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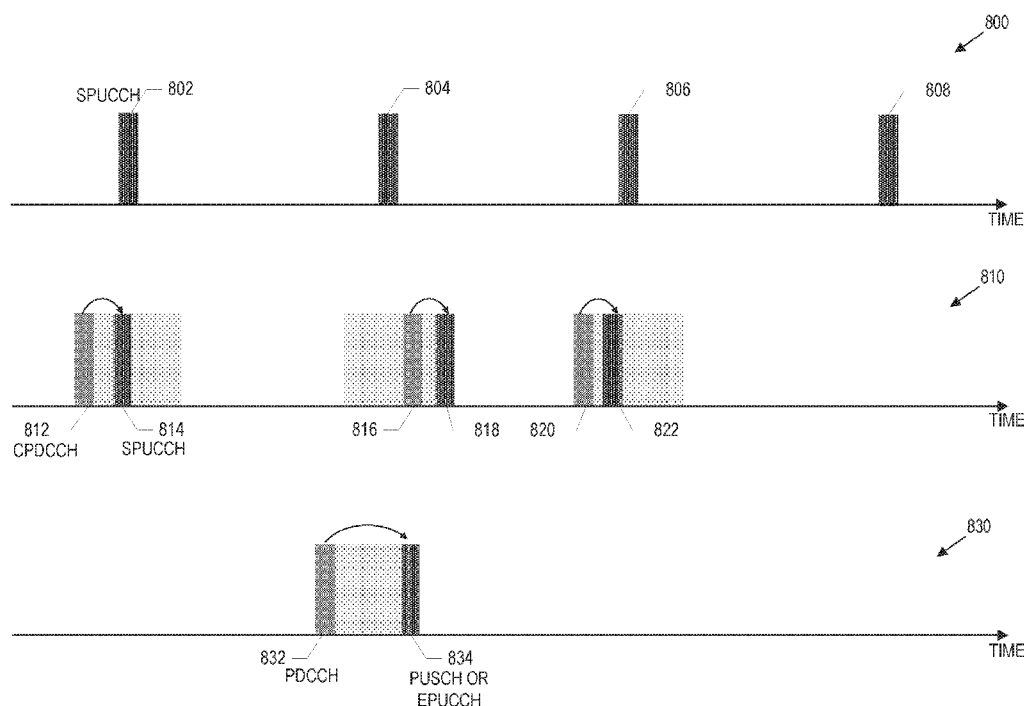
(71) Applicant: **INTEL IP CORPORATION** [US/US]; 2200
Mission College Boulevard, Santa Clara, California 95054
(US).

(72) Inventors: **NIU, Huaning**; 1308 Knollview Drive, Milpitas, California 95035 (US). **CHANG, Wenting**; 8F, Raycom Infotech Park A, No2, Kexueyuan South Road, Beijing 100190 (CN). **YE, Qiaoyang**; 4536 Piper St, Fremont, California 94538 (US). **LEE, Anthony**; 14843 Gable Ridge Road, San Diego, California 92128 (US). **LIM, Seau S.**; 15 Withering Road, Swindon SWD SN1 4GU (GB).

(74) Agent: **PERDOK, Monique M.** et al.; P.O. Box 2938, Minneapolis, Minnesota 55402 (US).

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(54) Title: RACH-LESS HANDOVER

**FIG. 8**

(57) **Abstract:** Devices and methods performing handover with or without the use of random access channel (RACH). An apparatus of a user equipment (UE) can include processing circuitry configured to decode a configuration message to initiate a RACH-less handover from a source eNB to a target eNB, the configuration message including an uplink grant information and a resource type information. Synchronization information is encoded for transmission to the target eNB using a first uplink resource indicated by the uplink grant information. A second uplink resource on an unlicensed wireless band is selected based on the resource type information. A confirmation message indicating completion of the RACH-less handover is encoded for transmission to the target eNB on the unlicensed wireless band using the second uplink resource.



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RACH-LESS HANDOVER

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PRIORITY CLAIM

[0001] This application claims the benefit of priority to United States Provisional Patent Application Serial No. 62/423,046, filed November 16, 2016, and entitled "RACH__LESS HANDOVER," which provisional application is incorporated herein by reference in its entirety.

10

TECHNICAL FIELD

[0002] Aspects pertain to wireless communications. Some aspects relate to wireless networks including 3GPP (Third Generation Partnership Project) networks, 3GPP LTE (Long Term Evolution) networks, 3GPP LTE-A (LTE Advanced) networks, and fifth-generation (5G) networks including new radio (NR) networks. Some aspects are directed to performing handover. Other aspects are directed to performing handover without the use of a random access channel (RACH) procedure (or RACH-less handover).

20

BACKGROUND

[0003] With the increase in different types of devices communicating with various network devices, usage of 3GPP LTE systems has increased. The penetration of mobile devices (user equipment or UEs) in modern society has continued to drive demand for a wide variety of networked devices in a number of disparate environments. The use of networked UEs using 3GPP LTE systems has increased in all areas of home and work life. Fifth generation (5G) wireless systems are forthcoming, and are expected to enable even greater speed, connectivity, and usability.

30

[0004] LTE and LTE-Advanced are standards for wireless communications of high-speed data for user equipment (UE) such as mobile telephones. In LTE-Advanced and various wireless systems, carrier aggregation is a technology where multiple carrier signals operating on

different frequencies may be used to carry communications for a single UE, thus increasing the bandwidth available to a single device. In some aspects, carrier aggregation may be used where one or more component carriers operate on unlicensed frequencies.

5 **[0005]** The explosive wireless traffic growth leads to a need of rate improvement. With mature physical layer techniques, further improvement in the spectral efficiency will be marginal. On the other hand, the scarcity of licensed spectrum in low frequency bands results in a deficit in the data rate boost. Thus, there are emerging interests in the operation of LTE systems in
10 the unlicensed spectrum. As a result, an important enhancement for LTE in 3GPP Release 13 has been to enable its operation in the unlicensed spectrum via Licensed-Assisted Access (LAA), which expands the system bandwidth by utilizing the flexible carrier aggregation (CA) framework introduced by the LTE-Advanced system. Rel-13 LAA system focuses on the design of DL
15 operation on unlicensed spectrum via CA, while Rel-14 enhanced LAA (eLAA) system focuses on the design of UL operation on unlicensed spectrum via CA. Further enhanced operation of LTE systems in the unlicensed spectrum is expected in future releases and 5G systems. Potential LTE operation in the unlicensed spectrum includes (and is not limited to) the
20 LTE operation in the unlicensed spectrum via dual connectivity (DC), or DC-based LAA, and the standalone LTE system in the unlicensed spectrum, where LTE-based technology solely operates in unlicensed spectrum without requiring an “anchor” in the licensed spectrum, called MulteFire. MulteFire, combines the performance benefits of LTE technology with the simplicity of
25 Wi-Fi-like deployments, is envisioned as a significantly important technology component to meet the ever-increasing wireless traffic.

BRIEF DESCRIPTION OF THE FIGURES

[0006] In the figures, which are not necessarily drawn to scale, like
30 numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components. The figures illustrate generally, by way of example,

but not by way of limitation, various aspects discussed in the present document.

[0007] FIG. 1A illustrates an architecture of a network in accordance with some aspects.

5 [0008] FIG. 1B is a simplified diagram of a next generation wireless network in accordance with some aspects.

[0009] FIG. 2 illustrates example components of a device 200 in accordance with some aspects.

[0010] FIG. 3 illustrates example interfaces of baseband circuitry in
10 accordance with some aspects.

[0011] FIG. 4 is an illustration of a control plane protocol stack in accordance with some aspects.

[0012] FIG. 5 is an illustration of a user plane protocol stack in accordance with some aspects.

15 [0013] FIG. 6 is a block diagram illustrating components, according to some example aspects, able to read instructions from a machine-readable or computer-readable medium (e.g., a non-transitory machine-readable storage medium) and perform any one or more of the methodologies discussed herein.

20 [0014] FIG. 7 illustrates an example communication sequence for a handover with or without the use of a random access channel (RACH) in accordance with some aspects.

[0015] FIG. 8 illustrates various resource types, which can be used to communicate a handover completion acknowledgement in accordance
25 with some aspects.

[0016] FIG. 9 illustrates example physical uplink control channel (PUCCH) resources, which can be used in a MulteFire or new radio – unlicensed (NR-U) communication environment in accordance with some aspects.

30 [0017] FIG. 10 is a flow diagram illustrating example functionalities for performing RACH-less handover and communicating a confirmation message in accordance with some aspects.

[0018] FIG. 11 illustrates a block diagram of a communication device such as an evolved Node-B (eNB), a new generation Node-B (gNB), an access point (AP), a wireless station (STA), or a user equipment (UE), in accordance with some aspects.

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DETAILED DESCRIPTION

[0019] The following description and the drawings sufficiently illustrate specific aspects to enable those skilled in the art to practice them. Other aspects may incorporate structural, logical, electrical, process, and
10 other changes. Portions and features of some aspects may be included in, or substituted for, those of other aspects. Aspects set forth in the claims encompass all available equivalents of those claims.

[0020] Any of the radio links described herein may operate according to any one or more of the following radio communication
15 technologies and/or standards including but not limited to: a Global System for Mobile Communications (GSM) radio communication technology, a General Packet Radio Service (GPRS) radio communication technology, an Enhanced Data Rates for GSM Evolution (EDGE) radio communication technology, and/or a Third Generation Partnership Project
20 (3GPP) radio communication technology, for example Universal Mobile Telecommunications System (UMTS), Freedom of Multimedia Access (FOMA), 3GPP Long Term Evolution (LTE), 3GPP Long Term Evolution Advanced (LTE Advanced), Code division multiple access 2000 (CDMA2000), Cellular Digital Packet Data (CDPD), Mobitex, Third
25 Generation (3G), Circuit Switched Data (CSD), High-Speed Circuit-Switched Data (HSCSD), Universal Mobile Telecommunications System (Third Generation) (UMTS (3G)), Wideband Code Division Multiple Access (Universal Mobile Telecommunications System) (W-CDMA (UMTS)), High Speed Packet Access (HSPA), High-Speed Downlink
30 Packet Access (HSDPA), High-Speed Uplink Packet Access (HSUPA), High Speed Packet Access Plus (HSPA+), Universal Mobile Telecommunications System-Time-Division Duplex (UMTS-TDD), Time Division-Code Division Multiple Access (TD-CDMA), Time Division-

Synchronous Code Division Multiple Access (TD-CDMA), 3rd Generation
 Partnership Project Release 8 (Pre-4th Generation) (3GPP Rel. 8 (Pre-4G)),
 3GPP Rel. 9 (3rd Generation Partnership Project Release 9), 3GPP Rel. 10
 (3rd Generation Partnership Project Release 10) , 3GPP Rel. 11 (3rd
 5 Generation Partnership Project Release 11), 3GPP Rel. 12 (3rd Generation
 Partnership Project Release 12), 3GPP Rel. 13 (3rd Generation Partnership
 Project Release 13), 3GPP Rel. 14 (3rd Generation Partnership Project
 Release 14), 3GPP Rel. 15 (3rd Generation Partnership Project Release 15),
 3GPP Rel. 16 (3rd Generation Partnership Project Release 16), 3GPP Rel.
 10 17 (3rd Generation Partnership Project Release 17), 3GPP Rel. 18 (3rd
 Generation Partnership Project Release 18), 3GPP 5G, 3GPP LTE Extra,
 LTE-Advanced Pro, LTE Licensed-Assisted Access (LAA), MulteFire,
 UMTS Terrestrial Radio Access (UTRA), Evolved UMTS Terrestrial
 Radio Access (E-UTRA), Long Term Evolution Advanced (4th
 15 Generation) (LTE Advanced (4G)), cdmaOne (2G), Code division multiple
 access 2000 (Third generation) (CDMA2000 (3G)), Evolution-Data
 Optimized or Evolution-Data Only (EV-DO), Advanced Mobile Phone
 System (1st Generation) (AMPS (1G)), Total Access Communication
 System/Extended Total Access Communication System (TACS/ETACS),
 20 Digital AMPS (2nd Generation) (D-AMPS (2G)), Push-to-talk (PTT),
 Mobile Telephone System (MTS), Improved Mobile Telephone System
 (IMTS), Advanced Mobile Telephone System (AMTS), OLT (Norwegian
 for Offentlig Landmobil Telefoni, Public Land Mobile Telephony), MTD
 (Swedish abbreviation for Mobiltelefonisystem D, or Mobile telephony
 25 system D), Public Automated Land Mobile (Autotel/PALM), ARP (Finnish
 for Autoradiopuhelin, "car radio phone"), NMT (Nordic Mobile
 Telephony), High capacity version of NTT (Nippon Telegraph and
 Telephone) (Hicap), Cellular Digital Packet Data (CDPD), Mobitex,
 DataTAC, Integrated Digital Enhanced Network (iDEN), Personal Digital
 30 Cellular (PDC), Circuit Switched Data (CSD), Personal Handy-phone
 System (PHS), Wideband Integrated Digital Enhanced Network (WiDEN),
 iBurst, Unlicensed Mobile Access (UMA), also referred to as also referred
 to as 3GPP Generic Access Network, or GAN standard), Zigbee,
 Bluetooth(r), Wireless Gigabit Alliance (WiGig) standard, mmWave

standards in general (wireless systems operating at 10-300 GHz and above such as WiGig, IEEE 802.11ad, IEEE 802.11ay, etc.), technologies operating above 300 GHz and THz bands, (3GPP/LTE based or IEEE 802.11p and other) Vehicle-to-Vehicle (V2V) and Vehicle-to-X (V2X) and
 5 Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) communication technologies, 3GPP cellular V2X, DSRC (Dedicated Short Range Communications) communication systems such as Intelligent-Transport-Systems and others, etc.

[0021] Aspects described herein can be used in the context of any
 10 spectrum management scheme including dedicated licensed spectrum, unlicensed spectrum, (licensed) shared spectrum (such as LSA = Licensed Shared Access in 2.3-2.4 GHz, 3.4-3.6 GHz, 3.6-3.8 GHz and further frequencies and SAS = Spectrum Access System in 3.55-3.7 GHz and further frequencies). Applicable spectrum bands include IMT (International
 15 Mobile Telecommunications) spectrum (including 450 - 470 MHz, 790 - 960 MHz, 1710 - 2025 MHz, 2110 - 2200 MHz, 2300 - 2400 MHz, 2500 - 2690 MHz, 698-790 MHz, 610 - 790 MHz, 3400 - 3600 MHz, etc). Note that some bands are limited to specific region(s) and/or countries), IMT-advanced spectrum, IMT-2020 spectrum (expected to include 3600-3800
 20 MHz, 3.5 GHz bands, 700 MHz bands, bands within the 24.25-86 GHz range, etc.), spectrum made available under FCC's "Spectrum Frontier" 5G initiative (including 27.5 - 28.35 GHz, 29.1 - 29.25 GHz, 31 - 31.3 GHz, 37 - 38.6 GHz, 38.6 - 40 GHz, 42 - 42.5 GHz, 57 - 64 GHz, 71 - 76 GHz, 81 - 86 GHz and 92 - 94 GHz, etc), the ITS (Intelligent Transport Systems)
 25 band of 5.9 GHz (typically 5.85-5.925 GHz) and 63-64 GHz, bands currently allocated to WiGig such as WiGig Band 1 (57.24-59.40 GHz), WiGig Band 2 (59.40-61.56 GHz) and WiGig Band 3 (61.56-63.72 GHz) and WiGig Band 4 (63.72-65.88 GHz), the 70.2 GHz - 71 GHz band, any band between 65.88 GHz and 71 GHz, bands currently allocated to
 30 automotive radar applications such as 76-81 GHz, and future bands including 94-300 GHz and above. Furthermore, the scheme can be used on a secondary basis on bands such as the TV White Space bands (typically below 790 MHz) where in particular the 400 MHz and 700 MHz bands are

promising candidates. Besides cellular applications, specific applications for vertical markets may be addressed such as PMSE (Program Making and Special Events), medical, health, surgery, automotive, low-latency, drones, etc. applications.

5 **[0022]** Aspects described herein can also implement a hierarchical application of the scheme is possible, e.g. by introducing a hierarchical prioritization of usage for different types of users (e.g., low/medium/high priority, etc.), based on a prioritized access to the spectrum e.g. with highest priority to tier-1 users, followed by tier-2, then tier-3, etc. users, etc.

10 **[0023]** Aspects described herein can also be applied to different Single Carrier or OFDM flavors (CP-OFDM, SC-FDMA, SC-OFDM, filter bank-based multicarrier (FBMC), OFDMA, etc.) and in particular 3GPP NR (New Radio) by allocating the OFDM carrier data bit vectors to the corresponding symbol resources.

15 **[0024]** FIG. 1A illustrates an architecture of a network in accordance with some aspects. The network 100 is shown to include a user equipment (UE) 101 and a UE 102. The UEs 101 and 102 are illustrated as smartphones (e.g., handheld touchscreen mobile computing devices connectable to one or more cellular networks), but may also comprise any
20 mobile or non-mobile computing device, such as Personal Data Assistants (PDAs), pagers, laptop computers, desktop computers, wireless handsets, or any computing device including a wireless communications interface.

[0025] In some aspects, any of the UEs 101 and 102 can comprise an Internet of Things (IoT) UE, which can comprise a network access layer
25 designed for low-power IoT applications utilizing short-lived UE connections. An IoT UE can utilize technologies such as machine-to-machine (M2M) or machine-type communications (MTC) for exchanging data with an MTC server or device via a public land mobile network (PLMN), Proximity-Based Service (ProSe) or device-to-device (D2D)
30 communication, sensor networks, or IoT networks. The M2M or MTC exchange of data may be a machine-initiated exchange of data. An IoT network describes interconnecting IoT UEs, which may include uniquely identifiable embedded computing devices (within the Internet

infrastructure), with short-lived connections. The IoT UEs may execute background applications (e.g., keep-alive messages, status updates, etc.) to facilitate the connections of the IoT network.

