 1054 stored on the computer-readable medium 1006 to implement one or more functions described herein.

[0124] The processor 1004 may further include one or more SCG, reselection and other functions including functions related to device mobility. For example, the processor 1004 may further include SCG management circuitry 1046 configured to manage requests sent between base stations. The requests may relate to establishing network connections, which may be used to establish PDU sessions. The SCG management circuitry 1046 may further be configured to execute SCG management software 1056 stored on the computer-readable medium 1006 to implement one or more functions described herein.

[0125] In one example, the scheduling entity 1000 has a processor, a transceiver communicatively coupled to the processor, and a memory communicatively coupled to the processor. In some instances, the scheduling entity 1000 may transmit a first connection reconfiguration request to the UE while the UE is configured for 5G NSA operation and while the UE is connected in a first LTE cell. In some instances, the scheduling entity 1000 may participate in a first random access procedure in a first 5G NR cell, and/or participate in a first cell reselection procedure.

[0126] FIG. 11 is a conceptual diagram illustrating an example of a hardware implementation for an exemplary scheduled entity 1100 employing a processing system 1114. In accordance with various aspects of the disclosure, an element, or any portion of an element, or any combination of elements may be implemented with a processing system 1114 that includes one or more processors 1104. For example, the scheduled entity 1100 may be a user equipment (UE) as illustrated in any one or more of FIGs. 1, 2 and/or 4-9.

[0127] The processing system 1114 may be substantially the same as the processing system 1114 illustrated in FIG. 11, including a bus interface 1108, a bus 1102, memory 1105, a processor 1104, and a computer-readable medium 1106. Furthermore, the scheduled entity 1100 may include a user interface 1112 and a transceiver 1110 substantially similar to those described above in FIG. 11. That is, the processor 1104, as utilized in a scheduled entity 1100, may be used to implement any one or more of the processes described herein.

[0128] In some aspects of the disclosure, the processing system 1114 may be coupled to one or more UICCs 1116. Each UICC 1116 may include a universal subscriber identity module (USIM) application. The USIM application may maintain and/or provide subscription-related information and/or subscriber-related information. In one example, the USIM application may maintain cryptographic keys shared with a home network of the subscriber.

[0129] In some aspects of the disclosure, the processor 1104 may include communication and processing circuitry 1142, configured to communicate with one or more base stations. In some examples, the communication and processing circuitry 1142 may include one or more hardware components that provide the physical structure that performs processes related to wireless communication (e.g., signal reception and/or signal transmission) and signal processing (e.g., processing a received signal and/or processing a signal for transmission). In some examples, the communication and processing circuitry 1142 may be configured to receive and process one or more scheduling transmissions from the one or more base stations via the transceiver 1110. In one example, the communication and processing circuitry 1142 may be configured to identify uplink resources that may be utilized to transmit an RRC messages to a base station. The communication and processing circuitry 1142 may further be configured to transmit RRC messages utilizing the uplink resources. The communication and processing circuitry 1142 may further be configured to execute communication and processing software 1152 stored on the computer-readable medium 1106 to implement one or more functions described herein.

[0130] The processor 1104 may further include connection establishment circuitry 1144, configured to establish network connections with networks on behalf of one or more network subscription associated with the UE. The connection establishment circuitry 1144 may be further configured to execute connection establishment software 1154 stored on the computer-readable medium 1106 to implement one or more functions described herein.

[0131] The processor 1104 may further include RACH handling circuitry 1146, configured to establish connections for one or more network subscription associated with the UE using random access procedures. The RACH handling circuitry 1146 may be further configured to execute RACH handling software 1156 stored on the computer-readable medium 1106 to implement one or more functions described herein.

[0132] The processor 1104 may further include Barred Cell List management circuitry 1148, configured to add cells (e.g., through cell identifiers) to one or more Barred Cells Lists, and/or to propagate changes between Barred Cell Lists 1115. The Barred Cell List management circuitry 1148 may be further configured to execute Barred Cell List management software 1158 stored on the computer-readable medium 1106 to implement one or more functions described herein.

[0133] In one example, the scheduled entity 1100 has a processor, a transceiver communicatively coupled to the processor, and a memory communicatively coupled to the processor. The processor may be configured to may receive a first connection reconfiguration request at the UE while the UE is configured for 5G NSA operation and while the UE is connected in a first LTE cell, initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request, initiate a first cell reselection procedure to camp in a second LTE cell when the random access procedure failures, and after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE, add the first LTE cell to a first barred cell list, and refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list

[0134] In some examples, the processor may be configured to receive a second connection reconfiguration request at the UE while the UE is connected in the second LTE cell, initiate a second random access procedure in a second 5G NR cell indicated by the connection reconfiguration request, and transmit data through the second 5G NR cell after completing the second random access procedure.

[0135] In some implementations, the processor may be configured to initiate a timer after listing the first LTE cell in the first barred cell list, and remove the first LTE cell from the first barred cell list when the timer expires.

[0136] In one example, the first connection reconfiguration request is received in an RRC message.

[0137] In certain implementations, the processor may be configured to increment a counter when the first random access procedure fails, and initiate the first cell reselection procedure when the counter equals or exceeds a preconfigured threshold value.

[0138] In certain implementations, the UE is a multi-subscription UE. The first connection reconfiguration request may be directed to a first subscription, and the cell reselection procedure may be initiated on behalf of the first subscription. The first barred cell list may be associated with the first subscription. The processor may be configured to synchronize the first barred cell list with a second barred cell list associated with a second subscription after the first LTE cell is added to the first barred cell list. The first LTE cell may be added to the second barred cell list by synchronizing the first barred cell list with a second barred cell list. The processor may be configured to initiate a cell reselection procedure on behalf of the second subscription after the first LTE cell is added to the second barred cell list. The cell reselection procedure may be initiated on behalf of the second subscription in response to addition of the first LTE cell to the second barred cell list by synchronizing the first barred cell list with a second barred cell list. The processor may be configured to receive a first connection reconfiguration request on behalf of the second subscription while the second subscription is camped on the first LTE cell, initiate a first random access procedure in the first 5G NR cell on behalf of the second subscription, and initiate the cell reselection procedure on behalf of the second subscription in response to failure of the first random access procedure. The processor may be configured to receive a first connection reconfiguration request directed to the second subscription after completion of the cell reselection procedure on behalf of the second subscription, initiate a second random access procedure in the second 5G NR cell on behalf of the second subscription, and transmit data through the second 5G NR cell on behalf of the second subscription.

[0139] In certain implementations, a first UICC 1116 coupled to the processing system 1114 maintains information that identifies the first network subscription, and a second UICC 1116 coupled to the processing system 1114 maintains information that identifies the second network subscription. A first SIM in the UE may maintain information that identifies the first network subscription. A second SIM in the UE may maintain information that identifies the second network subscription.

[0140] FIG. 12 is a flow chart illustrating an example of a process 1200 for managing connection reconfigurations in a 5G NSA UE in accordance with some aspects of the present disclosure. As described below, some or all illustrated features may be omitted in a particular implementation within the scope of the present disclosure, and some illustrated features may not be required for implementation of all embodiments. In some examples, the process 1200 may be carried out by the scheduled entity 1100 illustrated in FIG. 11. In some examples, the process 1200 may be carried out by any suitable apparatus or means for carrying out the functions or algorithm described below.

[0141] At block 1202, the scheduled entity 1100 may receive a first connection reconfiguration request at the UE while the UE is configured for 5G NSA operation and while the UE is connected in a first LTE cell. At block 1204, the scheduled entity 1100 may initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request. At block 1206, the scheduled entity 1100 may initiate a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE. At block 1208, the scheduled entity 1100 may add the first LTE cell to a first barred cell list. At block 1210, the scheduled entity 1100 may refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list. The first LTE cell may provide an anchor before the first cell reselection procedure is completed. The second LTE cell may provide the anchor after the first cell reselection procedure is completed.

[0142] In some examples, the scheduled entity 1100 may receive a second connection reconfiguration request at the UE while the UE is connected in the second LTE cell, initiate a second random access procedure in a second 5G NR cell indicated by the connection reconfiguration request, and transmit data through the second 5G NR cell after completing the second random access procedure.

[0143] In some implementations, the scheduled entity 1100 may initiate a timer after listing the first LTE cell in the first barred cell list, and remove the first LTE cell from the first barred cell list when the timer expires.

[0144] In one example, the first connection reconfiguration request is received in an RRC message.

[0145] In certain implementations, the scheduled entity 1100 may increment a counter when the first random access procedure fails, and initiate the first cell reselection procedure when the counter equals or exceeds a preconfigured threshold value.

[0146] In certain implementations, the UE is a multi-subscription UE. The first connection reconfiguration request may be directed to a first subscription, and the cell reselection procedure may be initiated on behalf of the first subscription. The first barred cell list may be associated with the first subscription. The scheduled entity 1100 may synchronize the first barred cell list with a second barred cell list associated with a second subscription after the first LTE cell is added to the first barred cell list. The first LTE cell may be added to the second barred cell list by synchronizing the first barred cell list with a second barred cell list. The scheduled entity 1100 may initiate a cell reselection procedure on behalf of the second subscription after the first LTE cell is added to the second barred cell list. The cell reselection procedure may be initiated on behalf of the second subscription in response to addition of the first LTE cell to the second barred cell list by synchronizing the first barred cell list with a second barred cell list. The scheduled entity 1100 may receive a first connection reconfiguration request on behalf of the second subscription while the second subscription is camped on the first LTE cell, initiate a first random access procedure in the first 5G NR cell on behalf of the second subscription, and initiate the cell reselection procedure on behalf of the second subscription in response to failure of the first random access procedure. The scheduled entity 1100 may receive a first connection reconfiguration request directed to the second subscription after completion of the cell reselection procedure on behalf of the second subscription, initiate a second random access procedure in the second 5G NR cell on behalf of the second subscription, and transmit data through the second 5G NR cell on behalf of the second subscription.

