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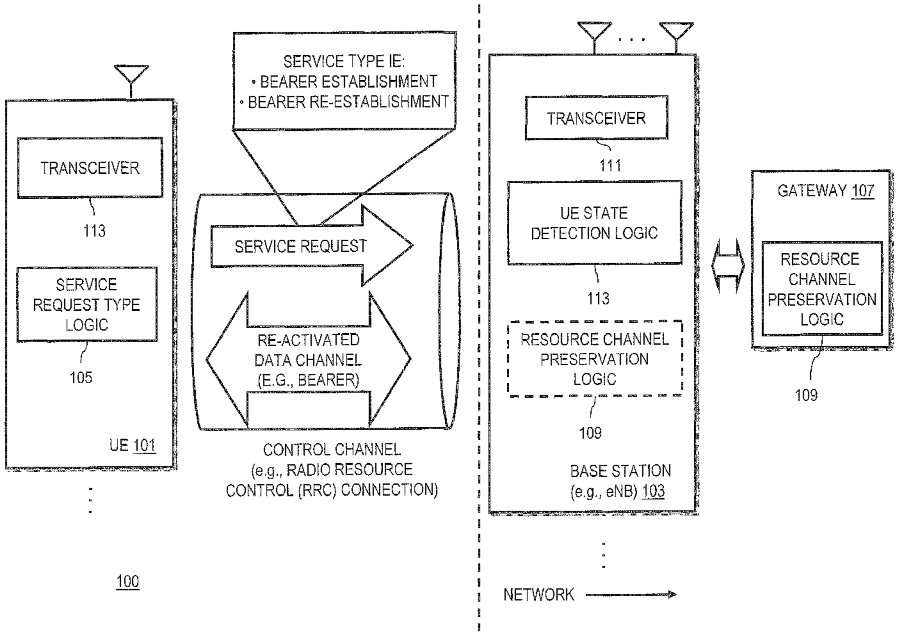
FIG. 1



(57) Abstract: An approach is provided for reactivating a bearer channel. An idle state of communication of a user equipment is detected. A control message, which specifies a service type relating to reactivation of a bearer channel during the idle state for use upon transition to an active state, is generated.

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METHOD AND APPARATUS FOR REACTIVATING A DATA CHANNEL

RELATED APPLICATIONS

[0001] This application claims the benefit of the earlier filing date under 35 U.S.C. §119(e) of U.S. Provisional Application Serial No. 60/983,418 filed October 29, 2007, entitled "Method and Apparatus for Reactivating a Bearer Channel," the entirety of which is incorporated herein by reference.

BACKGROUND

[0002] Radio communication systems, such as a wireless data networks (e.g., Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) systems, spread spectrum systems (such as Code Division Multiple Access (CDMA) networks), Time Division Multiple Access (TDMA) networks, WiMAX (Worldwide Interoperability for Microwave Access), etc.), provide users with the convenience of mobility along with a rich set of services and features. This convenience has spawned significant adoption by an ever growing number of consumers as an accepted mode of communication for business and personal uses. To promote greater adoption, the telecommunication industry, from manufacturers to service providers, has agreed at great expense and effort to develop standards for communication protocols that underlie the various services and features. One area of effort involves managing connections, such as data (or bearer) channels, to enhance user experience. In particular, it is noted that when a user equipment (UE) enters an idle state, any connections previously established for transmitting data are torn down. Consequently, if the UE has data to send, the UE must wait for the connections to be re-established. This re-establishment time translates into delay for the user, thus diminishing the user experience.

SOME EXEMPLARY EMBODIMENTS

[0003] Therefore, there is a need for an approach for providing a mechanism to minimize or eliminate the re-establishment time.

[0004] According to one embodiment of the invention, a method comprises detecting an idle state of communication of a user equipment. The method also comprises generating a control message specifying a service type relating to reactivation of a data channel during the idle state for use upon transition to an active state.

[0005] According to another embodiment of the invention, an apparatus comprises logic configured to detect an idle state of communication of a user equipment. The logic is further configured to generate a control message specifying a service type relating to reactivation of a data channel during the idle state for use upon transition to an active state.

[0006] According to another embodiment of the invention, a method comprises detecting a transition from an idle state to an active state of operations. The method also comprises receiving a control message specifying re-establishment of a bearer channel that has been preserved during the idle state for use upon transitioning to the active state.

[0007] According to another embodiment of the invention, an apparatus comprises logic configured to detect a transition from an idle state to an active state of operations. The logic is further configured to receive a control message specifying re-establishment of a bearer channel that has been preserved during the idle state for use upon transitioning to the active state.

[0008] Still other aspects, features, and advantages of the invention are readily apparent from the following detailed description, simply by illustrating a number of particular embodiments and implementations, including the best mode contemplated for carrying out the invention. The invention is also capable of other and different embodiments, and its several details can be modified in various obvious respects, all without departing from the spirit and scope of the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The embodiments of the invention are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings:

[0010] FIG. 1 is a diagram of a communication system capable of reactivating data channels when user equipment (UE) transitions operational states, according to an exemplary embodiment;

[0011] FIGs. 2 and 3 are flowcharts of processes for reactivating a data channel, according to various exemplary embodiments;

[0012] FIG. 4 is a diagram of an exemplary message flow involving state transition by a user equipment, according to various exemplary embodiments;

[0013] FIGs. 5A-5D are diagrams of communication systems having exemplary long-term evolution (LTE) and E-UTRA (Evolved Universal Terrestrial Radio Access) architectures, in which the system of FIG. 1 can operate to provide detection of a compatible network, according to various exemplary embodiments;

[0014] FIG. 6 is a diagram of hardware that can be used to implement an embodiment of the invention; and

[0015] FIG. 7 is a diagram of exemplary components of a user terminal configured to operate in the systems of FIGs. 5A-5D, according to an embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

[0016] An apparatus, method, and software for reactivating a data channel for use upon transition from an idle state and back to an active state are disclosed. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the embodiments of the invention. It is apparent, however, to one skilled in the art that the embodiments of the invention may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the embodiments of the invention.

[0017] Although the embodiments of the invention are discussed with respect to a wireless network compliant with the Third Generation Partnership Project (3GPP) Long Term Evolution

(LTE) or EUTRAN (Evolved UMTS (Universal Mobile Telecommunications System) Terrestrial Radio Access Network)) architecture, it is recognized by one of ordinary skill in the art that the embodiments of the inventions have applicability to any type of communication system and equivalent functional capabilities. Additionally, it is contemplated that the approach has applicability to various channels, other than bearers.

[0018] FIG. 1 is a diagram of a communication system capable of reactivating data channels when user equipment (UE) transitions operational states, according to an exemplary embodiment. As shown in FIG. 1, a communication system 100 includes one or more user equipment (UEs) 101 communicating with a base station 103, which is part of an access network (e.g., WiMAX, 3GPP LTE (or E-UTRAN or Beyond 3G, 4G), etc.). Under the 3GPP LTE architecture (as shown in FIGs. 5A-5D), the base station 103 denoted as an enhanced Node B (eNB). In one embodiment, the system 100 can be an Evolved Packet System (EPS). The UE 101 can be any type of mobile stations, such as handsets, terminals, stations, units, devices, multimedia tablets, Internet nodes, communicators, Personal Digital Assistants or any type of interface to the user (such as "wearable" circuitry, etc.).

[0019] By way of example, the system 100 provides for fast user plane setup and data channel (bearer) preservation. Fast user plane setup handles signaling optimization starting from conventional sequential messaging to time optimized parallel signaling. Bearer preservation avoids bearer establishment time and also reduces signaling. For example, one or more data channels ("bearers") are preserved when the UE 101 is transferred to idle (or "sleep") state so that those bearers would be ready for use upon next transition to active (or "awake") state. The UE 101 and the eNB 103 are aware of the timing instant where a state transition occurs from when the UE 101 transitions from active state to idle state.

[0020] As shown, the UE 101, according to one embodiment, includes logic 105 that can specify the service request type to indicate whether bearers are preserved. Similarly, the network (e.g., gateway 107) employs a bearer preservation control logic 109, which is implemented by the network, to set up bearers that are to be preserved. Alternatively, the logic 109 can reside within the base station 103. The system 100, according to an exemplary embodiment, provides reactivation of preserved bearers upon transition by the UE 101 from an idle state to an active state.

[0021] The base station 103 employs a transceiver 111 to exchange information with a transceiver 113 of the UE 101 via one or more antennas, which transmit and receive electromagnetic signals. For instance, the base station 103 may utilize a Multiple Input Multiple Output (MIMO) antenna system for supporting the parallel transmission of independent data streams to achieve high data rates with the UE 101. The base station 103, in an exemplary embodiment, uses OFDM (Orthogonal Frequency Divisional Multiplexing) as a downlink (DL) transmission scheme and a single-carrier transmission (e.g., SC-FDMA (Single Carrier-Frequency Division Multiple Access) with cyclic prefix for the uplink (UL) transmission scheme. SC-FDMA can also be realized using a DFT-S-OFDM principle, which is detailed in 3GGP TR 25.814, entitled "Physical Layer Aspects for Evolved UTRA," v.1.5.0, May 2006 (which is incorporated herein by reference in its entirety). SC-FDMA, also referred to as Multi-User-SC-FDMA, allows multiple users to transmit simultaneously on different sub-bands.