[0026] The UEs 101 and 102 may be configured to connect, e.g.,
5 communicatively couple, with a radio access network (RAN) 110 - the RAN 110 may be, for example, an Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (E-UTRAN), a NextGen RAN (NG RAN), or some other type of RAN. The UEs 101 and 102 utilize connections 103 and 104, respectively, each
10 of which comprises a physical communications interface or layer (discussed in further detail below); in this example, the connections 103 and 104 are illustrated as an air interface to enable communicative coupling, and can be consistent with cellular communications protocols, such as a Global System for Mobile Communications (GSM) protocol, a
15 code-division multiple access (CDMA) network protocol, a Push-to-Talk (PTT) protocol, a PTT over Cellular (POC) protocol, a Universal Mobile Telecommunications System (UMTS) protocol, a 3GPP Long Term Evolution (LTE) protocol, a fifth generation (5G) protocol, a New Radio (NR) protocol, and the like.

[0027] In this aspect, the UEs 101 and 102 may further directly
20 exchange communication data via a ProSe interface 105. The ProSe interface 105 may alternatively be referred to as a sidelink interface comprising one or more logical channels, including but not limited to a Physical Sidelink Control Channel (PSCCH), a Physical Sidelink Shared
25 Channel (PSSCH), a Physical Sidelink Discovery Channel (PSDCH), and a Physical Sidelink Broadcast Channel (PSBCH).

[0028] The UE 102 is shown to be configured to access an access
point (AP) 106 via connection 107. The connection 107 can comprise a
local wireless connection, such as a connection consistent with any IEEE
30 802.11 protocol, wherein the AP 106 would comprise a wireless fidelity (WiFi®) router. In this example, the AP 106 is shown to be connected to the Internet without connecting to the core network of the wireless system (described in further detail below).

[0029] The RAN 110 can include one or more access nodes that enable the connections 103 and 104. These access nodes (ANs) can be referred to as base stations (BSs), NodeBs, evolved NodeBs (eNBs), next Generation NodeBs (gNB), RAN nodes, and so forth, and can comprise
5 ground stations (e.g., terrestrial access points) or satellite stations providing coverage within a geographic area (e.g., a cell). The RAN 110 may include one or more RAN nodes for providing macrocells, e.g., macro RAN node 111, and one or more RAN nodes for providing femtocells or picocells (e.g., cells having smaller coverage areas, smaller user capacity, or higher
10 bandwidth compared to macrocells), e.g., low power (LP) RAN node 112.

[0030] Any of the RAN nodes 111 and 112 can terminate the air interface protocol and can be the first point of contact for the UEs 101 and 102. In some aspects, any of the RAN nodes 111 and 112 can fulfill various logical functions for the RAN 110 including, but not limited to,
15 radio network controller (RNC) functions such as radio bearer management, uplink and downlink dynamic radio resource management and data packet scheduling, and mobility management. In an example, any of the nodes 111 and/or 112 can be a new generation node-B (gNB), an evolved node-B (eNB) or another type of RAN node.

[0031] In accordance with some aspects, the UEs 101 and 102 can be configured to communicate using Orthogonal Frequency-Division Multiplexing (OFDM) communication signals with each other or with any of the RAN nodes 111 and 112 over a multicarrier communication channel in accordance various communication techniques, such as, but not limited
25 to, an Orthogonal Frequency-Division Multiple Access (OFDMA) communication technique (e.g., for downlink communications) or a Single Carrier Frequency Division Multiple Access (SC-FDMA) communication technique (e.g., for uplink and ProSe or sidelink communications), although the scope of the aspects is not limited in this respect. The OFDM signals
30 can comprise a plurality of orthogonal subcarriers.

[0032] In some aspects, a downlink resource grid can be used for downlink transmissions from any of the RAN nodes 111 and 112 to the UEs 101 and 102, while uplink transmissions can utilize similar techniques.

The grid can be a time-frequency grid, called a resource grid or time-frequency resource grid, which is the physical resource in the downlink in each slot. Such a time-frequency plane representation is a common practice for OFDM systems, which makes it intuitive for radio resource allocation. Each column and each row of the resource grid corresponds to one OFDM symbol and one OFDM subcarrier, respectively. The duration of the resource grid in the time domain corresponds to one slot in a radio frame. The smallest time-frequency unit in a resource grid is denoted as a resource element. Each resource grid comprises a number of resource blocks, which describe the mapping of certain physical channels to resource elements. Each resource block comprises a collection of resource elements; in the frequency domain, this may represent the smallest quantity of resources that currently can be allocated. There are several different physical downlink channels that are conveyed using such resource blocks.

15 **[0033]** The physical downlink shared channel (PDSCH) may carry user data and higher-layer signaling to the UEs 101 and 102. The physical downlink control channel (PDCCH) may carry information about the transport format and resource allocations related to the PDSCH channel, among other things. It may also inform the UEs 101 and 102 about the transport format, resource allocation, and H-ARQ (Hybrid Automatic Repeat Request) information related to the uplink shared channel. Typically, downlink scheduling (assigning control and shared channel resource blocks to the UE 102 within a cell) may be performed at any of the RAN nodes 111 and 112 based on channel quality information fed back from any of the UEs 101 and 102. The downlink resource assignment information may be sent on the PDCCH used for (e.g., assigned to) each of the UEs 101 and 102.

25 **[0034]** The PDCCH may use control channel elements (CCEs) to convey the control information. Before being mapped to resource elements, the PDCCH complex-valued symbols may first be organized into quadruplets, which may then be permuted using a sub-block interleaver for rate matching. Each PDCCH may be transmitted using one or more of these CCEs, where each CCE may correspond to nine sets of four physical

resource elements known as resource element groups (REGs). Four Quadrature Phase Shift Keying (QPSK) symbols may be mapped to each REG. The PDCCH can be transmitted using one or more CCEs, depending on the size of the downlink control information (DCI) and the channel condition. There can be four or more different PDCCH formats defined in LTE with different numbers of CCEs (e.g., aggregation level, L=1, 2, 4, or 8).

[0035] Some aspects may use concepts for resource allocation for control channel information that are an extension of the above-described concepts. For example, some aspects may utilize an enhanced physical downlink control channel (EPDCCH) that uses PDSCH resources for control information transmission. The EPDCCH may be transmitted using one or more enhanced control channel elements (ECCEs). Similar to above, each ECCE may correspond to nine sets of four physical resource elements known as an enhanced resource element groups (EREGs). An ECCE may have other numbers of EREGs in some situations.

[0036] The RAN 110 is shown to be communicatively coupled to a core network (CN) 120 via an S1 interface 113. In aspects, the CN 120 may be an evolved packet core (EPC) network, a NextGen Packet Core (NPC) network, or some other type of CN. In this aspect the S1 interface 113 is split into two parts: the S1-U interface 114, which carries traffic data between the RAN nodes 111 and 112 and the serving gateway (S-GW) 122, and the S1-mobility management entity (MME) interface 115, which is a signaling interface between the RAN nodes 111 and 112 and MMEs 121.

[0037] In this aspect, the CN 120 comprises the MMEs 121, the S-GW 122, the Packet Data Network (PDN) Gateway (P-GW) 123, and a home subscriber server (HSS) 124. The MMEs 121 may be similar in function to the control plane of legacy Serving General Packet Radio Service (GPRS) Support Nodes (SGSN). The MMEs 121 may manage mobility aspects in access such as gateway selection and tracking area list management. The HSS 124 may comprise a database for network users, including subscription-related information to support the network entities' handling of communication sessions. The CN 120 may comprise one or

several HSSs 124, depending on the number of mobile subscribers, on the capacity of the equipment, on the organization of the network, etc. For example, the HSS 124 can provide support for routing/roaming, authentication, authorization, naming/addressing resolution, location dependencies, etc.

[0038] The S-GW 122 may terminate the S1 interface 113 towards the RAN 110, and routes data packets between the RAN 110 and the CN 120. In addition, the S-GW 122 may be a local mobility anchor point for inter-RAN node handovers and also may provide an anchor for inter-3GPP mobility. Other responsibilities may include lawful intercept, charging, and some policy enforcement.

[0039] The P-GW 123 may terminate an SGi interface toward a PDN. The P-GW 123 may route data packets between the EPC network 123 and external networks such as a network including the application server 130 (alternatively referred to as application function (AF)) via an Internet Protocol (IP) interface 125. Generally, the application server 130 may be an element offering applications that use IP bearer resources with the core network (e.g., UMTS Packet Services (PS) domain, LTE PS data services, etc.). In this aspect, the P-GW 123 is shown to be communicatively coupled to an application server 130 via an IP communications interface 125. The application server 130 can also be configured to support one or more communication services (e.g., Voice-over-Internet Protocol (VoIP) sessions, PTT sessions, group communication sessions, social networking services, etc.) for the UEs 101 and 102 via the CN 120.

[0040] The P-GW 123 may further be a node for policy enforcement and charging data collection. Policy and Charging Enforcement Function (PCRF) 126 is the policy and charging control element of the CN 120. In a non-roaming scenario, there may be a single PCRF in the Home Public Land Mobile Network (HPLMN) associated with a UE's Internet Protocol Connectivity Access Network (IP-CAN) session. In a roaming scenario with local breakout of traffic, there may be two PCRFs associated with a UE's IP-CAN session: a Home PCRF (H-

PCRF) within a HPLMN and a Visited PCRF (V-PCRF) within a Visited Public Land Mobile Network (VPLMN). The PCRF 126 may be communicatively coupled to the application server 130 via the P-GW 123. The application server 130 may signal the PCRF 126 to indicate a new
5 service flow and select the appropriate Quality of Service (QoS) and charging parameters. The PCRF 126 may provision this rule into a Policy and Charging Enforcement Function (PCEF) (not shown) with the appropriate traffic flow template (TFT) and QoS class of identifier (QCI), which commences the QoS and charging as specified by the application
10 server 130.

[0041] In an example, any of the nodes 111 or 112 can be configured to communicate to the UEs 101/102 (e.g., dynamically) an antenna panel selection and a receive (Rx) beam selection that should be used by the UE for data reception on a physical downlink shared channel
15 (PDSCH) as well as for channel state information reference signal (CSI-RS) measurements and channel state information (CSI) calculation.

[0042] In an example, any of the nodes 111 or 112 can be configured to communicate to the UEs 101/102 (e.g., dynamically) an antenna panel selection and a transmit (Tx) beam selection that should be
20 used by the UE for data transmission on a physical uplink shared channel (PUSCH) as well as for sounding reference signal (SRS) transmission.

[0043] In accordance with some aspects, the UEs 101 and 102, the eNBs 111 and 112, and the AP 106 can be configured to operate in a LAA, eLAA, MulteFire or another communication environment using licensed
25 and/or unlicensed spectrum (e.g., the 5 GHz Industrial, Scientific and Medical (ISM) band). The 5 GHz band in the US is governed by Unlicensed National Information Infrastructure (U-NII) rules by the Federal Communications Commission (FCC). The main incumbent system in the 5 GHz band is the Wireless Local Area Networks (WLAN),
30 specifically those based on the IEEE 802.11 a/n/ac technologies. Since WLAN systems are widely deployed both by individuals and operators for carrier-grade access service and data offloading, Listen-Before-Talk (LBT) procedure can be used for fair coexistence with an incumbent (e.g.,

WLAN) system. LBT is a procedure whereby radio transmitters first sense the medium and transmit if the medium is sensed to be idle.

[0044] In some aspects, a handover of a UE from a source eNB to a target eNB can take place with or without the use of a random access channel (RACH). In some aspects, RACH-less handover (i.e., a handover without the use of a RACH procedure) can be performed without introducing new timing alignment control or estimation mechanisms, as the network knows when the timing alignment is the same for both the source and target cells. In some aspects, RACH-less handover can be used in
10 unlicensed band communication systems (e.g., MulteFire and NR-U communication systems), as the cells size are typically small on the 5 GHz band, and the use of LBT can cause long delay with a typical handover procedure that uses RACH.

[0045] In some aspects, RACH-less handover can take place of the
15 UE (e.g., 101) from a source eNB (e.g., 111) to a target eNB (e.g. 112). A configuration message 190 can be sent to the UE 101, where the configuration message can originate from the target eNB and can be communicated to the UE 101 via the source eNB. In some aspects, the configuration message 190 can be a radio resource control connection
20 reconfiguration (RRCR) message. In some aspects, the configuration message 190 can include mobility control information. In some aspects, RACH-less handover can be configured by, e.g., higher layer signaling. In some aspects, the configuration information 190 can be a configuration message container that includes timing adjustment (TA) information 192,
25 an indication of the target eNB, an indication of a type of RACH procedure used in connection with a handover (e.g. RACH-less handover or a handover using a RACH procedure). Additionally, the configuration message 190 can indicate an LBT type 194 and a resource type 196 for a resource that can be used to send a confirmation message (e.g., RRC
30 connection reconfiguration complete message) that the handover (e.g., a RACH-less handover) is complete. In some aspects, RACH-less handover can be enabled by using a periodic non-anchors subframe, a floating grant of SPUCCH, an uplink grant on an EPUCCH, and an uplink grant on a

PUSCH to send the handover completion confirmation message. Further description of an example RACH-less handover procedure and various options for sending the handover completion confirmation message are described in greater detail in reference to FIGS. 7-10 herein below.

5 [0046] FIG. 1B is a simplified diagram of a next generation wireless network in accordance with some aspects. The wireless network may be similar to that shown in FIG. 1A but may contain components associated with a 5G network. The wireless network may contain, among other elements not shown, a RAN 110 coupled to the core network 120 (as
10 well as to the Internet which can connect the core network 120 with other core networks 120). In some aspects, the RAN 110 and the core network 120 may be a next generation (5G) 3GPP RAN and 5G core network, respectively. The RAN 110 may include an upper layer of a new generation node-B (gNB) (also referred to as a new radio (NR) base station
15 (BS) (ULNRBS)) 140 and multiple lower layers of different gNBs (NR BS (LLNRBS)) 111. The LLNRBSs 111 can be connected to the ULNRBS 140 via a Z interface. The Z interface can be open or proprietary. In some examples, the LLNRBS 111 can be referred to as a transmission-reception point (TRP). If the Z interface is proprietary, then the ULNRBS 140 and
20 the LLNRBS 111 may be provided by the same vendor. The LLNRBS 111 can be connected by a Y interface, which may be equivalent to the LTE X2 interface. The ULNRBS 140 may be connected to the core network 120 through the S1 interface 113.

[0047] As used herein, the term circuitry may refer to, be part of, or
25 include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), or memory (shared, dedicated, or group) that executes one or more software or firmware programs, a combinational logic circuit, or other suitable hardware components that provide the described functionality. In some aspects, the
30 circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some aspects, circuitry may include logic, at least partially operable in

hardware. Aspects described herein may be implemented into a system using any suitably configured hardware or software.

[0048] FIG. 2 illustrates example components of a device 200 in accordance with some aspects. In some aspects, the device 200 may include application circuitry 202, baseband circuitry 204, Radio Frequency (RF) circuitry 206, front-end module (FEM) circuitry 208, one or more antennas 210, and power management circuitry (PMC) 212 coupled together at least as shown. The components of the illustrated device 200 may be included in a UE or a RAN node. In some aspects, the device 200 may include less elements (e.g., a RAN node may not utilize application circuitry 202, and instead include a processor/controller to process IP data received from an EPC). In some aspects, the device 200 may include additional elements such as, for example, memory/storage, display, camera, sensor, or input/output (I/O) interface. In other aspects, the components described below may be included in more than one device (e.g., said circuitries may be separately included in more than one device for Cloud-RAN (C-RAN) implementations).

[0049] The application circuitry 202 may include one or more application processors. For example, the application circuitry 202 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications or operating systems to run on the device 200. In some aspects, processors of application circuitry 202 may process IP data packets received from an EPC.

[0050] The baseband circuitry 204 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 204 may include one or more baseband processors or control logic to process baseband signals received from a receive signal path of the RF circuitry 206 and to generate baseband signals for a transmit

signal path of the RF circuitry 206. Baseband processing circuitry 204 may interface with the application circuitry 202 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 206. For example, in some aspects, the baseband circuitry 204 may include a

5 third generation (3G) baseband processor 204A, a fourth generation (4G) baseband processor 204B, a fifth generation (5G) baseband processor 204C, or other baseband processor(s) 204D for other existing generations, generations in development or to be developed in the future (e.g., second generation (2G), sixth generation (6G), etc.). The baseband circuitry 204

10 (e.g., one or more of baseband processors 204A-D) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 206. In other aspects, some or all of the functionality of baseband processors 204A-D may be included in modules stored in the memory 204G and executed via a Central Processing Unit

15 (CPU) 204E. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some aspects, modulation/demodulation circuitry of the baseband circuitry 204 may include Fast-Fourier Transform (FFT), precoding, or constellation mapping/demapping functionality. In some

20 aspects, encoding/decoding circuitry of the baseband circuitry 204 may include convolution, tail-biting convolution, turbo, Viterbi, or Low Density Parity Check (LDPC) encoder/decoder functionality. Aspects of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other

25 aspects.

[0051] In some aspects, the baseband circuitry 204 may include one or more audio digital signal processor(s) (DSP) 204F. The audio DSP(s) 204F may include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other

30 aspects. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some aspects. In some aspects, some or all of the constituent components

of the baseband circuitry 204 and the application circuitry 202 may be implemented together such as, for example, on a system on a chip (SOC).

[0052] In some aspects, the baseband circuitry 204 may provide for communication compatible with one or more radio technologies. For example, in some aspects, the baseband circuitry 204 may support communication with an evolved universal terrestrial radio access network (EUTRAN) or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Aspects in which the baseband circuitry 204 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0053] RF circuitry 206 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various aspects, the RF circuitry 206 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 206 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 208 and provide baseband signals to the baseband circuitry 204. RF circuitry 206 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 204 and provide RF output signals to the FEM circuitry 208 for transmission.