[0147] In certain implementations, a first UICC installed in the UE maintains information that identifies the first network subscription, and a second UICC installed in the UE maintains information that identifies the second network subscription. A first SIM in the UE may maintain information that identifies the first network subscription. A second SIM in the UE may maintain information that identifies the second network subscription.

[0148] Several aspects of a wireless communication network have been presented with reference to an exemplary implementation. As those skilled in the art will readily appreciate, various aspects described throughout this disclosure may be extended to other telecommunication systems, network architectures and communication standards.

[0149] By way of example, various aspects may be implemented within other systems defined by 3GPP, such as Long-Term Evolution (LTE), the Evolved Packet System (EPS), the Universal Mobile Telecommunication System (UMTS), and/or the Global System for Mobile (GSM). Various aspects may also be extended to systems defined by the 3rd Generation Partnership Project 2 (3GPP2), such as CDMA2000 and/or Evolution-Data Optimized (EV-DO). Other examples may be implemented within systems employing IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Ultra-Wideband (UWB), Bluetooth, and/or other suitable systems. The actual telecommunication standard, network architecture, and/or communication standard employed will depend on the specific application and the overall design constraints imposed on the system.

[0150] Within the present disclosure, the word “exemplary” is used to mean “serving as an example, instance, or illustration.” Any implementation or aspect described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other aspects of the disclosure. Likewise, the term “aspects” does not require that all aspects of the disclosure include the discussed feature, advantage or mode of operation. The term “coupled” is used herein to refer to the direct or indirect coupling between two objects. For example, if object A physically touches object B, and object B touches object C, then objects A and C may still be considered coupled to one another—even if they do not directly physically touch each other. For instance, a first object may be coupled to a second object even though the first object is never directly physically in contact with the second object. The terms "circuit" and "circuitry" are used broadly, and intended to include both hardware implementations of electrical devices and conductors that, when connected and configured, enable the performance of the functions described in the present disclosure, without limitation as to the type of electronic circuits, as well as software implementations of information and instructions that, when executed by a processor, enable the performance of the functions described in the present disclosure.

[0151] One or more of the components, steps, features and/or functions illustrated in FIGs. 1-14 may be rearranged and/or combined into a single component, step, feature or function or embodied in several components, steps, or functions. Additional elements, components, steps, and/or functions may also be added without departing from novel features disclosed herein. The apparatus, devices, and/or components illustrated in FIGs. 1, 2, 4, 10, and/or 11 may be configured to perform one or more of the methods, features, or steps escribed herein. The novel algorithms described herein may also be efficiently implemented in software and/or embedded in hardware.

[0152] It is to be understood that the specific order or hierarchy of steps in the methods disclosed is an illustration of exemplary processes. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the methods may be rearranged. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented unless specifically recited therein.

[0153] 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 are to be accorded the full scope consistent with the language of the 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." Unless specifically stated otherwise, the term "some" refers to one or more. A phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of: a, b, or c" is intended to cover: a; b; c; a and b; a and c; b and c; and a, b and 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. No claim element is to be construed under the provisions of 35 U.S.C. §112(f) unless the element is expressly recited using the phrase "means for" or, in the case of a method claim, the element is recited using the phrase "step for."

CLAIMS

1. A method of wireless communication at a user equipment (UE), comprising:

receiving a first connection reconfiguration request at the UE while the UE is configured for fifth generation (5G) new radio (NR) non-standalone (NSA) operation and while the UE is connected in a first long-term evolution (LTE) cell;

initiating a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request;

initiating a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE;

adding the first LTE cell to a first barred cell list; and

refraining from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

2. The method of claim 1, further comprising:

receiving a second connection reconfiguration request at the UE while the UE is connected in the second LTE cell;

initiating a second random access procedure in a second 5G NR cell indicated by the second connection reconfiguration request; and

transmitting data through a second 5G NR cell after completing the second random access procedure.

3. The method of claim 1, further comprising:

initiating a timer after adding the first LTE cell in the first barred cell list; and

removing the first LTE cell from the first barred cell list when the timer expires.

4. The method of claim 1, wherein the first connection reconfiguration request is received in a radio resource control (RRC) message.

5. The method of claim 1, wherein the first LTE cell provides an anchor before the first cell reselection procedure is completed, and wherein the second LTE cell provides the anchor after the first cell reselection procedure is completed.

6. The method of claim 1, further comprising:

incrementing a counter when the first random access procedure fails; and

initiating the first cell reselection procedure when the counter equals or exceeds a preconfigured threshold value.

7. The method of claim 1, wherein the UE is a multi-subscription UE, wherein the first connection reconfiguration request is directed to a first subscription, wherein the first cell reselection procedure is initiated on behalf of the first subscription, and wherein the first barred cell list is associated with the first subscription.

8. The method of claim 7, further comprising:

synchronizing the first barred cell list with a second barred cell list associated with a second subscription after the first LTE cell is added to the first barred cell list, wherein the first LTE cell is added to the second barred cell list by synchronizing the first barred cell list with a second barred cell list.

9. The method of claim 8, further comprising:

initiating a cell reselection procedure on behalf of the second subscription after the first LTE cell is added to the second barred cell list.

10. The method of claim 9, wherein the cell reselection procedure is initiated on behalf of the second subscription in response to addition of the first LTE cell to the second barred cell list by synchronizing the first barred cell list with a second barred cell list.

11. The method of claim 9, further comprising:

receiving a first connection reconfiguration request on behalf of the second subscription while the second subscription is camped on the first LTE cell;

initiating a first random access procedure in the first 5G NR cell on behalf of the second subscription; and

initiating the cell reselection procedure on behalf of the second subscription in response to failure of the first random access procedure.

12. The method of claim 9, further comprising:

receiving a first connection reconfiguration request directed to the second subscription after completion of the cell reselection procedure on behalf of the second subscription;

initiating a second random access procedure in a second 5G NR cell on behalf of the second subscription; and

transmitting data through the second 5G NR cell on behalf of the second subscription.

13. A user equipment (UE) configured for wireless communication, comprising:

a processor;

a transceiver communicatively coupled to the processor; and

a memory communicatively coupled to the processor, wherein the processor is configured to:

receive a first connection reconfiguration request at the UE while the UE is configured for fifth generation (5G) new radio (NR) non-standalone (NSA) operation and while the UE is connected in a first long-term evolution (LTE) cell;

initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request;

initiate a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE;

add the first LTE cell to a first barred cell list; and

refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

14. The UE of claim 13, wherein the processor is further configured to:

receive a second connection reconfiguration request at the UE while the UE is connected in the second LTE cell;

initiate a second random access procedure in a second 5G NR cell indicated by the second connection reconfiguration request; and

transmit data through the second 5G NR cell after completing the second random access procedure.

15. The UE of claim 13, wherein the processor is further configured to:
initiate a timer after adding the first LTE cell in the first barred cell list; and
remove the first LTE cell from the first barred cell list when the timer expires.

16. The UE of claim 13, wherein the first connection reconfiguration request is received in a radio resource control (RRC) message.

17. The UE of claim 13, wherein the first LTE cell provides an anchor before the first cell reselection procedure is completed, and wherein the second LTE cell provides the anchor after the first cell reselection procedure is completed.

18. The UE of claim 13, wherein the processor is further configured to:
increment a counter when the first random access procedure fails; and
initiate the first cell reselection procedure when the counter equals or exceeds a preconfigured threshold value.

19. The UE of claim 13, wherein the UE is a multi-subscription UE, wherein the first connection reconfiguration request is directed to a first subscription, wherein the first cell reselection procedure is initiated on behalf of the first subscription, and wherein the first barred cell list is associated with the first subscription.

20. The UE of claim 19, wherein the processor is further configured to:
synchronize the first barred cell list with a second barred cell list associated with a second subscription after the first LTE cell is added to the first barred cell list, wherein the first LTE cell is added to the second barred cell list by synchronizing the first barred cell list with a second barred cell list.

21. The UE of claim 20, wherein the processor is further configured to:
initiate a cell reselection procedure on behalf of the second subscription after the first LTE cell is added to the second barred cell list.

22. The UE of claim 21, wherein the cell reselection procedure is initiated on behalf of the second subscription in response to addition of the first LTE cell to the second barred cell list by synchronizing the first barred cell list with a second barred cell list.

23. The UE of claim 21, wherein the processor is further configured to:

receive a first connection reconfiguration request on behalf of the second subscription while the second subscription is camped on the first LTE cell;

initiate a first random access procedure in the first 5G NR cell on behalf of the second subscription; and

initiate the cell reselection procedure on behalf of the second subscription in response to failure of the first random access procedure.

24. The UE of claim 21, wherein the processor is further configured to:

receive a first connection reconfiguration request directed to the second subscription after completion of the cell reselection procedure on behalf of the second subscription;

initiate a second random access procedure in a second 5G NR cell on behalf of the second subscription; and

transmit data through the second 5G NR cell on behalf of the second subscription.

