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(54) Title: SUPPORT OF TRANSMISSION MODE AND IMPACT ON PDCCH BLIND DECODES OF PTM (POINT-TO-MULTIPOINT) TRANSMISSION

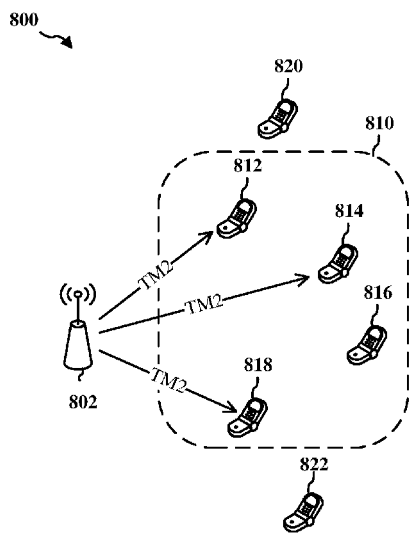

FIG. 8A

(57) Abstract: A method, an apparatus, and a computer program product for wireless communication are provided. The apparatus may be an UE. The UE receives, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes, configures downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration, and receives a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode. In another aspect, The UE receives, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes, configures downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration, and receives a service via PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

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SUPPORT OF TRANSMISSION MODE AND IMPACT ON PDCCH BLIND DECODES OF PTM (POINT-TO-MULTIPOINT) TRANSMISSION

BACKGROUND

Field

[0001] The present disclosure relates generally to communication systems, and more particularly, to a point-to-multipoint transmission.

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 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. 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 multiaccess 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. The apparatus may be a user equipment (UE). The UE receives, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes. The UE configures downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration, and receives a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode.

[0005] In another aspect of the disclosure, a method, a computer program product, and an apparatus are provided. The apparatus may be an UE. The UE receives, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes. The UE configures downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration, and receives a service via PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

[0006] In another aspect of the disclosure, a method, a computer program product, and an apparatus are provided. The apparatus may be a base station. The base station determines one of a plurality of downlink transmission modes for a service via PTM transmission, and transmits a service to a UE via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a diagram illustrating an example of a network architecture.

[0008] FIG. 2 is a diagram illustrating an example of an access network.

[0009] FIG. 3 is a diagram illustrating an example of a DL frame structure in LTE.

[0010] FIG. 4 is a diagram illustrating an example of an UL frame structure in LTE.

[0011] FIG. 5 is a diagram illustrating an example of a radio protocol architecture for the user and control planes.

[0012] FIG. 6 is a diagram illustrating an example of an evolved Node B and user equipment in an access network.

[0013] FIG. 7A is a diagram illustrating an example of an evolved Multimedia Broadcast Multicast Service channel configuration in a Multicast Broadcast Single Frequency Network.

[0014] FIG. 7B is a diagram illustrating a format of a Multicast Channel Scheduling Information Media Access Control control element.

[0015] FIG. 8A is an example diagram illustrating the first approach of the disclosure.

[0016] FIG. 8B is an example diagram illustrating the second approach of the disclosure.

[0017] FIG. 9 is a flow chart of a method of wireless communication, according to the first approach of the disclosure.

[0018] FIG. 10 is a flow chart of a method of wireless communication, according to the second approach of the disclosure.

[0019] FIG. 11A is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 10.

[0020] FIG. 11B is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 10.

[0021] FIG. 12A is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 10.

[0022] FIG. 12B is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 10.

[0023] FIG. 13A is a flow chart of a method of wireless communication, according to the disclosure.

[0024] FIG. 13B is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 13A.

[0025] FIG. 14A is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 13A.

[0026] FIG. 14B is a flow chart of a method of wireless communication expanding from the flow chart of FIG. 13A.

[0027] FIG. 15 is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

[0028] FIG. 16 is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

[0029] FIG. 17 is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

[0030] FIG. 18 is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

[0031] FIG. 19 is a conceptual data flow diagram illustrating the data flow between different modules/means/components in an exemplary apparatus.

[0032] FIG. 20 is a diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

DETAILED DESCRIPTION

[0033] 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 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.

[0034] 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.

[0035] 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.

[0036] 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, combinations of the aforementioned types of computer-readable media, or any other medium that can be used to store computer executable code in the form of instructions or data structures that can be accessed by a computer.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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 a particular coverage area. Further, the terms "eNB," "base station," and "cell" may be used interchangeably herein.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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).

[0045] 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 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.

[0046] 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.

[0047] 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 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.

[0048] 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 a single PRACH attempt per frame (10 ms).

[0049] 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.

[0050] 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.).

[0051] 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.

[0052] 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.

[0053] 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.

[0054] 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.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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 controller/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.