[0054] In some aspects, the receive signal path of the RF circuitry 206 may include mixer circuitry 206A, amplifier circuitry 206B and filter circuitry 206C. In some aspects, the transmit signal path of the RF circuitry 206 may include filter circuitry 206C and mixer circuitry 206A. RF circuitry 206 may also include synthesizer circuitry 206D for synthesizing a frequency for use by the mixer circuitry 206A of the receive signal path and the transmit signal path. In some aspects, the mixer circuitry 206A of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 208 based on the synthesized frequency provided by synthesizer circuitry 206D. The amplifier circuitry 206B may be configured to amplify the down-converted signals and the filter circuitry

206C may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 204 for further processing. In some aspects, the output
5 baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some aspects, mixer circuitry 206A of the receive signal path may comprise passive mixers, although the scope of the aspects is not limited in this respect.

[0055] In some aspects, the mixer circuitry 206A of the transmit
10 signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 206D to generate RF output signals for the FEM circuitry 208. The baseband signals may be provided by the baseband circuitry 204 and may be filtered by filter circuitry 206C.

15 [0056] In some aspects, the mixer circuitry 206A of the receive signal path and the mixer circuitry 206A of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and upconversion, respectively. In some aspects, the mixer circuitry 206A of the receive signal path and the mixer circuitry
20 206A of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some aspects, the mixer circuitry 206A of the receive signal path and the mixer circuitry 206A may be arranged for direct downconversion and direct upconversion, respectively. In some aspects, the mixer circuitry 206A of
25 the receive signal path and the mixer circuitry 206A of the transmit signal path may be configured for super-heterodyne operation.

[0057] In some aspects, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the aspects is not limited in this respect. In some alternate aspects, the output
30 baseband signals and the input baseband signals may be digital baseband signals. In these alternate aspects, the RF circuitry 206 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC)

circuitry and the baseband circuitry 204 may include a digital baseband interface to communicate with the RF circuitry 206.

[0058] In some dual-mode aspects, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the aspects is not limited in this respect.

[0059] In some aspects, the synthesizer circuitry 206D may be a fractional-N synthesizer or a fractional $N/N+1$ synthesizer, although the scope of the aspects is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 206D may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[0060] The synthesizer circuitry 206D may be configured to synthesize an output frequency for use by the mixer circuitry 206A of the RF circuitry 206 based on a frequency input and a divider control input. In some aspects, the synthesizer circuitry 206D may be a fractional $N/N+1$ synthesizer.

[0061] In some aspects, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 204 or the applications processor 202 depending on the desired output frequency. In some aspects, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 202.

[0062] Synthesizer circuitry 206D of the RF circuitry 206 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some aspects, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some aspects, the DMD may be configured to divide the input signal by either N or $N+1$ (e.g., based on a carry out) to provide a fractional division ratio. In some example aspects, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these aspects, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the

number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[0063] In some aspects, synthesizer circuitry 206D may be configured to generate a carrier frequency as the output frequency, while in other aspects, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some aspects, the output frequency may be a LO frequency (f_{LO}). In some aspects, the RF circuitry 206 may include an IQ/polar converter.

[0064] FEM circuitry 208 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 210, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 206 for further processing. FEM circuitry 208 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 206 for transmission by one or more of the one or more antennas 210. In various aspects, the amplification through the transmit signal paths or the receive signal paths may be done solely in the RF circuitry 206, solely in the FEM 208, or in both the RF circuitry 206 and the FEM 208.

[0065] In some aspects, the FEM circuitry 208 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include an LNA to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 206). The transmit signal path of the FEM circuitry 208 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 206), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 210).

[0066] In some aspects, the PMC 212 may manage power provided to the baseband circuitry 204. In particular, the PMC 212 may control power-source selection, voltage scaling, battery charging, or DC-to-DC conversion. The PMC 212 may often be included when the device 200 is
5 capable of being powered by a battery, for example, when the device is included in a UE. The PMC 212 may increase the power conversion efficiency while providing desirable implementation size and heat dissipation characteristics.

[0067] While FIG. 2 shows the PMC 212 coupled only with the
10 baseband circuitry 204. However, in other aspects, the PMC 212 may be additionally or alternatively coupled with, and perform similar power management operations for, other components such as, but not limited to, application circuitry 202, RF circuitry 206, or FEM 208.

[0068] In some aspects, the PMC 212 may control, or otherwise be
15 part of, various power saving mechanisms of the device 200. For example, if the device 200 is in an RRC_Connected state, where it is still connected to the RAN node as it expects to receive traffic shortly, then it may enter a state known as Discontinuous Reception Mode (DRX) after a period of inactivity. During this state, the device 200 may power down for brief
20 intervals of time and thus save power.

[0069] If there is no data traffic activity for an extended period of time, then the device 200 may transition off to an RRC_Idle state, where it disconnects from the network and does not perform operations such as channel quality feedback, handover, etc. The device 200 goes into a very
25 low power state and it performs paging where again it periodically wakes up to listen to the network and then powers down again. The device 200 may transition back to RRC_Connected state in order to receive data.

[0070] An additional power saving mode may allow a device to be unavailable to the network for periods longer than a paging interval
30 (ranging from seconds to a few hours). During this time, the device is totally unreachable to the network and may power down completely. Any data sent during this time incurs a large delay and it is assumed the delay is acceptable.

[0071] Processors of the application circuitry 202 and processors of the baseband circuitry 204 may be used to execute elements of one or more instances of a protocol stack. For example, processors of the baseband circuitry 204, alone or in combination, may be used execute Layer 3, Layer 2, or Layer 1 functionality, while processors of the application circuitry 204 may utilize data (e.g., packet data) received from these layers and further execute Layer 4 functionality (e.g., transmission communication protocol (TCP) and user datagram protocol (UDP) layers). As referred to herein, Layer 3 may comprise a radio resource control (RRC) layer, described in further detail below. As referred to herein, Layer 2 may comprise a medium access control (MAC) layer, a radio link control (RLC) layer, and a packet data convergence protocol (PDCP) layer, described in further detail below. As referred to herein, Layer 1 may comprise a physical (PHY) layer of a UE/RAN node, described in further detail below.

[0072] FIG. 3 illustrates example interfaces of baseband circuitry in accordance with some aspects. As discussed above, the baseband circuitry 204 of FIG. 2 may comprise processors 204A-204E and a memory 204G utilized by said processors. Each of the processors 204A-204E may include a memory interface, 304A-304E, respectively, to send/receive data to/from the memory 204G.

[0073] The baseband circuitry 204 may further include one or more interfaces to communicatively couple to other circuitries/devices, such as a memory interface 312 (e.g., an interface to send/receive data to/from memory external to the baseband circuitry 204), an application circuitry interface 314 (e.g., an interface to send/receive data to/from the application circuitry 202 of FIG. 2), an RF circuitry interface 316 (e.g., an interface to send/receive data to/from RF circuitry 206 of FIG. 2), a wireless hardware connectivity interface 318 (e.g., an interface to send/receive data to/from Near Field Communication (NFC) components, Bluetooth® components (e.g., Bluetooth® Low Energy), Wi-Fi® components, and other communication components), and a power management interface 320 (e.g., an interface to send/receive power or control signals to/from the PMC 212).

[0074] FIG. 4 is an illustration of a control plane protocol stack in accordance with some aspects. In this aspect, a control plane 400 is shown as a communications protocol stack between the UE 101 (or alternatively, the UE 102), the RAN node 111 (or alternatively, the RAN node 112), and the MME 121.

[0075] The PHY layer 401 may transmit or receive information used by the MAC layer 402 over one or more air interfaces. The PHY layer 401 may further perform link adaptation or adaptive modulation and coding (AMC), power control, cell search (e.g., for initial synchronization and handover purposes), and other measurements used by higher layers, such as the RRC layer 405. The PHY layer 401 may still further perform error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, modulation/demodulation of physical channels, interleaving, rate matching, mapping onto physical channels, and Multiple Input Multiple Output (MIMO) antenna processing.

[0076] The MAC layer 402 may perform mapping between logical channels and transport channels, multiplexing of MAC service data units (SDUs) from one or more logical channels onto transport blocks (TB) to be delivered to PHY via transport channels, de-multiplexing MAC SDUs to one or more logical channels from transport blocks (TB) delivered from the PHY via transport channels, multiplexing MAC SDUs onto TBs, scheduling information reporting, error correction through hybrid automatic repeat request (HARQ), and logical channel prioritization.

[0077] The RLC layer 403 may operate in a plurality of modes of operation, including: Transparent Mode (TM), Unacknowledged Mode (UM), and Acknowledged Mode (AM). The RLC layer 403 may execute transfer of upper layer protocol data units (PDUs), error correction through automatic repeat request (ARQ) for AM data transfers, and concatenation, segmentation and reassembly of RLC SDUs for UM and AM data transfers. The RLC layer 403 may also execute re-segmentation of RLC data PDUs for AM data transfers, reorder RLC data PDUs for UM and AM data transfers, detect duplicate data for UM and AM data transfers, discard RLC

SDUs for UM and AM data transfers, detect protocol errors for AM data transfers, and perform RLC re-establishment.

- [0078] The PDCP layer 404 may execute header compression and decompression of IP data, maintain PDCP Sequence Numbers (SNs),
- 5 perform in-sequence delivery of upper layer PDUs at re-establishment of lower layers, eliminate duplicates of lower layer SDUs at re-establishment of lower layers for radio bearers mapped on RLC AM, cipher and decipher control plane data, perform integrity protection and integrity verification of control plane data, control timer-based discard of data, and perform
- 10 security operations (e.g., ciphering, deciphering, integrity protection, integrity verification, etc.).

- [0079] The main services and functions of the RRC layer 405 may include broadcast of system information (e.g., included in Master Information Blocks (MIBs) or System Information Blocks (SIBs) related to
- 15 the non-access stratum (NAS)), broadcast of system information related to the access stratum (AS), paging, establishment, maintenance and release of an RRC connection between the UE and E-UTRAN (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), establishment, configuration, maintenance and
- 20 release of point to point Radio Bearers, security functions including key management, inter radio access technology (RAT) mobility, and measurement configuration for UE measurement reporting. Said MIBs and SIBs may comprise one or more information elements (IEs), which may each comprise individual data fields or data structures.

- 25 [0080] The UE 101 and the RAN node 111 may utilize a Uu interface (e.g., an LTE-Uu interface) to exchange control plane data via a protocol stack comprising the PHY layer 401, the MAC layer 402, the RLC layer 403, the PDCP layer 404, and the RRC layer 405.

- [0081] The non-access stratum (NAS) protocols 406 form the
- 30 highest stratum of the control plane between the UE 101 and the MME 121. The NAS protocols 406 support the mobility of the UE 101 and the session management procedures to establish and maintain IP connectivity between the UE 101 and the P-GW 123.

- [0082] The S1 Application Protocol (S1-AP) layer 415 may support the functions of the S1 interface and comprise Elementary Procedures (EPs). An EP is a unit of interaction between the RAN node 111 and the CN 120. The S1-AP layer services may comprise two groups: UE-associated services and non UE-associated services. These services perform functions including, but not limited to: E-UTRAN Radio Access Bearer (E-RAB) management, UE capability indication, mobility, NAS signaling transport, RAN Information Management (RIM), and configuration transfer.
- 10 [0083] The Stream Control Transmission Protocol (SCTP) layer (alternatively referred to as the SCTP/IP layer) 414 may ensure reliable delivery of signaling messages between the RAN node 111 and the MME 121 based, in part, on the IP protocol, supported by the IP layer 413. The L2 layer 412 and the L1 layer 411 may refer to communication links (e.g.,
- 15 wired or wireless) used by the RAN node and the MME to exchange information.
- [0084] The RAN node 111 and the MME 121 may utilize an S1-MME interface to exchange control plane data via a protocol stack comprising the L1 layer 411, the L2 layer 412, the IP layer 413, the SCTP
- 20 layer 414, and the S1-AP layer 415.
- [0085] FIG. 5 is an illustration of a user plane protocol stack in accordance with some aspects. In this aspect, a user plane 500 is shown as a communications protocol stack between the UE 101 (or alternatively, the UE 102), the RAN node 111 (or alternatively, the RAN node 112), the S-
- 25 GW 122, and the P-GW 123. The user plane 500 may utilize at least some of the same protocol layers as the control plane 400. For example, the UE 101 and the RAN node 111 may utilize a Uu interface (e.g., an LTE-Uu interface) to exchange user plane data via a protocol stack comprising the PHY layer 401, the MAC layer 402, the RLC layer 403, and the PDCP
- 30 layer 404.
- [0086] The General Packet Radio Service (GPRS) Tunneling Protocol for the user plane (GTP-U) layer 504 may be used for carrying user data within the GPRS core network and between the radio access

network and the core network. The user data transported can be packets in any of IPv4, IPv6, or PPP formats, for example. The UDP and IP security (UDP/IP) layer 503 may provide checksums for data integrity, port numbers for addressing different functions at the source and destination, and encryption and authentication on the selected data flows. The RAN node 111 and the S-GW 122 may utilize an S1-U interface to exchange user plane data via a protocol stack comprising the L1 layer 411, the L2 layer 412, the UDP/IP layer 503, and the GTP-U layer 504. The S-GW 122 and the P-GW 123 may utilize an S5/S8a interface to exchange user plane data via a protocol stack comprising the L1 layer 411, the L2 layer 412, the UDP/IP layer 503, and the GTP-U layer 504. As discussed above with respect to FIG. 4, NAS protocols support the mobility of the UE 101 and the session management procedures to establish and maintain IP connectivity between the UE 101 and the P-GW 123.

[0087] FIG. 6 is a block diagram illustrating components, according to some example aspects, able to read instructions from a machine-readable or computer-readable medium (e.g., a non-transitory machine-readable storage medium) and perform any one or more of the methodologies discussed herein. Specifically, FIG. 6 shows a diagrammatic representation of hardware resources 600 including one or more processors (or processor cores) 610, one or more memory/storage devices 620, and one or more communication resources 630, each of which may be communicatively coupled via a bus 640. For aspects where node virtualization (e.g., NFV) is utilized, a hypervisor 602 may be executed to provide an execution environment for one or more network slices/sub-slices to utilize the hardware resources 600

[0088] The processors 610 (e.g., a central processing unit (CPU), a reduced instruction set computing (RISC) processor, a complex instruction set computing (CISC) processor, a graphics processing unit (GPU), a digital signal processor (DSP) such as a baseband processor, an application specific integrated circuit (ASIC), a radio-frequency integrated circuit (RFIC), another processor, or any suitable combination thereof) may include, for example, a processor 612 and a processor 614.

[0089] The memory/storage devices 620 may include main memory, disk storage, or any suitable combination thereof. The memory/storage devices 620 may include, but are not limited to any type of volatile or non-volatile memory such as dynamic random access memory (DRAM), static random-access memory (SRAM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), Flash memory, solid-state storage, etc.

[0090] The communication resources 630 may include interconnection or network interface components or other suitable devices to communicate with one or more peripheral devices 604 or one or more databases 606 via a network 608. For example, the communication resources 630 may include wired communication components (e.g., for coupling via a Universal Serial Bus (USB)), cellular communication components, NFC components, Bluetooth® components (e.g., Bluetooth® Low Energy), Wi-Fi® components, and other communication components.

[0091] Instructions 650 may comprise software, a program, an application, an applet, an app, or other executable code for causing at least any of the processors 610 to perform any one or more of the methodologies discussed herein. The instructions 650 may reside, completely or partially, within at least one of the processors 610 (e.g., within the processor's cache memory), the memory/storage devices 620, or any suitable combination thereof. Furthermore, any portion of the instructions 650 may be transferred to the hardware resources 600 from any combination of the peripheral devices 604 or the databases 606. Accordingly, the memory of processors 610, the memory/storage devices 620, the peripheral devices 604, and the databases 606 are examples of computer-readable and machine-readable media.

[0092] FIG. 7 illustrates an example communication sequence 700 for a handover with or without the use of a random access channel (RACH) in accordance with some aspects. Referring to FIG. 7, the communication sequence 700, can take place between a UE 702, a source eNB 704, a target eNB 706, and MME 708, and a serving gateway 710, in the context of a 5G communication environment, such as MulteFire or NR-U communication

environment. At 712, at connection establishment, area restrictions can be provided by one or more of the entities 704 – 710. The UE context within the source eNB can include information regarding roaming and access restrictions provided at 712, either at connection establishment or at the last tracking area (TA) update.

[0093] At 714, the source eNB 704 can configure the UE measurement procedures according to the roaming and access restriction information and, e.g., the available multiple frequency band information. Measurements provided by the source eNB 704 may assist the function controlling the UE's connection mobility. At 716, packet data may be communicated/exchanged between the UE 702, source eNB 704, and the serving gateway 710. At 718, source eNB 704 can communicate an uplink location to the UE 702 via L1/L2 signaling.

[0094] At 720, a measurement report can be triggered and sent by the UE 702 to the source eNB 704. At 722, the source eNB 704 can make a decision based on the measurement report and radio resource management (RRM) information from the UE 702 to hand off the UE. At 724, the source eNB 704 can issue a handover (HO) request message to the target eNB 706, passing information to prepare the HO at the target side (e.g., UE X2 signaling context reference at source eNB, UE S1 EPC signaling context reference, target cell ID, K_{eNB^*} , RRC context including the cell radio network temporary identifier (C-RNTI) of the UE 702 in the source eNB 704, AS-configuration, E-UTRAN radio access bearer (E-RAB) context and physical layer ID of the source cell, short MAC-I for possible RLF recovery, and so on). UE X2 / UE S1 signaling references can be used to enable the target eNB 706 to address the source eNB 704 and the EPC. The E-RAB context can include necessary radio network layer (RNL) and transport network layer (TNL) addressing information, and QoS profiles of the E-RABs.