25. A computer-readable medium storing computer executable code, the code when executed by a processor cause the processor to:

receive a first connection reconfiguration request at a UE while the UE is configured for fifth generation (5G) new radio (NR) non-standalone (NSA) operation and while the UE is connected in a first long-term evolution (LTE) cell;

initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request;

initiate a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE;

add the first LTE cell to a first barred cell list; and

refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list.

26. The computer-readable medium of claim 25, wherein the code further causes the processor to:

receive a second connection reconfiguration request at the UE while the UE is connected in the second LTE cell;

initiate a second random access procedure in a second 5G NR cell indicated by the second connection reconfiguration request; and

transmit data through the second 5G NR cell after completing the second random access procedure.

27. The computer-readable medium of claim 25, wherein the code further causes the processor to:

initiate a timer after adding the first LTE cell in the first barred cell list; and

remove the first LTE cell from the first barred cell list when the timer expires.

28. The computer-readable medium of claim 25, wherein the first connection reconfiguration request is received in a radio resource control (RRC) message.

29. The computer-readable medium of claim 25, wherein the first LTE cell provides an anchor before the first cell reselection procedure is completed, and wherein the second LTE cell provides the anchor after the first cell reselection procedure is completed.

30. The computer-readable medium of claim 25, wherein the code further causes the processor to:

increment a counter when the first random access procedure fails; and

initiate the first cell reselection procedure when the counter equals or exceeds a preconfigured threshold value.

31. The computer-readable medium of claim 25, wherein the UE is a multi-subscription UE, wherein the first connection reconfiguration request is directed to a first subscription, wherein the first cell reselection procedure is initiated on behalf of the first subscription, and wherein the first barred cell list is associated with the first subscription.

32. The computer-readable medium of claim 31, wherein the code further causes the processor to:

synchronize the first barred cell list with a second barred cell list associated with a second subscription after the first LTE cell is added to the first barred cell list, wherein the first LTE cell is added to the second barred cell list by synchronizing the first barred cell list with a second barred cell list.

33. The computer-readable medium of claim 32, wherein the code further causes the processor to:

initiate a cell reselection procedure on behalf of the second subscription after the first LTE cell is added to the second barred cell list.

34. The computer-readable medium of claim 33, wherein the cell reselection procedure is initiated on behalf of the second subscription in response to addition of the first LTE cell to the second barred cell list by synchronizing the first barred cell list with a second barred cell list.

35. The computer-readable medium of claim 33, wherein the code further causes the processor to:

receive a first connection reconfiguration request on behalf of the second subscription while the second subscription is camped on the first LTE cell;

initiate a first random access procedure in the first 5G NR cell on behalf of the second subscription; and

initiate the cell reselection procedure on behalf of the second subscription in response to failure of the first random access procedure.

36. The computer-readable medium of claim 33, wherein the code further causes the processor to:

receive a first connection reconfiguration request directed to the second subscription after completion of the cell reselection procedure on behalf of the second subscription;

initiate a second random access procedure in a second 5G NR cell on behalf of the second subscription; and transmit data through the second 5G NR cell on behalf of the second subscription.

37. A user equipment (UE) in a wireless communication network, comprising:

means for receiving signaling from a first long-term evolution (LTE) cell, including a connection reconfiguration request at the UE while the UE is configured for fifth generation (5G) new radio (NR) non-standalone (NSA) operation;

means for initiating random access procedures, including a first random access procedure in a first 5G NR cell indicated by the connection reconfiguration request; and

means for initiating cell reselection procedures, including a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE,

wherein the UE is configured to add the first LTE cell to a barred cell list, and

wherein the UE refrains from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the barred cell list.

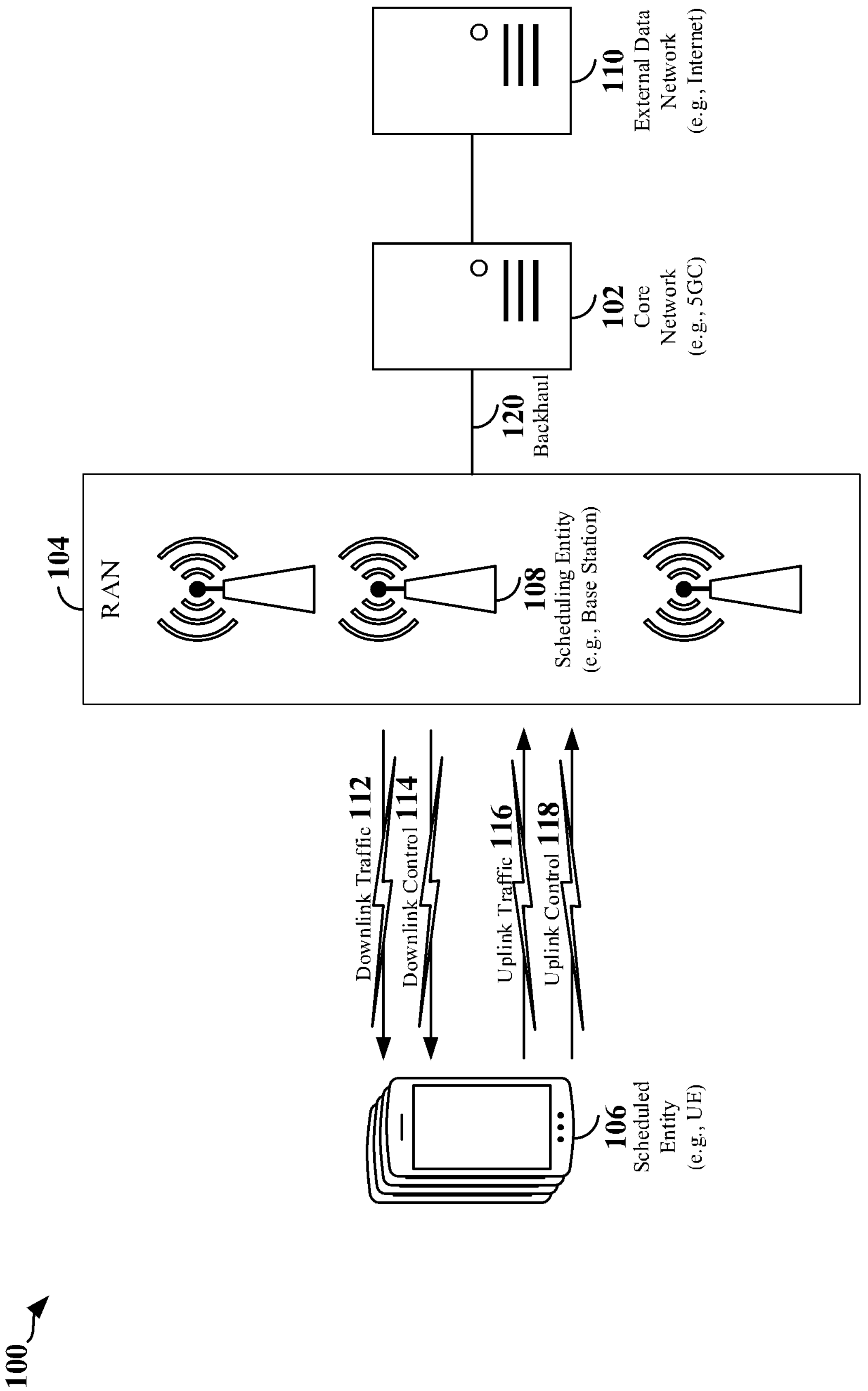
110
External Data
Network
(e.g., Internet)
102
Core
Network
(e.g., 5GC)
120
Backhaul
104
RAN
108
Scheduling Entity
(e.g., Base Station)
Downlink Traffic 112
Downlink Control 114
Uplink Traffic 116
Uplink Control 118
106
Scheduled
Entity
(e.g., UE)
100

