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[Continued on next page]

(54) Title: METHOD TO OPTIMIZE LTE DATA PERFORMANCE THROUGH FAST OR QUICK SCHEDULING REQUEST APPROACH FOR SINGLE RADIO HYBRID TUNE AWAY DEVICES

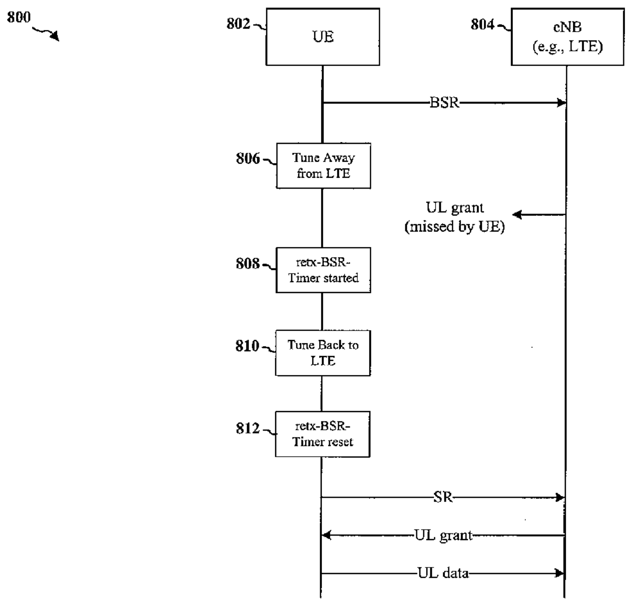

FIG. 8

(57) Abstract: A method, an apparatus, and a computer program product for wireless communication are provided. The apparatus, e.g., UE, tunes away from a first radio access technology (RAT) to a second RAT during data transfer activity between the UE and a network device, e.g., eNB, over the first RAT. Tuning away starts at least one timer, either in the UE or in the eNB, that affects the data transfer activity. The UE initiates a continuance of the data transfer activity immediately upon tuning back to the first RAT. In the case of uplink data transfer activity, the UE resets its buffer status report timer and sends a scheduling request to the eNB. In the case of downlink data, the UE sends a scheduling request to the eNB, which in turn causes the eNB to reset a timer at the eNB.

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METHOD TO OPTIMIZE LTE DATA PERFORMANCE THROUGH FAST OR QUICK SCHEDULING REQUEST APPROACH FOR SINGLE RADIO HYBRID TUNE AWAY DEVICES

BACKGROUND

Field

[0001] The present disclosure relates generally to communication systems, and more particularly, to a method to optimize LTE data performance through fast or quick scheduling request approach for single radio hybrid tune away devices.

Background

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

[0003] These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example of an emerging telecommunication standard is Long Term Evolution (LTE). LTE is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) mobile standard promulgated by Third Generation Partnership Project (3GPP). LTE is designed to better support mobile broadband Internet access by improving spectral efficiency, lowering costs, improving services, making use of new spectrum, and better integrating with other open standards using OFDMA on the downlink (DL), SC-FDMA on the uplink (UL), and multiple-input multiple-output (MIMO) antenna technology, etc. However, as the demand for mobile broadband access continues to increase, there exists a need for further improvements in LTE technology. Preferably, these improvements should be applicable to other multi-access technologies and the telecommunication standards that employ these technologies.

SUMMARY

[0004] In an aspect of the disclosure, a method, a computer program product, and an apparatus are provided. A method, an apparatus, and a computer program product for wireless communication are provided. The apparatus, e.g., UE, tunes away from a first radio access technology (RAT) to a second RAT during data transfer activity between the UE and a network device, e.g., eNB, over the first RAT. Tuning away starts at least one timer, either in the UE or in the eNB, that affects the data transfer activity. The UE initiates a continuance of the data transfer activity immediately upon tuning back to the first RAT. In the case of uplink data transfer activity, the UE resets its buffer status report timer and sends a scheduling request to the eNB. In the case of downlink data, the UE sends a scheduling request to the eNB, which in turn causes the eNB to reset a timer at the eNB.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a diagram illustrating an example of a network architecture.

[0006] FIG. 2 is a diagram illustrating an example of an access network.

[0007] FIG. 3 is a diagram illustrating an example of a DL frame structure in LTE.

[0008] FIG. 4 is a diagram illustrating an example of an UL frame structure in LTE.

[0009] FIG. 5 is a diagram illustrating an example of a radio protocol architecture for the user and control planes.

[0010] FIG. 6 is a diagram illustrating an example of an evolved Node B and user equipment in an access network.

[0011] FIG. 7 is a diagram illustrating an exemplary deployment in which multiple wireless networks have overlapping coverage.

[0012] FIG. 8 is a call flow diagram involving uplink data transfer activity between a UE and an eNB.

[0013] FIG. 9 is a call flow diagram involving downlink data transfer activity between a UE and an eNB.

[0014] FIG. 10 is a flow chart of a method of wireless communication.

[0015] FIG. 11 is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

[0016] FIG. 12 is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

DETAILED DESCRIPTION

[0017] The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0018] Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, modules, components, circuits, steps, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0019] By way of example, an element, or any portion of an element, or any combination of elements may be implemented with a "processing system" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

[0020] Accordingly, in one or more exemplary embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), compact disk ROM (CD-ROM) or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Combinations of the above should also be included within the scope of computer-readable media.

[0021] FIG. 1 is a diagram illustrating an LTE network architecture 100. The LTE network architecture 100 may be referred to as an Evolved Packet System (EPS) 100. The EPS 100 may include one or more user equipment (UE) 102, an Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) 104, an Evolved Packet Core (EPC) 110, and an Operator's Internet Protocol (IP) Services 122. The EPS can interconnect with other access networks, but for simplicity those entities/interfaces are not shown. As shown, the EPS provides packet-switched services, however, as those skilled in the art will readily appreciate, the various concepts presented throughout this disclosure may be extended to networks providing circuit-switched services.

[0022] The E-UTRAN includes the evolved Node B (eNB) 106 and other eNBs 108, and may include a Multicast Coordination Entity (MCE) 128. The eNB 106 provides user and control planes protocol terminations toward the UE 102. The eNB 106 may be connected to the other eNBs 108 via a backhaul (e.g., an X2 interface). The MCE 128 allocates time/frequency radio resources for evolved Multimedia Broadcast Multicast Service (MBMS) (eMBMS), and determines the radio configuration (e.g., a modulation and coding scheme (MCS)) for the eMBMS. The MCE 128 may be a separate entity or part of the eNB 106. The eNB 106 may also be referred to as a base station, a Node B, an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), or some other suitable terminology. The eNB 106 provides an access point to the EPC 110 for a UE 102. Examples of UEs 102 include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, a tablet, or any other similar functioning device. The UE 102 may also be referred to by those skilled in the art as a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology.

[0023] The eNB 106 is connected to the EPC 110. The EPC 110 may include a Mobility Management Entity (MME) 112, a Home Subscriber Server (HSS) 120, other MMEs 114, a Serving Gateway 116, a Multimedia Broadcast Multicast Service (MBMS) Gateway 124, a Broadcast Multicast Service Center (BM-SC) 126, and a Packet Data Network (PDN) Gateway 118. The MME 112 is the control node that processes the signaling between the UE 102 and the EPC 110. Generally, the MME 112 provides bearer and connection management. All user IP packets are transferred through the Serving Gateway 116, which itself is connected to the PDN Gateway 118. The PDN Gateway 118 provides UE IP address allocation as well as other functions. The PDN Gateway 118 and the BM-SC 126 are connected to the IP Services 122. The IP Services 122 may include the Internet, an intranet, an IP Multimedia Subsystem (IMS), a PS Streaming Service (PSS), and/or other IP services. The BM-SC 126 may provide functions for MBMS user service provisioning and delivery. The BM-SC 126 may serve as an entry point for content provider MBMS transmission, may be used to authorize and initiate MBMS Bearer Services within a PLMN, and may be used to schedule and deliver MBMS transmissions. The MBMS Gateway 124 may be used to distribute MBMS traffic to the eNBs (e.g., 106, 108) belonging to a Multicast Broadcast Single Frequency Network (MBSFN) area broadcasting a particular service, and may be responsible for session management (start/stop) and for collecting eMBMS related charging information.

[0024] FIG. 2 is a diagram illustrating an example of an access network 200 in an LTE network architecture. In this example, the access network 200 is divided into a number of cellular regions (cells) 202. One or more lower power class eNBs 208 may have cellular regions 210 that overlap with one or more of the cells 202. The lower power class eNB 208 may be a femto cell (e.g., home eNB (HeNB)), pico cell, micro cell, or remote radio head (RRH). The macro eNBs 204 are each assigned to a respective cell 202 and are configured to provide an access point to the EPC 110 for all the UEs 206 in the cells 202. There is no centralized controller in this example of an access network 200, but a centralized controller may be used in alternative configurations. The eNBs 204 are responsible for all radio related functions including radio bearer control, admission control, mobility control, scheduling, security, and connectivity to the serving gateway 116. An eNB may support one or multiple (e.g., three) cells (also referred to as a sectors). The term “cell” can refer to the smallest coverage area of an eNB and/or an eNB subsystem serving are particular coverage area. Further, the terms “eNB,” “base station,” and “cell” may be used interchangeably herein.

[0025] The modulation and multiple access scheme employed by the access network 200 may vary depending on the particular telecommunications standard being deployed. In LTE applications, OFDM is used on the DL and SC-FDMA is used on the UL to support both frequency division duplex (FDD) and time division duplex (TDD). As those skilled in the art will readily appreciate from the detailed description to follow, the various concepts presented herein are well suited for LTE applications. However, these concepts may be readily extended to other telecommunication standards employing other modulation and multiple access techniques. By way of example, these concepts may be extended to Evolution-Data Optimized (EV-DO) or Ultra Mobile Broadband (UMB). EV-DO and UMB are air interface standards promulgated by the 3rd Generation Partnership Project 2 (3GPP2) as part of the CDMA2000 family of standards and employs CDMA to provide broadband Internet access to mobile stations. These concepts may also be extended to Universal Terrestrial Radio Access (UTRA) employing Wideband-CDMA (W-CDMA) and other variants of CDMA, such as TD-SCDMA; Global System for Mobile Communications (GSM) employing TDMA; and Evolved UTRA (E-UTRA), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, and Flash-OFDM employing OFDMA. UTRA, E-UTRA, UMTS, LTE and GSM are described in documents from the 3GPP organization. CDMA2000 and UMB are described in documents from the 3GPP2 organization. The actual wireless communication standard and the multiple access technology employed will depend on the specific application and the overall design constraints imposed on the system.

[0026] The eNBs 204 may have multiple antennas supporting MIMO technology. The use of MIMO technology enables the eNBs 204 to exploit the spatial domain to support spatial multiplexing, beamforming, and transmit diversity. Spatial multiplexing may be used to transmit different streams of data simultaneously on the same frequency. The data streams may be transmitted to a single UE 206 to increase the data rate or to multiple UEs 206 to increase the overall system capacity. This is achieved by spatially precoding each data stream (i.e., applying a scaling of an amplitude and a phase) and then transmitting each spatially precoded stream through multiple transmit antennas on the DL. The spatially precoded data streams arrive at the UE(s) 206 with different spatial signatures, which enables each of the UE(s) 206 to recover the one or more data streams destined for that UE 206. On the UL, each UE 206 transmits a spatially precoded data stream, which enables the eNB 204 to identify the source of each spatially precoded data stream.

[0027] Spatial multiplexing is generally used when channel conditions are good. When channel conditions are less favorable, beamforming may be used to focus the transmission energy in one or more directions. This may be achieved by spatially precoding the data for transmission through multiple antennas. To achieve good coverage at the edges of the cell, a single stream beamforming transmission may be used in combination with transmit diversity.