[0095] At 726, admission control may be performed by the target eNB 706 dependent on the received E-RAB QoS information to increase the likelihood of a successful HO, if the resources can be granted by target eNB 706. The target eNB 706 can configure the required resources

according to the received E-RAB QoS information and can reserve a C-RNTI. The AS-configuration to be used in the target cell can either be specified independently (i.e., an "establishment") or as a delta compared to the AS-configuration used in the source cell (i.e., a "reconfiguration").

5 [0096] At 728, the target eNB 706 can prepare a HO with L1/L2 can and send the handover request to acknowledge message to the source eNB 704. The handover request acknowledge message can include a transparent container to be sent to the UE 702 as an RRC message to perform the handover. The container can include a new C-RNTI, target
10 eNB security algorithm identifiers for the selected security algorithms, may include a dedicated RACH preamble, and other parameters such as access parameters, SIBs, etc. If RACH-less HO is configured, the container may include timing adjustment indication and an uplink grant. If an UL grant is not included, the UE 702 can be configured to monitor PDCCH of the
15 target eNB 706 to receive an UL grant. The handover request acknowledge message may also include RNL/TNL information for the forwarding tunnels, if necessary. In instances when Make-Before-Break HO is not configured, as soon as the source eNB 704 receives the handover request acknowledge, or as soon as the transmission of the handover command is
20 initiated in the downlink, data forwarding may be initiated. At 730, source eNB 704 can communicate a downlink a location to the UE 702 using L1/L2 signaling.

 [0097] At 732, the target eNB 706 can generate the RRC message to perform the handover, i.e. RRCConnectionReconfiguration message
25 including the mobilityControlInformation, to be sent by the source eNB 704 to the UE 702. The source eNB 704 can be configured to perform the necessary integrity protection and ciphering of the message.

 [0098] The UE 702 can receive the RRCConnectionReconfiguration message with parameters (i.e., new C-
30 RNTI, target eNB security algorithm identifiers, and optionally, dedicated RACH preamble, target eNB SIBs, etc.), and can be commanded by the source eNB 704 to perform the HO. In instances when RACH-less HO is configured, the RRCConnectionReconfiguration can include timing

adjustment (TA) indication and an uplink grant for access to the target eNB 706. In instances when Make-Before-Break HO is not configured, the UE does not need to delay the handover execution for delivering the HARQ/ARQ responses to source eNB. In instances when Make-Before-Break is configured, the connection can be maintained in the source cell until the UE executes initial uplink transmission to the target eNB. In instances when Make-Before-Break HO is configured, the source eNB 704 can be configured to decide when to stop transmitting to the UE. The target eNB 706 can optionally signal to the source eNB 704 when the UE has completed handover. In some aspects, the UE 702 can be configured with Make-Before-Break and RACH-less HO simultaneously.

[0099] At 734, the source eNB 704 can deliver buffered and in-transit packets to the target eNB 706. At 736 and 740, packet data can be exchanged between the UE 702 and the source eNB 704.

[00100] At 742, the source eNB 704 can send the SN STATUS TRANSFER message to the target eNB 706 to convey the uplink PDCP SN receiver status and the downlink PDCP SN transmitter status of E-RABs for which PDCP status preservation applies (i.e., for RLC AM). The uplink PDCP SN receiver status can include at least the PDCP SN of the first missing UL SDU and may include a bit map of the receive status of the out of sequence UL SDUs that the UE needs to retransmit in the target cell, if there are any such SDUs. The downlink PDCP SN transmitter status can indicate the next PDCP SN that the target eNB shall assign to new SDUs, not having a PDCP SN yet. The source eNB may omit sending this message if none of the E-RABs of the UE shall be treated with PDCP status preservation. At 744, data can be forwarded from the source eNB 704 to the target eNB 706.

[00101] At 748, the UE 702 can detach from the old cell associated with source eNB 704 and synchronize to the new self associated with the target eNB 706. At 750, the target eNB 706 can buffer packets received from the source eNB 704.

[00102] At 752, after receiving the RRCConnectionReconfiguration message including the mobilityControlInformation, the UE 702 can

perform synchronization to the target eNB 706 and accesses the target cell, via RACH (if RACH-less HO is not configured), following a contention-free procedure if a dedicated RACH preamble was indicated in the mobilityControlInformation, or following a contention-based procedure if
5 no dedicated preamble was indicated, or via PUSCH if RACH-less HO is configured. The UE 702 can be configured to derive target eNB 706 specific keys and can configure the selected security algorithms to be used in the target cell.

[00103] At 754, in instances when RACH-less HO is not configured, the target eNB 706 can respond with UL allocation and timing advance
10 information. At 738 and 746, in instances when RACH-less HO is configured, the target eNB 706 may send an UL grant to the UE 702 indicated in the RRCConnectionReconfiguration message. In instances when the UE 702 does not get the UL grant from RRC signaling, the UE
15 can be configured to monitor the PDCCH of the target eNB 706 for UL grant.

[00104] At 736, when the UE 702 has successfully accessed the target cell, the UE 702 can be configured to send a handover completion confirmation/acknowledgment message, such as
20 RRCConnectionReconfigurationComplete message (including a C-RNTI), to confirm the handover, along with an uplink Buffer Status Report, whenever possible, to the target eNB 706 to indicate that the handover procedure is completed for the UE 702. The target eNB 706 can be configured to verify the C-RNTI sent in the
25 RRCConnectionReconfigurationComplete message. The target eNB 706 can then begin sending data to the UE 702 as indicated at 758.

[00105] At 760, the target eNB 706 can communicate a path switch request to the MME 708. At 762, the MME 708 can send a modify bearer request to the serving gateway 710. At 764, the serving gateway 710 can
30 switch a downlink path and communicate in and marker to the source eNB 704, at 766. After packet data is communicated at 768 between the target eNB 706 and the serving gateway 710, an end marker can be communicated at 770 from the source eNB 704 to the target eNB 706. At

772, a modify bearer response is communicated from the serving gateway 710 to the MME 708. At 774, a path switch request acknowledgment is communicated from the MME 708 to the target eNB 706. At 776, a UE context release is communicated from the target eNB 706 to the source eNB 704, and at 778 the source eNB 704 releases the UE resources, completing the handover.

[00106] In some aspects, various techniques (e.g. as described herein below) can be used in 5G communication environments (e.g. MulteFire or NR-U communication environments) can be used to enable RACH-less handover as well as to communicate the handover completion confirmation message (e.g., the RRCConnectionReconfigurationComplete message at 756) from the UE 702 to the target eNB 706.

[00107] FIG. 8 illustrates various resource types, which can be used to communicate a handover completion acknowledgement in accordance with some aspects. In some aspects, to enable RACH-less handover in MulteFire or new radio – unlicensed (NR-U) communication environment, configuration information (e.g., mobilityControlInformation carried by RRCConnectionReconfiguration as depicted in step 732 in FIG. 7) can be modified to indicate, e.g., the target eNB (e.g., an identification of the target eNB), the type of RACH procedure, and the resource type (e.g., resource used to communicate handover completion confirmation in step 756, where the resource can include (1) RRC-configured periodic non-anchor subframe, (2) an RRC-configured floating sPUCCH grant with cPDCCH monitoring, or (3) no RRC configured periodic resource with dynamic determination of an uplink resource). The RRC message communicated at step 732 can also contain other configuration information, such as a common TA (e.g., 192), an LBT type (e.g., 194), and so forth.

[00108] In some aspects, the RRCConnectionReconfigurationComplete message can be used (e.g., at 756) to confirm the successful completion of an RRC connection reconfiguration. In some aspects, the message can be sent using sPUCCH format 1, 2, or 3 resource as defined in MulteFire, or short-PUCCH format as defined in NR-U. For each sPUCCH format, the content in the

RRConnectionReconfigurationComplete message can vary, as explained herein below in reference to FIG. 8. The message size can be kept small with only mandatory content and limited optional fields. In case the message is send using ePUCCH defined in MulteFire, or long-PUCCH defined in NR-U, or PUSCH, larger size with more optional fields can be used.

[00109] Communication Resource (1): RRC-configured periodic non-anchor subframe allocation with sPUCCH format 1, 2, or 3.

[00110] Referring to FIG. 8, an example RRC-configured periodic non-anchor subframe allocation using SPUCCH is illustrated at 800. More specifically, SPUCCH resources 802, 804, 806, and 808 can be used to communicate the RRC connection reconfiguration complete message at step 756 in FIG. 7.

[00111] In example aspects associated with, e.g., MulteFire communication systems, the RACH channel can be configured using sPUCCH format 0, where 1 or 2 interlaces per RACH can be configured, and orthogonal cover code (OCC), cyclic delay diversity (CDD) and different root sequence can be used.

[00112] In in some aspects when a RACH-less handover is used, additional interlaces with new sPUCCH format 1 can be configured. The sPUCCH format 1 includes two demodulation reference signal (DMRS) symbols and two data symbols, which can be utilized for RRConnectionReconfigurationComplete message transmission. In some aspects, a total of two sPUCCH can be allocated per interlace. The source eNB can be configured to notify the exact resource including DMRS configuration, interlace index and OCC to the UE through a configuration information transmission, such as a mobilityControlInformation information element (IE).

[00113] FIG. 9 illustrates example physical uplink control channel (PUCCH) resources, which can be used in a MulteFire or new radio -- unlicensed (NR-U) communication environment in accordance with some aspects. Referring to FIG. 9, there is illustrated an interlace 900, which can include 10 resource blocks (RBs) 902, 904, 906, 908, 910, 912, 914, 916,

918, and 920. Example SPUCCH resources are illustrated at 930 and 940. More specifically, the SPUCCH resource 930 can be used with a MulteFire communication system, while the SPUCCH resource 940 can be used in an NR-U communication system. The SPUCCH resource 930 can include two
5 DMRS symbols 932 and two data tone symbols 934. In some aspects, an orthogonal cover code (OCC) can be used to locate the SPUCCH resources within the interlace 900 (the interlace index and OCC can be used to locate the SPUCCH resources). In some aspects, the DMRS symbols 932 can serve as a RACH preamble as well as a reference signal for data estimation.

10 [00114] Referring again to FIG. 8 and FIG. 9, in some aspects, the SPUCCH format 2 can be adopted to carry the RRCConnectionReconfigurationComplete message in step 756 in FIG. 7. In this case, four SPUCCH format 2 entries can be contained within one interlace (e.g., 900), and a length-2 OCC can be applied on two adjacent
15 data symbols. In addition, length-2 inter-symbol OCC is applied. The source eNB can be configured to notify the exact resource configuration including DMRS configuration, interlace and inter/intra OCC to UE through configuration information transmission, such as a mobilityControlInformation IE.

20 [00115] In some aspects, the SPUCCH format 3 can be adopted to carry the RRCConnectionReconfigurationComplete message. In this case, twelve PUCCH format 3 resources can be contained within one interlace, and a length-6 OCC can be applied on two adjacent data symbols. In some aspects, a length-2 intra-symbol OCC can be applied. The source eNB can
25 be configured to notify the exact resource configuration including DMRS configuration, interlace and inter/intra OCC to the UE through, e.g., a mobilityControlInformation IE. In instances when SPUCCH format 3 is configured, the RRCConnectionReconfigurationComplete message size can be the smallest in comparison to instances when SPUCCH formats 1 and 2
30 are used.

[00116] In some aspects, a NR-U SPUCCH format can be used to carry the RRCConnectionReconfigurationComplete message. As seen in FIG. 9, the SPUCCH format 940, which can be used in a NR-U

communication system, can include DMRS symbols 942 and data tones 944.

[00117] In some aspects, UE transmission of the RRCConnectionReconfigurationComplete message on the periodic non-anchor subframe can follow a RACH transmission, after a single shot LBT. In another aspect, UE transmission of the RRCConnectionReconfigurationComplete message can be followed by a CAT-4 LBT priority class 1.

[00118] In instances when the communication resource used in step 756 in FIG. 7 includes RRC-configured periodic non-anchor subframe allocation with sPUCCH format 1, 2, or 3, the UE does not need to monitor the CPDCCH or PDCCH during RACH-less handover.

[00119] **Communication Resource (2):** An RRC-configured floating SPUCCH grant with CPDCCH monitoring.

[00120] In some aspects, as illustrated at 810 in FIG. 8, periodic allocation of SPUCCH format can be performed with a window. More specifically, the source eNB can configure the UE with a floating SPUCCH grant. The configuration can include a nominal periodicity, offset, and a window size, and can be communicated via a mobility control IE. For example, the UE can monitor the target cell's CPDCCH (e.g., 812, 816, and 820) to identify the SPUCCH locations (e.g., 814, 818, and 822) within the window, and then transmit using the identified SPUCCH resource.

[00121] In some aspects, the source eNB can also configure the LBT type for the UE to send the RRCConnectionReconfigurationComplete message. In some aspects, no LBT or 25us one shot LBT can be configured. In instances when no LBT is configured, the target cell eNB can configure the DL/UL gap to be within 16us.

[00122] In instances when periodic allocation of SPUCCH format is performed with a window (i.e., determining a communication resource as illustrated at 810), the UE needs to monitor CPDCCH before transmission of the RRCConnectionReconfigurationComplete message.

[00123] **Communication Resource (3):** No RRC-configured periodic resource with dynamic determination of an uplink resource.

[00124] In some aspects, the UE can be configured to monitor target cell's CPDCCH and PDCCH to determine an EPUCCH resource based on the PDCCH monitoring (e.g., using downlink control information (DCI) in the PDCCH). In instances when the source eNB does not configure periodic resource specified with either fixed location or floating location, the UE can monitor the target cell for an EPUCCH allocation using, e.g., DCI. For example and as seen at 830 in FIG. 8, the UE can monitor the PDCCH 832 (e.g., DCI within the PDCCH) to determine the EPUCCH resource 834. The target cell eNB can send the grant within a configured period of time. In some aspects, a T304 timer can be reused, which can start when the UE receives RRCConnectionReconfiguration that includes mobility control information, and stop when the MAC layer completes the first PUSCH transmission. In some aspects, the UE can perform an LBT following the EPUCCH 834 allocation indication.

[00125] In some aspects, an NR-U long-PUCCH format can be adopted to carry the RRCConnectionReconfigurationComplete message.

[00126] In some aspects, the UE can be configured to monitor target cell's CPDCCH and PDCCH to determine a PUSCH resource (e.g., 834) based on the PDCCH (e.g., 832) monitoring (e.g., using downlink control information (DCI) in the PDCCH).

[00127] In instances when the source eNB does not configure periodic resource specified with either fixed location or floating location, the UE can monitor the target cell for a PUSCH allocation using, e.g., DCI. The target cell eNB can send the grant within a configured period of time. In some aspects, a T304 timer can be reused, which can start when the UE receives the RRCConnectionReconfiguration that include mobility control information, and stop when the MAC layer completes the first PUSCH transmission.

[00128] In some aspects, an NR-U PUSCH format can be adapted to carry the RRCConnectionReconfigurationComplete message.

[00129] In some aspects, either one stage grant or two stage grants can be used to schedule the RRCConnectionReconfigurationComplete message transmission. The UE can be configured to perform an LBT

procedure following the PUSCH allocation indication. Since the PUSCH allocation can carry many bits, it is also possible to use other MAC messages, such as buffer status reports, to carry the handover completion notification.

5 **[00130]** FIG. 10 is a flow diagram illustrating example functionalities for performing RACH-less handover and communicating a confirmation message in accordance with some aspects. Referring to FIG. 10, the example method 1000 can start at 1002, when a radio resource control (RRC) Connection Reconfiguration (RRCR) message can be
10 decoded at the UE. For example, the RRCR can be received at step 732 from the source eNB 704, as seen in FIG. 7. The RRCR message can include a handover configuration and a resource type for communicating acknowledgement information using an unlicensed wireless band. At 1004, a random access channel (RACH)-less handover from a source evolved
15 Node-B (eNB) to a target eNB can be initiated based on, e.g., a common timing adjustment (TA) information within the handover configuration. At 1006, an uplink resource can be selected on the unlicensed wireless band based on the resource type information indicated by the RRCR message (e.g., as described in reference to FIG. 8 and FIG. 9 above). At 1008, a
20 confirmation message indicating completion of the RACH-less handover can be encoded for transmission to the target eNB on the unlicensed wireless band using the selected uplink resource (e.g., as communicated in step 756 in FIG. 7).

[00131] FIG. 11 illustrates a block diagram of a communication
25 device such as an evolved Node-B (eNB), a new generation Node-B (gNB), an access point (AP), a wireless station (STA), or a user equipment (UE), in accordance with some aspects. In alternative aspects, the communication device 1100 may operate as a standalone device or may be connected (e.g., networked) to other communication devices. In a networked deployment,
30 the communication device 1100 may operate in the capacity of a server communication device, a client communication device, or both in server-client network environments. In an example, the communication device 1100 may act as a peer communication device in peer-to-peer (P2P) (or

other distributed) network environment. The communication device 1100 may be a UE, eNB, PC, a tablet PC, a STB, a PDA, a mobile telephone, a smart phone, a web appliance, a network router, switch or bridge, or any communication device capable of executing instructions (sequential or
5 otherwise) that specify actions to be taken by that communication device. Further, while only a single communication device is illustrated, the term "communication device" shall also be taken to include any collection of communication devices that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the
10 methodologies discussed herein, such as cloud computing, software as a service (SaaS), other computer cluster configurations.

[00132] Examples, as described herein, may include, or may operate on, logic or a number of components, modules, or mechanisms. Modules are tangible entities (e.g., hardware) capable of performing specified
15 operations and may be configured or arranged in a certain manner. In an example, circuits may be arranged (e.g., internally or with respect to external entities such as other circuits) in a specified manner as a module. In an example, the whole or part of one or more computer systems (e.g., a standalone, client or server computer system) or one or more hardware
20 processors may be configured by firmware or software (e.g., instructions, an application portion, or an application) as a module that operates to perform specified operations. In an example, the software may reside on a communication device readable medium. In an example, the software, when executed by the underlying hardware of the module, causes the
25 hardware to perform the specified operations.