FIG. 1

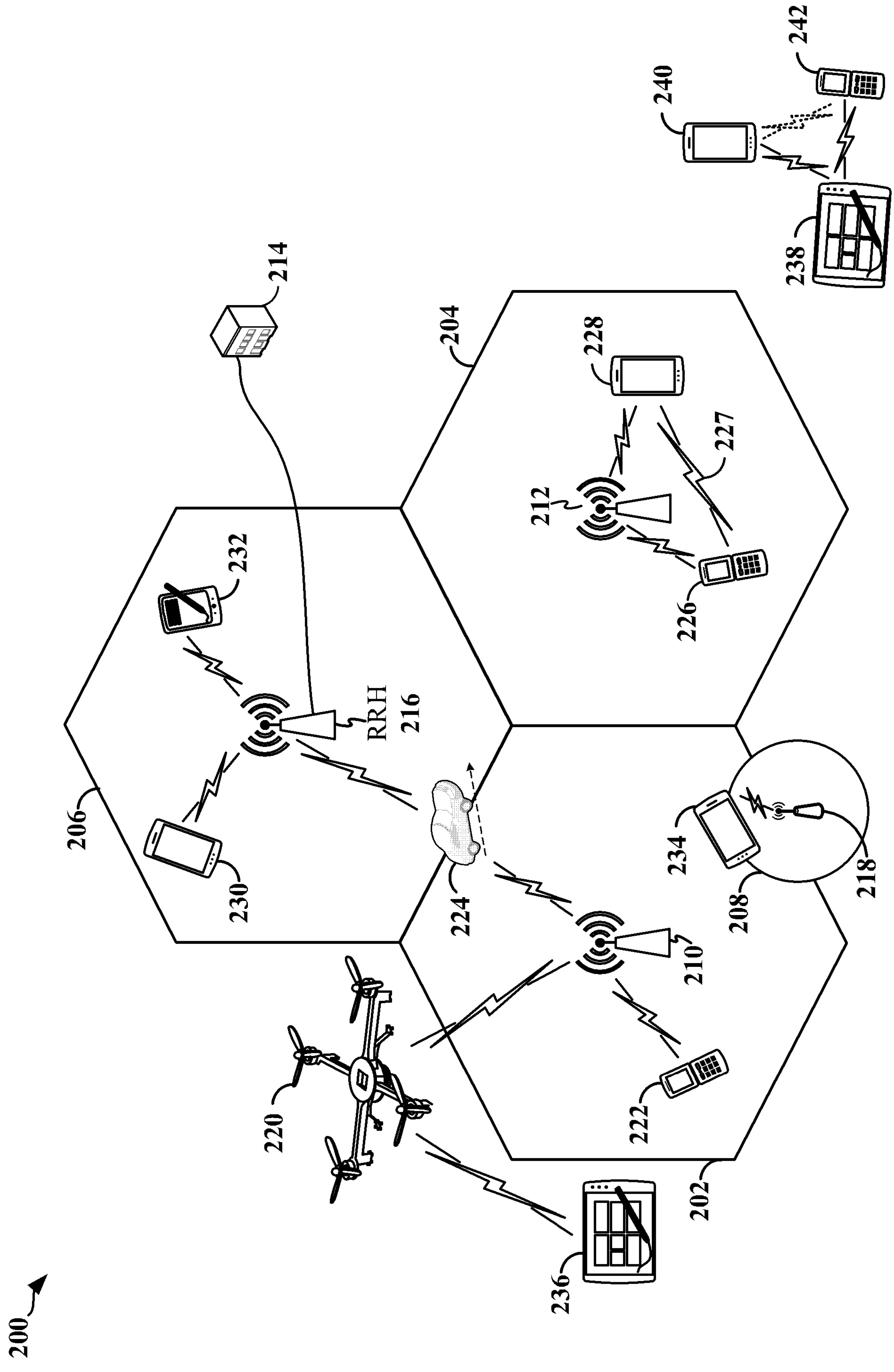
200
202
204
206
208
210
212
214
RRH
216
218
220
222
224
226
227
228
230
232
234
236
238
240
242

FIG. 2

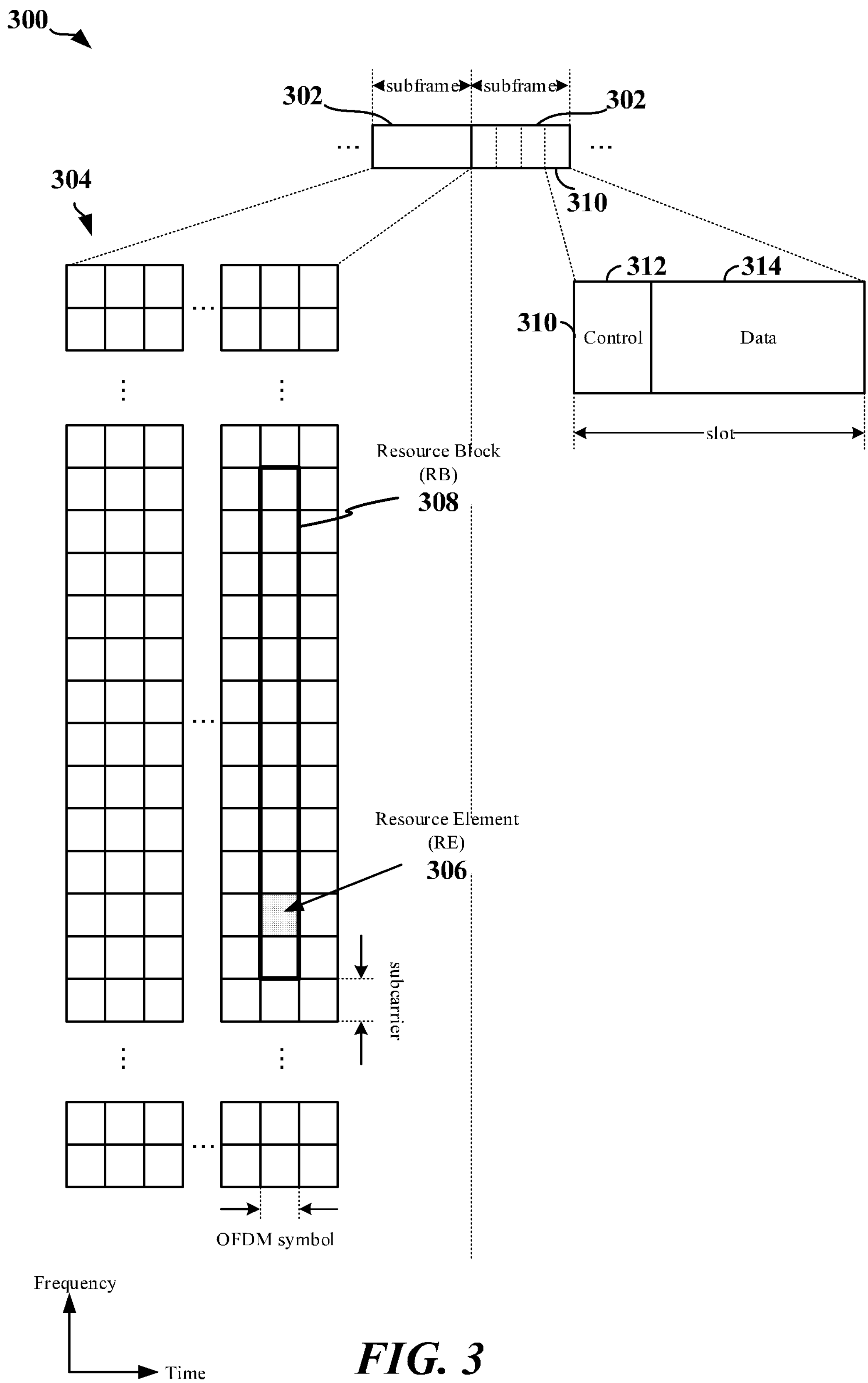
300
302
subframe
subframe
302
304
310
312
314
310
Control
Data
slot
Resource Block
(RB)
308
Resource Element
(RE)
306
subcarrier
OFDM symbol
Frequency
Time

FIG. 3

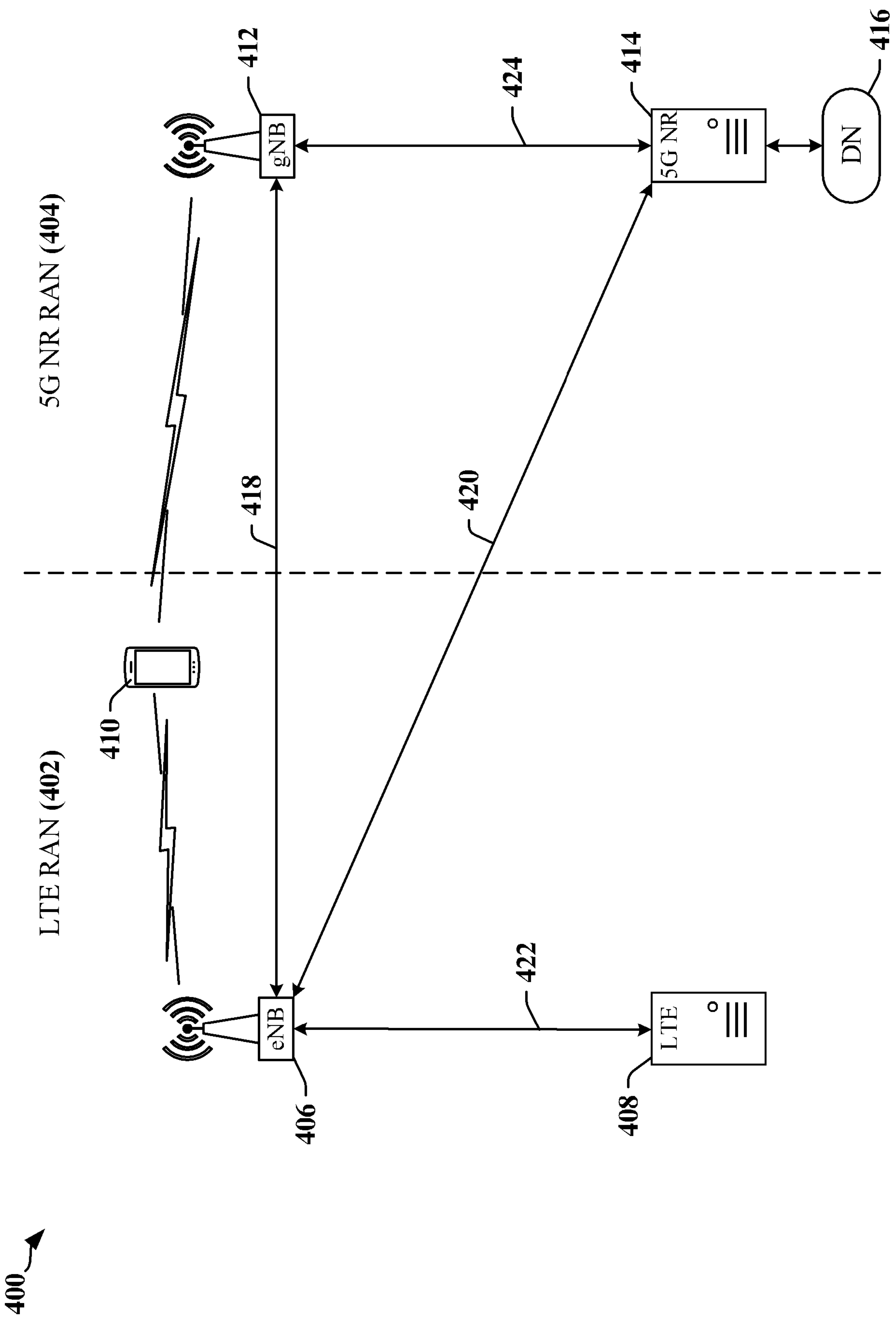
400
LTE RAN (402)
5G NR RAN (404)
410
406
eNB
LTE
408
422
418
420
412
gNB
424
414
5G NR
416
DN