[0028] In the detailed description that follows, various aspects of an access network will be described with reference to a MIMO system supporting OFDM on the DL. OFDM is a spread-spectrum technique that modulates data over a number of subcarriers within an OFDM symbol. The subcarriers are spaced apart at precise frequencies. The spacing provides "orthogonality" that enables a receiver to recover the data from the subcarriers. In the time domain, a guard interval (e.g., cyclic prefix) may be added to each OFDM symbol to combat inter-OFDM-symbol interference. The UL may use SC-FDMA in the form of a DFT-spread OFDM signal to compensate for high peak-to-average power ratio (PAPR).

[0029] FIG. 3 is a diagram 300 illustrating an example of a DL frame structure in LTE. A frame (10 ms) may be divided into 10 equally sized subframes. Each subframe may include two consecutive time slots. A resource grid may be used to represent two time slots, each time slot including a resource block. The resource grid is divided into multiple resource elements. In LTE, for a normal cyclic prefix, a resource block contains 12 consecutive subcarriers in the frequency domain and 7 consecutive OFDM symbols in the time domain, for a total of 84 resource elements. For an extended cyclic prefix, a resource block contains 12 consecutive subcarriers in the frequency domain and 6 consecutive OFDM symbols in the time domain, for a total of 72 resource elements. Some of the resource elements, indicated as R 302, 304, include DL reference signals (DL-RS). The DL-RS include Cell-specific RS (CRS) (also sometimes called common RS) 302 and UE-specific RS (UE-RS) 304. UE-RS 304 are transmitted only on the resource blocks upon which the corresponding physical DL shared channel (PDSCH) is mapped. The number of bits carried by each resource element depends on the modulation scheme. Thus, the more resource blocks that a UE receives and the higher the modulation scheme, the higher the data rate for the UE.

[0030] FIG. 4 is a diagram 400 illustrating an example of an UL frame structure in LTE. The available resource blocks for the UL may be partitioned into a data section and a control section. The control section may be formed at the two edges of the system bandwidth and may have a configurable size. The resource blocks in the control section may be assigned to UEs for transmission of control information. The data section may include all resource blocks not included in the control section. The UL frame structure results in the data section including contiguous subcarriers, which may allow a single UE to be assigned all of the contiguous subcarriers in the data section.

[0031] A UE may be assigned resource blocks 410a, 410b in the control section to transmit control information to an eNB. The UE may also be assigned resource blocks 420a, 420b in the data section to transmit data to the eNB. The UE may transmit control information in a physical UL control channel (PUCCH) on the assigned resource blocks in the control section. The UE may transmit only data or both data and control information in a physical UL shared channel (PUSCH) on the assigned resource blocks in the data section. A UL transmission may span both slots of a subframe and may hop across frequency.

[0032] A set of resource blocks may be used to perform initial system access and achieve UL synchronization in a physical random access channel (PRACH) 430. The PRACH 430 carries a random sequence and cannot carry any UL data/signaling. Each random access preamble occupies a bandwidth corresponding to six consecutive resource blocks. The starting frequency is specified by the network. That is, the transmission of the random access preamble is restricted to certain time and frequency resources. There is no frequency hopping for the PRACH. The PRACH attempt is carried in a single subframe (1 ms) or in a sequence of few contiguous subframes and a UE can make only a single PRACH attempt per frame (10 ms).

[0033] FIG. 5 is a diagram 500 illustrating an example of a radio protocol architecture for the user and control planes in LTE. The radio protocol architecture for the UE and the eNB is shown with three layers: Layer 1, Layer 2, and Layer 3. Layer 1 (L1 layer) is the lowest layer and implements various physical layer signal processing functions. The L1 layer will be referred to herein as the physical layer 506. Layer 2 (L2 layer) 508 is above the physical layer 506 and is responsible for the link between the UE and eNB over the physical layer 506.

[0034] In the user plane, the L2 layer 508 includes a media access control (MAC) sublayer 510, a radio link control (RLC) sublayer 512, and a packet data convergence protocol (PDCP) 514 sublayer, which are terminated at the eNB on the network side. Although not shown, the UE may have several upper layers above the L2 layer 508 including a network layer (e.g., IP layer) that is terminated at the PDN gateway 118 on the network side, and an application layer that is terminated at the other end of the connection (e.g., far end UE, server, etc.).

[0035] The PDCP sublayer 514 provides multiplexing between different radio bearers and logical channels. The PDCP sublayer 514 also provides header compression for upper layer data packets to reduce radio transmission overhead, security by ciphering the data packets, and handover support for UEs between eNBs. The RLC sublayer 512 provides segmentation and reassembly of upper layer data packets, retransmission of lost data packets, and reordering of data packets to compensate for out-of-order reception due to hybrid automatic repeat request (HARQ). The MAC sublayer 510 provides multiplexing between logical and transport channels. The MAC sublayer 510 is also responsible for allocating the various radio resources (e.g., resource blocks) in one cell among the UEs. The MAC sublayer 510 is also responsible for HARQ operations.

[0036] In the control plane, the radio protocol architecture for the UE and eNB is substantially the same for the physical layer 506 and the L2 layer 508 with the exception that there is no header compression function for the control plane. The control plane also includes a radio resource control (RRC) sublayer 516 in Layer 3 (L3 layer). The RRC sublayer 516 is responsible for obtaining radio resources (e.g., radio bearers) and for configuring the lower layers using RRC signaling between the eNB and the UE.

[0037] FIG. 6 is a block diagram of an eNB 610 in communication with a UE 650 in an access network. In the DL, upper layer packets from the core network are provided to a controller/processor 675. The controller/processor 675 implements the functionality of the L2 layer. In the DL, the controller/processor 675 provides header compression, ciphering, packet segmentation and reordering, multiplexing between logical and transport channels, and radio resource allocations to the UE 650 based on various priority metrics. The controller/processor 675 is also responsible for HARQ operations, retransmission of lost packets, and signaling to the UE 650.

[0038] The transmit (TX) processor 616 implements various signal processing functions for the L1 layer (i.e., physical layer). The signal processing functions include coding and interleaving to facilitate forward error correction (FEC) at the UE 650 and mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols are then split into parallel streams. Each stream is then mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator 674 may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE 650. Each spatial stream may then be provided to a different antenna 620 via a separate transmitter 618TX. Each transmitter 618TX may modulate an RF carrier with a respective spatial stream for transmission.

[0039] At the UE 650, each receiver 654RX receives a signal through its respective antenna 652. Each receiver 654RX recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor 656. The RX processor 656 implements various signal processing functions of the L1 layer. The RX processor 656 may perform spatial processing on the information to recover any spatial streams destined for the UE 650. If multiple spatial streams are destined for the UE 650, they may be combined by the RX processor 656 into a single OFDM symbol stream. The RX processor 656 then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal comprises a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the eNB 610. These soft decisions may be based on channel estimates computed by the channel estimator 658. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the eNB 610 on the physical channel. The data and control signals are then provided to the controller/processor 659.

[0040] The controller/processor 659 implements the L2 layer. The controller/processor can be associated with a memory 660 that stores program codes and data. The memory 660 may be referred to as a computer-readable medium. In the UL, the controller/processor 659 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the core network. The upper layer packets are then provided to a data sink 662, which represents all the protocol layers above the L2 layer. Various control signals may also be provided to the data sink 662 for L3 processing. The controller/processor 659 is also responsible for error detection using an acknowledgement (ACK) and/or negative acknowledgement (NACK) protocol to support HARQ operations.

[0041] In the UL, a data source 667 is used to provide upper layer packets to the controller/processor 659. The data source 667 represents all protocol layers above the L2 layer. Similar to the functionality described in connection with the DL transmission by the eNB 610, the controller/processor 659 implements the L2 layer for the user plane and the control plane by providing header compression, ciphering, packet segmentation and reordering, and multiplexing between logical and transport channels based on radio resource allocations by the eNB 610. The controller/processor 659 is also responsible for HARQ operations, retransmission of lost packets, and signaling to the eNB 610.

[0042] Channel estimates derived by a channel estimator 658 from a reference signal or feedback transmitted by the eNB 610 may be used by the TX processor 668 to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor 668 may be provided to different antenna 652 via separate transmitters 654TX. Each transmitter 654TX may modulate an RF carrier with a respective spatial stream for transmission.

[0043] The UL transmission is processed at the eNB 610 in a manner similar to that described in connection with the receiver function at the UE 650. Each receiver 618RX receives a signal through its respective antenna 620. Each receiver 618RX recovers information modulated onto an RF carrier and provides the information to a RX processor 670. The RX processor 670 may implement the L1 layer.

[0044] The controller/processor 675 implements the L2 layer. The controller/processor 675 can be associated with a memory 676 that stores program codes and data. The memory 676 may be referred to as a computer-readable medium. In the UL, the control/processor 675 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the UE 650. Upper layer packets from the controller/processor 675 may be provided to the core network. The controller/processor 675 is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0045] Certain techniques have been designed to provide wireless device operational modes that comply with requirements established for operations on certain frequency bands of radio access networks (RANs). One such technique involves a wireless device receiving voice service from a legacy network (e.g., a CDMA 2000 1x or simply "1x" network) which provides service that geographically overlaps the service of an enhanced network (e.g., a long term evolution—LTE network).

[0046] In networks that support both LTE and CDMA, it may be necessary for the UE chipset to support both LTE and CDMA 1x. There may be two system architectures to support monitoring 1x while operating in LTE. The first architecture may have two separate radio frequency (RF) chains, one for LTE and the other for 1x. This architecture may allow for 1x voice pages to be decoded in parallel when LTE data calls are active. This architecture/algorithm is generally referred to as SVLTE (simultaneous voice and LTE). The MSM8960™ chipset from Qualcomm™ uses this architecture.

[0047] Another architecture may have just one RF chain. This RF chain may have to be shared between LTE and 1x, with a constraint that LTE and CDMA technologies may not be active simultaneously. In order to monitor 1x paging, the UE may have to periodically tune away from LTE while an LTE data call is active. While the one RF chain architecture improves battery consumption, saves board area and bill of material (BOM), a problem may arise when the UE has to periodically monitor 1x voice pages while an LTE data call is active. During the RF-tune time to 1x, the LTE call is suspended or virtually suspended, and this may lead to disruption in LTE UE function that may not be expected by the network.

[0048] FIG. 7 shows an exemplary deployment in which multiple wireless networks have overlapping coverage. An evolved universal terrestrial radio access network (E-UTRAN) 720 may support LTE and may include a number of evolved Node Bs (eNBs) 722 and other network entities that can support wireless communication for user equipments (UEs). Each eNB may provide communication coverage for a particular geographic area. The term "cell" can refer to a coverage area of an eNB and/or an eNB subsystem serving this coverage area. A serving gateway (S-GW) 724 may communicate with E-UTRAN 720 and may perform various functions such as packet routing and forwarding, mobility anchoring, packet buffering, initiation of network triggered services, etc. A mobility management entity (MME) 726 may communicate with E-UTRAN 720 and serving gateway 724 and may perform various functions such as mobility management, bearer management, distribution of paging messages, security control, authentication, gateway selection, etc. The network entities in LTE are described in 3GPP TS 36.300, entitled "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description," which is publicly available.

[0049] A radio access network (RAN) 730 may support 1xRTT and may include a number of base stations 732 and other network entities that can support wireless communication for UEs. A mobile switching center (MSC) 734 may communicate with the RAN 730 and may support voice services, provide routing for circuit-switched calls, and perform mobility management for UEs located within the area served by MSC 734. An inter-working function (IWF) 740 may facilitate communication between MME 726 and MSC 734. The network entities in 1xRTT are described in publicly available documents from 3GPP2.

[0050] E-UTRAN 720, serving gateway 724, and MME 726 may be part of an LTE network 702. RAN 730 and MSC 734 may be part of a 1xRTT network 704. For simplicity, FIG. 7 shows only some network entities in the LTE network and the 1xRTT network. The LTE and 1xRTT networks may also include other network entities that may support various functions and services.

[0051] In general, any number of wireless networks may be deployed in a given geographic area. Each wireless network may support a particular RAT and may operate on one or more frequencies. A RAT may also be referred to as a radio technology, an air interface, etc. A frequency may also be referred to as a carrier, a frequency channel, etc. Each frequency may support a single RAT in a given geographic area in order to avoid interference between wireless networks of different RATs.