[00133] Accordingly, the term "module" is understood to encompass a tangible entity, be that an entity that is physically constructed, specifically configured (e.g., hardwired), or temporarily (e.g., transitorily) configured (e.g., programmed) to operate in a specified manner or to perform part or
30 all of any operation described herein. Considering examples in which modules are temporarily configured, each of the modules need not be instantiated at any one moment in time. For example, where the modules comprise a general-purpose hardware processor configured using software,

the general-purpose hardware processor may be configured as respective different modules at different times. Software may accordingly configure a hardware processor, for example, to constitute a particular module at one instance of time and to constitute a different module at a different instance of time.

5 [00134] Communication device (e.g., UE) 1100 may include a hardware processor 1102 (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory 1104 and a static memory 1106, some or all of which may communicate with each other via an interlink (e.g., bus) 1108. 10 The communication device 1100 may further include a display unit 1110, an alphanumeric input device 1112 (e.g., a keyboard), and a user interface (UI) navigation device 1114 (e.g., a mouse). In an example, the display unit 1110, input device 1112 and UI navigation device 1114 may be a touch 15 screen display. The communication device 1100 may additionally include a storage device (e.g., drive unit) 1116, a signal generation device 1118 (e.g., a speaker), a network interface device 1120, and one or more sensors 1121, such as a global positioning system (GPS) sensor, compass, accelerometer, or other sensor. The communication device 1100 may 20 include an output controller 1128, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate or control one or more peripheral devices (e.g., a printer, card reader, etc.).

[00135] The storage device 1116 may include a communication 25 device readable medium 1122 on which is stored one or more sets of data structures or instructions 1124 (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions 1124 may also reside, completely or at least partially, within the main memory 1104, within static memory 1106, or within the hardware 30 processor 1102 during execution thereof by the communication device 1100. In an example, one or any combination of the hardware processor 1102, the main memory 1104, the static memory 1106, or the storage device 1116 may constitute communication device readable media.

[00136] While the communication device readable medium 1122 is illustrated as a single medium, the term "communication device readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions 1124.

[00137] The term "communication device readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the communication device 1100 and that cause the communication device 1100 to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding or carrying data structures used by or associated with such instructions. Non-limiting communication device readable medium examples may include solid-state memories, and optical and magnetic media. Specific examples of communication device readable media may include: non-volatile memory, such as semiconductor memory devices (e.g., Electrically Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; Random Access Memory (RAM); and CD-ROM and DVD-ROM disks. In some examples, communication device readable media may include non-transitory communication device readable media. In some examples, communication device readable media may include communication device readable media that is not a transitory propagating signal.

[00138] The instructions 1124 may further be transmitted or received over a communications network 1126 using a transmission medium via the network interface device 1120 utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communication networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), Plain Old Telephone (POTS) networks, and wireless data networks (e.g., Institute of

Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®, IEEE 802.15.4 family of standards, a Long Term Evolution (LTE) family of standards, a Universal Mobile Telecommunications System (UMTS) family of standards, peer-to-peer (P2P) networks, among others. In an example, the network interface device 1120 may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network 1126. In an example, the network interface device 1120 may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), MIMO, or multiple-input single-output (MISO) techniques. In some examples, the network interface device 1120 may wirelessly communicate using Multiple User MIMO techniques. The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the communication device 1100, and includes digital or analog communications signals or other intangible medium to facilitate communication of such software.

[00139] Additional notes and examples:

[00140] Example 1 is an apparatus of a user equipment (UE), the apparatus comprising: processing circuitry, the processing circuitry configured to: decode a configuration message to initiate a random access channel (RACH)-less handover on an unlicensed wireless band from a source evolved Node-B (eNB) to a target eNB, the configuration message including an uplink grant information and a resource type information; encode synchronization information for transmission to the target eNB using a first uplink resource indicated by the uplink grant information; select a second uplink resource on the unlicensed wireless band based on the resource type information; and encode a confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the second uplink resource; and memory coupled to the processing circuitry, the memory configured to store the resource type information.

[00141] In Example 2, the subject matter of Example 1 includes, wherein the configuration message is a radio resource control (RRC) Connection Reconfiguration (RRCConnectionReconfiguration) message, and the first uplink resource is a physical uplink shared channel (PUSCH).

5 [00142] In Example 3, the subject matter of Examples 1–2 includes, wherein the configuration message further includes common timing adjustment (TA) information for transmitting the synchronization information to the target eNB.

[00143] In Example 4, the subject matter of Examples 1–3 includes, 10 wherein the configuration message further includes an indication of a type of random access channel (RACH) procedure, and wherein the processing circuitry is configured to initiate the RACH-less handover based on the indication of the RACH procedure type.

[00144] In Example 5, the subject matter of Examples 1–4 includes, 15 wherein the confirmation message is a Radio Resource Control Connection Reconfiguration Complete (RRCConnectionReconfigurationComplete) message.

[00145] In Example 6, the subject matter of Examples 1–5 includes, wherein the resource type information is one of: a radio resource control 20 (RRC)-configured periodic non-anchor subframe; a RRC-configured floating physical uplink control channel (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and a non-RRC configured periodic resource.

[00146] In Example 7, the subject matter of Example 6 includes, 25 wherein when the resource type information is the RRC-configured periodic non-anchor subframe, the processing circuitry is configured to: decode a control information element (IE) within the configuration message to determine a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC).

30 [00147] In Example 8, the subject matter of Example 7 includes, wherein the control IE is a mobilityControlInformation IE.

[00148] In Example 9, the subject matter of Examples 7–8 includes, wherein the processing circuitry is further configured to: determine a shorter physical uplink control channel (sPUCCH) resource based on the

interlace index and the OCC code; and encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the determined sPUCCH resource.

[00149] In Example 10, the subject matter of Example 9 includes,
5 wherein the sPUCCH resource is one of a sPUCCH format 1, sPUCCH format 2, or sPUCCH format 3 resource.

[00150] In Example 11, the subject matter of Example 10 includes, wherein when the sPUCCH resource comprises the sPUCCH format 2 resource, the OCC is a length-2 OCC.

10 [00151] In Example 12, the subject matter of Examples 10–11 includes, wherein when the sPUCCH resource comprises the sPUCCH format 3 resource, the OCC is a length-6 OCC.

[00152] In Example 13, the subject matter of Examples 10–12 includes, wherein the short-PUCCH resource includes a modified sPUCCH
15 format 2 resource as defined in NR-U.

[00153] In Example 14, the subject matter of Examples 1–13 includes, wherein the configuration message further includes a listen-before-talk (LBT) procedure type, and the processing circuitry is further configured to: perform an LBT procedure of the LBT procedure type prior
20 to transmission of the confirmation message.

[00154] In Example 15, the subject matter of Examples 6–14 includes, wherein when the resource type information is the RRC-configured floating PUCCH resource with PDCCH monitoring, the processing circuitry is configured to: decode a control information element
25 (IE) within the configuration message to determine a nominal periodicity, a timing offset, and a window size; monitor a timing window with the window size within a common PDCCH (cPDCCH) of a target cell associated with the target eNB based on the nominal periodicity, to identify a shorter PUCCH (sPUCCH) resource; and encode the confirmation
30 message indicating completion of the RACH-less handover for transmission to the target eNB using the identified sPUCCH resource and based on the timing offset.

[00155] In Example 16, the subject matter of Examples 6–15 includes, wherein when the resource type information is the non-RRC

configured periodic resource, the processing circuitry is configured to:
 monitor a PDCCH of a target cell associated with the target eNB to detect a
 PUCCH allocation; and encode the confirmation message indicating
 completion of the RACH-less handover for transmission to the target eNB
 5 using the detected PUCCH allocation.

[00156] In Example 17, the subject matter of Example 16 includes,
 wherein the processing circuitry is configured to: detect the PUCCH
 allocation within downlink control information (DCI) received via the
 monitored PDCCH.

10 [00157] In Example 18, the subject matter of Examples 16–17
 includes, wherein the PUCCH allocation is a MulteFire extended PUCCH
 (ePUCCH) allocation or an NR-U long-PUCCH allocation.

[00158] In Example 19, the subject matter of Examples 6–18
 includes, wherein when the resource type information is the non-RRC
 15 configured periodic resource, the processing circuitry is configured to:
 monitor a PDCCH of a target cell associated with the target eNB to detect a
 PUSCH allocation; and encode the confirmation message indicating
 completion of the RACH-less handover for transmission to the target eNB
 using the detected PUSCH allocation.

20 [00159] In Example 20, the subject matter of Example 19 includes,
 wherein the PUSCH allocation is a new radio – unlicensed (NR-U) PUSCH
 allocation.

[00160] In Example 21, the subject matter of Examples 1–20
 includes, transceiver circuitry coupled to the processing circuitry; and, one
 25 or more antennas coupled to the transceiver circuitry.

[00161] Example 22 is a non-transitory computer-readable storage
 medium that stores instructions for execution by one or more processors of
 a user equipment (UE), the instructions to configure the one or more
 processors to cause the UE to: decode a radio resource control (RRC)
 30 Connection Reconfiguration (RRCR) message, the RRCR message
 including a handover configuration and a resource type for communicating
 acknowledgement information using an unlicensed wireless band; initiate a
 random access channel (RACH)-less handover from a source evolved
 Node-B (eNB) to a target eNB based on common timing adjustment (TA)

information within the handover configuration; select an uplink resource on the unlicensed wireless band based on the resource type information indicated by the RRCCR message; and encode a confirmation message indicating completion of the RACH-less handover for transmission to the target eNB on the unlicensed wireless band using the selected uplink resource.

[00162] In Example 23, the subject matter of Example 22 includes, wherein the resource type is one of: a radio resource control (RRC)-configured periodic non-anchor subframe; a RRC-configured floating physical uplink control channel (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and a non-RRC configured periodic resource.

[00163] In Example 24, the subject matter of Example 23 includes, wherein when the resource type is the RRC-configured periodic non-anchor subframe, the one or more processors further cause the UE to: decode a control information element (IE) within the RRCCR message to determine a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC); determine a shorter physical uplink control channel (sPUCCH) resource based on the interlace index and the OCC code; and encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the determined sPUCCH resource.

[00164] In Example 25, the subject matter of Examples 23–24 includes, wherein when the resource type information is the RRC-configured floating PUCCH resource with PDCCH monitoring, the one or more processors further cause the UE to: decode a control information element (IE) within the RRCCR message to determine a nominal periodicity, a timing offset, and a window size; monitor a timing window with the window size within a common PDCCH (cPDCCH) of a target cell associated with the target eNB based on the nominal periodicity, to identify a shorter PUCCH (sPUCCH) resource; and encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the identified sPUCCH resource and based on the timing offset.

[00165] In Example 26, the subject matter of Examples 23–25 includes, wherein when the resource type information is the non-RRC configured periodic resource, the one or more processors further cause the UE to: monitor a PDCCH of a target cell associated with the target eNB to
5 detect a PUCCH allocation; and encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the detected PUCCH allocation.

[00166] In Example 27, the subject matter of Example 26 includes, wherein the one or more processors further cause the UE to: detect the
10 PUCCH allocation within downlink control information (DCI) received via the monitored PDCCH.

[00167] In Example 28, the subject matter of Examples 26–27 includes, wherein the PUCCH allocation is an extended PUCCH (ePUCCH) allocation.

[00168] In Example 29, the subject matter of Examples 23–28 includes, wherein when the resource type information is the non-RRC configured periodic resource, the one or more processors further cause the UE to: monitor a PDCCH of a target cell associated with the target eNB to
15 detect a PUSCH allocation; and encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the detected PUSCH allocation.

[00169] Example 30 is an apparatus of a target Node-B (NB), the apparatus comprising: memory; and processing circuitry, configured to: encode a handover acknowledgement message for transmission to a source
25 NB, in response to a handover request; encode a radio resource control (RRC) Connection Reconfiguration (RRCR) message, the RRCR message including a handover configuration for a random access channel (RACH)-less handover and a resource type for communicating acknowledgement information using an unlicensed wireless band; decode
30 an acknowledgement message indicating completion of the RACH-less handover, the acknowledgement message received on the unlicensed wireless band via an uplink resource associated with the resource type indicated in the RRCR message; and encode packet data for transmission on the unlicensed wireless band.

[00170] In Example 31, the subject matter of Example 30 includes, wherein the resource type is one of: a RRC-configured periodic non-anchor subframe; a RRC-configured floating physical uplink control channel (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and a non-RRC configured periodic resource.

[00171] In Example 32, the subject matter of Example 31 includes, wherein when the resource type is the RRC-configured periodic non-anchor subframe, the processing circuitry is further configured to: encode a control information element (IE) within the RRCCR message, the control IE including a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC); and reserve a shorter physical uplink control channel (sPUCCH) resource corresponding to the interlace index and the OCC code; wherein the acknowledgement message indicating completion of the RACH-less handover is received via the reserved sPUCCH resource.

[00172] In Example 33, the subject matter of Examples 31–32 includes, wherein when the resource type information is the RRC-configured floating PUCCH resource with PDCCH monitoring, the processing circuitry is further configured to: encode a control information element (IE) within the RRCCR message, the control IE including a nominal periodicity and a window size; and encode for periodic transmission a common PDCCH (cPDCCH) based on the nominal periodicity, the cPDCCH identifying a shorter PUCCH (sPUCCH) resource within a timing window of the window size; wherein the acknowledgement message indicating completion of the RACH-less handover is received via the sPUCCH resource.

[00173] In Example 34, the subject matter of Examples 31–33 includes, wherein when the resource type information is the non-RRC configured periodic resource, the processing circuitry is further configured to: encode downlink control information (DCI) for transmission on a PDCCH, the DCI including a PUCCH allocation for an uplink resource; wherein the acknowledgement message indicating completion of the RACH-less handover is received via the PUCCH allocation.

[00174] In Example 35, the subject matter of Examples 30–34 includes, wherein the NB is one of a Next Generation Node-B (gNB) or an Evolved Node-B (eNB).

[00175] Example 36 is an apparatus of a user equipment (UE), the
5 apparatus comprising: means for decoding a radio resource control (RRC) Connection Reconfiguration (RRCR) message, the RRCR message including a handover configuration and a resource type for communicating acknowledgement information using an unlicensed wireless band; means
10 for initiating a random access channel (RACH)-less handover from a source evolved Node-B (eNB) to a target eNB based on common timing adjustment (TA) information within the handover configuration; means for selecting an uplink resource on the unlicensed wireless band based on the resource type information indicated by the RRCR message; and means for
15 encoding a confirmation message indicating completion of the RACH-less handover for transmission to the target eNB on the unlicensed wireless band using the selected uplink resource.

[00176] In Example 37, the subject matter of Example 36 includes, wherein the resource type is one of: a radio resource control (RRC)-configured periodic non-anchor subframe; a RRC-configured floating
20 physical uplink control channel (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and a non-RRC configured periodic resource.

[00177] In Example 38, the subject matter of Example 37 includes, wherein when the resource type is the RRC-configured periodic non-anchor
25 subframe, the apparatus further comprises: means for decoding a control information element (IE) within the RRCR message to determine a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC); means for determining a shorter physical uplink control channel (sPUCCH) resource based on the interlace
30 index and the OCC code; and means for encoding the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the determined sPUCCH resource.

[00178] In Example 39, the subject matter of Examples 37–38 includes, wherein when the resource type information is the RRC-

configured floating PUCCH resource with PDCCH monitoring, the apparatus further comprises: means for decoding a control information element (IE) within the RRCR message to determine a nominal periodicity, a timing offset, and a window size; means for monitoring a
5 timing window with the window size within a common PDCCH (cPDCCH) of a target cell associated with the target eNB based on the nominal periodicity, to identify a shorter PUCCH (sPUCCH) resource; and means for encoding the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the identified
10 sPUCCH resource and based on the timing offset.

[00179] In Example 40, the subject matter of Examples 37–39 includes, wherein when the resource type information is the non-RRC configured periodic resource, the apparatus further comprises: means for monitoring a PDCCH of a target cell associated with the target eNB to
15 detect a PUCCH allocation; and means for encoding the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the detected PUCCH allocation.

[00180] In Example 41, the subject matter of Example 40 includes, the apparatus further comprising: means for detecting the PUCCH
20 allocation within downlink control information (DCI) received via the monitored PDCCH.

[00181] In Example 42, the subject matter of Examples 40–41 includes, wherein the PUCCH allocation is an extended PUCCH (ePUCCH) allocation.

25 [00182] Example 43 is at least one machine-readable medium including instructions that, when executed by processing circuitry, cause the processing circuitry to perform operations to implement of any of Examples 1–42.

[00183] Example 44 is an apparatus comprising means to implement
30 of any of Examples 1–42.

[00184] Example 45 is a system to implement of any of Examples 1–42.

[00185] Example 46 is a method to implement of any of Examples 1–42.

[00186] Although an aspect has been described with reference to specific example aspects, it will be evident that various modifications and changes may be made to these aspects without departing from the broader scope of the present disclosure. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof show, by way of illustration, and not of limitation, specific aspects in which the subject matter may be practiced. The aspects illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other aspects may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various aspects is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

[00187] Such aspects of the inventive subject matter may be referred to herein, individually and/or collectively, merely for convenience and without intending to voluntarily limit the scope of this application to any single aspect or inventive concept if more than one is in fact disclosed. Thus, although specific aspects have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific aspects shown. This disclosure is intended to cover any and all adaptations or variations of various aspects. Combinations of the above aspects, and other aspects not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

[00188] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single aspect for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed aspects require more features than are expressly recited in each claim.

Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed aspect. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate aspect.