FIG. 4

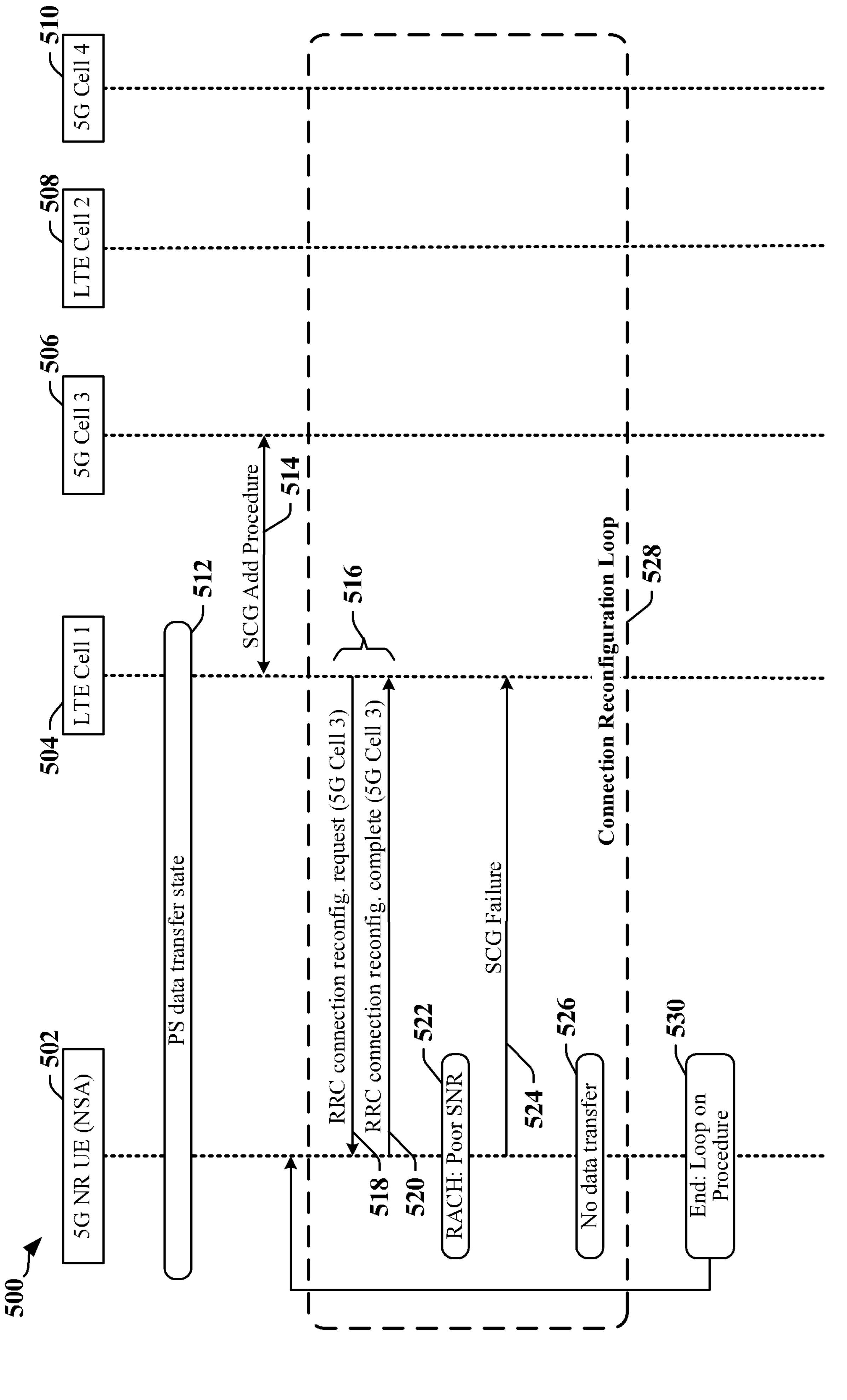
500
502
5G NR UE (NSA)
504
LTE Cell 1
506
5G Cell 3
508
LTE Cell 2
510
5G Cell 4
512
PS data transfer state
514
SCG Add Procedure
516
RRC connection reconfig. request (5G Cell 3)
518
RRC connection reconfig. complete (5G Cell 3)
520
522
RACH: Poor SNR
524
SCG Failure
526
No data transfer
528
Connection Reconfiguration Loop
530
End: Loop on Procedure

FIG. 5

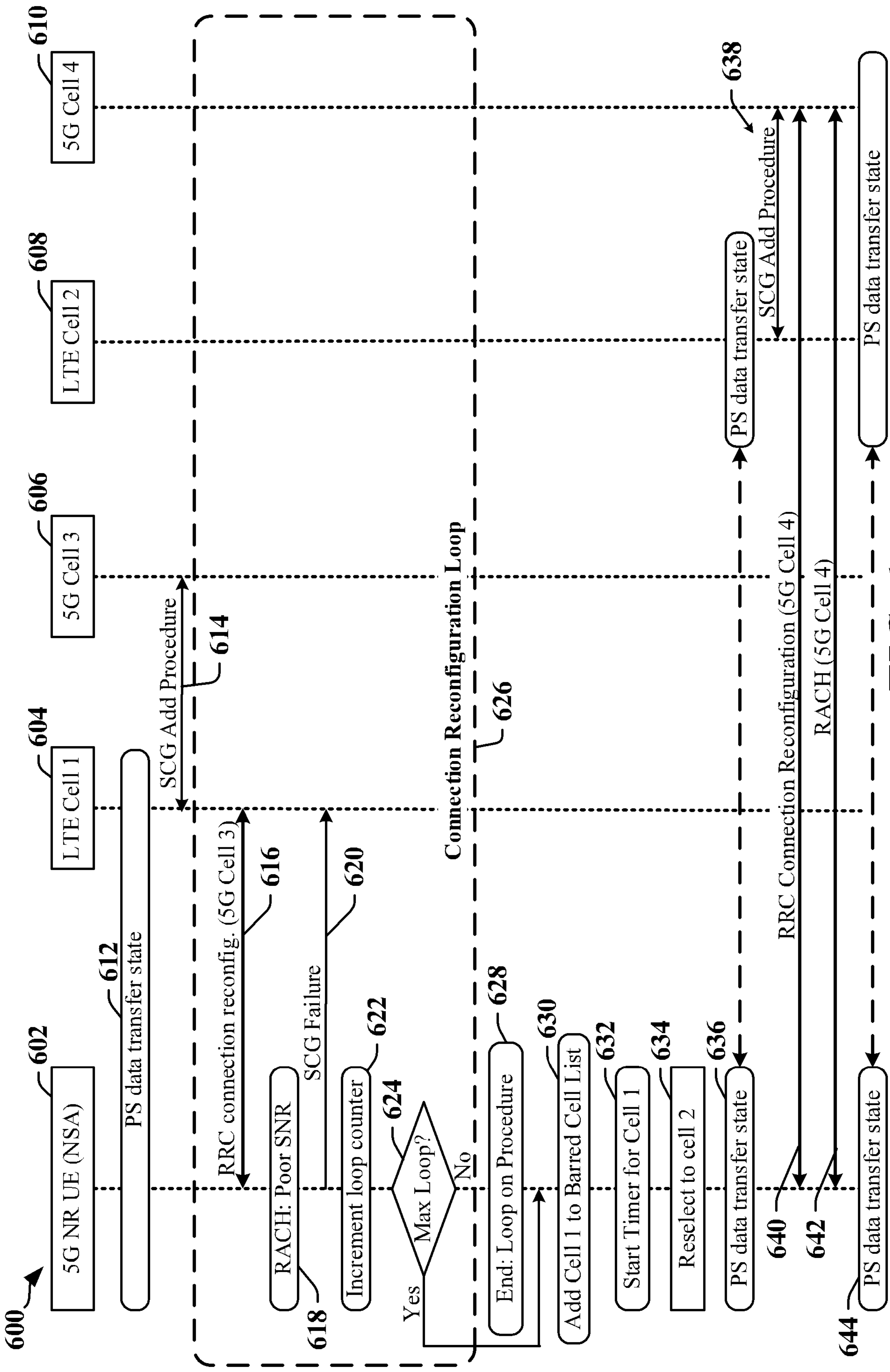
600
602
5G NR UE (NSA)
604
LTE Cell 1
606
5G Cell 3
608
LTE Cell 2
610
5G Cell 4
612
PS data transfer state
614
SCG Add Procedure
616
RRC connection reconfig. (5G Cell 3)
618
RACH: Poor SNR
620
SCG Failure
622
Increment loop counter
624
Max Loop?
Yes
No
626
Connection Reconfiguration Loop
628
End: Loop on Procedure
630
Add Cell 1 to Barred Cell List
632
Start Timer for Cell 1
634
Reselect to cell 2
636
PS data transfer state
PS data transfer state
638
SCG Add Procedure
640
RRC Connection Reconfiguration (5G Cell 4)
642
RACH (5G Cell 4)
644
PS data transfer state
PS data transfer state