[0022] Communications between the UE 101 and the base station 103 (and thus, the network) is governed, in part, by control information exchanged between the two entities. Such control information, in an exemplary embodiment, is transported over a control channel on, for example, the downlink from the base station 103 to the UE 101. By way of example, a number of communication channels are defined for use in the system 100. The channel types include: physical channels, transport channels, and logical channels. For instance in LTE system, the physical channels include, among others, a Physical Downlink Shared channel (PDSCH), Physical Downlink Control Channel (PDCCH), Physical Uplink Shared Channel (PUSCH), and Physical Uplink Control Channel (PUCCH). The transport channels can be defined by how they transfer data over the radio interface and the characteristics of the data. In LTE downlink, the transport channels include, among others, a broadcast channel (BCH), paging channel (PCH), and Down Link Shared Channel (DL-SCH). In LTE uplink, the exemplary transport channels are a Random Access Channel (RACH) and UpLink Shared Channel (UL-SCH). Each transport channel is mapped to one or more physical channels according to its physical characteristics.

[0023] Each logical channel can be defined by the type and required Quality of Service (QoS) of information that it carries. In LTE system, the associated logical channels include, for example, a broadcast control channel (BCCH), a paging control channel (PCCH), Dedicated Control Channel (DCCH), Common Control Channel (CCCH), Dedicated Traffic Channel (DTCH), etc.

[0024] In LTE system, the BCCH (Broadcast Control Channel) can be mapped onto both BCH and DL-SCH. As such, this is mapped to the PDSCH; the time-frequency resource can be dynamically allocated by using L1/L2 control channel (PDCCH). In this case, BCCH (Broadcast Control Channel)-RNTI (Radio Network Temporary Identifier) is used to identify the resource allocation information.

[0025] To ensure reliable data transmission, the system 100 of FIG. 1, in certain embodiments, uses concatenation of Forward Error Correction (FEC) coding and an Automatic Repeat Request (ARQ) protocol commonly known as Hybrid ARQ (HARQ). Automatic Repeat Request (ARQ) is an error detection mechanism using error detection logic (not shown). This mechanism permits the receiver to indicate to the transmitter that a packet or sub-packet has been received incorrectly, and thus, the receiver can request the transmitter to resend the particular packet(s). This can be accomplished with a Stop and Wait (SAW) procedure, in which the transmitter waits for a response from the receiver before sending or resending packets. The erroneous packets are used in conjunction with retransmitted packets.

[0026] Furthermore, the base station 103 employs a UE state detection logic 115 for determining the state of the UE 101 – i.e., whether the UE 101 is in idle mode or active mode. This UE state detection logic 115 operates in conjunction with the resource channel preservation logic 109 to minimize overhead signaling with respect to maintaining a bearer channel.

[0027] According to certain embodiments, a fast user plane setup from idle mode UEs 101 is desirable. For example, reactivation of bearer channels can be indicated in a service request; under an LTE architecture such a request can be a NAS (Non Access Stratum) within a RRC (Radio Resource Control) connection establishment procedure. The NAS protocol is provided between the gateway 107 (which can be a Mobile Management Entity (MME) in LTE) and the

UE 101; this layer is used for control-purposes, such as network attach, authentication, setting up of bearers, and mobility management. NAS messages, for example, can be ciphered and integrity protected by the MME 107 and UE 101.

[0028] A RRC layer in the eNB 103 makes handover decisions based on neighbor cell measurements sent by the UE 101, pages for the UEs 101 over the air, broadcasts system information, controls UE measurement reporting such as the periodicity of Channel Quality Information (CQI) reports and allocates cell-level temporary identifiers to active UEs. It also executes transfer of UE context from the source eNB to the target eNB during handover, and does integrity protection of RRC messages. The RRC layer is responsible for the setting up and maintenance of radio bearers.

[0029] Certain conventional approaches introduce greater signaling overhead – i.e., more IEs (Information Elements) are likely needed. For instance, one approach is to define and specify a service request message with a length that fits into a NAS container of RRC connection message (e.g., the length of the message is totalling 72 bits, which is relatively small). NAS messages typically consume more bytes than real time optimized radio access layer messages. Another approach is to interpret the content of the service request message to be just a protocol identifier with message identity.

[0030] By contrast, the approach, according to certain embodiments, introduces a service type IE with values specifying EUTRAN bearer use relating to state transitions. The service type values are: "Bearer Establishment" and "Bearer Re-establishment". This approach is more fully detailed below.

[0031] FIGs. 2 and 3 are flowcharts of processes for reactivating a data channel, according to various exemplary embodiments. As shown in FIG. 2, the UE 101 detects an idle state of communication, as in step 201. This triggers generation of a control message (e.g., NAS service request), per step 203. The control message can specify the service type; for example, this process utilizes a service type IE with values for "Bearer Establishment" and "Bearer Re-establishment". The use of these service types is defines as follows. Bearer Establishment is used when the UE 101 seeks to transfer data and is in idle state, having no bearer preserved that matches the new user's data flow (default bearer existence ignored). For example, the data flow can be an Internet Protocol (IP) data flow. Bearer re-establishment is utilized when the UE 101 in idle state has new data to be sent and has already a preserved bearer for such purpose. The service type and the service using preserved bearer(s) are known by the UE 101 and the network. Consequently, this allows the Service Request message to be more compact (i.e., less information is required), thus fitting into RRC connection message and allowing faster signaling in AS (Access Stratum) and NAS layers. The control message is then transmitted, as in step 205, over a control channel (e.g., RRC connection).

[0032] In an EUTRAN system, the duration of the call setup (or call setup delay) from idle mode to active mode UE having a requested service is a factor in the quality of service (QoS) experienced by the user.

[0033] There are two modes in mobility management based on mobility-state of the UE 101. In idle mode, the UE 101 does not inform the network of each cell change. In this mode, the idle state is in a power conservation state for the UE 101, where typically the UE 101 is not transmitting or receiving packets. The network, however, knows the location of the UE 101 to the granularity of a few cells, called the Tracking Area (TA). In active mode, the UE 101 is registered with the network and has an RRC connection with the eNB 103. In active state (i.e., LTE active state) the network knows the cell to which the UE 101 belongs and can transmit/receive data from the UE 101.

[0034] According to one embodiment, Bearer Establishment information is sent over an RRC Initial Transfer message. RRC knows the message to be used from NAS layer request that contains the requested establishment cause. Bearer re-establishment is sent over RRC connection request. Similarly as above, RRC knows the message from NAS establishment request.

[0035] On the network side (as shown in FIG. 3), the control message (e.g., service request) is received, per step 301. The process then extracts the service type information from the request (step 303). If the value corresponds to "Bearer Re-establishment," then the bearer channel is preserved for when the UE 101 transitions from idle to active. In other words, the bearer channel is re-activated based on the determined service type and network policy (step 305).

[0036] The above approach, according to certain embodiments, enables the use of less IEs for re-establishment, without requiring context synchronizations or any other "added value" features. This is due to the fact that the bearer establishment and bearer re-establishment are not considered new IEs. In other words, bearer re-establishment can be performed without context synchronization, e.g., PDP (Packet Data Protocol) and MBMS (Multimedia Broadcast Multicast Services).

[0037] It is noted that the service is new and needs new bearer, then a "traditional" kind of sequential signaling can be assumed having a little more signaling, but allowing more information to be sent in the NAS message to the network.

[0038] This arrangement allows faster service reactivation, while still providing the capability to send enough information to the network, for example, in the case of activation of a new service.

[0039] FIG. 4 is a diagram of an exemplary message flow involving state transition by a user equipment, according to various exemplary embodiments. In step 401, the UE 101 sends a random access channel (RACH) preamble to the eNB 103. In response, the eNB 103 transmits a Tracking Area (TA) and scheduling grant (step 403). In this exemplary process, the UE 101 sends a RRC connection request, per step 405, through the random access channel (RACH) -- that is, the uplink common transportation channel. Accordingly, before the RRC connection request message is sent, the UE 101 sends a RACH preamble for try-access. If access is successful, the RRC connection is sent to set up messages from the eNB 103 to the MME 107.

[0040] Connection establishment between the eNB 103 and the MME 107 is also performed. In step 407, the eNB 103 submits a connection request to the MME 107. After receiving the RRC Connection Request, the MME 107 determines whether to permit the access of UE 101. If so, MME 107 will send a connection setup message to the eNB 103, as in step 409. It is noted that this connection establishment procedure can occur concurrently with the RRC connection establishment, or alternatively, after completion of the RRC connection establishment.

[0041] In step 411, the UE 101 sends RRC connection setup complete messages to indicate that RRC connection setup is successfully finished (step 413). Thereafter, data transfer can commence, per step 415. As shown, the HARQ mechanism is executed for the communication between the eNB 103 and the UE 101. This message flow is further detailed in 3GPP TS 25.912, *Feasibility study for evolved Universal Terrestrial Radio Access Network (Release 7)*, V7.2.0, June 2007 – which is incorporated herein by reference in its entirety.

[0042] As explained, the above arrangement and associated processes can be effected in an LTE system. Such a system is now explained. However, it is recognized that other communication architectures can be utilized as well.

[0043] FIGs. 5A-5D are diagrams of communication systems having exemplary long-term evolution (LTE) architectures, in which the user equipment (UE) and the base station of FIG. 1 can operate, according to various exemplary embodiments. By way of example (shown in FIG. 5A), a base station (e.g., destination node) and a user equipment (UE) (e.g., source node) can communicate in system 500 using any access scheme, such as Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), Wideband Code Division Multiple Access (WCDMA), Orthogonal Frequency Division Multiple Access (OFDMA) or Single Carrier Frequency Division Multiple Access (FDMA) (SC-FDMA) or a combination of thereof. In an exemplary embodiment, both uplink and downlink can utilize WCDMA. In another exemplary embodiment, uplink utilizes SC-FDMA, while downlink utilizes OFDMA.