5

CLAIMS

What is claimed is:

1. An apparatus of a user equipment (UE), the apparatus comprising:
 5 processing circuitry, the processing circuitry configured to:
 decode a configuration message to initiate a random access
 channel (RACH)-less handover on an unlicensed wireless band
 from a source evolved Node-B (eNB) to a target eNB, the
 configuration message including an uplink grant information and a
 10 resource type information;
 encode synchronization information for transmission to the
 target eNB using a first uplink resource indicated by the uplink
 grant information;
 select a second uplink resource on the unlicensed wireless
 15 band based on the resource type information; and
 encode a confirmation message indicating completion of the
 RACH-less handover for transmission to the target eNB using the
 second uplink resource; and
 memory coupled to the processing circuitry, the memory configured
 20 to store the resource type information.
2. The apparatus of claim 1, wherein the configuration message is a
 radio resource control (RRC) Connection Reconfiguration
 (RRCConnectionReconfiguration) message, and the first uplink resource is
 25 a physical uplink shared channel (PUSCH).
3. The apparatus of any of claims 1–2, wherein the configuration
 message further includes common timing adjustment (TA) information for
 transmitting the synchronization information to the target eNB.

30

4. The apparatus of any of claims 1–2, wherein the configuration message further includes an indication of a type of random access channel (RACH) procedure, and wherein the processing circuitry is configured to initiate the RACH-less handover based on the indication of the RACH procedure type.

5. The apparatus of any of claims 1–2, wherein the confirmation message is a Radio Resource Control Connection Reconfiguration Complete (RRCConnectionReconfigurationComplete) message.

6. The apparatus of any of claims 1–2, wherein the resource type information is one of:

- a radio resource control (RRC)-configured periodic non-anchor subframe;
- a RRC-configured floating physical uplink control channel (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and
- a non-RRC configured periodic resource.

7. The apparatus of claim 6, wherein when the resource type information is the RRC-configured periodic non-anchor subframe, the processing circuitry is configured to:

- decode a control information element (IE) within the configuration message to determine a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC).

8. The apparatus of claim 7, wherein the control IE is a mobilityControlInformation IE.

9. The apparatus of claim 7, wherein the processing circuitry is further configured to:
- determine a shorter physical uplink control channel (sPUCCH) resource based on the interlace index and the OCC code; and
 - 5 encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the determined sPUCCH resource.
10. The apparatus of claim 9, wherein the sPUCCH resource is one of a
10 sPUCCH format 1, sPUCCH format 2, or sPUCCH format 3 resource.
11. The apparatus of claim 10, wherein when the sPUCCH resource comprises the sPUCCH format 2 resource, the OCC is a length-2 OCC.
- 15 12. The apparatus of claim 10, wherein when the sPUCCH resource comprises the sPUCCH format 3 resource, the OCC is a length-6 OCC.
13. The apparatus of claim 10, wherein the short-PUCCH resource includes a modified sPUCCH format 2 resource as defined in NR-U.
20
14. The apparatus of any of claims 1–2, wherein the configuration message further includes a listen-before-talk (LBT) procedure type, and the processing circuitry is further configured to:
- perform an LBT procedure of the LBT procedure type prior to
25 transmission of the confirmation message.

15. The apparatus of claim 6, wherein when the resource type information is the RRC-configured floating PUCCH resource with PDCCH monitoring, the processing circuitry is configured to:

5 decode a control information element (IE) within the configuration message to determine a nominal periodicity, a timing offset, and a window size;

monitor a timing window with the window size within a common PDCCH (cPDCCH) of a target cell associated with the target eNB based on the nominal periodicity, to identify a shorter PUCCH (sPUCCH) resource;

10 and

encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the identified sPUCCH resource and based on the timing offset.

15 16. The apparatus of claim 6, wherein when the resource type information is the non-RRC configured periodic resource, the processing circuitry is configured to:

monitor a PDCCH of a target cell associated with the target eNB to detect a PUCCH allocation; and

20 encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the detected PUCCH allocation.

17. The apparatus of claim 16, wherein the processing circuitry is
25 configured to:

detect the PUCCH allocation within downlink control information (DCI) received via the monitored PDCCH.

18. A non-transitory computer-readable storage medium that stores instructions for execution by one or more processors of a user equipment (UE), the instructions to configure the one or more processors to cause the UE to:

- 5 decode a radio resource control (RRC) Connection Reconfiguration (RRCR) message, the RRCR message including a handover configuration and a resource type for communicating acknowledgement information using an unlicensed wireless band;
 - initiate a random access channel (RACH)-less handover from a
 - 10 source evolved Node-B (eNB) to a target eNB based on common timing adjustment (TA) information within the handover configuration;
 - select an uplink resource on the unlicensed wireless band based on the resource type information indicated by the RRCR message; and
 - encode a confirmation message indicating completion of the
 - 15 RACH-less handover for transmission to the target eNB on the unlicensed wireless band using the selected uplink resource.

19. The non-transitory computer-readable storage medium of claim 18, wherein the resource type is one of:

- 20 a radio resource control (RRC)-configured periodic non-anchor subframe;
 - a RRC-configured floating physical uplink control channel (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and
 - 25 a non-RRC configured periodic resource.

20. The non-transitory computer-readable storage medium of claim 19, wherein when the resource type is the RRC-configured periodic non-anchor subframe, the one or more processors further cause the UE to:

5 decode a control information element (IE) within the RRCCR message to determine a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC);
 determine a shorter physical uplink control channel (sPUCCH) resource based on the interlace index and the OCC code; and
 encode the confirmation message indicating completion of the
10 RACH-less handover for transmission to the target eNB using the determined sPUCCH resource.

21. The non-transitory computer-readable storage medium of any of claims 19–20, wherein when the resource type information is the RRC-
15 configured floating PUCCH resource with PDCCH monitoring, the one or more processors further cause the UE to:

 decode a control information element (IE) within the RRCCR message to determine a nominal periodicity, a timing offset, and a window size;
20 monitor a timing window with the window size within a common PDCCH (cPDCCH) of a target cell associated with the target eNB based on the nominal periodicity, to identify a shorter PUCCH (sPUCCH) resource; and
 encode the confirmation message indicating completion of the
25 RACH-less handover for transmission to the target eNB using the identified sPUCCH resource and based on the timing offset.

22. The non-transitory computer-readable storage medium of any of claims 19–20, wherein when the resource type information is the non-RRC configured periodic resource, the one or more processors further cause the UE to:
- 5 monitor a PDCCH of a target cell associated with the target eNB to detect a PUCCH allocation; and
- encode the confirmation message indicating completion of the RACH-less handover for transmission to the target eNB using the detected PUCCH allocation.
- 10
23. An apparatus of a target Node-B (NB), the apparatus comprising: memory; and processing circuitry, configured to:
- encode a handover acknowledgement message for transmission to a source NB, in response to a handover request;
- 15 encode a radio resource control (RRC) Connection Reconfiguration (RRCR) message, the RRCR message including a handover configuration for a random access channel (RACH)-less handover and a resource type for communicating acknowledgement information using an unlicensed wireless band;
- 20 decode an acknowledgement message indicating completion of the RACH-less handover, the acknowledgement message received on the unlicensed wireless band via an uplink resource associated with the resource type indicated in the RRCR message; and
- encode packet data for transmission on the unlicensed wireless
- 25 band.
24. The apparatus of claim 23, wherein the resource type is one of:
- a RRC-configured periodic non-anchor subframe;
- a RRC-configured floating physical uplink control channel
- 30 (PUCCH) resource with physical downlink control channel (PDCCH) monitoring; and
- a non-RRC configured periodic resource.

25. The apparatus of claim 24, wherein when the resource type is the RRC-configured periodic non-anchor subframe, the processing circuitry is further configured to:

- 5 encode a control information element (IE) within the RRCCR message, the control IE including a demodulation reference signal (DMRS) configuration, an interlace index, and an orthogonal cover code (OCC); and
- reserve a shorter physical uplink control channel (sPUCCH) resource corresponding to the interlace index and the OCC code;
- 10 wherein the acknowledgement message indicating completion of the RACH-less handover is received via the reserved sPUCCH resource.

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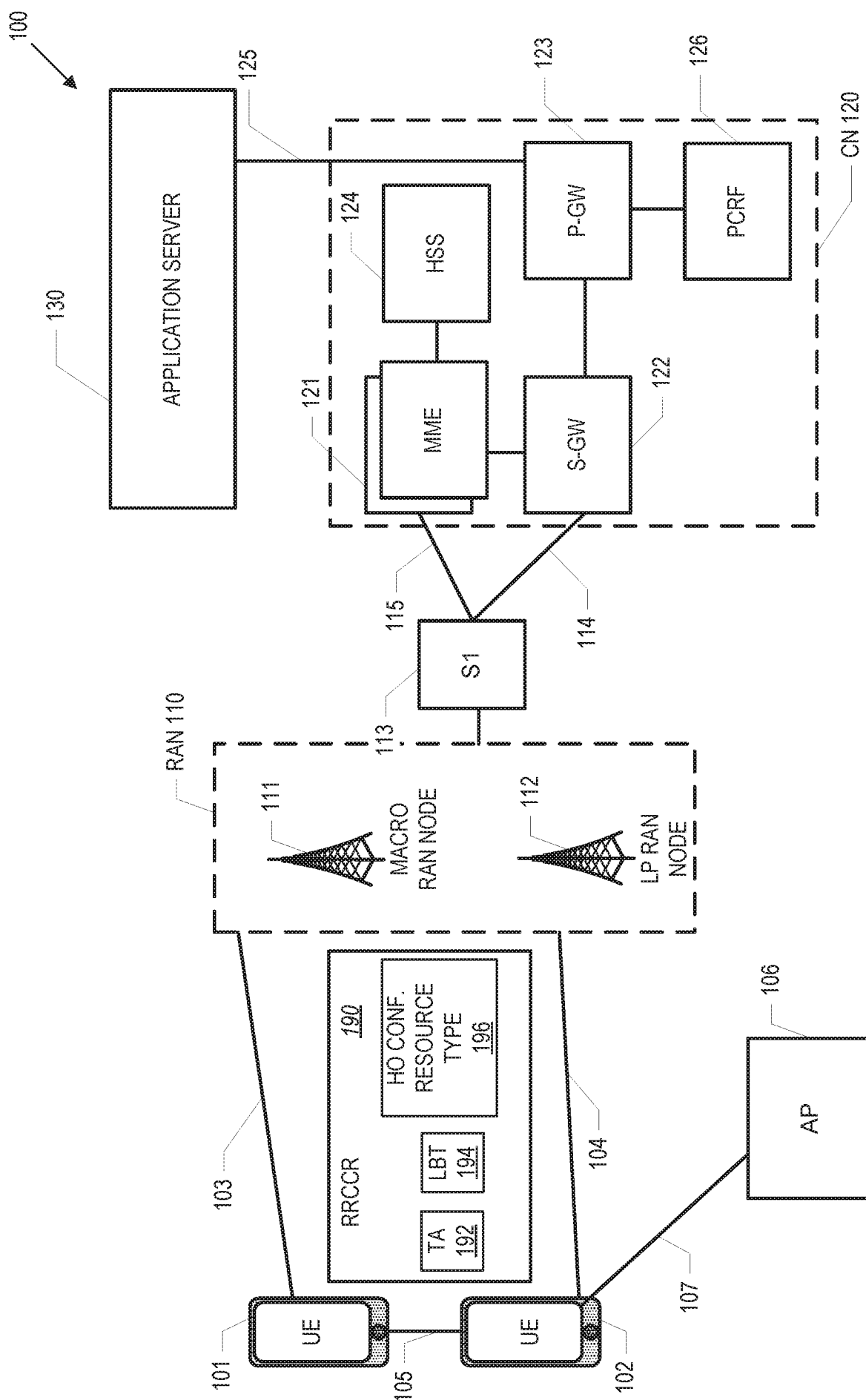