[0052] A UE 710 may be stationary or mobile and may also be referred to as a mobile station, a terminal, an access terminal, a subscriber unit, a station, etc. UE 710 may be a cellular phone, a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a laptop computer, a cordless phone, a wireless local loop (WLL) station, etc.

[0053] Upon power up, UE 710 may search for wireless networks from which it can receive communication services. If more than one wireless network is detected, then a wireless network with the highest priority may be selected to serve UE 710 and may be referred to as the serving network. UE 710 may perform registration with the serving network, if necessary. UE 710 may then operate in a connected mode to actively communicate with the serving network. Alternatively, UE 710 may operate in an idle mode and camp on the serving network if active communication is not required by UE 710.

[0054] UE 710 may be located within the coverage of cells of multiple frequencies and/or multiple RATs while in the idle mode. For LTE, UE 710 may select a frequency and a RAT to camp on based on a priority list. This priority list may include a set of frequencies, a RAT associated with each frequency, and a priority assigned to each frequency. For example, the priority list may include three frequencies X, Y and Z. Frequency X may be used for LTE and may have the highest priority, frequency Y may be used for 1xRTT and may have the lowest priority, and frequency Z may also be used for 1xRTT and may have medium priority. In general, the priority list may include any number of frequencies for any set of RATs and may be specific for the UE location. UE 710 may be configured to prefer LTE, when available, by defining the priority list with LTE frequencies at the highest priority and with frequencies for other RATs at lower priorities, e.g., as given by the example above.

[0055] UE 710 may operate in the idle mode as follows. UE 710 may identify all frequencies/RATs on which it is able to find a “suitable” cell in a normal scenario or an “acceptable” cell in an emergency scenario, where “suitable” and “acceptable” are specified in the LTE standards. UE 710 may then camp on the frequency/RAT with the highest priority among all identified frequencies/RATs. UE 710 may remain camped on this frequency/RAT until either (i) the frequency/RAT is no longer available at a predetermined threshold or (ii) another frequency/RAT with a higher priority reaches this threshold. This operating behavior for UE 710 in the idle mode is described in 3GPP TS 36.304, entitled “Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode,” which is publicly available.

[0056] UE 710 may be able to receive packet-switched (PS) data services from LTE network 702 and may camp on the LTE network while in the idle mode. LTE network 702 may have limited or no support for voice-over-Internet protocol (VoIP), which may often be the case for early deployments of LTE networks. Due to the limited VoIP support, UE 710 may be transferred to another wireless network of another RAT for voice calls. This transfer may be referred to as circuit-switched (CS) fallback. UE 710 may be transferred to a RAT that can support voice service such as 1xRTT, WCDMA, GSM, etc. For call origination with CS fallback, UE 710 may initially become connected to a wireless network of a source RAT (e.g., LTE) that may not support voice service. The UE may originate a voice call with this wireless network and may be transferred through higher-layer signaling to another wireless network of a target RAT that can support the voice call. The higher-layer signaling to transfer the UE to the target RAT may be for various procedures, e.g., connection release with redirection, PS handover, etc.

[0057] Aspects of the present disclosure provide techniques that may help improve performance when resuming operations in a first radio access network (RAN) after suspending operations, for example, to perform measurements in a second RAN. The techniques presented herein may be particularly applicable for UEs that share a single RF chain between networks.

[0058] As noted above, in some cases, it may be desirable for a device to operate with a single RF chain, for example, to reduce cost, reduce size, and limit power consumption. In such cases, the single RF chain may be shared between multiple RAT networks, for example, an LTE network for packet switched (PS) service and a 1x network for circuit switched (CS) service. Therefore, it may not be possible for LTE and 1x technologies (e.g., CDMA, GSM, or UMTS) to be active at the same time.

[0059] Issues may arise when the UE periodically monitors 1x voice pages while an LTE data call is active. During the RF-tune time to 1x, an LTE call may be virtually suspended, and this can lead to disruption in LTE UE functions that may not be expected by the network. This can have many adverse impacts on the LTE call upon resumption from the suspended operations. This architecture/algorithm of a device operating with one RF chain is generally known as suspended LTE.

[0060] In order to minimize the impact to the LTE call on resumption from suspended operations, certain aspects of the present disclosure provide techniques for implementing behavioral changes at the UE on resumption after a tune out to a 1x network. This disclosure pertains to enhancing LTE data throughput and latency performance of hybrid tune away devices (single radio devices) through a quick or fast scheduling request (SR) mechanism after UE tune back to LTE system.

[0061] As noted above, LTE hybrid tune away devices may tune away to other legacy voice service technologies like 1x RTT, GSM, TD-SCDMA or other 3G technologies. When the UE tunes away to other technologies for monitoring any incoming pages or overhead message updates, the UE misses any data scheduled by LTE eNB during the time of the tune away. If a continuous discontinuous reception (CDRX) or discontinuous transmission (DTX) state is entered during a tune away or if UE buffer status report (BSR) retransmission timers are running, further significant delay for LTE UL and DL data scheduling after the UE tunes back to LTE system may occur. This disclosure provides UE based quick SR enhancements after tune back to LTE system in order to quickly resume LTE data services and improve LTE data throughput performance.

[0062] FIG. 8 is a call flow diagram 800 involving uplink data transfer activity between a UE 802 and an eNB 804 in accordance with one aspect of the disclosure. When a UE 802 has UL data to send over a first RAT, such as LTE, the UE sends a buffer status report (BSR) to the eNB 804. The eNB 804 may receive the BSR and send an UL grant to the UE. The UE 802, however, may miss the grant if it has tuned away 806 from the LTE system. For example, assume the UE is doing an UL active data transfer on an LTE system and sends a BSR to an eNB to indicate the UE has data in its UL data buffer. When a BSR is sent and then the UE tunes away to another RAT, the UE may miss the PUSCH grant from the eNB due to the tune away. As a result of missing the UL grant, the UE 802 MAC starts a "retxBSR-Timer" 808. The retxBSR-Timer continues to run on the LTE stack during the time the UE is tuned away. The typical setting for this timer is 320ms. This setting, however, may be changed based on network configuration. The typical tune away time is variable and may be in the range of 20-160ms. The setting may be based on UE operation when the UE tunes away to another RAT. After the UE tunes back to the LTE system 810, data will be pending in UE UL buffer due to the UE missing the PUSCH UL grants during the tune away. In current UE operations, the UE will send another BSR, upon expiration of the retxBSR-Timer. The delay in time between when the UE tunes back to the LTE system and the time when the retxBSR-Timer expires causes significant delay for UL data packets, and thus a loss of UL throughput.

[0063] With continued reference to FIG. 8, to address the foregoing delay issue, in one aspect of the disclosure, upon tuning back to the LTE system, the UE determines if there is a buffered BSR pending. In other words, the UE determines if it had sent a BSR prior to tune away and if the data in the UL data transfer buffer is still present in the buffer after the UE tunes back to the LTE system. If a buffered BSR is pending, the UE MAC immediately and automatically resets the "retxBSR-Timer" 812 and immediately triggers or sends a SR to the eNB to request UL PUSCH resources. This immediate SR may be referred to as a "quick SR" or a "fast SR." Upon receipt of the UL grants sent by the eNB in response to the quick SR, the UE may transmit the buffered UL data in accordance with the resources indicated in the grant. Accordingly, the UE is able to transmit data in a more time-efficient manner, without having to wait for expiration of the retxBSR-Timer.

[0064] In another scenario related to UL data transfer, there may be a bursty UL data transfer is in progress, in which case the UE UL buffer data may not be available at all times. Assume that there is some data in UE UL data buffer that caused the UE to send a SR and receive a UL PUSCH grant from an eNB. Further assume that the UE transmitted UL PUSCH data using RV0 and failed to receive DL PHICH ACK/NACK from the eNB due to UE tune away. If the eNB failed to receive PUSCH data, it can send PHICH NACK. In the case of UL adaptive retransmission, the eNB can allocate a new UL grant for PUSCH re-transmission. This re-allocation, however, would be missed by the UE since the UE is tuned away. After the UE tunes back to the LTE system, if the UE blindly re-uses the same PUSCH resources received by the UE prior to tune away to transmit UL data, this data may not be successfully decoded by the eNB if the UE has used UL adaptive HARQ resources for PUSCH re-transmission. Also, if the same resources previously allocated to a first UE that tuned away are subsequently allocated by eNB to a second UE, then blind re-use of the same PUSCH resources by the first UE after it tunes back to the LTE system for re-transmission will cause interference with the second UE to which the same resources have been allocated. This interference results in an overall loss of throughput for both the first and second UEs.

[0065] The foregoing issues of failed decoding and interference may be addressed in the same manner as presented with respect to FIG. 8. The UE may avoid blind re-use of previously allocated UL grant resources by automatically and immediately resetting the retx-BSR-Timer upon tuning back to the LTE system and immediately sending a SR to obtain UL grants.

[0066] FIG. 9 is a call flow diagram 900 involving downlink data transfer activity between a UE 902 and an eNB 904 in accordance with one aspect of the disclosure. A DL data transfer between a UE 902 and a network device 904, e.g., eNB, is in progress on an LTE system. The UE 902 tunes away 906 to another RAT 904 during the DL data transfer. When the UE 902 tunes away to the other RAT, the UE will miss the scheduled DL data, e.g., PDSCH data. Because the UE 902 missed the DL data, the UE will not transmit an UL HARQ ACK/NACK regarding the receipt of the DL data. As a result of no UL HARQ ACK/NACK from the UE 902, the eNB 904 may determine that the UE is no longer responding for any DL data and may enter into a power saving mode 908 with respect to that UE. For example, the eNB 904 may enter into either a CDRX state or a DTX state. Once is either of these states, the eNB 904 may try to schedule DL data to the UE during the ON durations of a power saving mode cycle, such as a CDRX cycle. Assume that eNB 904 entered into a long DRX cycle, which is typically 320ms, after a short CDRX cycle, which is typically 40ms, has ended and at the same time the UE tunes back 910 to the LTE system. In this case, even after the UE tuned back to the LTE system, the eNB schedules data upon expiration of the long CDRX cycle. This causes LTE DL throughput degradation and increased latency for data delivery.

[0067] With continued reference to FIG. 9, to address the foregoing delay issue, in one aspect of the disclosure, after the UE tunes back 910 to the LTE system, the UE determines whether to send a quick SR based on either the presence of UL data pending in the UE data buffer, or a criterion related to the reception of DL before the UE tuned away. If UL data is pending in the UE data buffer, then the UE automatically and immediately initiates a BSR transmission followed by a quick SR, as described above with reference to FIG. 8. If there is no UE UL buffer data pending, the UE determines if a DL data criterion is met. In one configuration, the UE may determine if an amount of DL data received over a period of “x” milliseconds before the UE tuned away 906 is above a threshold amount “y” bits. For example, if the size of a DL transport block received by the UE 902 during a time period 200 milliseconds, is greater than or equal to 72 bits, the criterion may be considered met. If the criterion is met, the UE 902 sends a quick SR. In response to the quick SR, the eNB 904 provides UL PUSCH grants to the UE. In this case, because the UE does not have any pending UL data in the data buffer or signaling information to send, the UE MAC layer may send padding data of, for example, all zeros in a given MAC transport block. The SR sent by the UE 902 causes the eNB 904 to exit the power saving mode 912, e.g., a DTX state or CDRX states, and start DL PDSCH data scheduling.

[0068] The SR procedures involved in the foregoing implementations still follow “SR-prohibit-timer” and “dsr-TransMax” if being configured by the network side. If SR-prohibit timer value is greater than 1 and still running after the UE tunes back to the LTE system, the UE can reset the timer and send a quick SR at the next available immediate SR transmission opportunity.