[0044] The communication system 500 is compliant with 3GPP LTE, entitled "Long Term Evolution of the 3GPP Radio Technology" (which is incorporated herein by reference in its entirety). As shown in FIG. 5A, one or more user equipment (UEs) communicate with a network equipment, such as a base station 103, which is part of an access network (e.g., WiMAX (Worldwide Interoperability for Microwave Access), 3GPP LTE (or E-UTRAN), etc.). Under the 3GPP LTE architecture, base station 103 is denoted as an enhanced Node B (eNB).

[0045] MME (Mobile Management Entity)/Serving Gateways 501 are connected to the eNBs 103 in a full or partial mesh configuration using tunneling over a packet transport network (e.g., Internet Protocol (IP) network) 503. Exemplary functions of the MME/Serving GW 501 include distribution of paging messages to the eNBs 103, termination of U-plane packets for paging reasons, and switching of U-plane for support of UE mobility. Since the GWs 501 serve as a gateway to external networks, e.g., the Internet or private networks 503, the GWs 501 include an Access, Authorization and Accounting system (AAA) 505 to securely determine the identity and privileges of a user and to track each user's activities. Namely, the MME Serving Gateway 501 is the key control-node for the LTE access-network and is responsible for idle mode UE tracking and paging procedure including retransmissions. Also, the MME 501 is involved in the bearer activation/deactivation process and is responsible for selecting the SGW (Serving Gateway) for a UE at the initial attach and at time of intra-LTE handover involving Core Network (CN) node relocation.

[0046] A more detailed description of the LTE interface is provided in 3GPP TR 25.813, entitled "E-UTRA and E-UTRAN: Radio Interface Protocol Aspects," which is incorporated herein by reference in its entirety.

[0047] In FIG. 5B, a communication system 502 supports GERAN (GSM/EDGE radio access) 504, and UTRAN 506 based access networks, E-UTRAN 512 and non-3GPP (not shown) based access networks, and is more fully described in TR 23.882, which is incorporated herein by reference in its entirety. A key feature of this system is the separation of the network entity that performs control-plane functionality (MME 508) from the network entity that performs bearer-plane functionality (Serving Gateway 510) with a well defined open interface between them S11. Since E-UTRAN 512 provides higher bandwidths to enable new services as well as to improve existing ones, separation of MME 508 from Serving Gateway 510 implies that Serving Gateway 510 can be based on a platform optimized for signaling transactions. This scheme enables selection of more cost-effective platforms for, as well as independent scaling of, each of these two elements. Service providers can also select optimized topological locations of Serving Gateways 510 within the network independent of the locations of MMEs 508 in order to reduce optimized bandwidth latencies and avoid concentrated points of failure.

[0048] As seen in FIG. 5B, the E-UTRAN (e.g., eNB) 512 interfaces with UE 101 via LTE-Uu. The E-UTRAN 512 supports LTE air interface and includes functions for radio resource control (RRC) functionality corresponding to the control plane MME 508. The E-UTRAN 512 also performs a variety of functions including radio resource management, admission control, scheduling, enforcement of negotiated uplink (UL) QoS (Quality of Service), cell information broadcast, ciphering/deciphering of user, compression/decompression of downlink and uplink user plane packet headers and Packet Data Convergence Protocol (PDCP).

[0049] The MME 508, as a key control node, is responsible for managing mobility UE identifies and security parameters and paging procedure including retransmissions. The MME 508 is involved in the bearer activation/deactivation process and is also responsible for choosing Serving Gateway 510 for the UE 101. MME 508 functions include Non Access Stratum (NAS) signaling and related security. MME 508 checks the authorization of the UE 101 to camp on the service provider's Public Land Mobile Network (PLMN) and enforces UE 101 roaming restrictions. The MME 508 also provides the control plane function for mobility between LTE and 2G/3G access networks with the S3 interface terminating at the MME 508 from the SGSN (Serving GPRS Support Node) 514.

[0050] The SGSN 514 is responsible for the delivery of data packets from and to the mobile stations within its geographical service area. Its tasks include packet routing and transfer, mobility management, logical link management, and authentication and charging functions. The S6a interface enables transfer of subscription and authentication data for authenticating/authorizing user access to the evolved system (AAA interface) between MME 508 and HSS (Home Subscriber Server) 516. The S10 interface between MMEs 508 provides MME relocation and MME 508 to MME 508 information transfer. The Serving Gateway 510 is the node that terminates the interface towards the E-UTRAN 512 via S1-U.

[0051] The S1-U interface provides a per bearer user plane tunneling between the E-UTRAN 512 and Serving Gateway 510. It contains support for path switching during handover between eNBs 103. The S4 interface provides the user plane with related control and mobility support between SGSN 514 and the 3GPP Anchor function of Serving Gateway 510.

[0052] The S12 is an interface between UTRAN 506 and Serving Gateway 510. Packet Data Network (PDN) Gateway 518 provides connectivity to the UE 101 to external packet data networks by being the point of exit and entry of traffic for the UE 101. The PDN Gateway 518 performs policy enforcement, packet filtering for each user, charging support, lawful interception and packet screening. Another role of the PDN Gateway 518 is to act as the anchor for mobility between 3GPP and non-3GPP technologies such as WiMax and 3GPP2 (CDMA 1X and EvDO (Evolution Data Only)).

[0053] The S7 interface provides transfer of QoS policy and charging rules from PCRF (Policy and Charging Role Function) 520 to Policy and Charging Enforcement Function (PCEF) in the PDN Gateway 518. The SGi interface is the interface between the PDN Gateway and the operator's IP services including packet data network 522. Packet data network 522 may be an operator external public or private packet data network or an intra operator packet data network, e.g., for provision of IMS (IP Multimedia Subsystem) services. Rx+ is the interface between the PCRF and the packet data network 522.

[0054] As seen in FIG. 5C, the eNB 103 utilizes an E-UTRA (Evolved Universal Terrestrial Radio Access) (user plane, e.g., RLC (Radio Link Control) 515, MAC (Media Access Control) 517, and PHY (Physical) 519, as well as a control plane (e.g., RRC 521)). The eNB 103 also includes the following functions: Inter Cell RRM (Radio Resource Management) 523, Connection Mobility Control 525, RB (Radio Bearer) Control 527, Radio Admission Control 529, eNB Measurement Configuration and Provision 531, and Dynamic Resource Allocation (Scheduler) 533.

[0055] The eNB 103 communicates with the aGW 501 (Access Gateway) via an S1 interface. The aGW 501 includes a User Plane 501a and a Control plane 501b. The control plane 501b provides the following components: SAE (System Architecture Evolution) Bearer Control 535 and MM (Mobile Management) Entity 537. The user plane 501b includes a PDCP (Packet Data Convergence Protocol) 539 and a user plane functions 541. It is noted that the functionality of the aGW 501 can also be provided by a combination of a serving gateway (SGW) and a packet data network (PDN) GW. The aGW 501 can also interface with a packet network, such as the Internet 543.

[0056] In an alternative embodiment, as shown in FIG. 5D, the PDCP (Packet Data Convergence Protocol) functionality can reside in the eNB 103 rather than the GW 501. Other than this PDCP capability, the eNB functions of FIG. 5C are also provided in this architecture.

[0057] In the system of FIG. 5D, a functional split between E-UTRAN and EPC (Evolved Packet Core) is provided. In this example, radio protocol architecture of E-UTRAN is provided for the user plane and the control plane. A more detailed description of the architecture is provided in 3GPP TS 56.300.

[0058] The eNB 103 interfaces via the S1 to the Serving Gateway 545, which includes a Mobility Anchoring function 547. According to this architecture, the MME (Mobility Management Entity) 549 provides SAE (System Architecture Evolution) Bearer Control 551, Idle State Mobility Handling 553, and NAS (Non-Access Stratum) Security 555.

[0059] One of ordinary skill in the art would recognize that the processes for resource scheduling may be implemented via software, hardware (e.g., general processor, Digital Signal Processing (DSP) chip, an Application Specific Integrated Circuit (ASIC), Field Programmable Gate Arrays (FPGAs), etc.), firmware, or a combination thereof. Such exemplary hardware for performing the described functions is detailed below with respect to FIG. 6.

[0060] FIG. 6 illustrates exemplary hardware upon which various embodiments of the invention can be implemented. A computing system 600 includes a bus 601 or other communication mechanism for communicating information and a processor 603 coupled to the bus 601 for processing information. The computing system 600 also includes main memory 605, such as a random access memory (RAM) or other dynamic storage device, coupled to the bus 601 for storing information and instructions to be executed by the processor 603. Main memory 605 can also be used for storing temporary variables or other intermediate information during execution of instructions by the processor 603. The computing system 600 may further include a read only memory (ROM) 607 or other static storage device coupled to the bus 601 for storing static information and instructions for the processor 603. A storage device 609, such as a magnetic disk or optical disk, is coupled to the bus 601 for persistently storing information and instructions.

[0061] The computing system 600 may be coupled via the bus 601 to a display 611, such as a liquid crystal display, or active matrix display, for displaying information to a user. An input device 613, such as a keyboard including alphanumeric and other keys, may be coupled to the bus 601 for communicating information and command selections to the processor 603. The input device 613 can include a cursor control, such as a mouse, a trackball, or cursor direction keys, for communicating direction information and command selections to the processor 603 and for controlling cursor movement on the display 611.

[0062] According to various embodiments of the invention, the processes described herein can be provided by the computing system 600 in response to the processor 603 executing an arrangement of instructions contained in main memory 605. Such instructions can be read into main memory 605 from another computer-readable medium, such as the storage device 609. Execution of the arrangement of instructions contained in main memory 605 causes the processor 603 to perform the process steps described herein. One or more processors in a multi-processing arrangement may also be employed to execute the instructions contained in main memory 605. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions to implement the embodiment of the invention. In another example, reconfigurable hardware such as Field Programmable Gate Arrays (FPGAs) can be used, in which the functionality and connection topology of its logic gates are customizable at run-time, typically by programming memory look up tables. Thus, embodiments of the invention are not limited to any specific combination of hardware circuitry and software.