FIG. 6

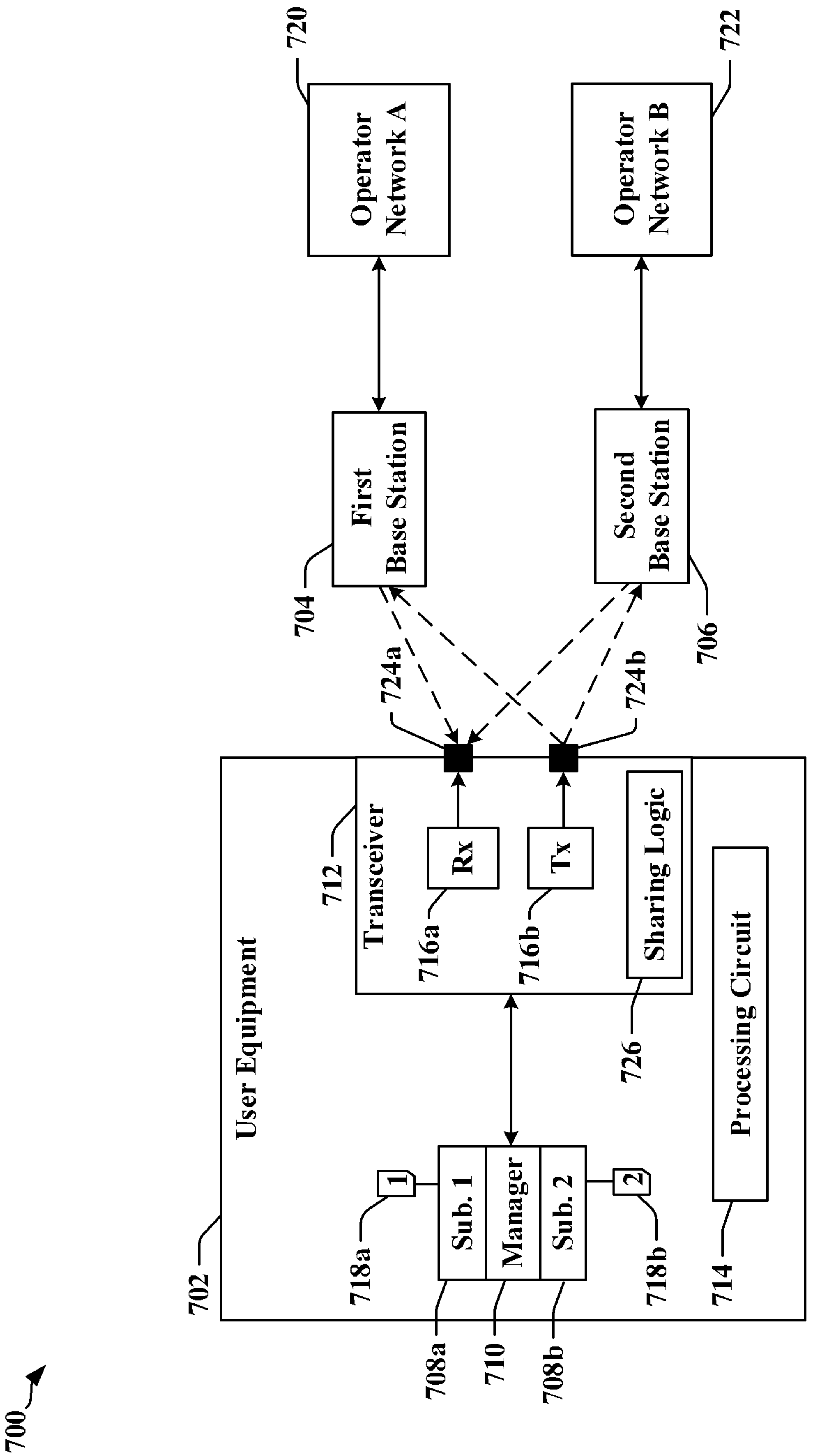
720
Operator Network A
722
Operator Network B
704
First Base Station
706
Second Base Station
724a
724b
702
User Equipment
712
Transceiver
716a
Rx
716b
Tx
Sharing Logic
726
Processing Circuit
714
Sub. 1
Manager
Sub. 2
1
2
718a
718b
708a
710
708b
700

FIG. 7

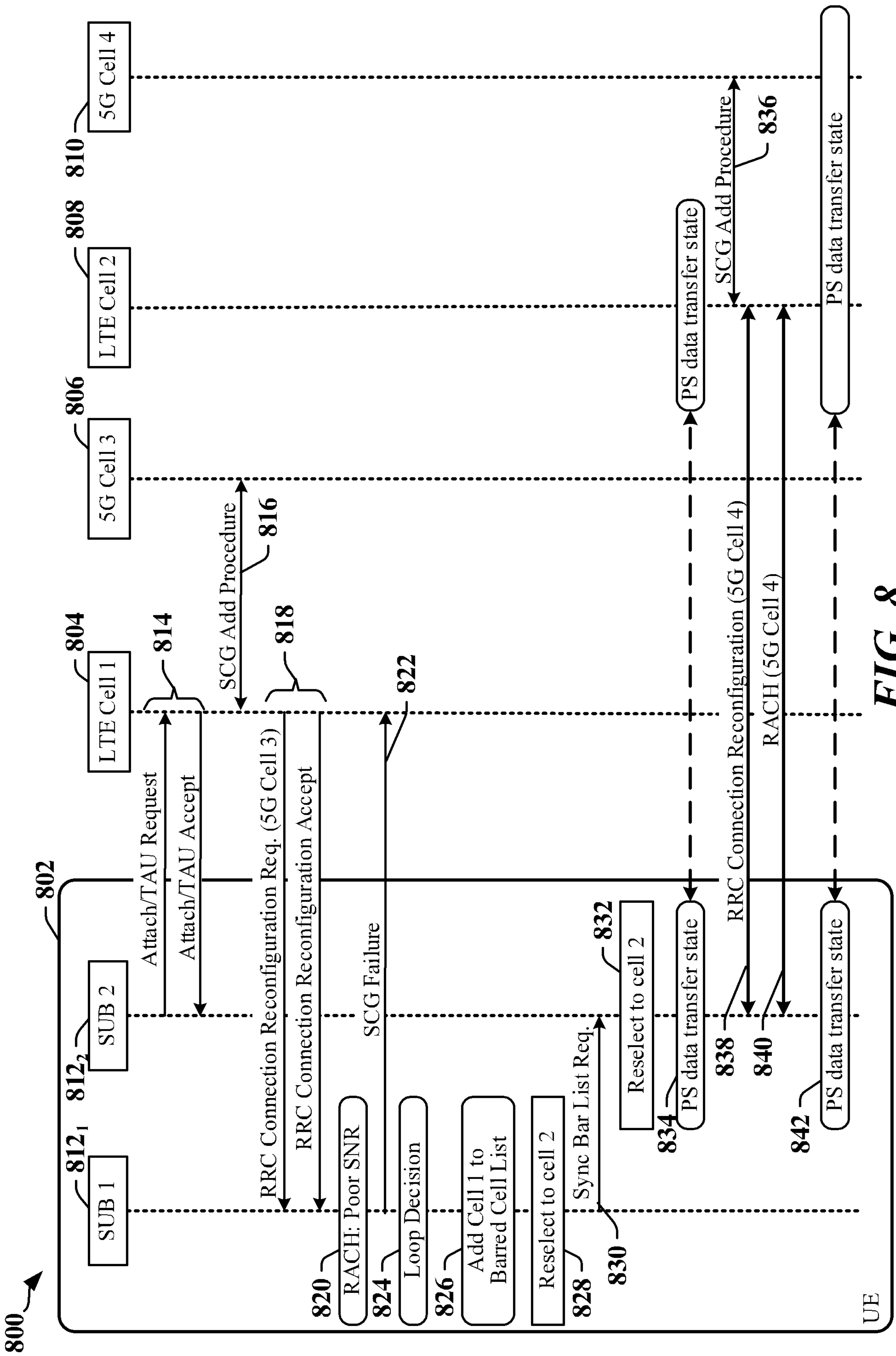
800
802
UE
SUB 1
SUB 2
LTE Cell 1
5G Cell 3
LTE Cell 2
5G Cell 4
812₁
812₂
804
806
808
810
Attach/TAU Request
Attach/TAU Accept
814
SCG Add Procedure
816
RRC Connection Reconfiguration Req. (5G Cell 3)
RRC Connection Reconfiguration Accept
818
RACH: Poor SNR
820
SCG Failure
822
Loop Decision
824
Add Cell 1 to Barred Cell List
826
Reselect to cell 2
828
Sync Bar List Req.
830
Reselect to cell 2
832
PS data transfer state
834
PS data transfer state
SCG Add Procedure
836
RRC Connection Reconfiguration (5G Cell 4)
838
RACH (5G Cell 4)
840
PS data transfer state
842
PS data transfer state