[0069] Conditions other than the examples described above may trigger a quick SR mechanism. For example, in a case where a UE enters into a power saving state, e.g., CDRX, while camped on a first RAT, and then tunes away to a second RAT, the UE will not receive any DL data that is scheduled by the eNB of the first RAT during the ON period of the CDRX cycle. Furthermore, if the duration of the UE tune away is long, e.g., one second or greater, the UE may miss all DL data scheduling attempts tried by the eNB. In accordance with an embodiment of a quick SR triggering, upon tuning back to the first RAT the UE may trigger a quick SR even if there is no UL/DL data activity seen by the UE. The UE may determine there is no UL/DL data activity based on an absence of active PDSCH or PUSCH data transfer activity prior to the UE tune away. This embodiment is different from the embodiment of FIG.8, wherein the UE looks for UL data in its buffer before sending a quick SR, and the embodiment of FIG. 9, wherein the UE looks for a DL grant received prior to tune away before sending a quick SR. In this embodiment, the UE and eNB will be running CDRX timers. Upon tune back by the UE, these CDRX timers are reset/stopped, pursuant to current standards, and the UE sends a quick SR.

[0070] FIG. 10 is a flow chart 1000 of a method of wireless communication. The method may be performed by a UE (e.g., the UE 802, 902, the apparatus 1102/1102'). At step 1002, the UE tune away from a first RAT, such as LTE, to a second RAT, such as 1xRTT. The tune away occurs during data transfer activity between the UE and a network device, such as an eNB, over the first RAT and starts at least one timer that affects the data transfer activity. At step 1004, the UE initiates a continuance of the data transfer activity immediately upon tuning back to the first RAT.

[0071] In one implementation, the data transfer activity relates to an uplink data transfer from the UE. With reference to FIG. 8, this activity may involve the UE sending a BSR to an eNB for the purpose of receiving UL scheduling grants. Accordingly, “data transfer activity” does not necessarily involve an actual, active transfer of data between the UE and the network device. Such data transfer activity may simply involve the sending of messages, e.g., BSR, that facilitate actual data transfer. In the case of uplink data, the at least one timer may define a time during which the UE refrains from requesting a data transfer. For example, if the UE tunes away after sending the BSR, the UE starts a timer during which the UE does not send another BSR. This timer corresponds to a BSR timer of the UE. With continued reference to FIG. 8, initiating a continuance of the data transfer activity may include resetting the at least one timer; and sending a SR to the network device upon resetting of the at least one timer.

[0072] In another implementation, the data transfer activity relates to a downlink data transfer to the UE. With reference to FIG. 9, this activity may involve receipt by the UE if a DL scheduling grant from an eNB followed by receipt of DL data from the eNB. Accordingly, in this case, “data transfer activity” involves actual and active transfer of DL data, and the UE tunes away during this active transfer of data. The at least one timer that affects data transfer activity defines a cycle of a power saving mode that the eNB enters after determining that the UE is not responding to the DL data transfer. The cycle has an off duration during which the network device refrains from sending downlink data. The timer may be a DRX or CDRX timer of the network device. With continued reference to FIG. 9, initiating a continuance of the data transfer activity includes causing the network device to exit the power saving mode, for example, by sending a SR to the network device.

[0073] FIG. 11 is a conceptual data flow diagram 1100 illustrating the data flow between different modules/means/components in an exemplary apparatus 1102. The apparatus may be a UE. The apparatus includes a tune away / tune back module 1104, an initiating module 1106 and a transmission module 1108.

[0074] The tune away / tune back module 1104 tunes away from a first RAT to a second RAT during data transfer activity between the UE and a network device 1150 over the first RAT. Tuning away starts at least one timer that affects the data transfer activity. In the case of uplink data transfer, the timer is included in the UE 1102. In the case of downlink data transfer, the timer is included in the network device 1150.

[0075] The initiating module 1106 initiates a continuance of the data transfer activity immediately upon tuning back of the UE to the first RAT. In the case of uplink data transfer, the initiating module 1106 resets the timer included in the UE and sends a SR to the network device 1150 through the transmission module 1108. In the case of downlink data, the initiating module resets a timer included in the network device by sending a SR to the network device through the transmission module 1108.

[0076] The apparatus 1102 may include additional modules that perform each of the steps of the algorithm in the aforementioned call flow diagrams of FIG. 8 and FIG. 9 and the flow chart of FIG. 10. As such, each step in the aforementioned call flow diagrams of FIG. 8 and FIG. 9 and the flow chart of FIG. 10 may be performed by a module and the apparatus may include one or more of those modules. The modules may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by a processor configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by a processor, or some combination thereof.

[0077] FIG. 12 is a diagram 1200 illustrating an example of a hardware implementation for an apparatus 1102' employing a processing system 1214. The processing system 1214 may be implemented with a bus architecture, represented generally by the bus

1224. The bus 1224 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 1214 and the overall design constraints. The bus 1224 links together various circuits including one or more processors and/or hardware modules, represented by the processor 1204, the modules 1104, 1106, 1108, and the computer-readable medium / memory 1206. The bus 1224 may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further.

[0078] The processing system 1214 may be coupled to a transceiver 1210. The transceiver 1210 is coupled to one or more antennas 1220. The transceiver 1210 provides a means for communicating with various other apparatus over a transmission medium. The transceiver 1210 receives a signal from the one or more antennas 1220, extracts information from the received signal, and provides the extracted information to the processing system 1214. In addition, the transceiver 1210 receives information from the processing system 1214, specifically the transmission module 1108`, and based on the received information, generates a signal to be applied to the one or more antennas 1220. The processing system 1214 includes a processor 1204 coupled to a computer-readable medium / memory 1206. The processor 1204 is responsible for general processing, including the execution of software stored on the computer-readable medium / memory 1206. The software, when executed by the processor 1204, causes the processing system 1214 to perform the various functions described *supra* for any particular apparatus. The computer-readable medium / memory 1206 may also be used for storing data that is manipulated by the processor 1204 when executing software. The processing system further includes at least one of the modules 1104, 1106, and 1108. The modules may be software modules running in the processor 1204, resident/stored in the computer readable medium / memory 1206, one or more hardware modules coupled to the processor 1204, or some combination thereof. The processing system 1214 may be a component of the UE 650 and may include the memory 660 and/or at least one of the TX processor 668, the RX processor 656, and the controller/processor 659.

[0079] In one configuration, the apparatus 1102/1102' for wireless communication includes means for tuning away from a first RAT to a second RAT during data transfer activity between the UE and a network device over the first RAT, wherein tuning away starts at least one timer that affects the data transfer activity, and means for initiating a continuance of the data transfer activity immediately upon tuning back to the first RAT.

[0080] The aforementioned means may be one or more of the aforementioned modules of the apparatus 1102 and/or the processing system 1214 of the apparatus 1102' configured to perform the functions recited by the aforementioned means. As described *supra*, the processing system 1214 may include the TX Processor 668, the RX Processor 656, and the controller/processor 659. As such, in one configuration, the aforementioned means may be the TX Processor 668, the RX Processor 656, and the controller/processor 659 configured to perform the functions recited by the aforementioned means.

[0081] It is understood that the specific order or hierarchy of steps in the processes / flow charts disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes / flow charts may be rearranged. Further, some steps may be combined or omitted. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0082] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "at least one of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "at least one of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and

C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed as a means plus function unless the element is expressly recited using the phrase “means for.”

CLAIMS

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

tuning away from a first radio access technology (RAT) to a second RAT during data transfer activity between the UE and a network device over the first RAT, wherein tuning away starts at least one timer that affects the data transfer activity; and

initiating a continuance of the data transfer activity immediately upon tuning back to the first RAT.

2. The method of claim 1, wherein the data transfer activity relates to an uplink data transfer from the UE.

3. The method of claim 2, wherein the at least one timer defines a time during which the UE refrains from requesting a data transfer.

4. The method of claim 3, wherein the at least one timer corresponds to a buffer status report (BSR) timer of the UE.

5. The method of claim 3, wherein initiating a continuance of the active data transfer comprises:

resetting the at least one timer; and

sending a scheduling request (SR) to the network device upon resetting of the at least one timer.

6. The method of claim 1, wherein the data transfer activity relates to a downlink data transfer to the UE.

7. The method of claim 6, wherein the at least one timer defines a cycle of a power saving mode, the cycle having an off duration during which the network device refrains from sending downlink data.

8. The method of claim 7, wherein the at least one timer corresponds to a discontinuous reception (DRX) timer of the network device.

9. The method of claim 7, wherein initiating a continuance of the data transfer activity comprises causing the network device to exit the power saving mode.

10. The method of claim 9, wherein causing the network device to exit the power saving mode comprises sending a scheduling request (SR) to the network device.

11. The method of claim 7, further comprising, prior to initiating a continuance of the data transfer activity, determining if a criterion related to downlink data activity prior to the UE tuning away is satisfied.

12. The method of claim 11, wherein the criterion comprises a measure of a size of downlink data received by the UE during a period of time prior to the UE tuning away.

13. An apparatus for wireless communication, comprising:

means for tuning away from a first radio access technology (RAT) to a second RAT during data transfer activity between the UE and a network device over the first RAT, wherein tuning away starts at least one timer that affects the data transfer activity; and

means for initiating a continuance of the data transfer activity immediately upon tuning back to the first RAT.

14. The apparatus of claim 11, wherein the data transfer activity relates to an uplink data transfer from the UE.

15. The apparatus of claim 12, wherein the at least one timer defines a time during which the UE refrains from requesting a data transfer.

16. The apparatus of claim 13, wherein the at least one timer corresponds to a buffer status report (BSR) timer of the UE.

17. The apparatus of claim1 3, wherein the means for initiating a continuance of the active data transfer is configured to:

reset the at least one timer; and

send a scheduling request (SR) to the network device upon resetting of the at least one timer.

18. The apparatus of claim 11, wherein the data transfer activity relates to a downlink data transfer to the UE.

19. The apparatus of claim 16, wherein the at least one timer defines a cycle of a power saving mode, the cycle having an off duration during which the network device refrains from sending downlink data.

20. The apparatus of claim 17, wherein the at least one timer corresponds to a discontinuous reception (DRX) timer of the network device.

21. The apparatus of claim 17, wherein the means for initiating a continuance of the data transfer activity is configured to cause the network device to exit the power saving mode.

22. The apparatus of claim 19, wherein to cause the network device to exit the power saving mode, the means for initiating is configured to send a scheduling request (SR) to the network device.

23. The apparatus of claim 16, further comprising, means for , prior to initiating a continuance of the data transfer activity, determining if a criterion related to downlink data activity prior to the UE tuning away is satisfied.

24. The apparatus of claim 23, wherein the criterion comprises a measure of a size of downlink data received by the UE during a period of time prior to the UE tuning away.

25. An apparatus for wireless communication, comprising:

a memory; and

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

tune away from a first radio access technology (RAT) to a second RAT during data transfer activity between the UE and a network device over the first RAT, wherein tuning away starts at least one timer that affects the data transfer activity; and

initiate a continuance of the data transfer activity immediately upon tuning back to the first RAT.

26. A computer program product stored on a computer-readable medium and comprising code that when executed on at least one processor causes the at least one processor to:

tune away from a first radio access technology (RAT) to a second RAT during data transfer activity between the UE and a network device over the first RAT, wherein tuning away starts at least one timer that affects the data transfer activity; and

initiate a continuance of the data transfer activity immediately upon tuning back to the first RAT.

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

entering into a power saving mode while camped on a first radio access technology (RAT), the power saving mode having an on duration during which the UE transmits and/or receives data over the first RAT;

tuning away from the first RAT to a second RAT, wherein tuning away affects the data reception and/or transmission between the UE and the first RAT during the on duration; and

initiating a continuance of the data reception and/or transmission between the UE and the first RAT immediately upon tuning back to the first RAT.

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

means for entering into a power saving mode while camped on a first radio access technology (RAT), the power saving mode having an on duration during which the UE transmits and/or receives data over the first RAT;

means for tuning away from the first RAT to a second RAT, wherein tuning away affects the data reception and/or transmission between the UE and the first RAT during the on duration; and

means for initiating a continuance of the data reception and/or transmission between the UE and the first RAT immediately upon tuning back to the first RAT.