FIG. 1A

100

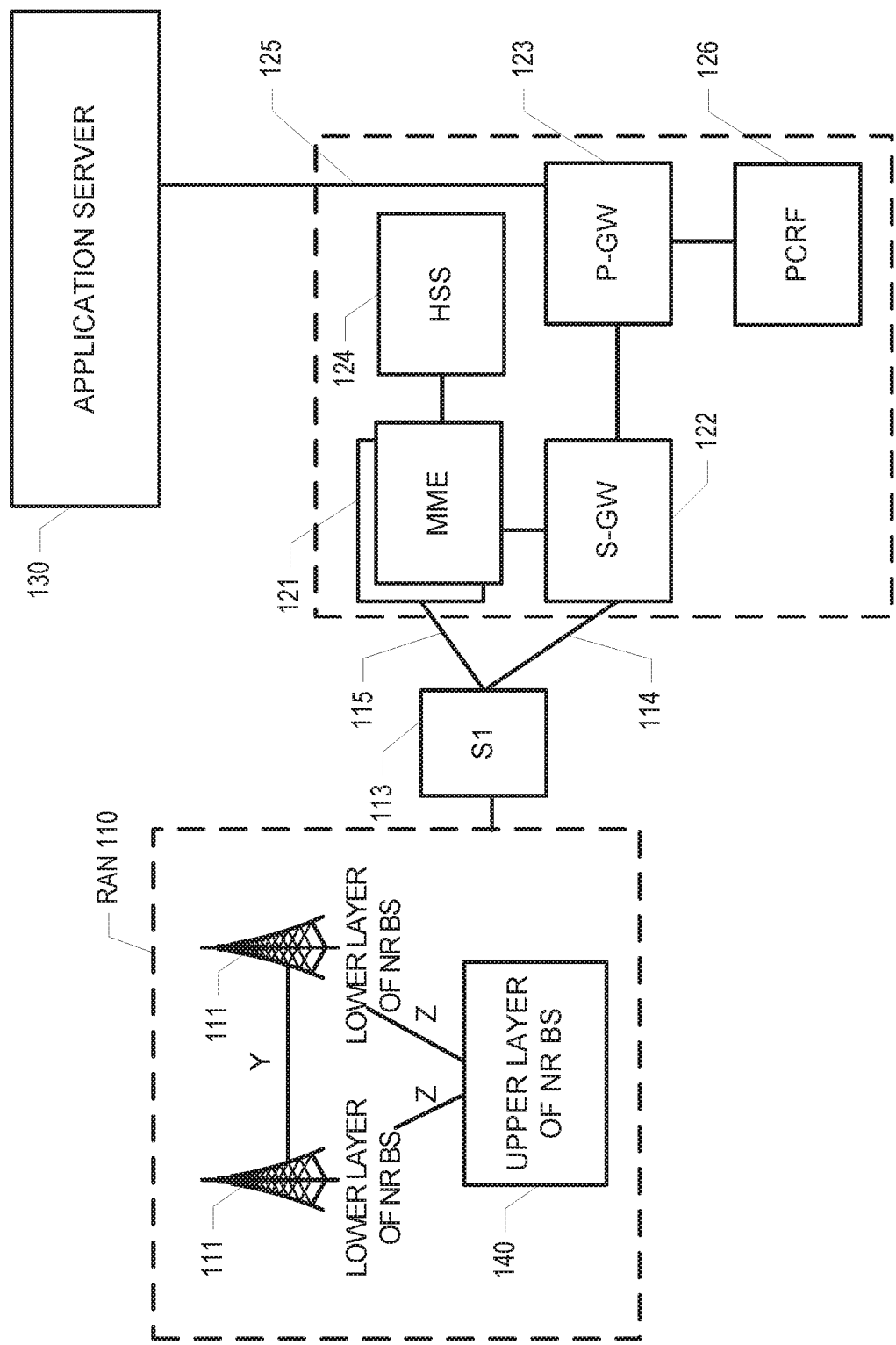


FIG. 1B

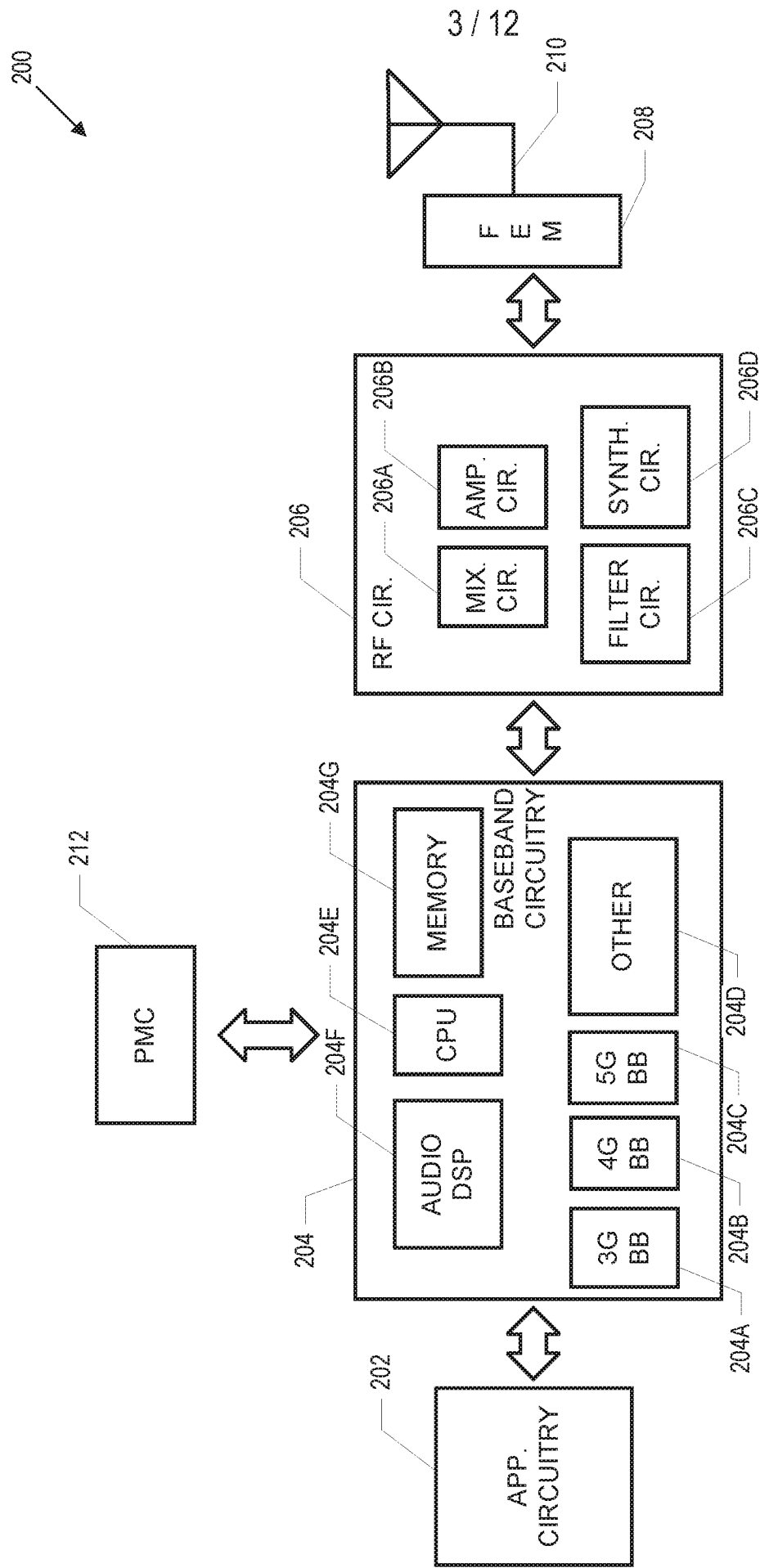


FIG. 2

300

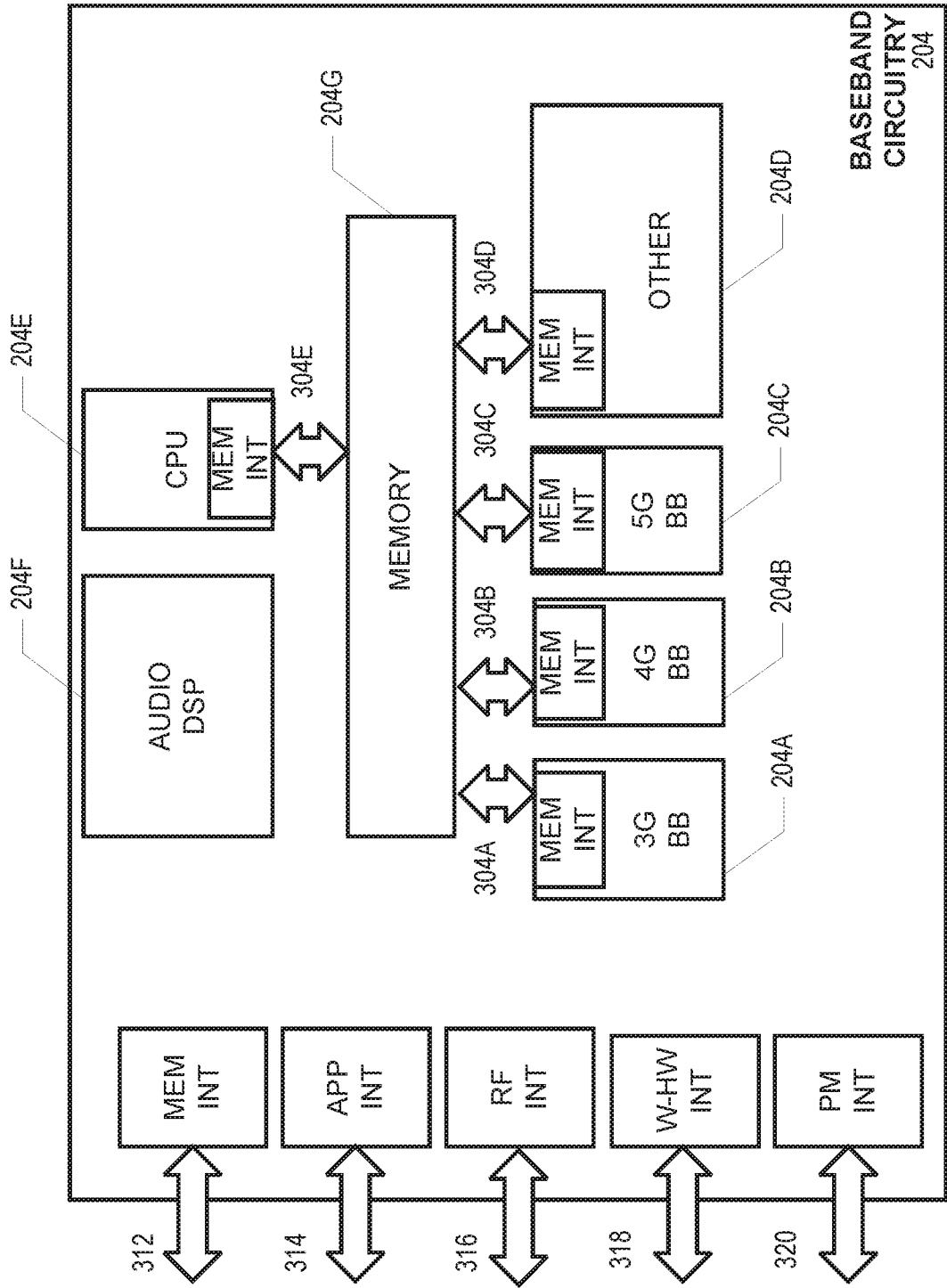


FIG. 3

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↘

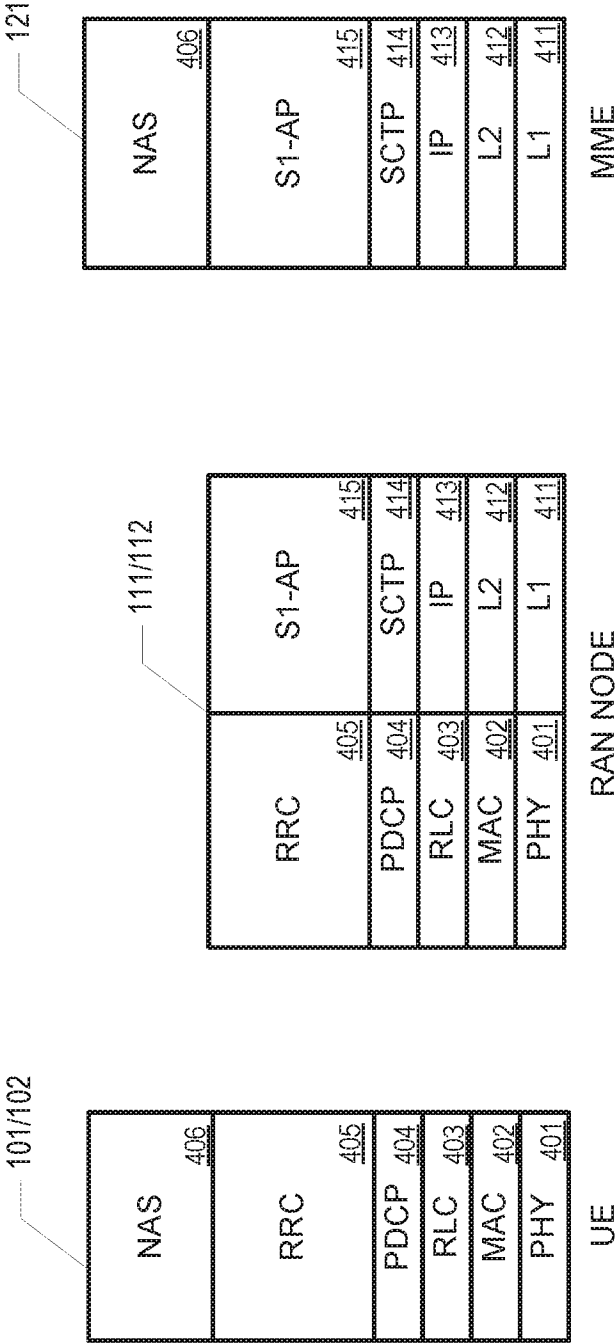


FIG. 4

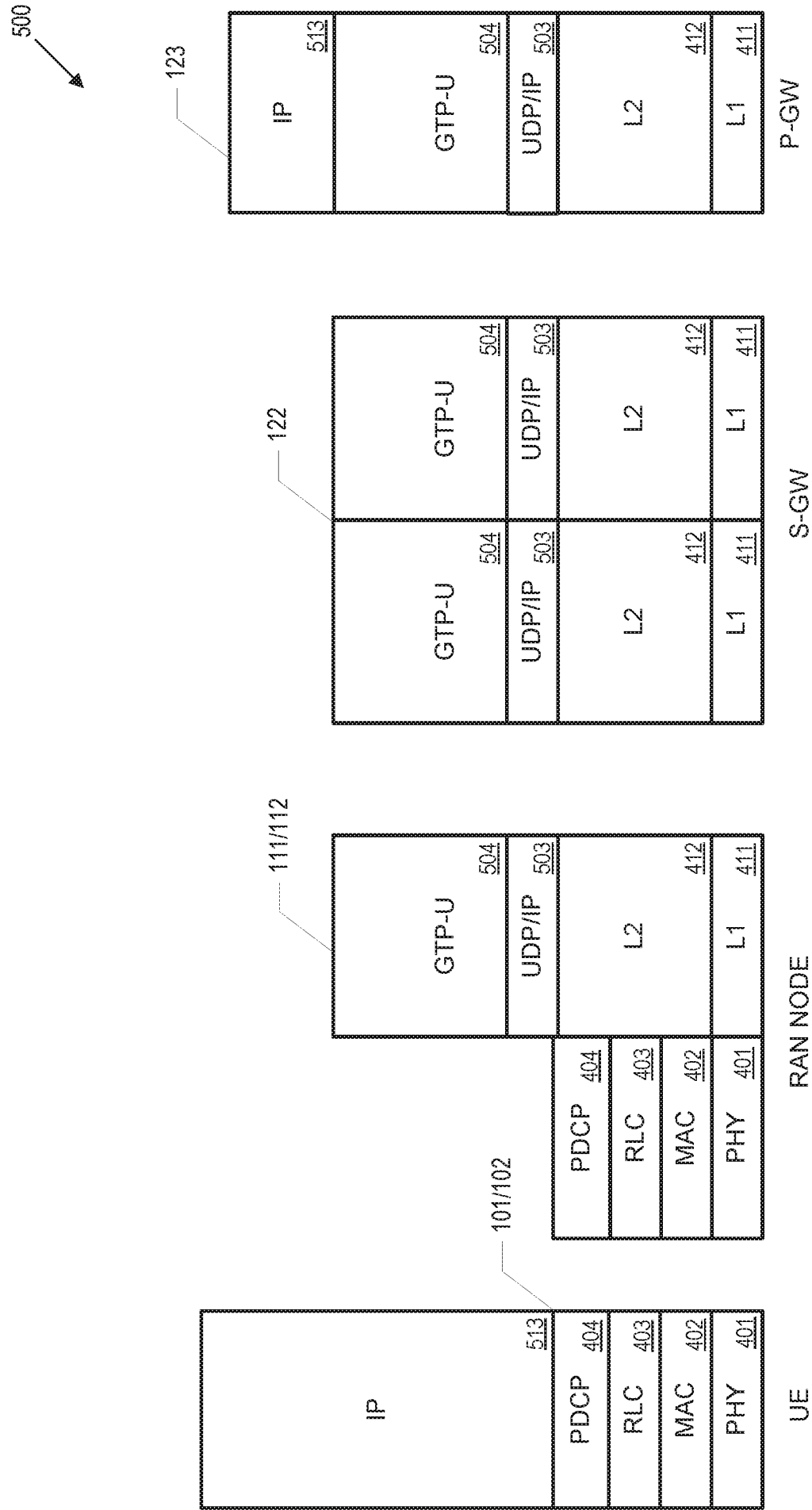


FIG. 5

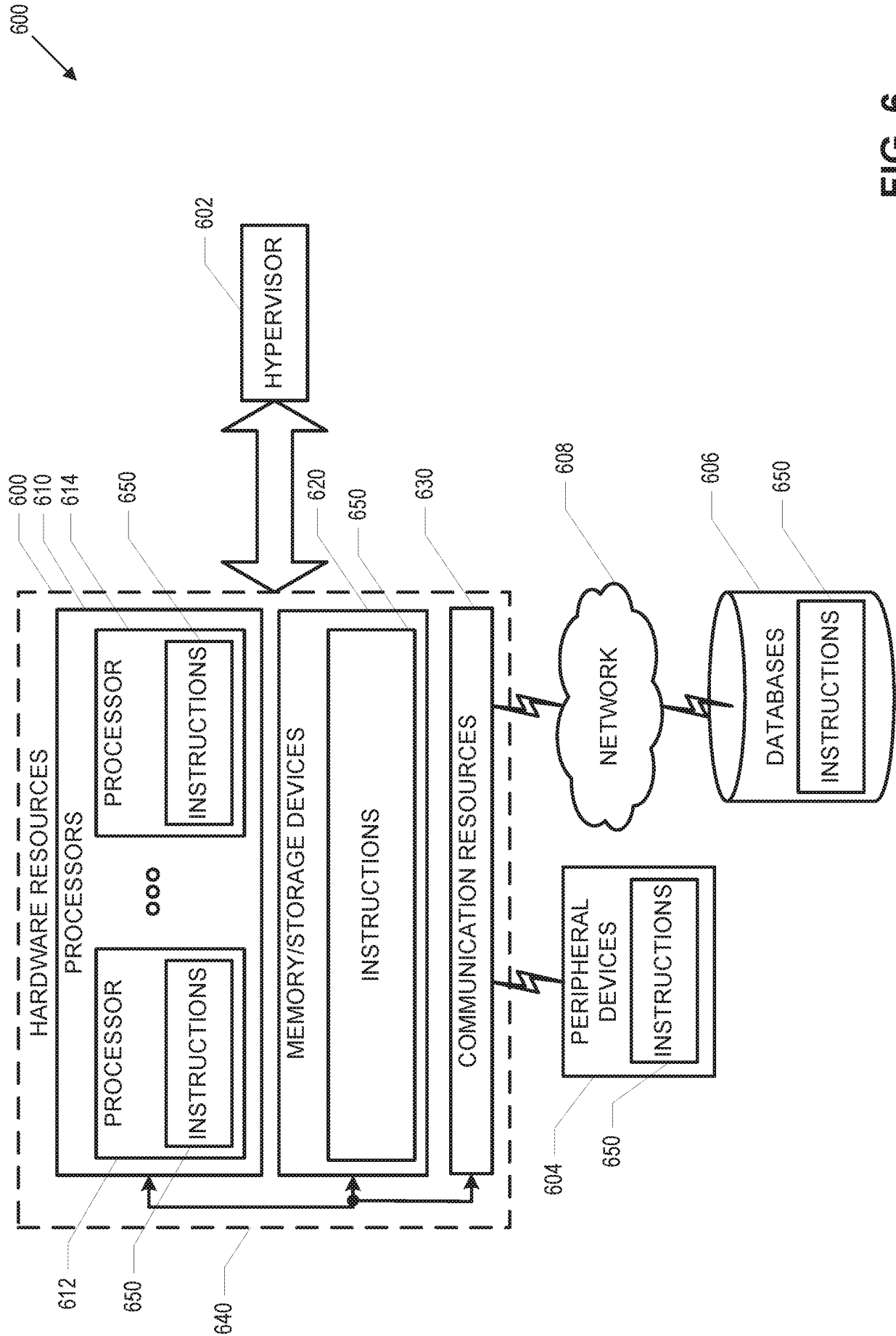


FIG. 6

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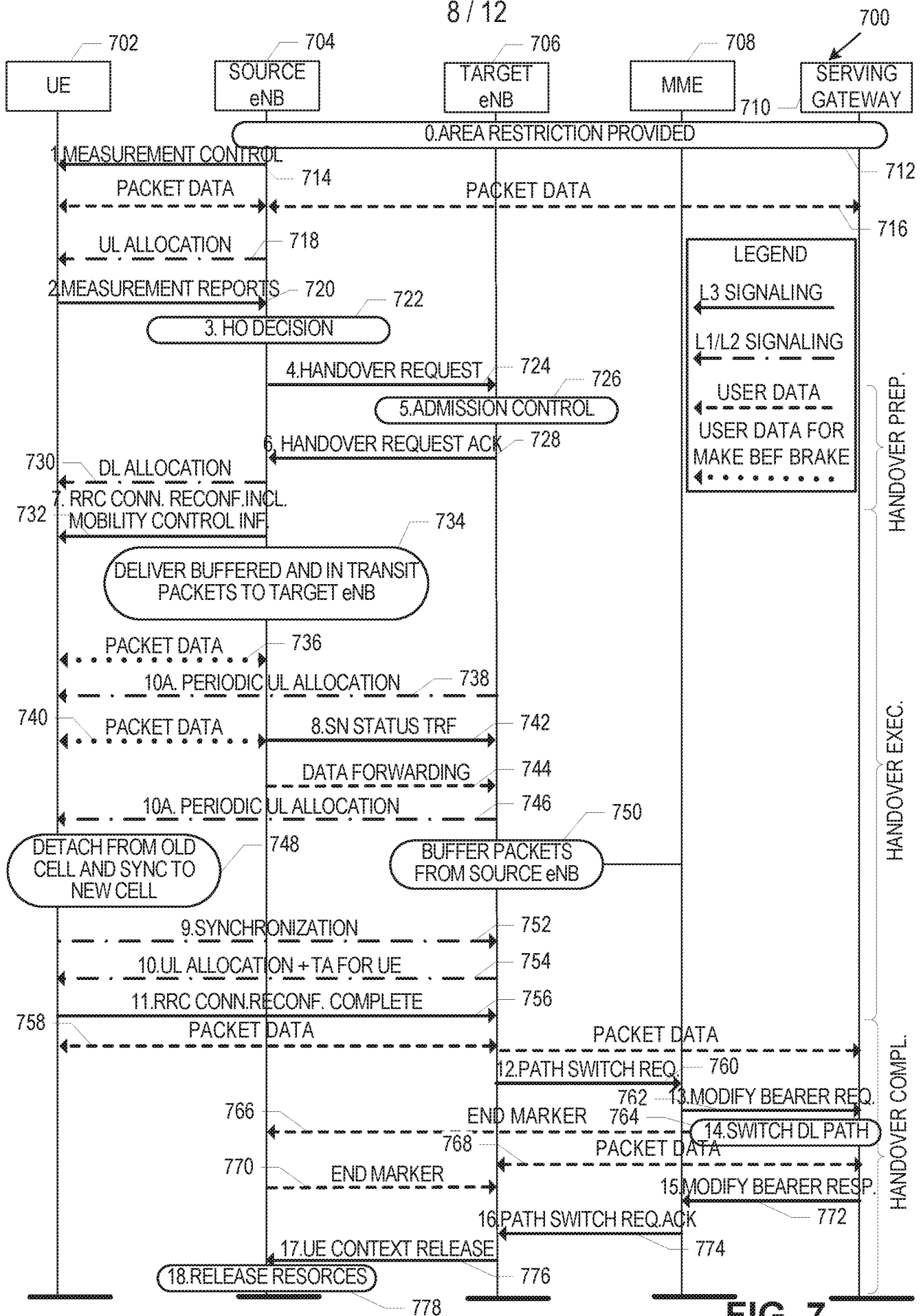