[0063] The computing system 600 also includes at least one communication interface 615 coupled to bus 601. The communication interface 615 provides a two-way data communication coupling to a network link (not shown). The communication interface 615 sends and receives electrical, electromagnetic, or optical signals that carry digital data streams representing various types of information. Further, the communication interface 615 can include peripheral interface devices, such as a Universal Serial Bus (USB) interface, a PCMCIA (Personal Computer Memory Card International Association) interface, etc.

[0064] The processor 603 may execute the transmitted code while being received and/or store the code in the storage device 609, or other non-volatile storage for later execution. In this manner, the computing system 600 may obtain application code in the form of a carrier wave.

[0065] The term "computer-readable medium" as used herein refers to any medium that participates in providing instructions to the processor 603 for execution. Such a medium may take many forms, including but not limited to non-volatile media, volatile media, and transmission media. Non-volatile media include, for example, optical or magnetic disks, such as the storage device 609. Volatile media include dynamic memory, such as main memory 605. Transmission media include coaxial cables, copper wire and fiber optics, including the wires that comprise the bus 601. Transmission media can also take the form of acoustic, optical, or electromagnetic waves, such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, CDRW, DVD, any other optical medium, punch cards, paper tape, optical mark sheets, any other physical medium with patterns of holes or other optically recognizable indicia, a RAM, a PROM, and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave, or any other medium from which a computer can read.

[0066] Various forms of computer-readable media may be involved in providing instructions to a processor for execution. For example, the instructions for carrying out at least part of the invention may initially be borne on a magnetic disk of a remote computer. In such a scenario, the remote computer loads the instructions into main memory and sends the instructions over a telephone line using a modem. A modem of a local system receives the data on the telephone line and uses an infrared transmitter to convert the data to an infrared signal and transmit the infrared signal to a portable computing device, such as a personal digital assistant (PDA) or a laptop. An infrared detector on the portable computing device receives the information and instructions borne by the infrared signal and places the data on a bus. The bus conveys the data to main memory, from which a processor retrieves and executes the instructions. The instructions received by main memory can optionally be stored on storage device either before or after execution by processor.

[0067] FIG. 7 is a diagram of exemplary components of a user terminal configured to operate in the systems of FIGs. 5A-5D, according to an embodiment of the invention. A user terminal 700 includes an antenna system 701 (which can utilize multiple antennas) to receive and transmit signals. The antenna system 701 is coupled to radio circuitry 703, which includes multiple transmitters 705 and receivers 707. The radio circuitry encompasses all of the Radio Frequency (RF) circuitry as well as base-band processing circuitry. As shown, layer-1 (L1) and layer-2 (L2) processing are provided by units 709 and 711, respectively. Optionally, layer-3 functions can be provided (not shown). L2 unit 711 can include module 713, which executes all Medium Access Control (MAC) layer functions. A timing and calibration module 715 maintains proper timing by interfacing, for example, an external timing reference (not shown). Additionally, a processor 717 is included. Under this scenario, the user terminal 700 communicates with a computing device 719, which can be a personal computer, work station, a Personal Digital Assistant (PDA), web appliance, cellular phone, etc.

[0068] While the invention has been described in connection with a number of embodiments and implementations, the invention is not so limited but covers various obvious modifications and equivalent arrangements, which fall within the purview of the appended claims. Although features of the invention are expressed in certain combinations among the claims, it is contemplated that these features can be arranged in any combination and order.

CLAIMS

WHAT IS CLAIMED IS:

1. A method comprising:

detecting an idle state of communication of a user equipment; and

generating a control message specifying a service type relating to reactivation of a data channel during the idle state for use upon transition to an active state.

2. A method according to claim 1, wherein the service type includes a bearer establishment type and a bearer re-establishment type, and the bearer establishment type indicates existence of data for transmission during the idle state and no reactivation of the data channel, the bearer re-establishment type existence of data for transmission during the idle state and reactivation of the data channel.

3. A method according to claim 1 or claim 2, further comprising:

transmitting the control message over a control channel.

4. A method according to claim 1 or claim 2, wherein the control message is generated for transmission over an EUTRAN (Enhanced UMTS (Universal Mobile Telecommunications System) Terrestrial Radio Access Network)).

5. A method according to claim 4, wherein the service request message is included in a radio resource control (RRC) connection message.

6. A computer-readable storage medium carrying one or more sequences of one or more instructions which, when executed by one or more processors, cause the one or more processors to perform the method of claim 1.

7. An apparatus comprising:

logic configured to detect an idle state of communication of a user equipment,

wherein the logic is further configured to generate a control message specifying a service type relating to reactivation of a data channel during the idle state for use upon transition to an active state.

8. An apparatus according to claim 7, wherein the service type includes a bearer establishment type and a bearer re-establishment type, and the bearer establishment type indicates existence of data for transmission during the idle state and no reactivation of the data channel, the bearer re-establishment type existence of data for transmission during the idle state and reactivation of the data channel.

9. An apparatus according to claim 7 or claim 8, further comprising:

a transceiver configured to transmit the control message over a control channel.

10. An apparatus according to claim 7 or claim 8, wherein the control message is generated for transmission over an EUTRAN (Enhanced UMTS (Universal Mobile Telecommunications System) Terrestrial Radio Access Network)).

11. An apparatus according to claim 10, wherein the service request message is included in a radio resource control (RRC) connection message.

12. A method comprising:

detecting a transition from an idle state to an active state of operations; and receiving a control message specifying re-establishment of a bearer channel that has been preserved during the idle state for use upon transitioning to the active state.

13. A method according to claim 12, wherein the control message includes a service type field that specifies either a bearer establishment type or a bearer re-establishment type, the bearer establishment type indicating existence of data for transmission during the idle state and no reactivation of the bearer channel, the bearer re-establishment type existence of data for transmission during the idle state and reactivation of the bearer channel.

14. A method according to claim 12 or claim 13, further comprising:
transmitting the data over the bearer channel.

15. A method according to claim 12 or claim 13, further comprising:
accessing a random access channel; and
upon successfully obtaining access to the random access channel, generating a connection request message for transmission of data over the bearer channel.

16. A method according to claim 15, wherein the step of accessing includes,
generating a random access channel preamble,
transmitting the random access channel preamble to a base station,
receiving a tracking area and scheduling grant from the base station in response to the random access channel preamble.

17. A computer-readable storage medium carrying one or more sequences of one or more instructions which, when executed by one or more processors, cause the one or more processors to perform the method of claim 12.

18. An apparatus comprising:

logic configured to detect a transition from an idle state to an active state of operations,

wherein the logic is further configured to receive a control message specifying re-establishment of a bearer channel that has been preserved during the idle state for use upon transitioning to the active state.

19. An apparatus according to claim 18, wherein the control message includes a service type field that specifies either a bearer establishment type or a bearer re-establishment type, the bearer establishment type indicating existence of data for transmission during the idle state and no reactivation of the bearer channel, the bearer re-establishment type existence of data for transmission during the idle state and reactivation of the bearer channel.

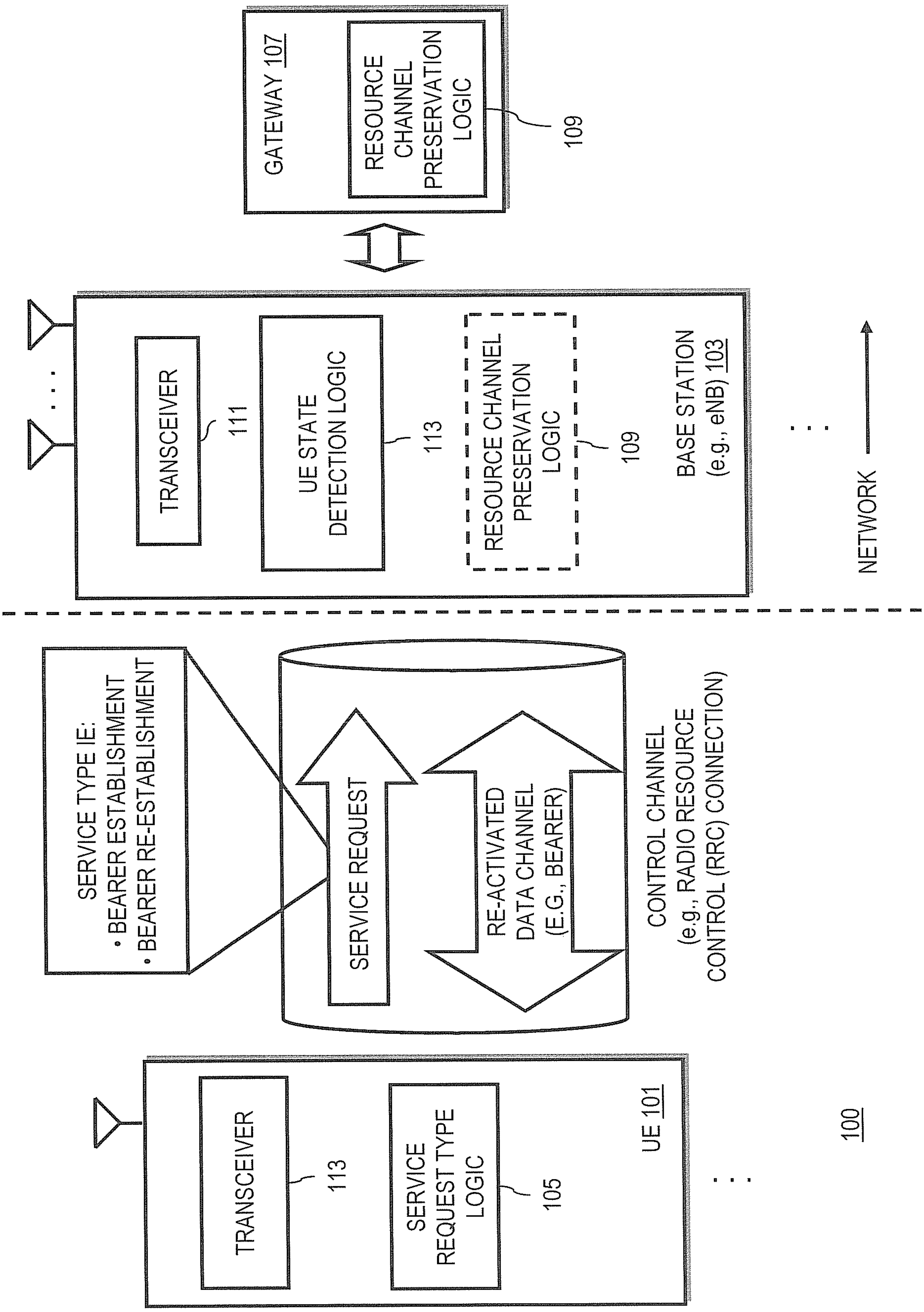
20. An apparatus according to claim 18 or claim 19, further comprising:

a transceiver configured to transmit the data over the bearer channel.