FIG. 8

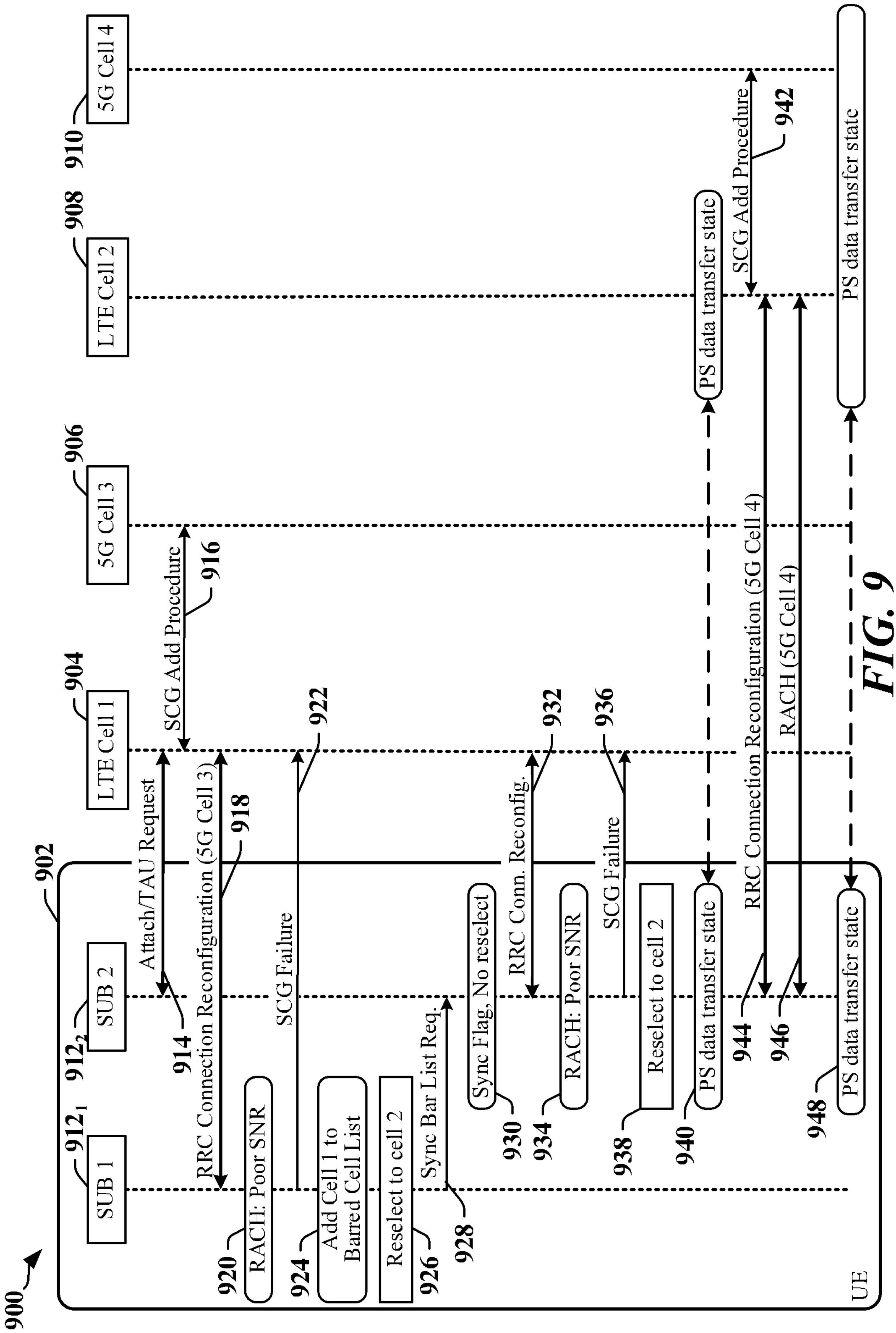
900
902
UE
SUB 1
912₁
SUB 2
912₂
LTE Cell 1
904
5G Cell 3
906
LTE Cell 2
908
5G Cell 4
910
Attach/TAU Request
914
SCG Add Procedure
916
RRC Connection Reconfiguration (5G Cell 3)
918
RACH: Poor SNR
920
SCG Failure
922
Add Cell 1 to Barred Cell List
924
Reselect to cell 2
926
Sync Bar List Req.
928
Sync Flag, No reselect
930
RRC Conn. Reconfig.
932
RACH: Poor SNR
934
SCG Failure
936
Reselect to cell 2
938
PS data transfer state
940
PS data transfer state
SCG Add Procedure
942
RRC Connection Reconfiguration (5G Cell 4)
944
RACH (5G Cell 4)
946
PS data transfer state
948
PS data transfer state

FIG. 9

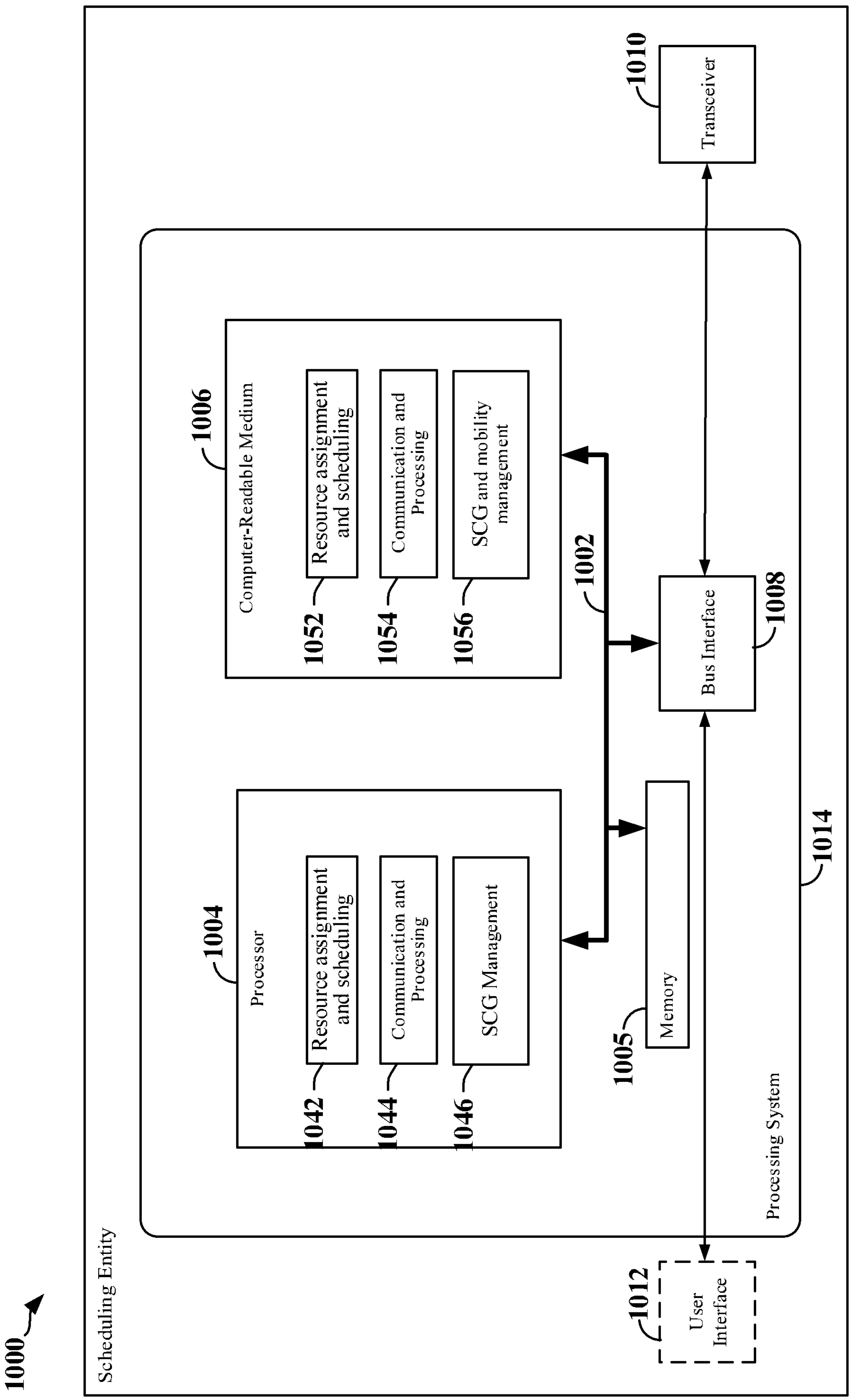
1000
Scheduling Entity
1014
Processing System
1004
Processor
1042
Resource assignment and scheduling
1044
Communication and Processing
1046
SCG Management
1006
Computer-Readable Medium
1052
Resource assignment and scheduling
1054
Communication and Processing
1056
SCG and mobility management
1002
1005
Memory
1008
Bus Interface
1010
Transceiver
1012
User Interface