FIG. 7

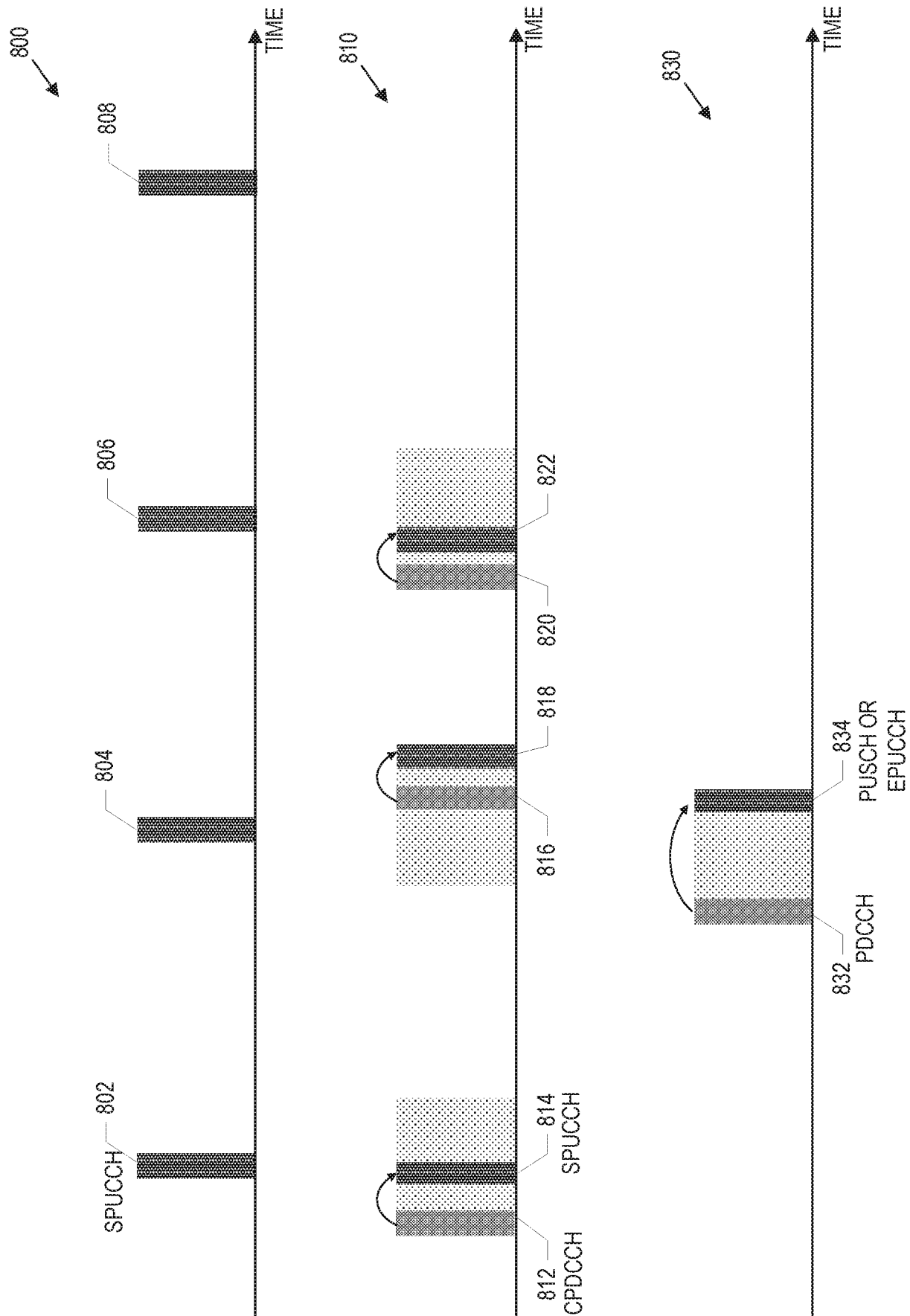


FIG. 8

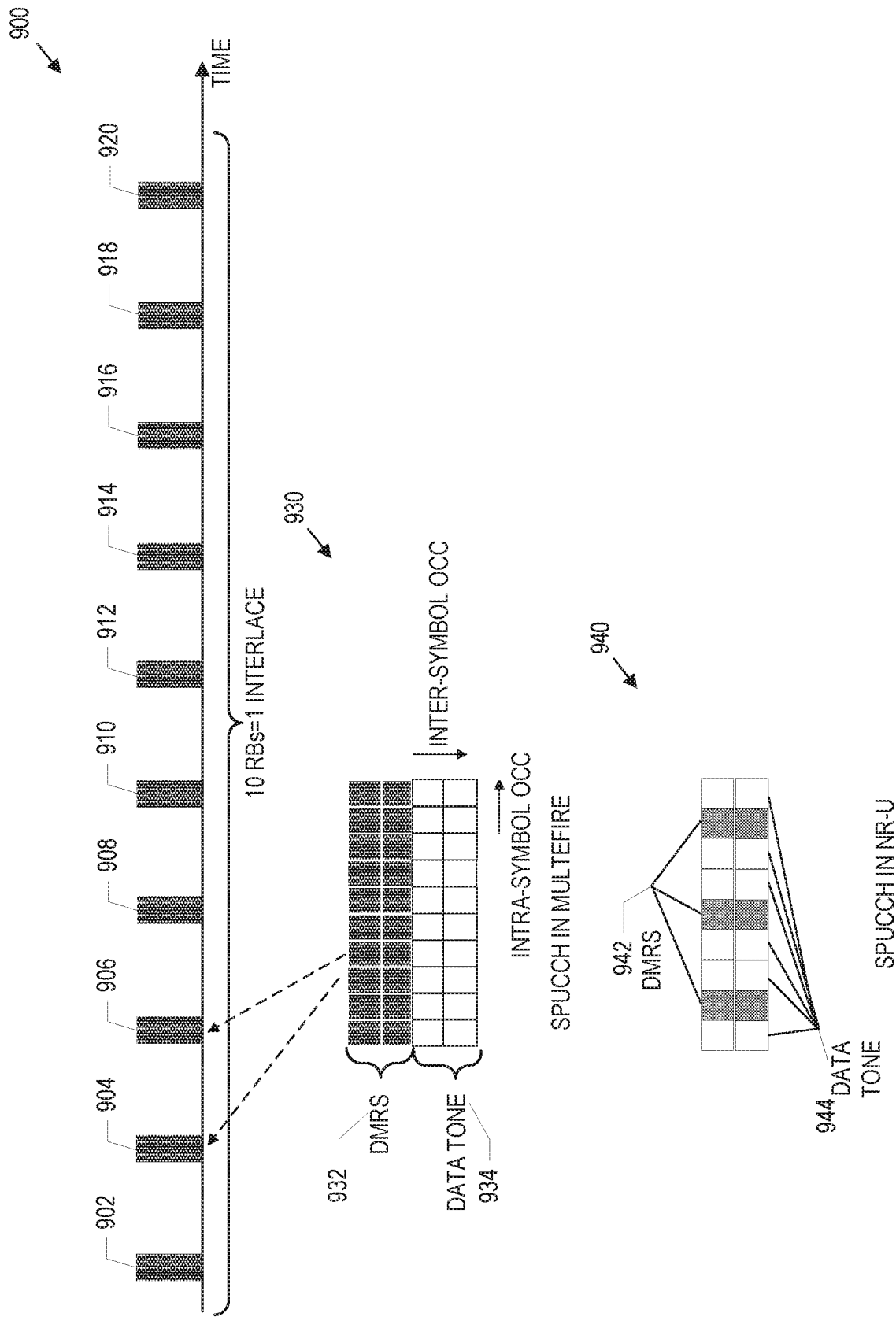


FIG. 9

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1000

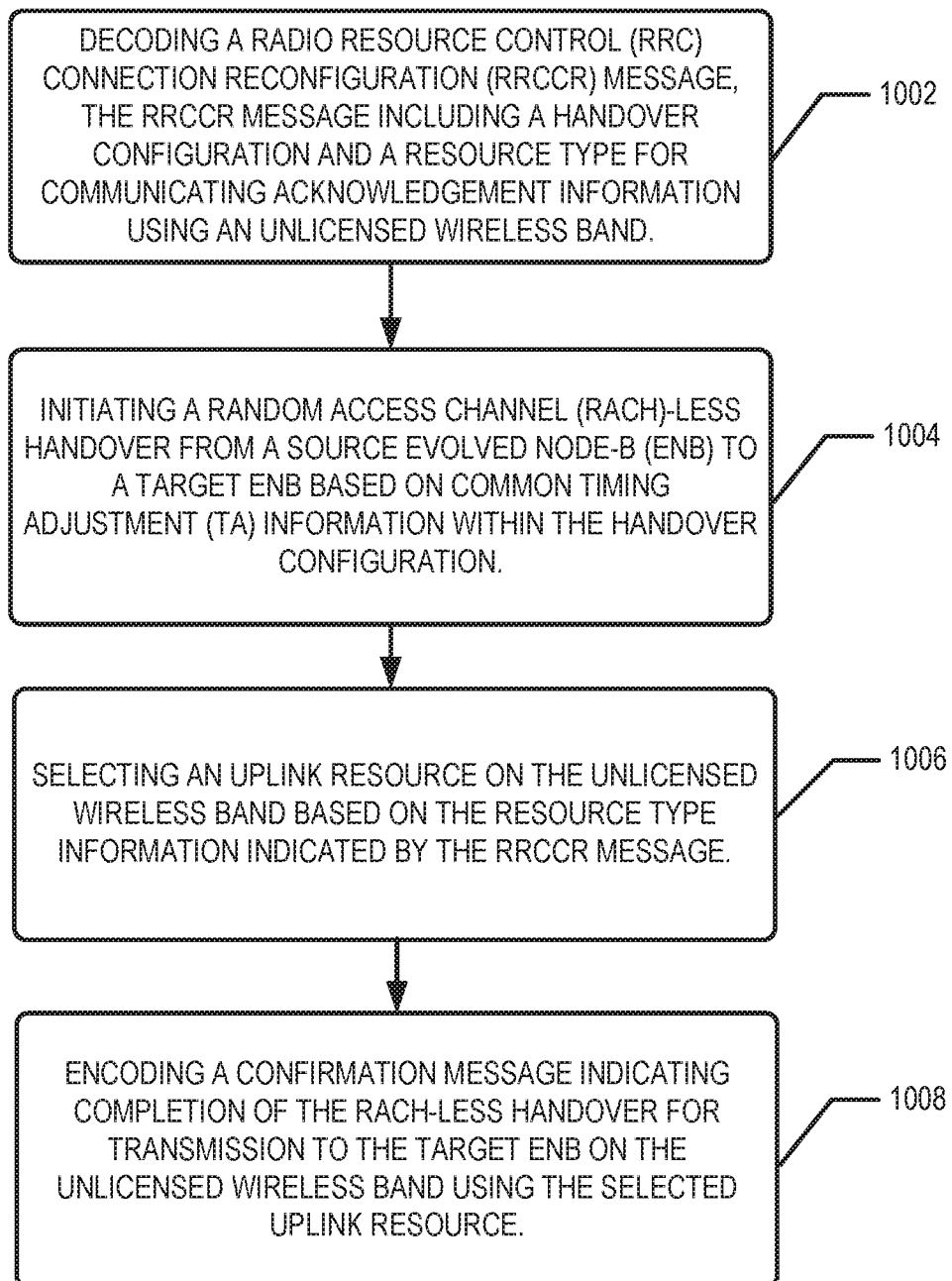
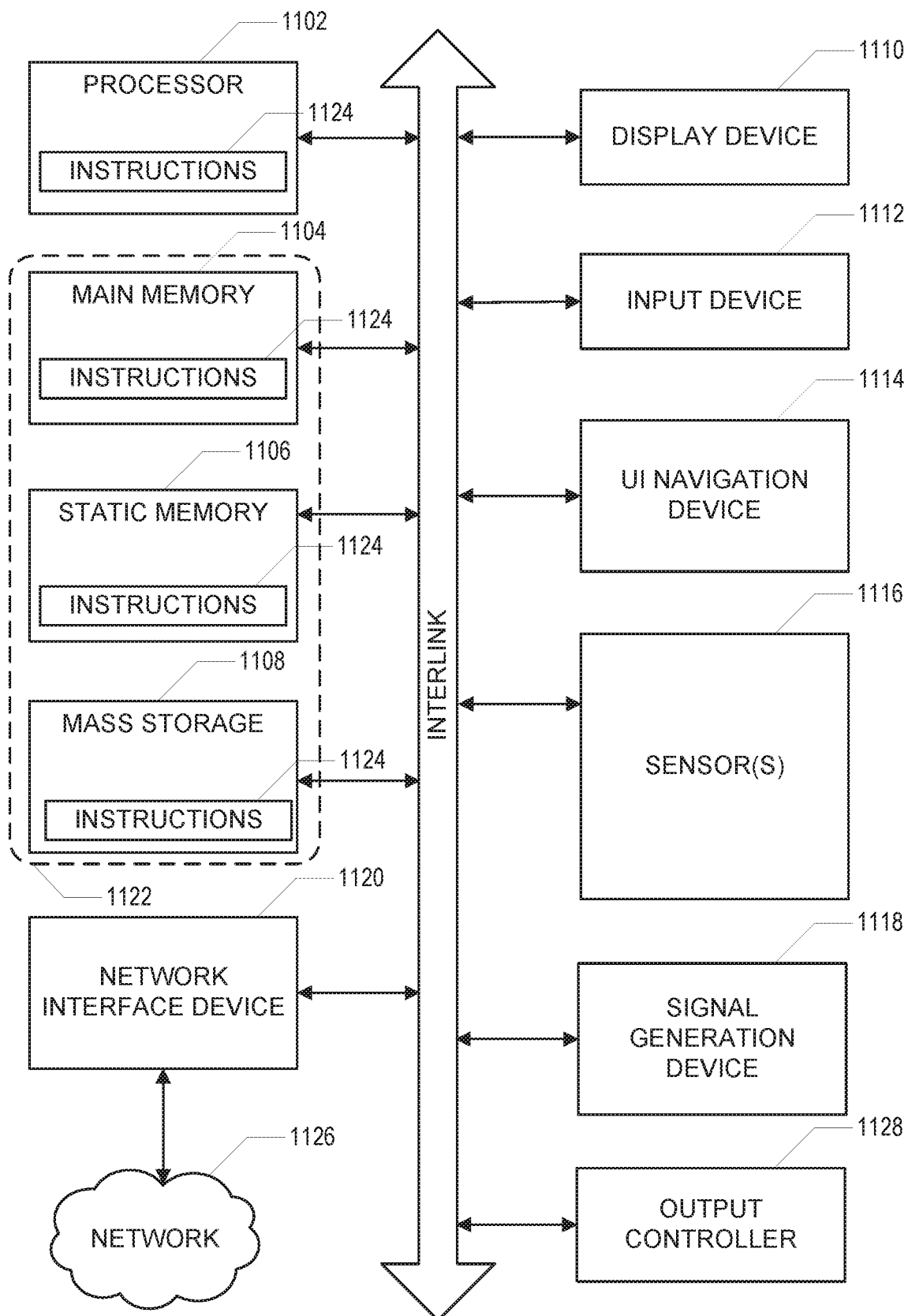


FIG. 10

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1100

**FIG. 11**

A. CLASSIFICATION OF SUBJECT MATTER**H04W 36/00(2009.01)i, H04W 36/08(2009.01)i, H04W 56/00(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 36/00; H04W 52/26; H04W 56/00; H04W 36/08

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: RACH-less handover (random access channel-less handover), unlicensed wireless band, confirmation message, resource type information

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	INTEL CORP., `Discussion of solution 1: RACH-less handover`, R2-162532, 3GPP TSG RAN WG2 Meeting #93bis, Dubrovnik, Croatia, 02 April 2016 See pages 2-3.	1-25
A	INTEL CORP., `UL grant for RACH-less handover`, R2-163605, 3GPP TSG RAN WG2 Meeting #94, Nanjing, China, 14 May 2016 See pages 1-2.	1-25
A	KR 10-2015-0017488 A (LG UPLUS CORP.) 17 February 2015 See paragraphs [0061]-[0087]; and figure 2.	1-25
A	JP 2012-531141 A (HUAWEI TECHNOLOGIES CO., LTD.) 06 December 2012 See paragraphs [0005]-[0012]; and figures 1-2.	1-25



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

29 March 2018 (29.03.2018)

Date of mailing of the international search report

29 March 2018 (29.03.2018)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

KIM, Jin Ho

Telephone No. +82-42-481-8699



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/061857Patent document
cited in search reportPublication
datePatent family
member(s)Publication
date

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