21. An apparatus according to claim 18 or claim 19, wherein upon successfully obtaining access to a random access channel, the logic being further configured to generate a connection request message for transmission of data over the bearer channel.

22. An apparatus according to claim 21, wherein the logic is further configured to generate a random access channel preamble for transmission to a base station, and to receive a tracking area and scheduling grant from the base station in response to the random access channel preamble.

FIG. 1


GATEWAY 107
RESOURCE CHANNEL PRESERVATION LOGIC
109
TRANSCEIVER
111
UE STATE DETECTION LOGIC
113
RESOURCE CHANNEL PRESERVATION LOGIC
109
BASE STATION (e.g., eNB) 103
NETWORK
SERVICE TYPE IE:
• BEARER ESTABLISHMENT
• BEARER RE-ESTABLISHMENT
SERVICE REQUEST
RE-ACTIVATED DATA CHANNEL (E.G., BEARER)
CONTROL CHANNEL (e.g., RADIO RESOURCE CONTROL (RRC) CONNECTION)
TRANSCEIVER
113
SERVICE REQUEST TYPE LOGIC
105
UE 101
100

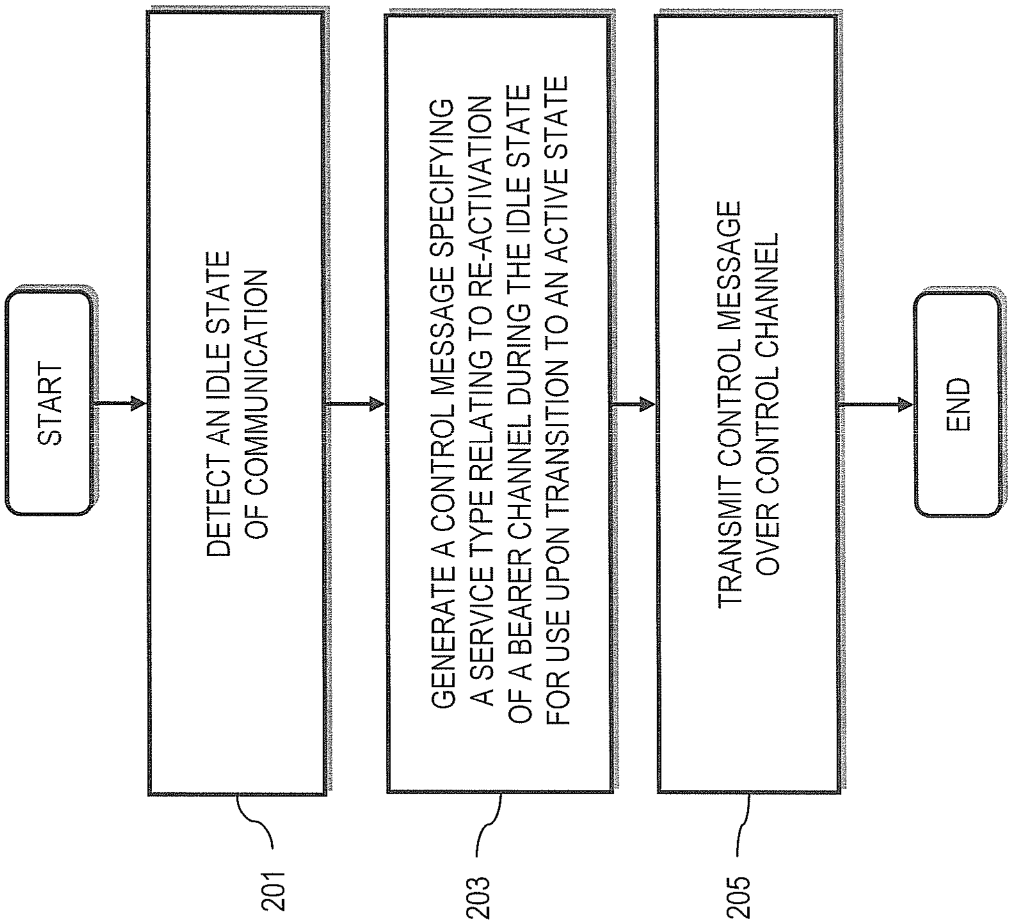

START
DETECT AN IDLE STATE OF COMMUNICATION
GENERATE A CONTROL MESSAGE SPECIFYING A SERVICE TYPE RELATING TO RE-ACTIVATION OF A BEARER CHANNEL DURING THE IDLE STATE FOR USE UPON TRANSITION TO AN ACTIVE STATE
TRANSMIT CONTROL MESSAGE OVER CONTROL CHANNEL
END
201
203
205

FIG. 2

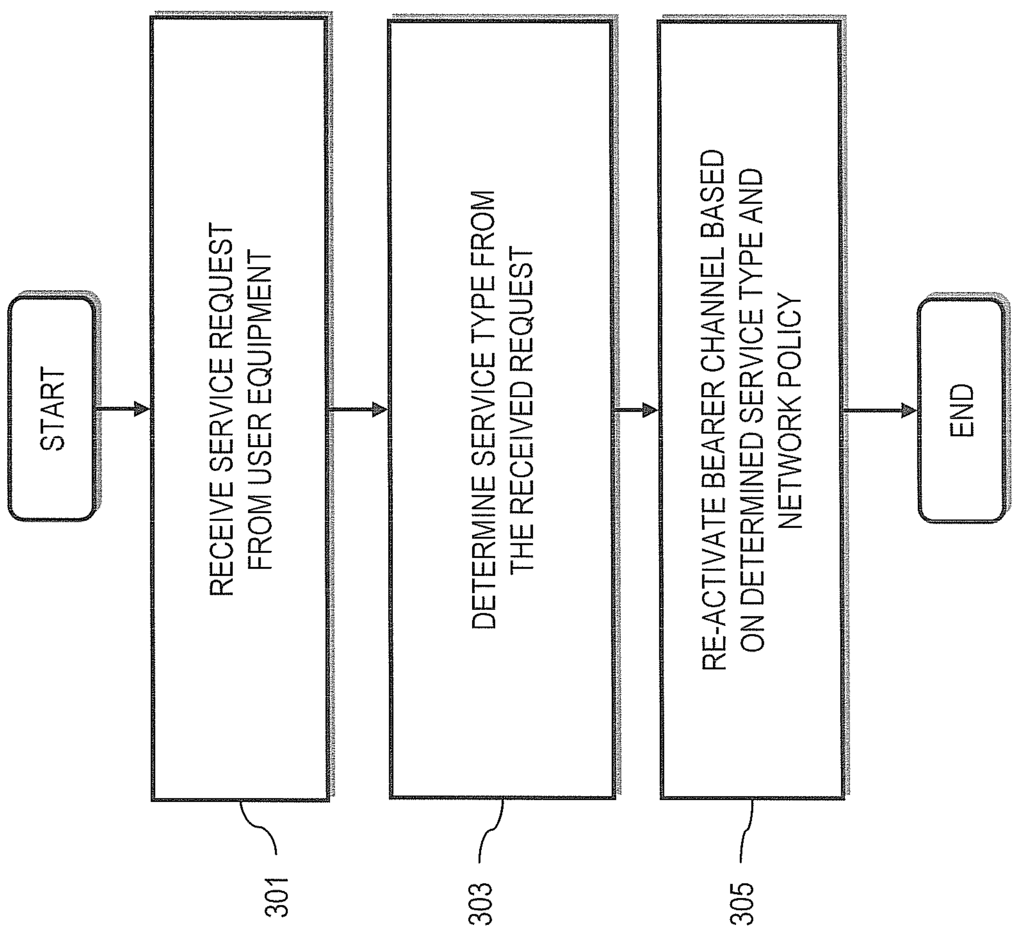

START
RECEIVE SERVICE REQUEST FROM USER EQUIPMENT
DETERMINE SERVICE TYPE FROM THE RECEIVED REQUEST
RE-ACTIVATE BEARER CHANNEL BASED ON DETERMINED SERVICE TYPE AND NETWORK POLICY
END
301
303
305