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

a memory; and

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

enter into a power saving mode while camped on a first radio access technology (RAT), the power saving mode having an on duration during which the UE transmits and/or receives data over the first RAT;

tune away from the first RAT to a second RAT, wherein tuning away affects the data reception and/or transmission between the UE and the first RAT during the on duration; and initiate a continuance of the data reception and/or transmission between the UE and the first RAT immediately upon tuning back to the first RAT.

30. A computer program product stored on a computer-readable medium of a user equipment (UE) and comprising code that when executed on at least one processor causes the at least one processor to:

enter into a power saving mode while camped on a first radio access technology (RAT), the power saving mode having an on duration during which the UE transmits and/or receives data over the first RAT;

tune away from the first RAT to a second RAT, wherein tuning away affects the data reception and/or transmission between the UE and the first RAT during the on duration; and

initiate a continuance of the data reception and/or transmission between the UE and the first RAT immediately upon tuning back to the first RAT.

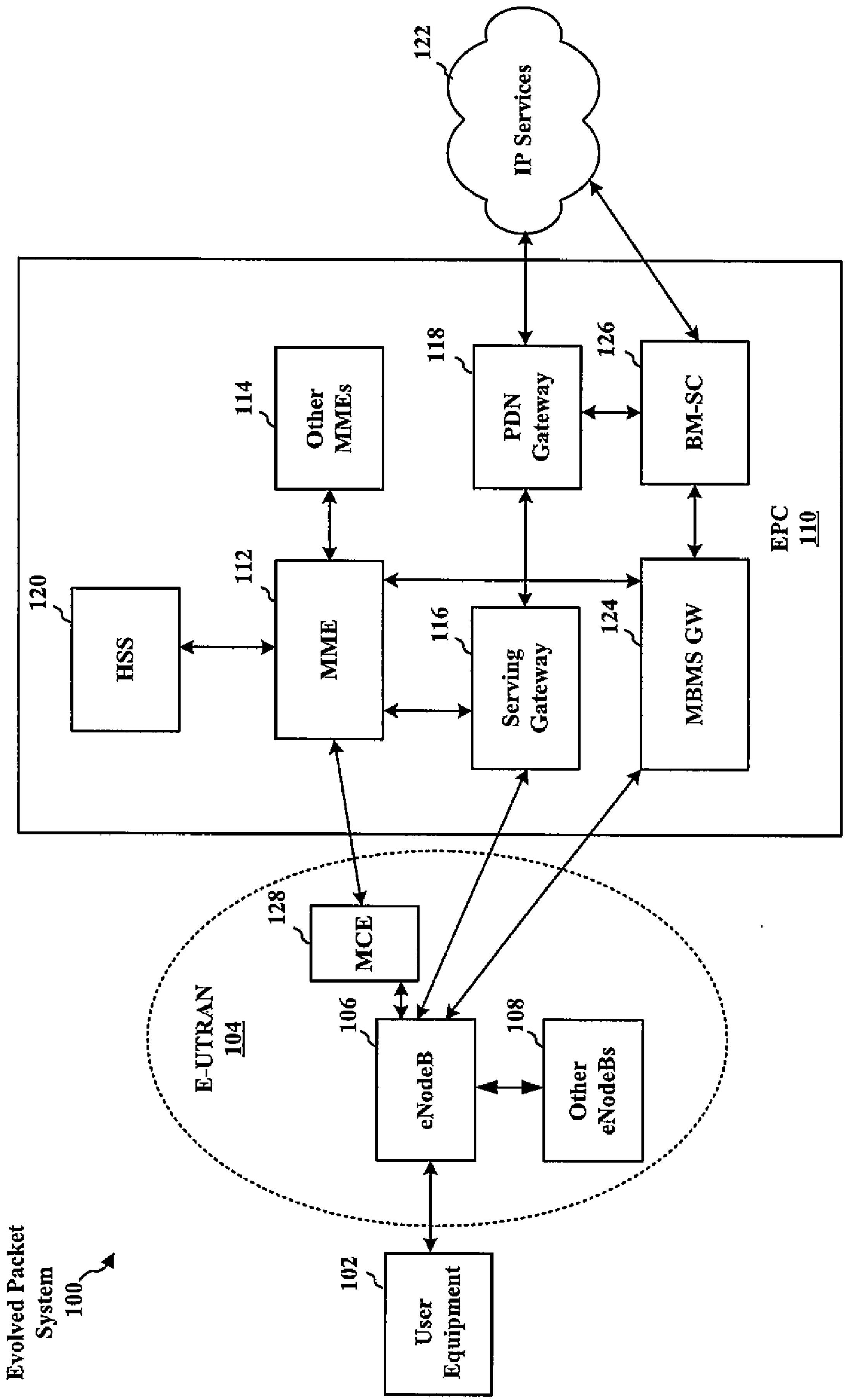
Evolved Packet System
100
User Equipment
102
E-UTRAN
104
eNodeB
106
Other eNodeBs
108
MCE
128
EPC
110
MME
112
Other MMEs
114
Serving Gateway
116
PDN Gateway
118
HSS
120
IP Services
122
MBMS GW
124
BM-SC
126

FIG. 1

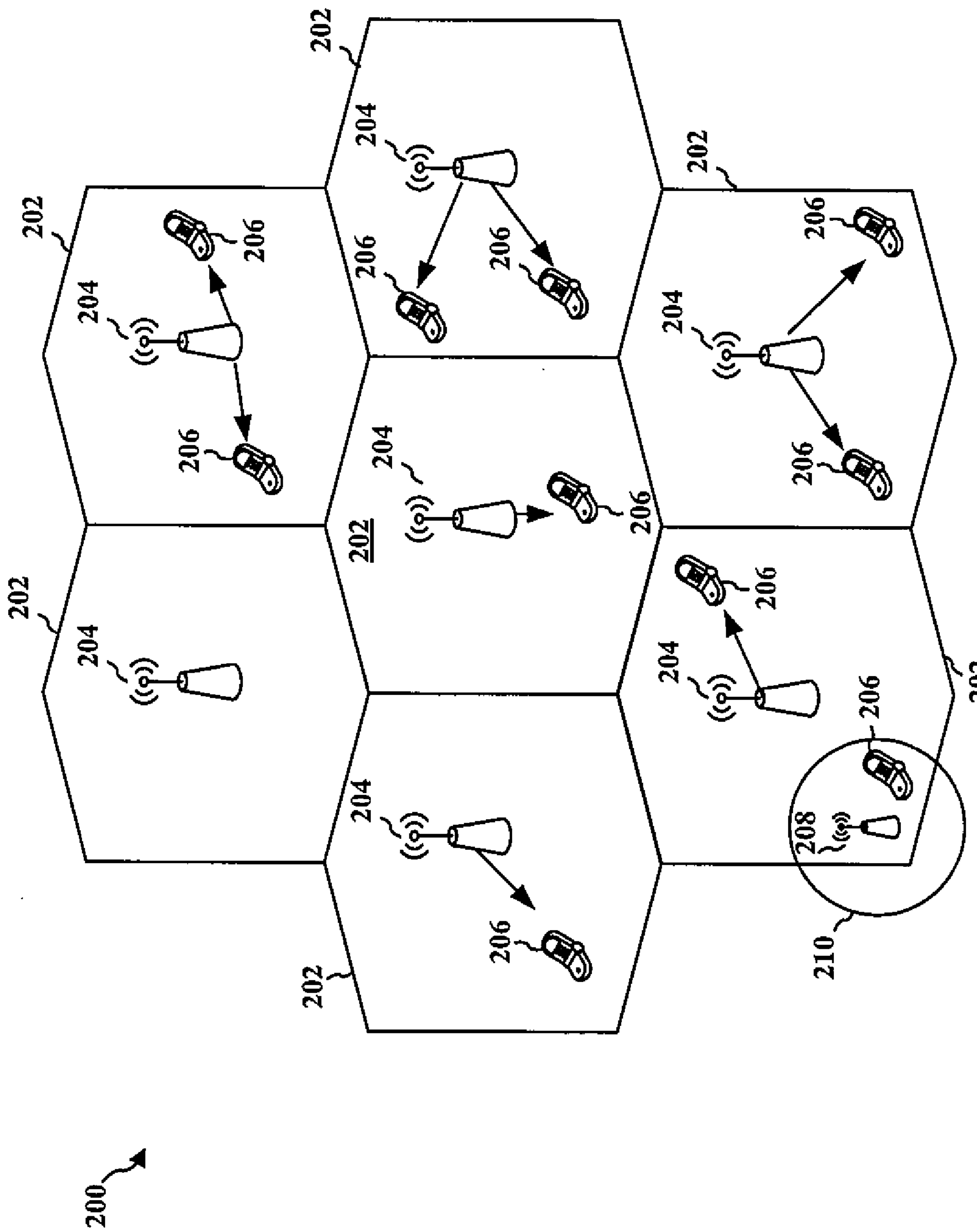

FIG. 2

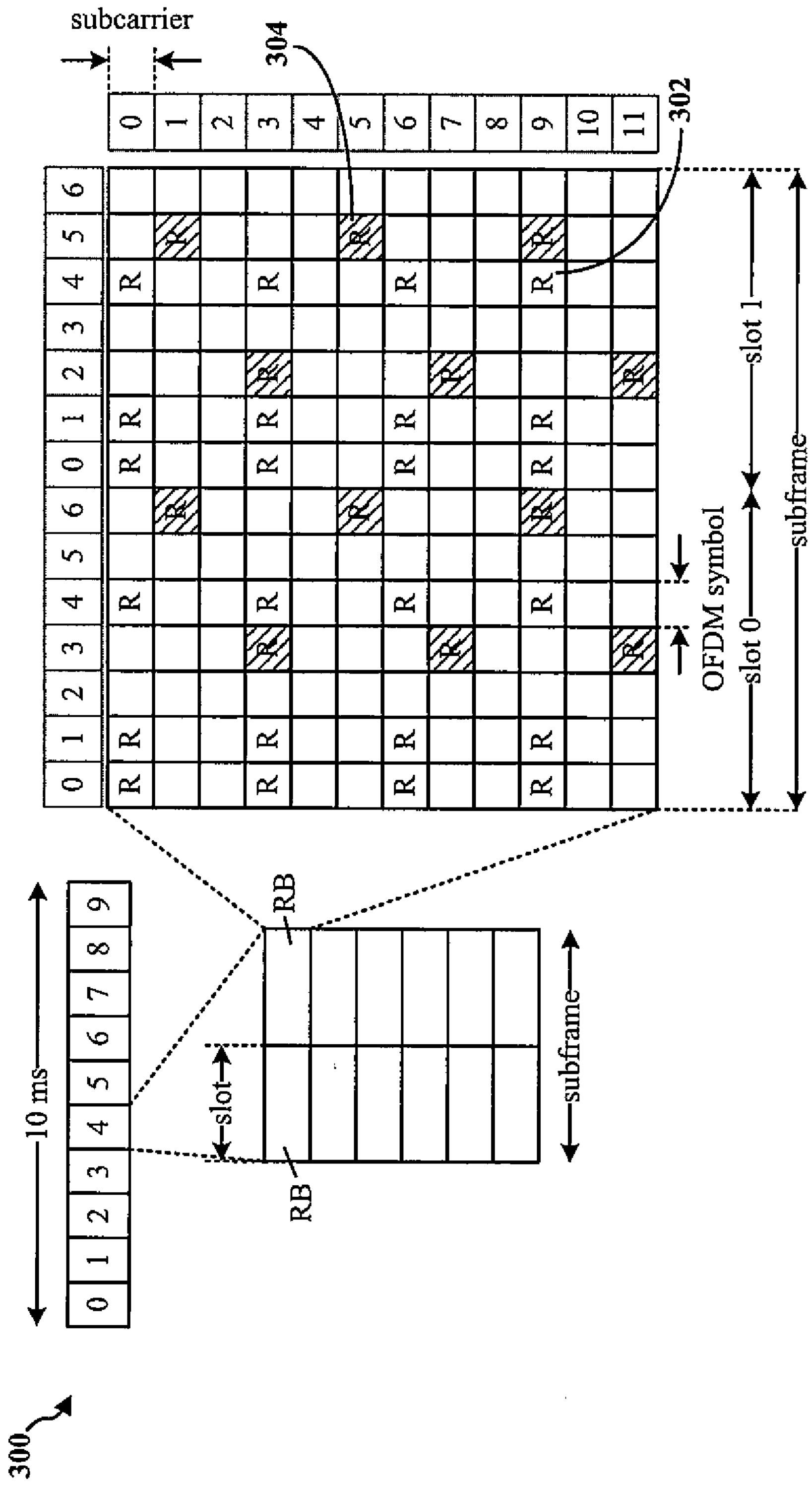
300
10 ms
0 1 2 3 4 5 6 7 8 9
slot
subframe
RB
RB
subcarrier
304
302
0 1 2 3 4 5 6 7 8 9 10 11
0 1 2 3 4 5 6 0 1 2 3 4 5 6
R
OFDM symbol
slot 0
slot 1
subframe