FIG. 10

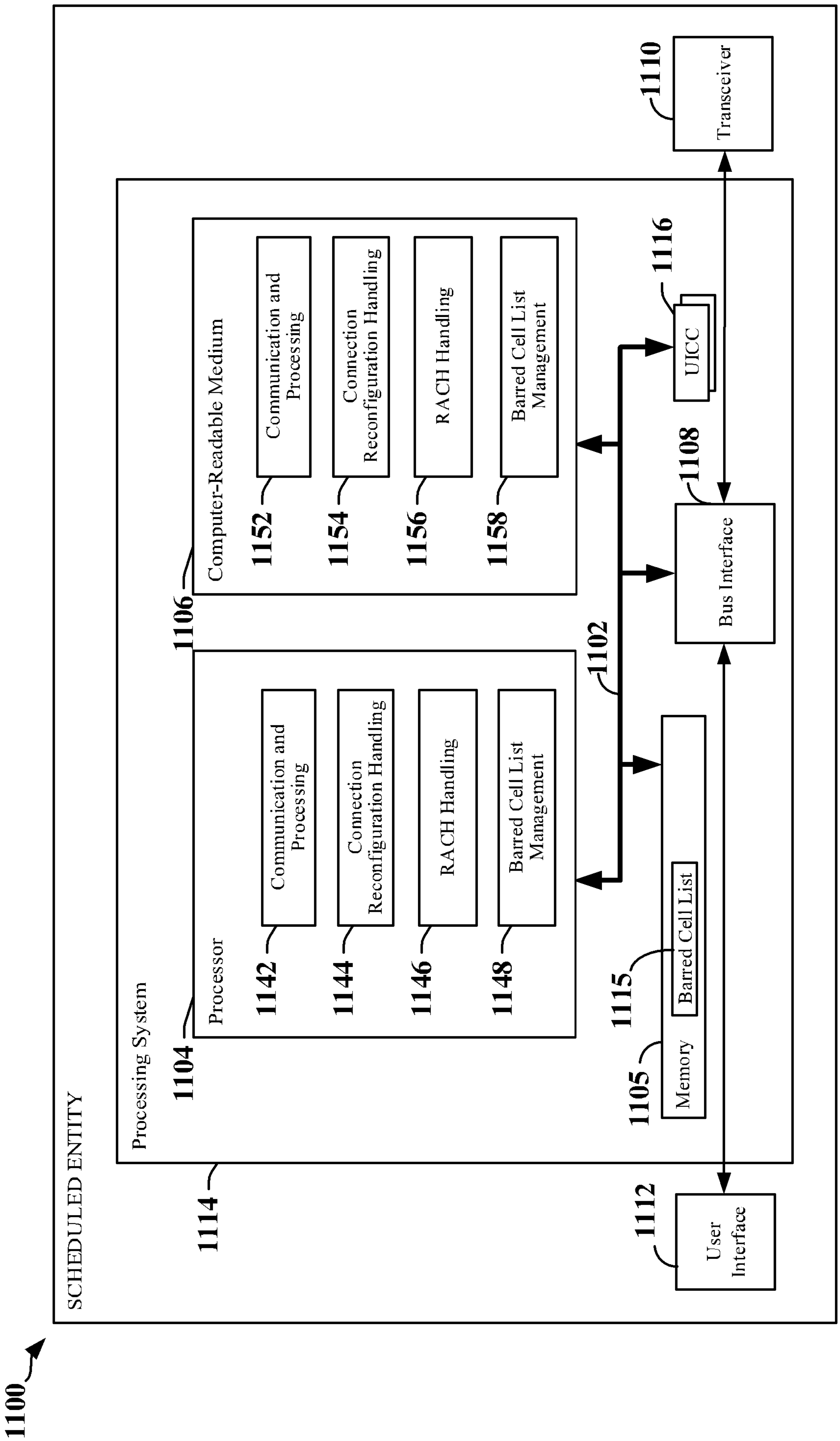
1100
SCHEDULED ENTITY
1114
Processing System
1104
Processor
1142
Communication and Processing
1144
Connection Reconfiguration Handling
1146
RACH Handling
1148
Barred Cell List Management
1106
Computer-Readable Medium
1152
Communication and Processing
1154
Connection Reconfiguration Handling
1156
RACH Handling
1158
Barred Cell List Management
1102
1105
Memory
1115
Barred Cell List
1108
Bus Interface
1116
UICC
1110
Transceiver
1112
User Interface

FIG. 11

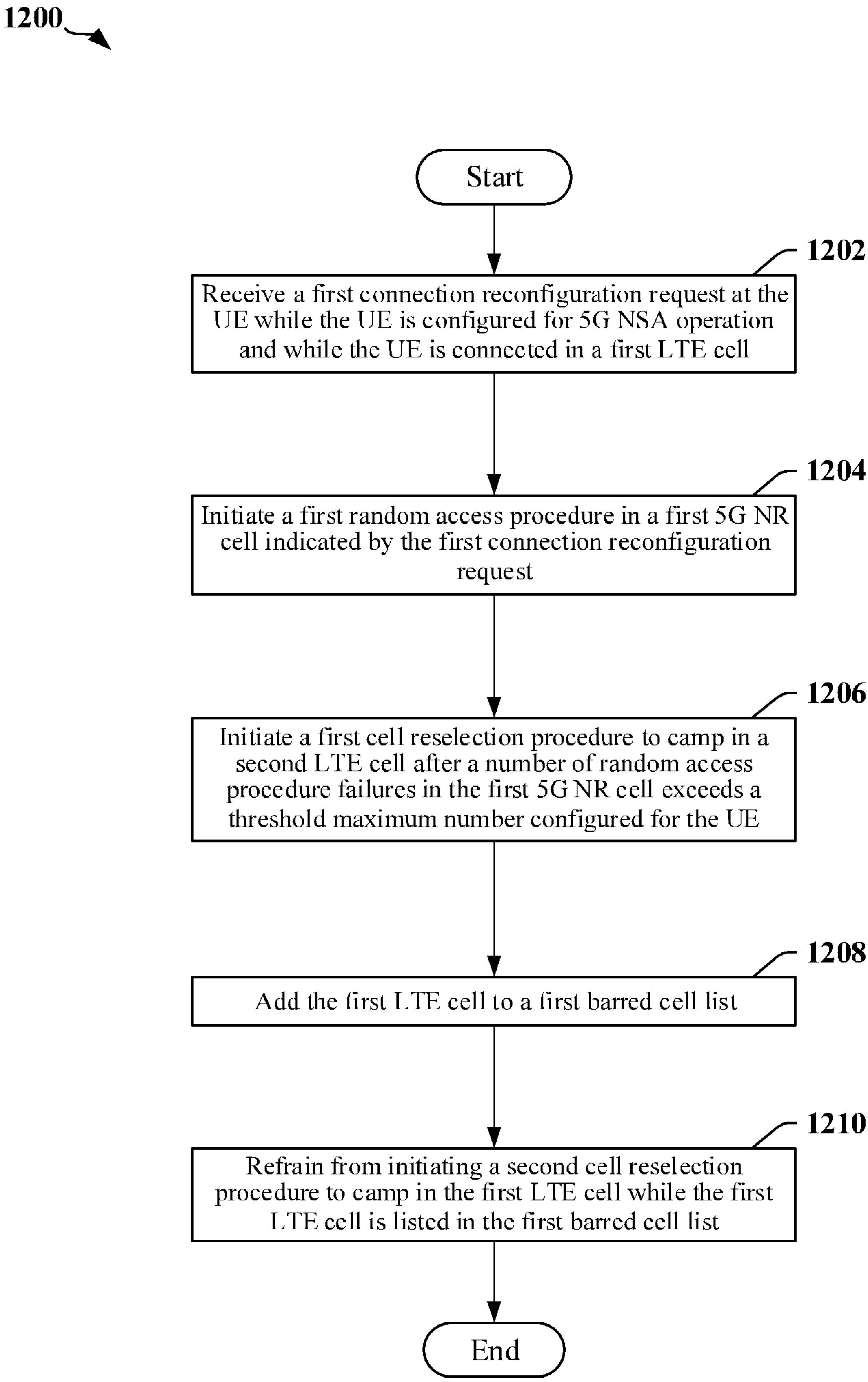
1200
Start
1202
Receive a first connection reconfiguration request at the UE while the UE is configured for 5G NSA operation and while the UE is connected in a first LTE cell
1204
Initiate a first random access procedure in a first 5G NR cell indicated by the first connection reconfiguration request
1206
Initiate a first cell reselection procedure to camp in a second LTE cell after a number of random access procedure failures in the first 5G NR cell exceeds a threshold maximum number configured for the UE
1208
Add the first LTE cell to a first barred cell list
1210
Refrain from initiating a second cell reselection procedure to camp in the first LTE cell while the first LTE cell is listed in the first barred cell list
End

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/093022

A. CLASSIFICATION OF SUBJECT MATTER

H04W 36/34(2009.01)i； H04W 88/06(2009.01)i

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; H04L

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)

CNTXT;CNABS;SIPOABS;CNKI;3GPP;DWPI;VEN;EPTXT;USTXT;WOTXT: non-standalone, NSA, new radio, NR, long-term evolution, LTE, dual connectivity, DC, reconfigurat+, request, random access, cell, reselect, failure, threshold, bar, list

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2019069205 A1 (QUALCOMM INC) 28 February 2019 (2019-02-28) the whole document	1-37
A	CN 110324822 A (CHINA MOBILE CO LTD RES INST et al.) 11 October 2019 (2019-10-11) the whole document	1-37
A	CN 108632923 A (CHINA MOBILE CO LTD RES INST et al.) 09 October 2018 (2018-10-09) the whole document	1-37
A	Qualcomm Incorporated et al. "Indication NR is available to use" *3GPP TSG-SA WG2 Meeting #122， S2-174466,* 20 June 2017 (2017-06-20), the whole document	1-37

☐ 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
25 January 2021	**20 February 2021**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**LIU,Yongzhe**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(010)-62412024**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/093022

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2019069205	A1	28 February 2019	WO	2019046028	A1	07 March 2019
				EP	3677072	A1	08 July 2020
				CN	111034277	A	17 April 2020
				IN	202027001897	A	28 February 2019
CN	110324822	A	11 October 2019	None			
CN	108632923	A	09 October 2018	None			