FIG. 3

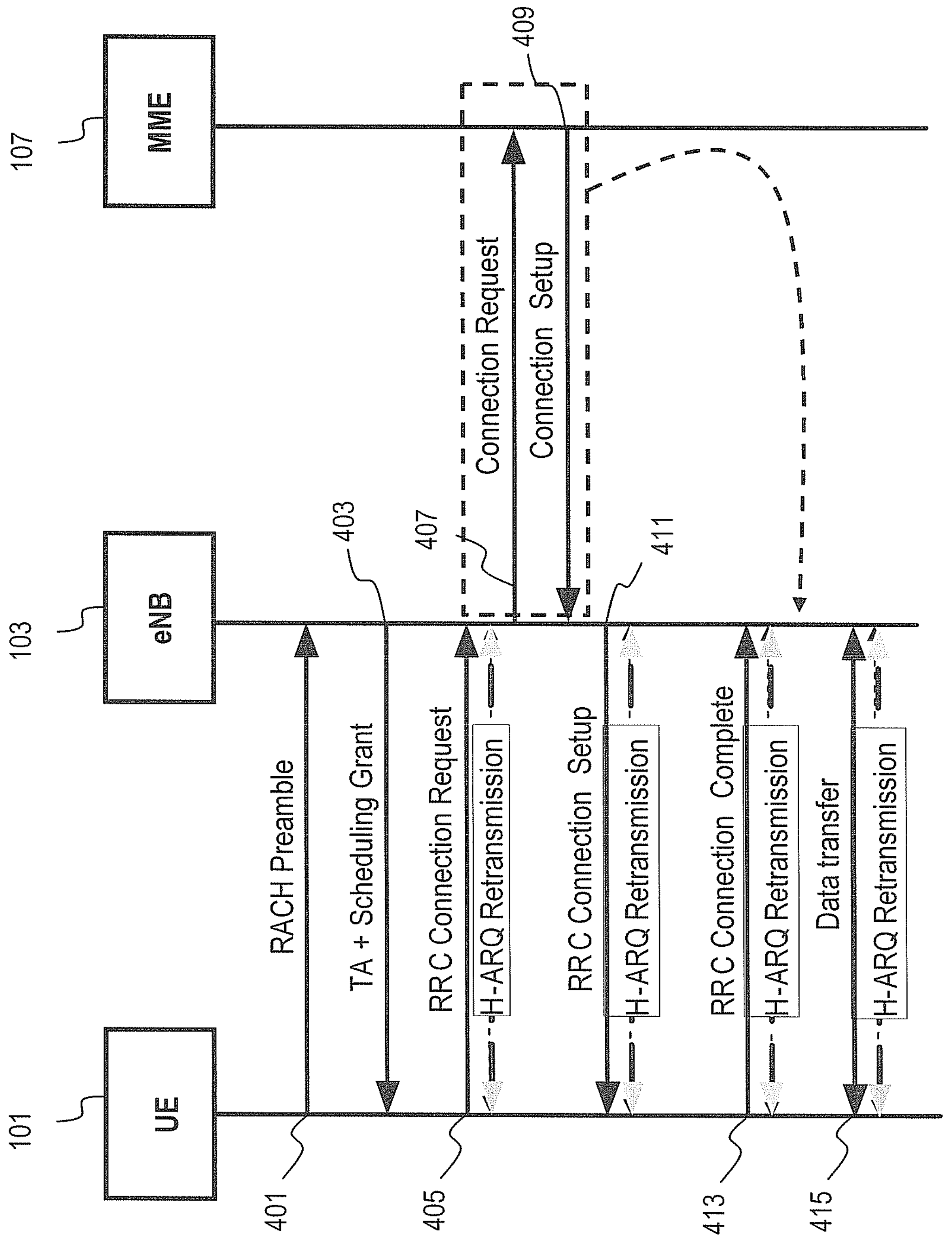

101
UE
103
eNB
107
MME
401
RACH Preamble
403
TA + Scheduling Grant
405
RR C Connection Request
H-ARQ Retransmission
407
409
Connection Request
Connection Setup
411
RR C Connection Setup
H-ARQ Retransmission
413
RR C Connection Complete
H-ARQ Retransmission
415
Data transfer
H-ARQ Retransmission

FIG. 4

FIG. 5A

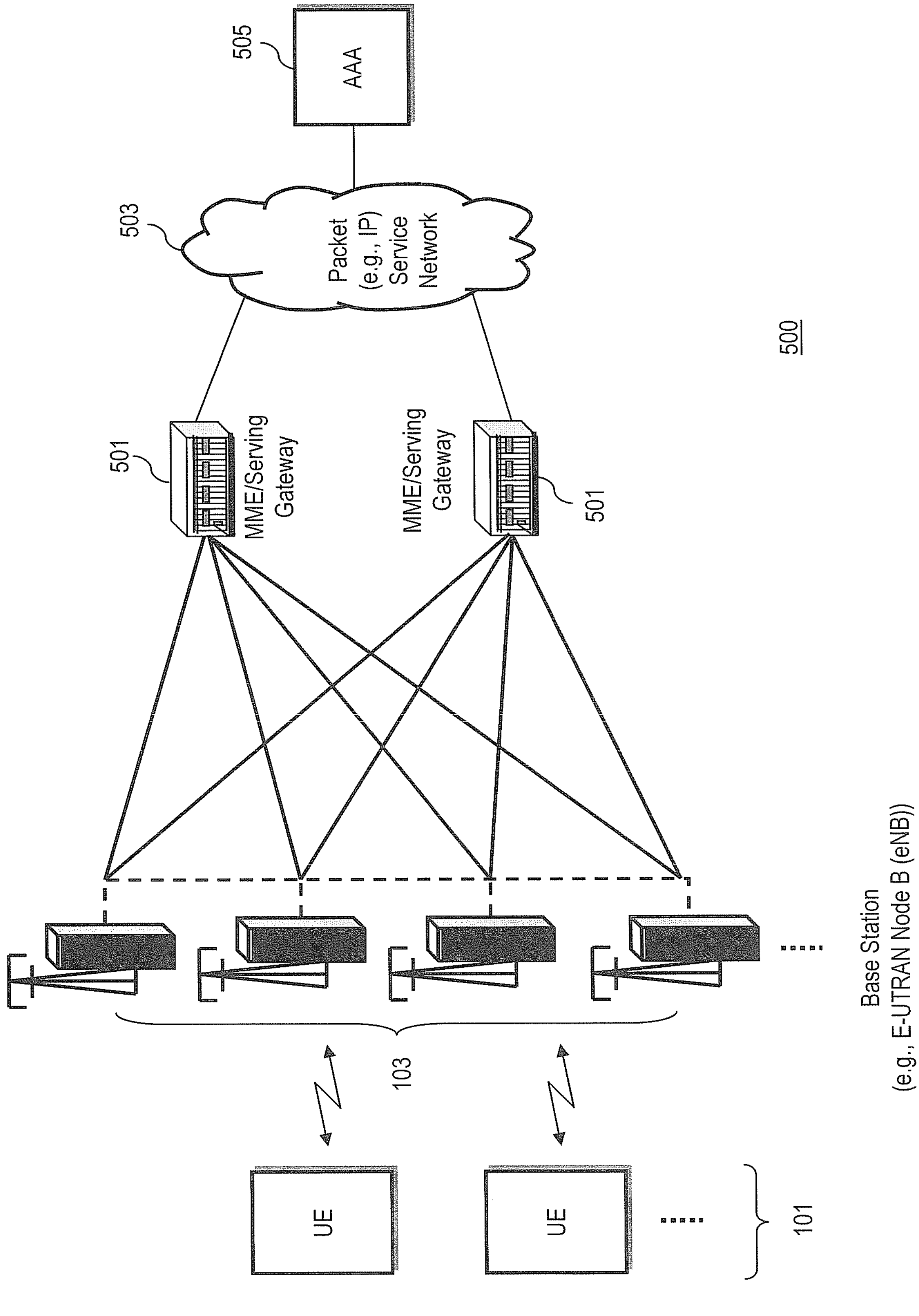
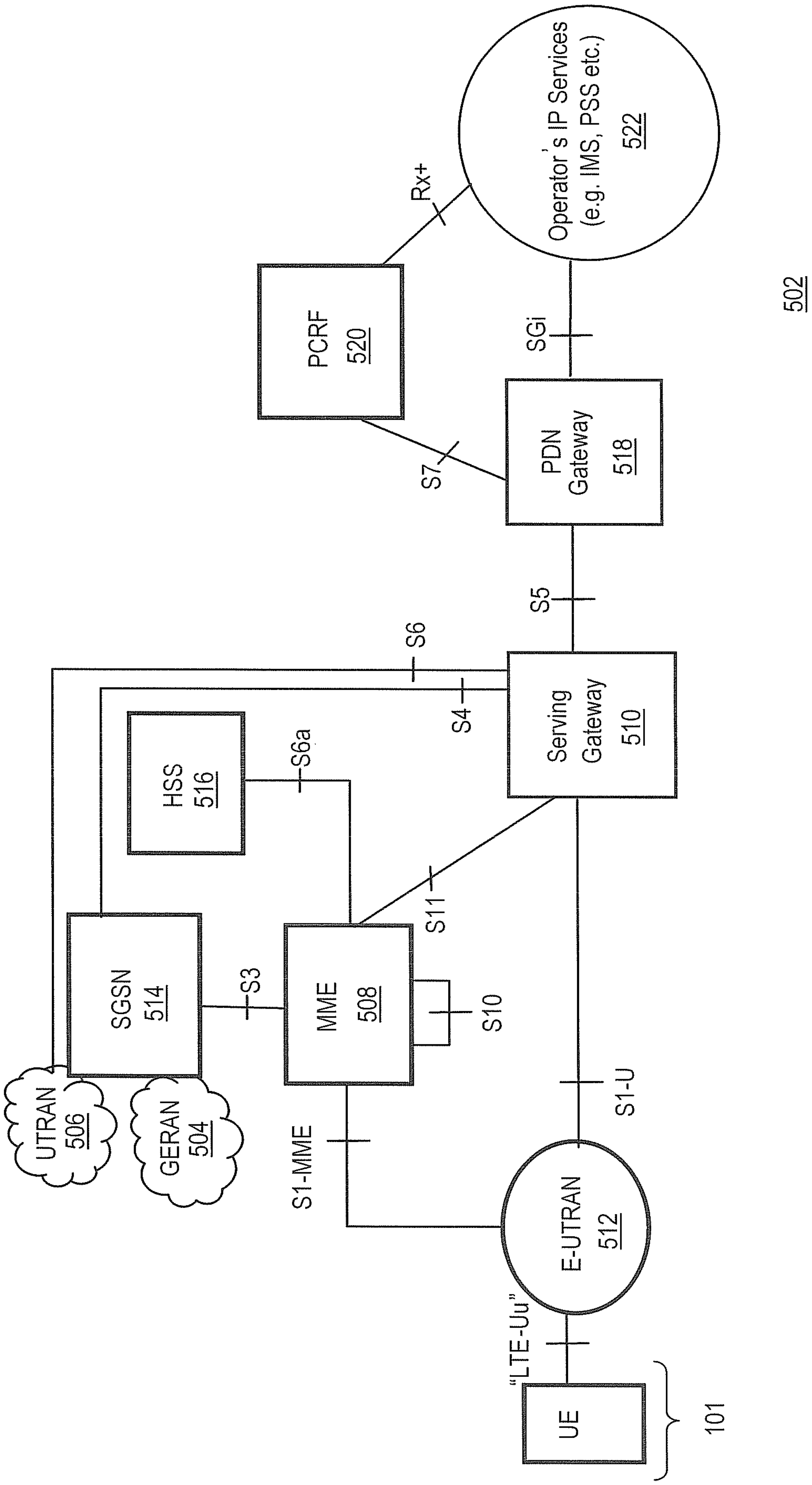