FIG. 3

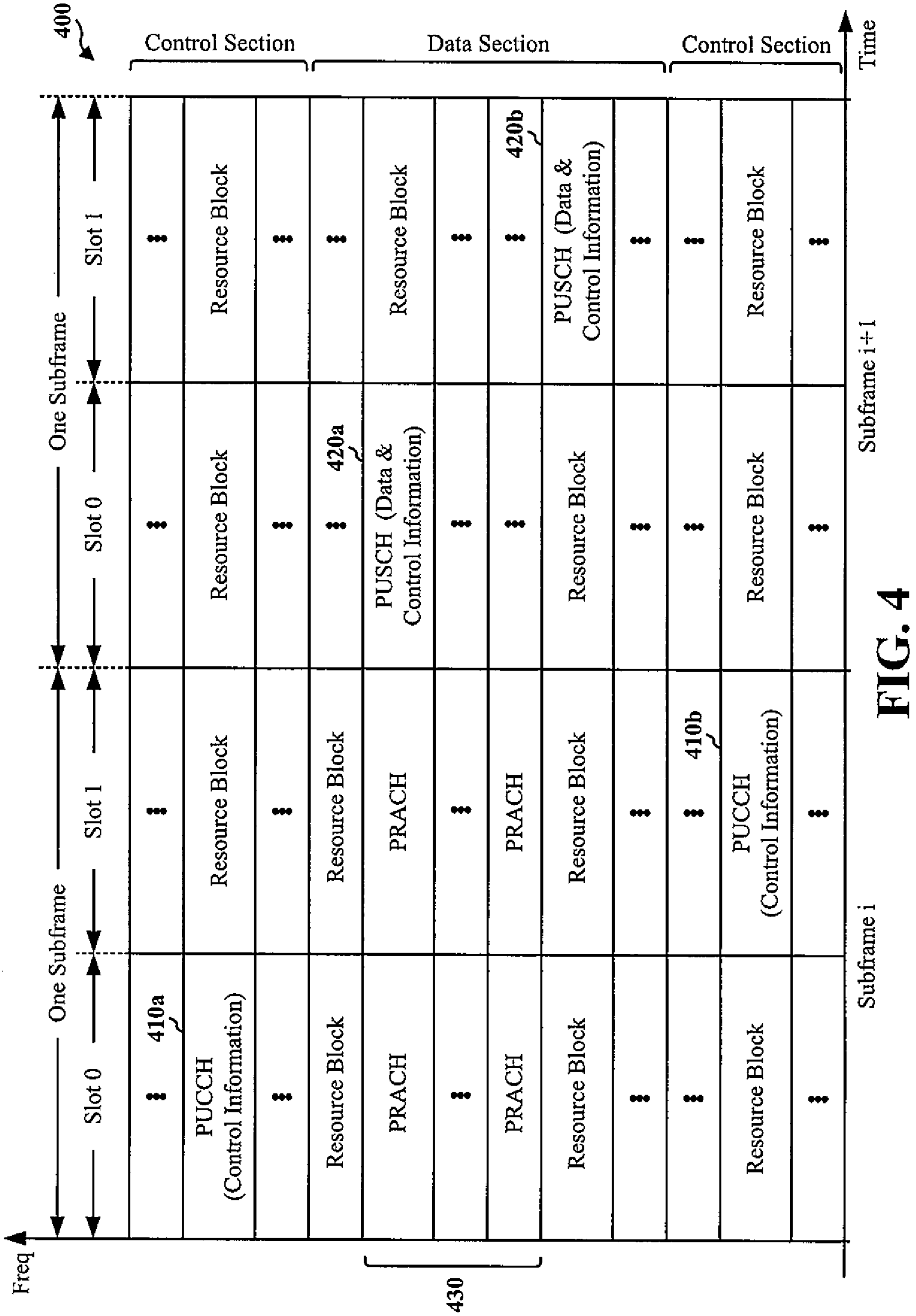
400
Control Section
Data Section
Control Section
Time
Freq
One Subframe
One Subframe
Slot 0
Slot 1
Slot 0
Slot 1
410a
PUCCH
(Control Information)
Resource Block
PRACH
PRACH
Resource Block
Resource Block
Resource Block
Resource Block
PRACH
PRACH
Resource Block
410b
PUCCH
(Control Information)
Resource Block
420a
PUSCH (Data &
Control Information)
Resource Block
Resource Block
Resource Block
Resource Block
420b
PUSCH (Data &
Control Information)
Resource Block
430
Subframe i
Subframe i+1

FIG. 4

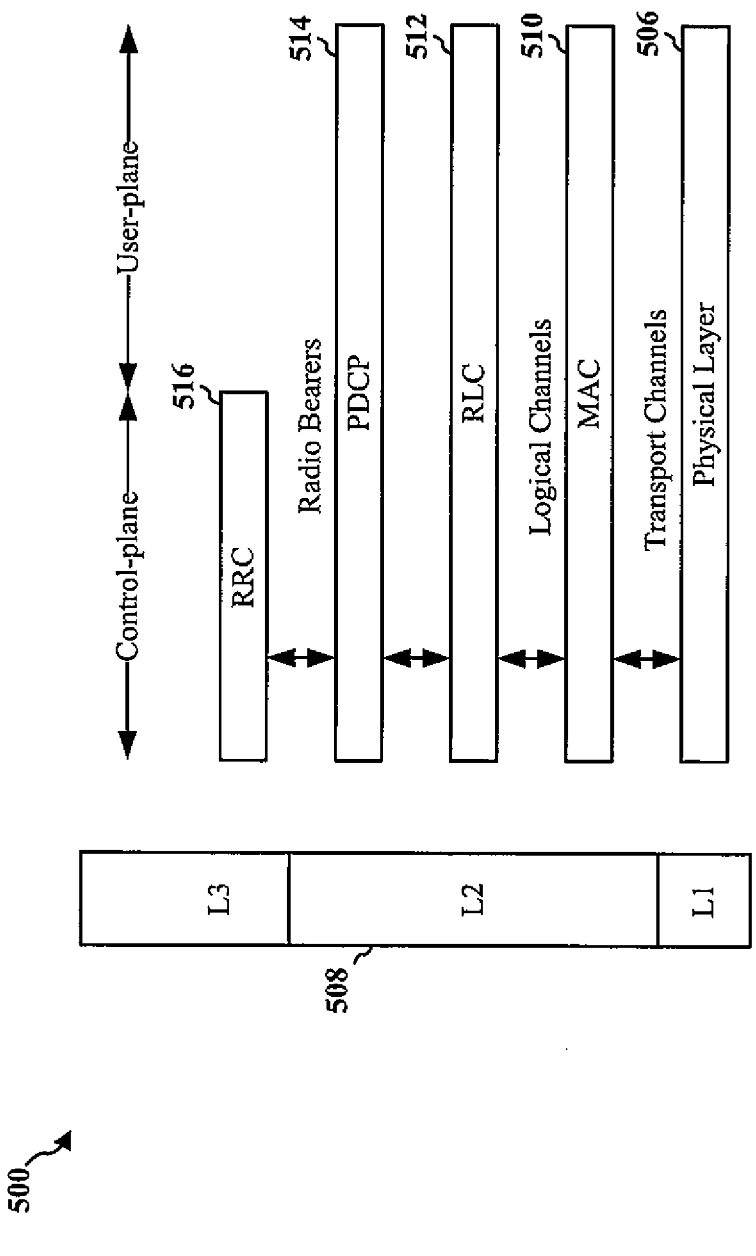
500
508
L3
L2
L1
Control-plane
User-plane
516
RRC
Radio Bearers
514
PDCP
512
RLC
Logical Channels
510
MAC
Transport Channels
506
Physical Layer

FIG. 5

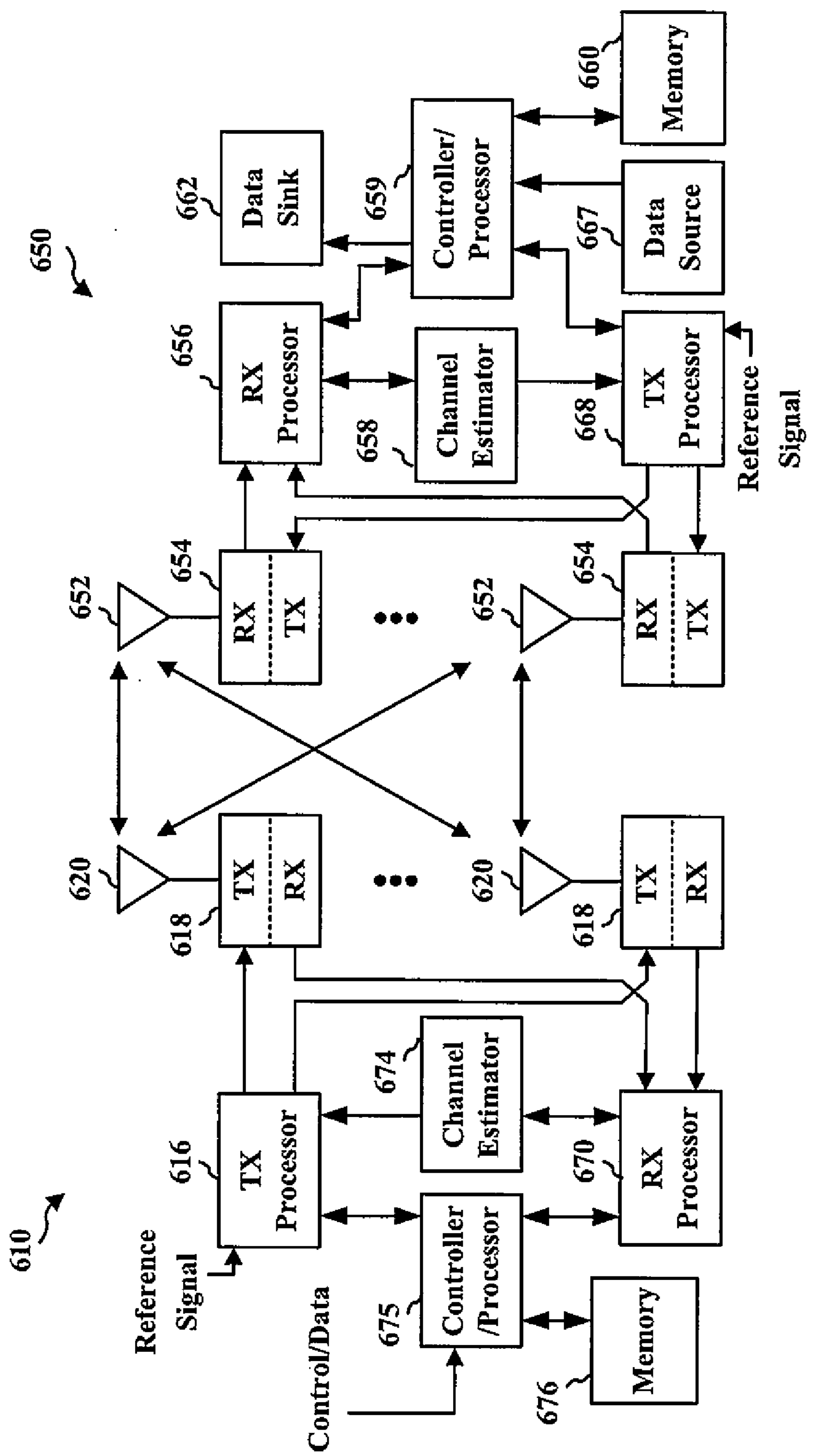
610
616
TX Processor
Reference Signal
Control/Data
675
Controller /Processor
676
Memory
674
Channel Estimator
670
RX Processor
618
TX
RX
620
650
656
RX Processor
662
Data Sink
659
Controller/ Processor
660
Memory
658
Channel Estimator
668
TX Processor
667
Data Source
Reference Signal
654
RX
TX
652