505
AAA
503
Packet (e.g., IP) Service Network
501
MME/Serving Gateway
MME/Serving Gateway
501
500
103
Base Station (e.g., E-UTRAN Node B (eNB))
UE
UE
101

FIG. 5B


UE
101
"LTE-Uu"
E-UTRAN
512
S1-MME
S1-U
UTRAN
506
GERAN
504
SGSN
514
S3
MME
508
S10
S11
HSS
516
S6a
S4
S6
Serving
Gateway
510
S5
PDN
Gateway
518
S7
PCRF
520
SGi
Rx+
Operator's IP Services
(e.g. IMS, PSS etc.)
522
502

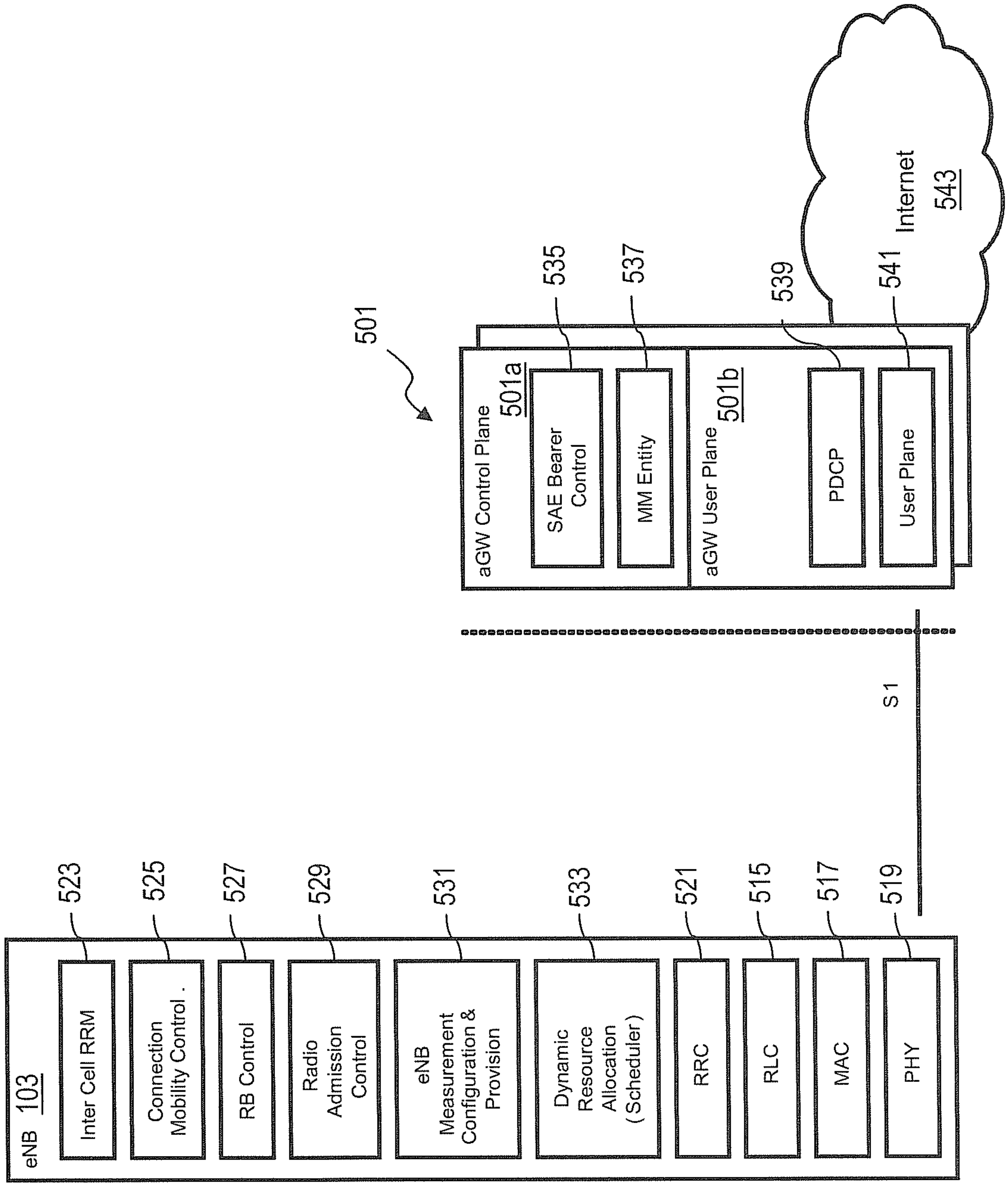
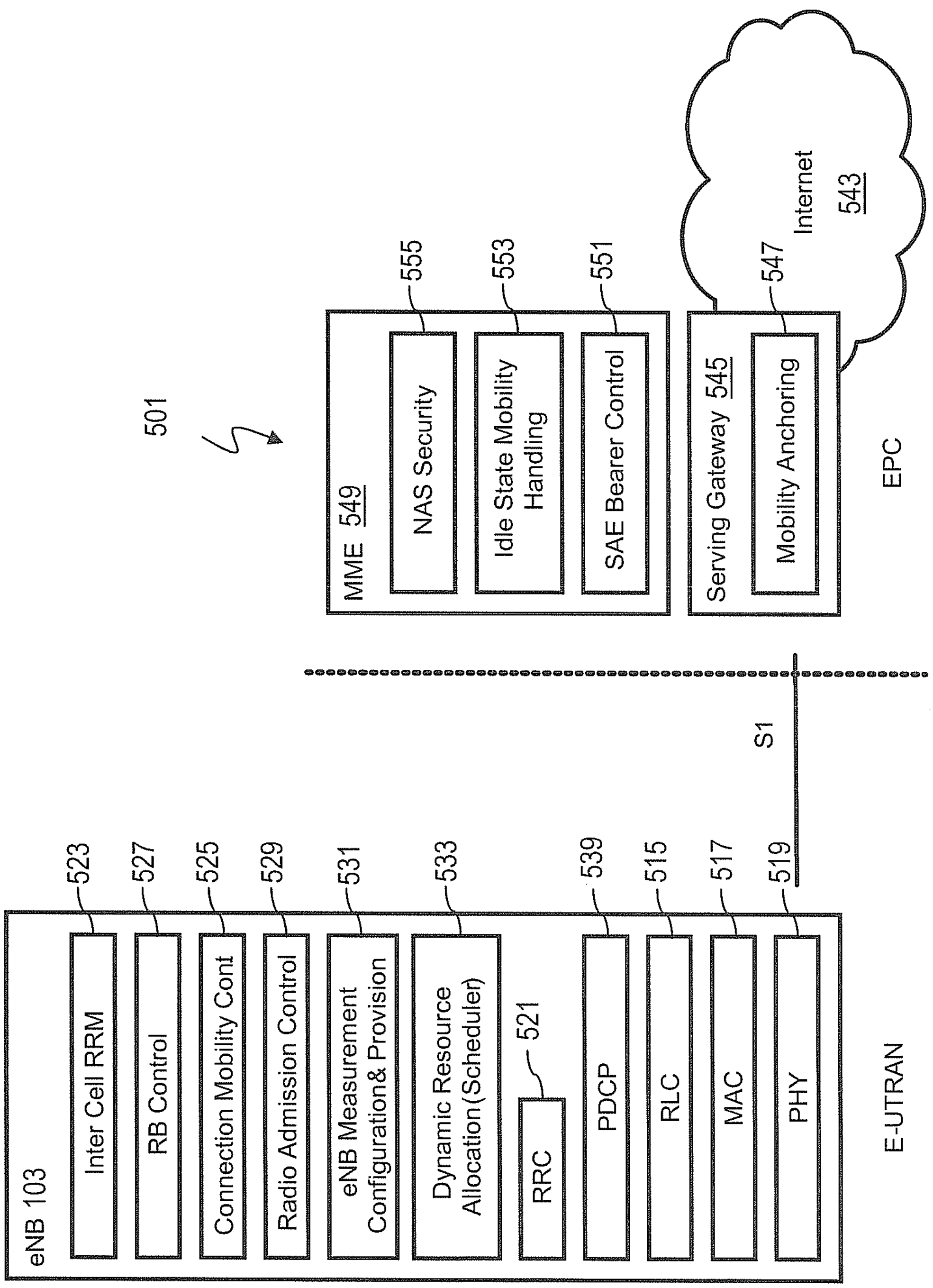

eNB 103
Inter Cell RRM
Connection Mobility Control .
RB Control
Radio Admission Control
eNB Measurement Configuration & Provision
Dynamic Resource Allocation (Scheduler)
RRC
RLC
MAC
PHY
523
525
527
529
531
533
521
515
517
519
S1
501
aGW Control Plane 501a
SAE Bearer Control
MM Entity
aGW User Plane 501b
PDCP
User Plane
535
537
539
541
Internet 543