FIG. 6

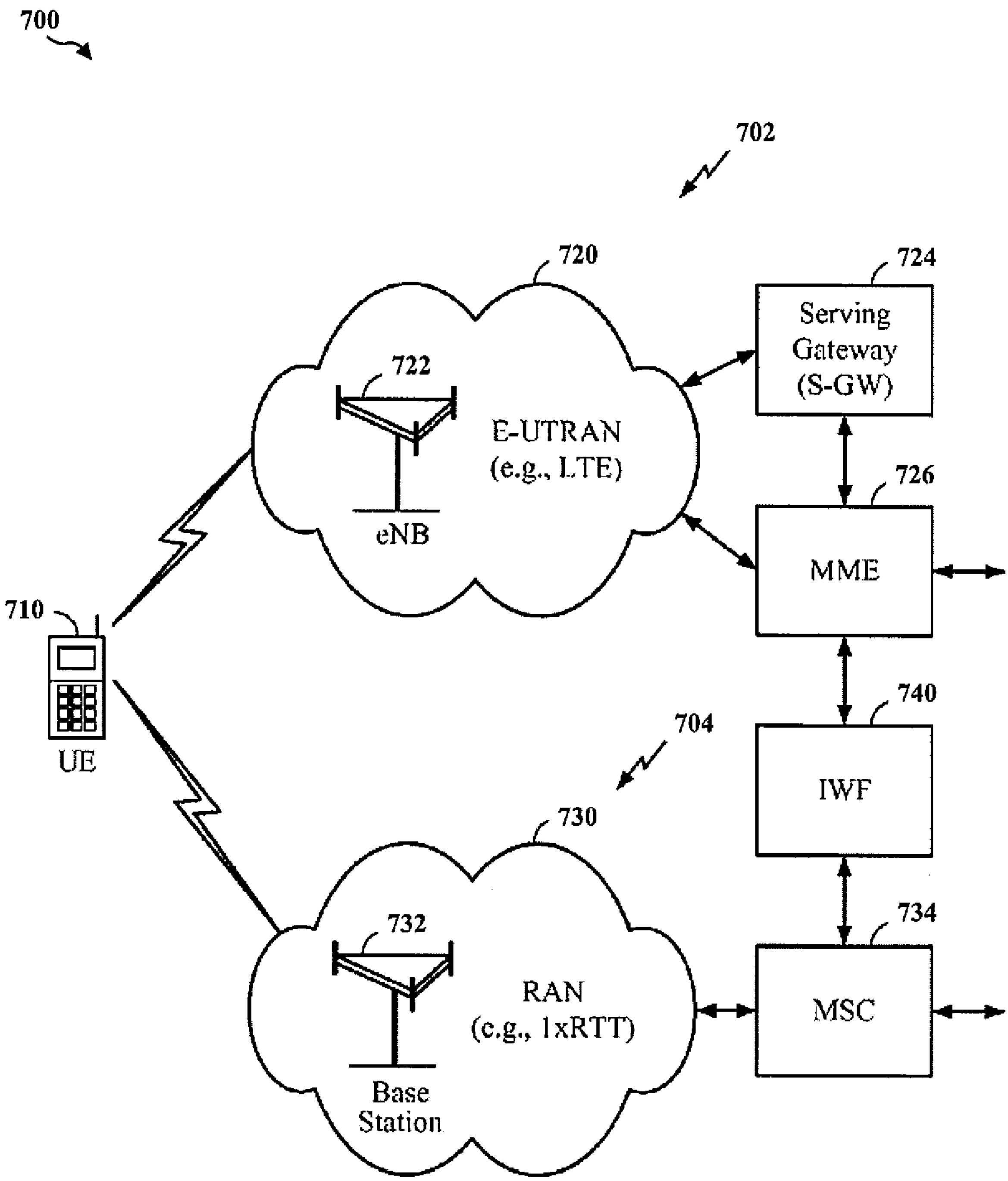
700
702
720
722
E-UTRAN
(e.g., LTE)
eNB
724
Serving
Gateway
(S-GW)
726
MME
710
UE
740
IWF
704
730
732
RAN
(e.g., 1xRTT)
Base
Station
734
MSC

FIG. 7

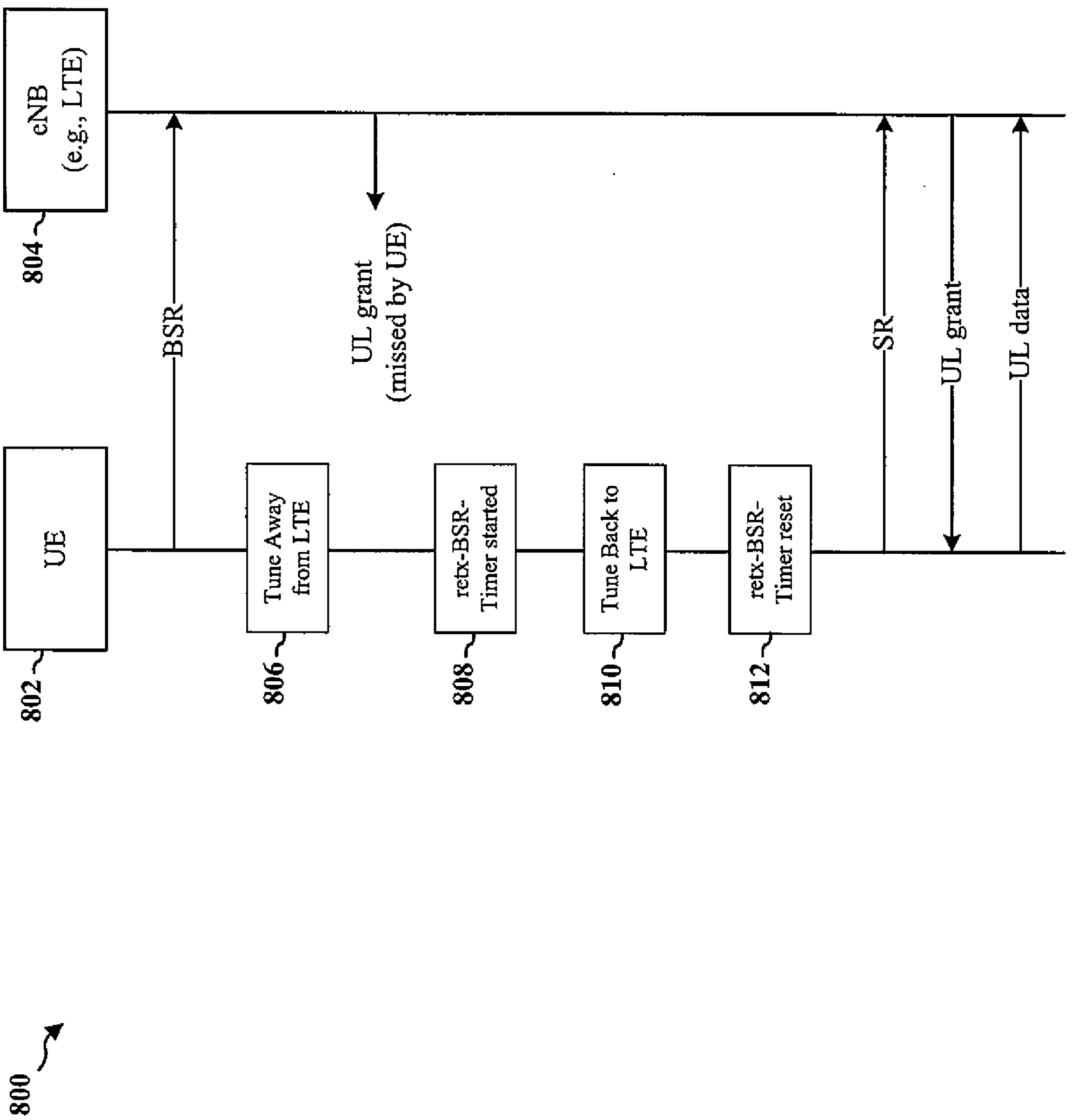
800
802
UE
804
eNB
(e.g., LTE)
BSR
806
Tune Away from LTE
UL grant
(missed by UE)
808
retx-BSR-Timer started
810
Tune Back to LTE
812
retx-BSR-Timer reset
SR
UL grant
UL data

FIG. 8

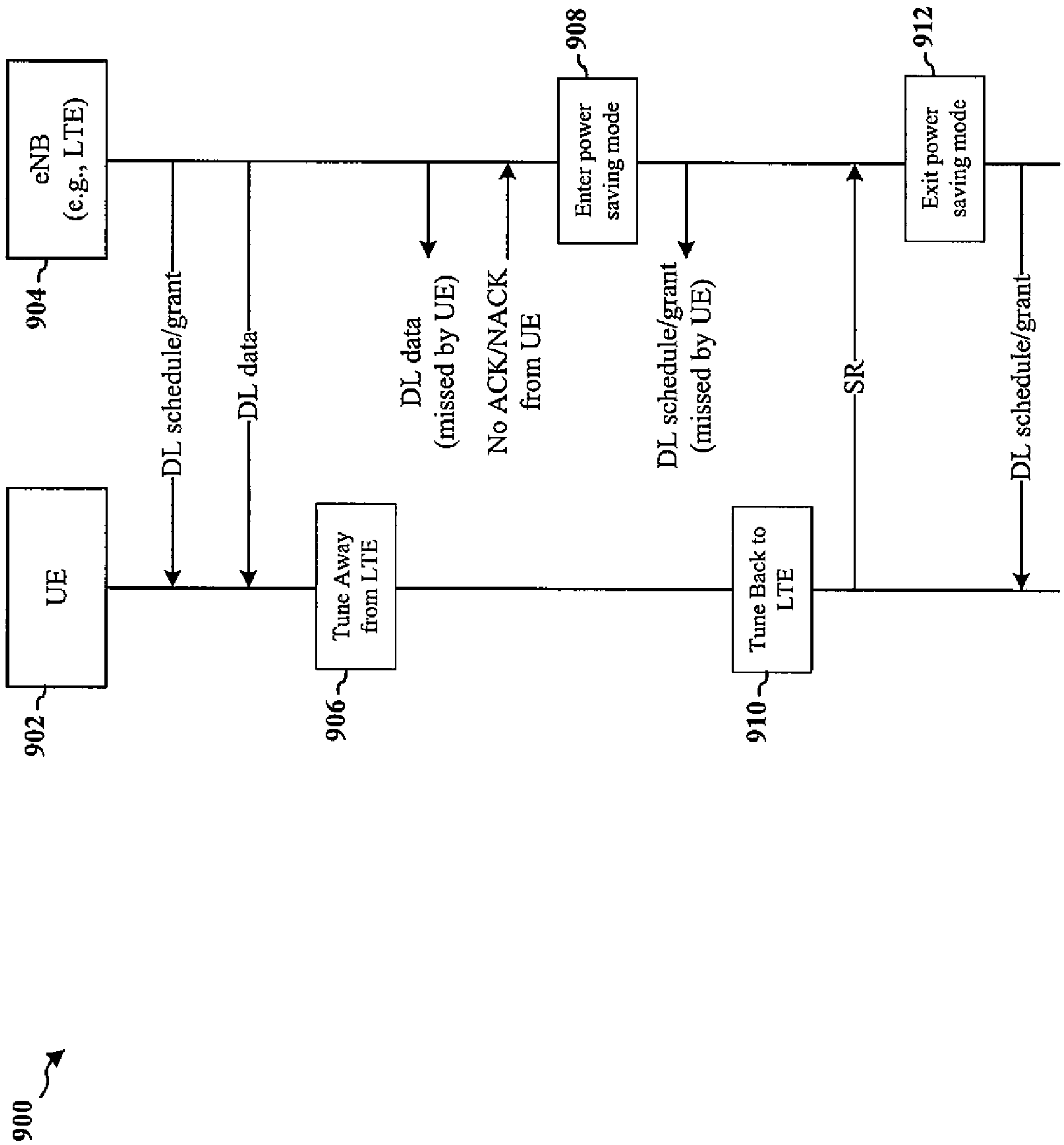
900
902
UE
904
eNB
(e.g., LTE)
DL schedule/grant
DL data
906
Tune Away from LTE
DL data
(missed by UE)
No ACK/NACK from UE
908
Enter power saving mode
DL schedule/grant
(missed by UE)
910
Tune Back to LTE
SR
912
Exit power saving mode
DL schedule/grant

FIG. 9

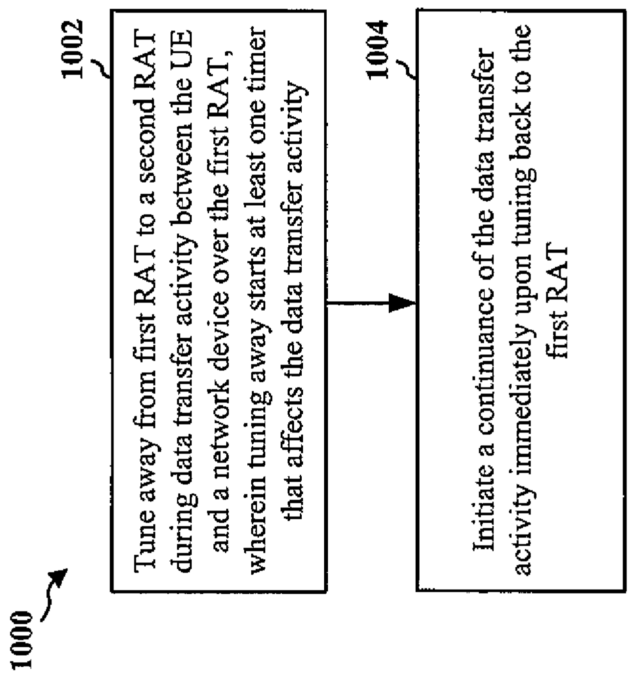
1000
1002
Tune away from first RAT to a second RAT during data transfer activity between the UE and a network device over the first RAT, wherein tuning away starts at least one timer that affects the data transfer activity
1004
Initiate a continuance of the data transfer activity immediately upon tuning back to the first RAT

FIG. 10

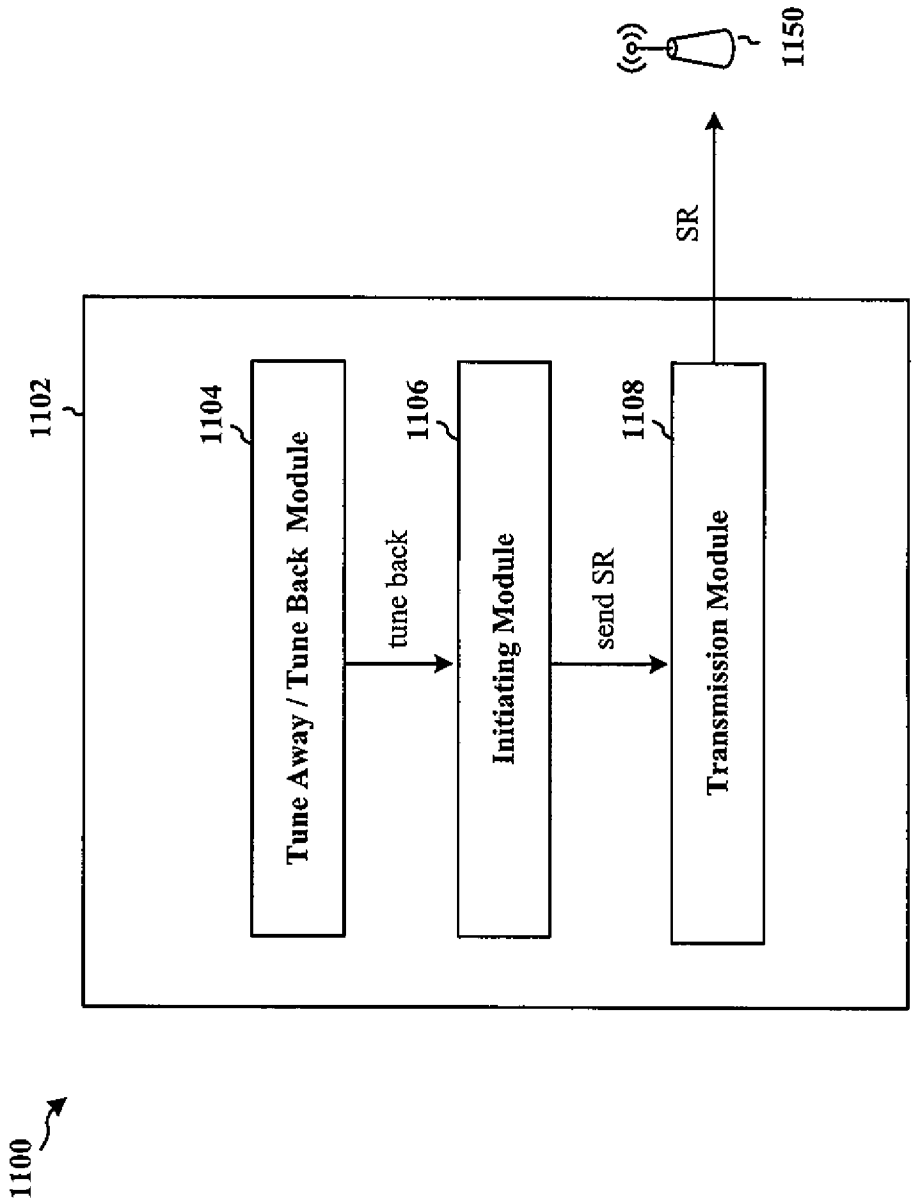
1100
1102
1104
Tune Away / Tune Back Module
tune back
1106
Initiating Module
send SR
1108
Transmission Module
SR
1150

FIG. 11

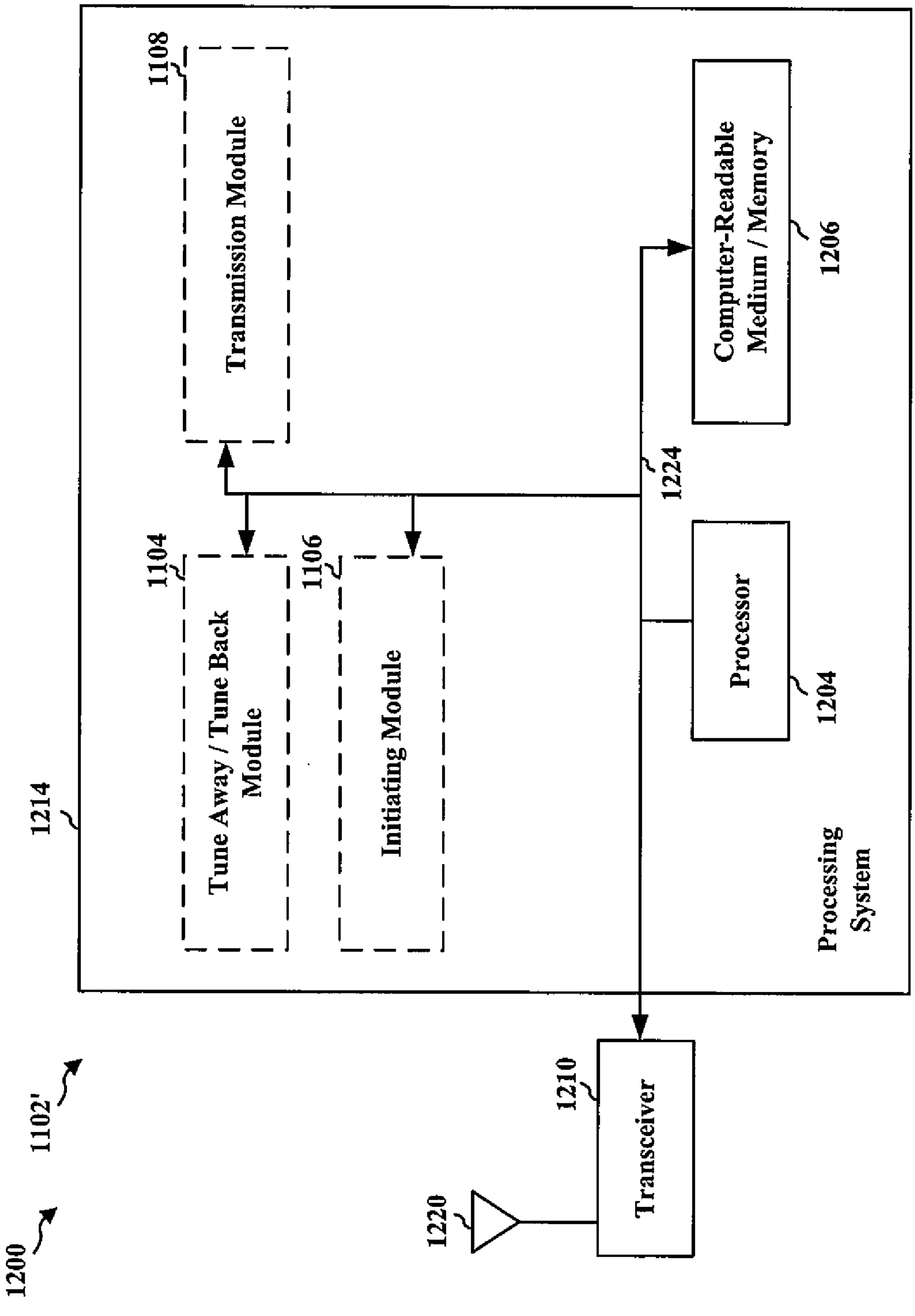
1200
1102'
1214
1108
Transmission Module
1104
Tune Away / Tune Back Module
1106
Initiating Module
1224
Computer-Readable Medium / Memory
1206
Processor
1204
Processing System
1210
Transceiver
1220

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/083028

A. CLASSIFICATION OF SUBJECT MATTER

H04W 88/06(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04L

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

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

WPI, EPODOC, CNPAT, CNKI: tun???, away, back, RAT, timer, trigger, data, trans+, activ+, continu+, BSR, DRX, power sav

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013250854 A1 (VIA TELECOM, INC.) 26 September 2013 (2013-09-26) abstract, description, paragraphs [0044]-[0053]	1-30
A	US 2014044046 A1 (APPLE INC.) 13 February 2014 (2014-02-13) the whole ducument	1-30
A	US 2011280141 A1 (CHIN, TOM ET AL.) 17 November 2011 (2011-11-17) the whole ducument	1-30
A	US 2013201850 A1 (QUALCOMM INCORPORATED) 08 August 2013 (2013-08-08) the whole ducument	1-30

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2015	**29 April 2015**

Name and mailing address of the ISA/CN

STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA(ISA/CN)
6,Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China

Facsimile No. **(86-10)62019451**

Authorized officer

LI,Puxin

Telephone No. **(86-10)62413345**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/083028

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2013250854	A1	26 September 2013	CN	103281735	A	04 September 2013
US	2014044046	A1	13 February 2014	WO	2014028423	A1	20 February 2014
				TW	201414244	A	01 April 2014
US	2011280141	A1	17 November 2011	CN	103826270	A	28 May 2014
				TW	201210362	A	01 March 2012
				CN	102356662	A	15 February 2012
				WO	2011146537	A1	24 November 2011
US	2013201850	A1	08 August 2013	EP	2810516	A1	10 December 2014
				KR	20140122744	A	20 October 2014
				CN	104081861	A	01 October 2014
				WO	2013116650	A1	08 August 2013
				JP	2015507438	A	05 March 2015