FIG. 5C

FIG. 5D


501
eNB 103
Inter Cell RRM
523
RB Control
527
Connection Mobility Cont
525
Radio Admission Control
529
eNB Measurement Configuration& Provision
531
Dynamic Resource Allocation (Scheduler)
533
RRC
521
PDCP
539
RLC
515
MAC
517
PHY
519
E-UTRAN
S1
MME 549
NAS Security
555
Idle State Mobility Handling
553
SAE Bearer Control
551
Serving Gateway 545
Mobility Anchoring
547
Internet
543
EPC

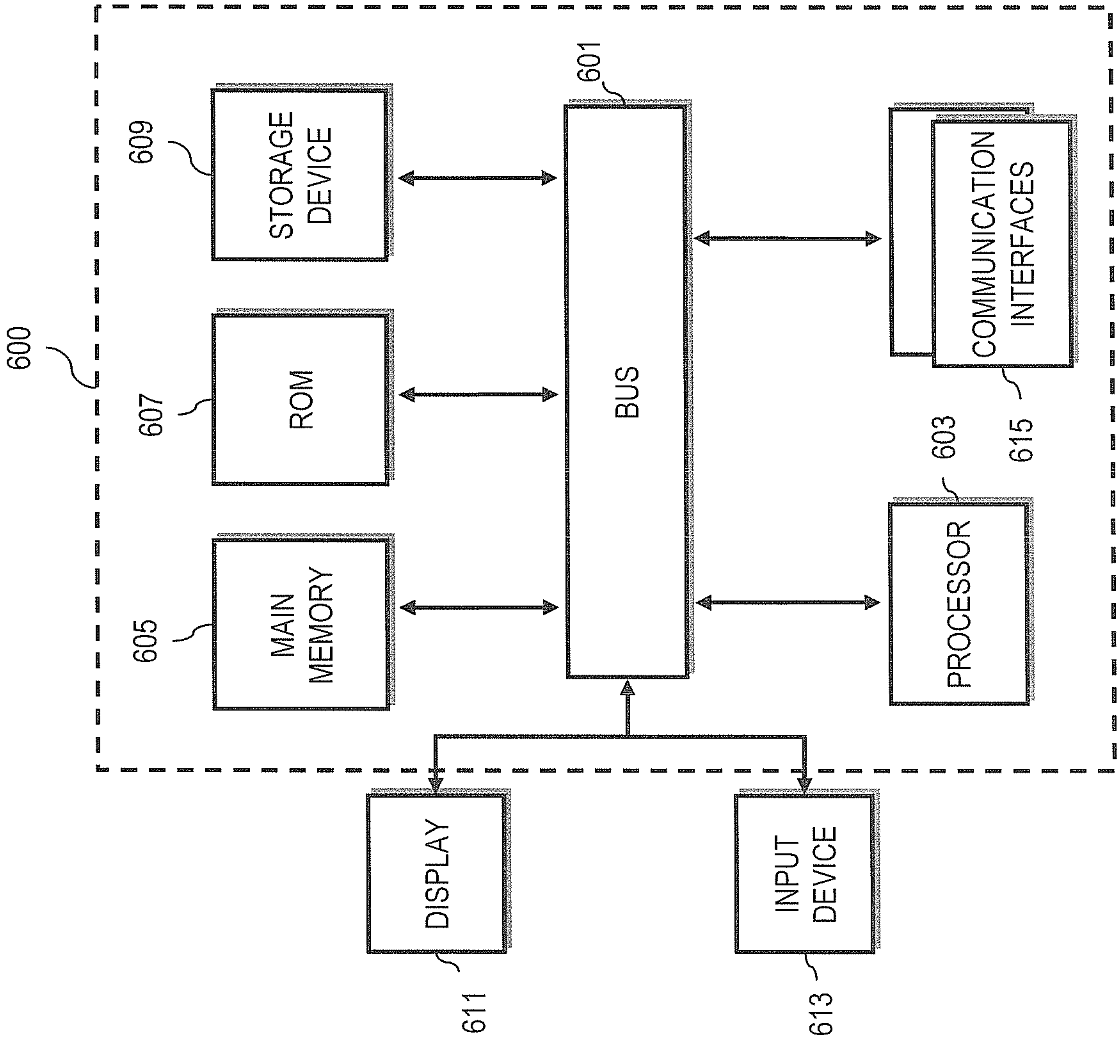
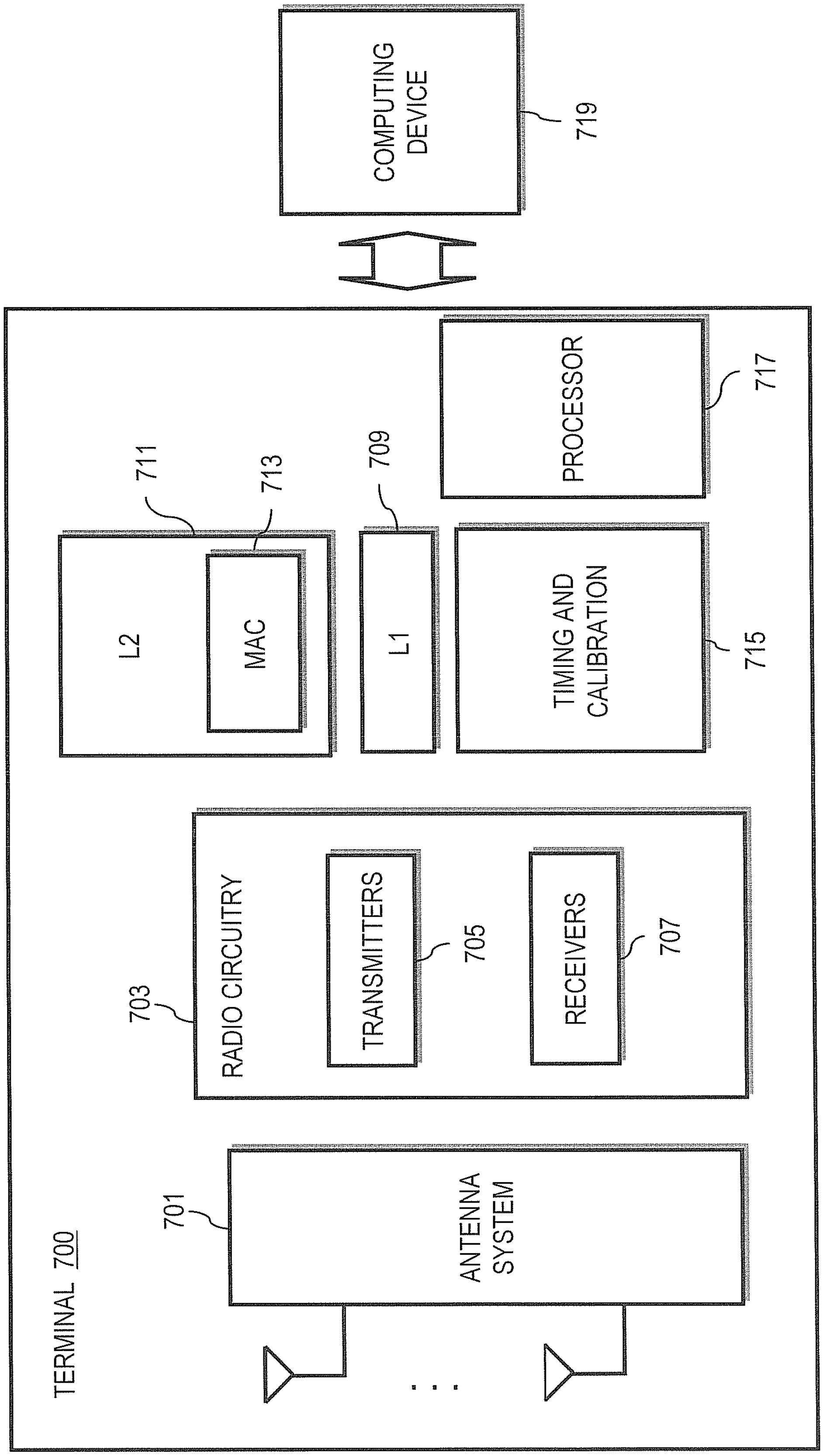

600
609
STORAGE DEVICE
607
ROM
605
MAIN MEMORY
601
BUS
COMMUNICATION INTERFACES
615
603
PROCESSOR
DISPLAY
611
INPUT DEVICE
613

FIG. 6

FIG. 7


COMPUTING DEVICE
719
PROCESSOR
717
711
713
709
L2
MAC
L1
TIMING AND CALIBRATION
715
RADIO CIRCUITRY
703
TRANSMITTERS
705
RECEIVERS
707
701
ANTENNA SYSTEM
TERMINAL 700
. . .