[0061] FIG. 7A is a diagram 750 illustrating an example of an evolved MBMS (eMBMS) channel configuration in an MBSFN. The eNBs 752 in cells 752' may form a first MBSFN area and the eNBs 754 in cells 754' may form a second MBSFN area. The eNBs 752, 754 may each be associated with other MBSFN areas, For example, up to a total of eight MBSFN areas. A cell within an MBSFN area may be designated a reserved cell. Reserved cells do not provide multicast/broadcast content, but are time-synchronized to the cells 752', 754' and may have restricted power on MBSFN resources in order to limit interference to the MBSFN areas. Each eNB in an MBSFN area synchronously transmits the same eMBMS control information and data. Each area may support broadcast, multicast, and unicast services. A unicast service is a service intended for a specific user, e.g., a voice call. A multicast service is a service that may be received by a group of users, e.g., a subscription video service. A broadcast service is a service that may be received by all users, e.g., a news broadcast. Referring to FIG. 7A, the first MBSFN area may support a first eMBMS broadcast service, such as by providing a particular news broadcast to UE 770. The second MBSFN area may support a second eMBMS broadcast service, such as by providing a different news broadcast to UE 760. Each MBSFN area supports one or more physical multicast channels (PMCH) (e.g., 15 PMCHs). Each PMCH corresponds to a multicast channel (MCH). Each MCH can multiplex a plurality (e.g., 29) of multicast logical channels. Each MBSFN area may have one multicast control channel (MCCH). As such, one MCH may multiplex one MCCH and a plurality of multicast traffic channels (MTCHs) and the remaining MCHs may multiplex a plurality of MTCHs.

[0062] A UE can camp on an LTE cell to discover the availability of eMBMS service access and a corresponding access stratum configuration. Initially, the UE may acquire a system information block (SIB) 13 (SIB13). Subsequently, based on the SIB13, the UE may acquire an MBSFN Area Configuration message on an MCCH. Subsequently, based on the MBSFN Area Configuration message, the UE may acquire an MCH scheduling information (MSI) MAC control element. The SIB13 may include (1) an MBSFN area identifier of each MBSFN area supported by the cell; (2) information for acquiring the MCCH such as an MCCH repetition period (e.g., 32, 64, …, 256 frames), an MCCH offset (e.g., 0, 1, …, 10 frames), an MCCH modification period (e.g., 512, 1024 frames), a signaling modulation and coding scheme (MCS), subframe allocation information indicating which subframes of the radio frame as indicated by repetition period and offset can transmit MCCH; and (3) an MCCH change notification configuration. There is one MBSFN Area Configuration message for each MBSFN area. The MBSFN Area Configuration message may indicate (1) a temporary mobile group identity (TMGI) and an optional session identifier of each MTCH identified by a logical channel identifier within the PMCH, and (2) allocated resources (i.e., radio frames and subframes) for transmitting each PMCH of the MBSFN area and the allocation period (e.g., 4, 8, …, 256 frames) of the allocated resources for all the PMCHs in the area, and (3) an MCH scheduling period (MSP) (e.g., 8, 16, 32, …, or 1024 radio frames) over which the MSI MAC control element is transmitted.

[0063] FIG. 7B is a diagram 790 illustrating the format of an MSI MAC control element. The MSI MAC control element may be sent once each MSP. The MSI MAC control element may be sent in the first subframe of each scheduling period of the PMCH. The MSI MAC control element can indicate the stop frame and subframe of each MTCH within the PMCH. There may be one MSI per PMCH per MBSFN area.

[0064] In an MBMS area, the cells associated with the MBMS area may transmit a service in a time synchronized manner. MBMS gain at the UE occurs because the broadcast/ multicast transmissions from multiple cells can be combined. However, there may be circumstances when such transmissions from the cells cannot be time synchronized or there may be a limited number of UEs interested in a particular service, e.g., a group call. In such circumstances MBMS transmissions from the cells in the MBMS area may not be feasible or may be inefficient. In such circumstances when there is one or more isolated cells (the neighboring cells are not serving UEs interested in the service), each serving two or more UEs, such one or more cells may be configured to operate in a single cell MBSFN mode. Therefore, performance for a single cell transmission targeting for multiple UEs should be improved.

[0065] In particular, a network (e.g., an eNB) may transmit the same service to multiple UEs via point-to-multipoint (PTM) transmission, where a single PTM transmission may target multiple UEs. Such PTM transmission may be implemented as a group call. In the PTM transmission, the UEs targeted by a single PTM transmission are in the same group, and thus may be configured with the same identifier such as a radio network temporary identifier (RNTI). For example, the UEs in the same group targeted by the same PTM transmission may be configured with a group RNTI (G-RNTI) that is common among the UEs in the same group, whereas each UE may be configured with another type of RNTI such as a cell RNTI (C-RNTI) for unicast transmission to each UE. In particular, the eNB scrambles a cyclic redundancy check (CRC) with an RNTI, and transmits a physical downlink control channel (PDCCH) with the scrambled CRC. When the UE receives the PDCCH with the scrambled CRC, the UE determines an RNTI corresponding to a service from the eNB, and descrambles the scrambled CRC using the determined RNTI. The UE also generates a CRC based on the received PDCCH, and compares the descrambled CRC and the CRC generated based on the received PDCCH. If the CRC based on the received PDCCH matches with the descrambled CRC, the UE decides to utilize the received PDCCH and determines a PDSCH indicated by the PDCCH.

[0066] In a PTM transmission example such as a group call setting, the same G-RNTI is shared among the UEs in the same group. Hence, in the PTM transmission example, each UE in the same group may determine a PDCCH based on the G-RNTI and may use a corresponding PDSCH accordingly in order to receive PTM transmission data on the PDSCH. Thus, in an aspect, PTM transmission may be G-RNTI based transmission. In a unicast transmission example, a UE may try to decode a PDCCH based on the UE's C-RNTI, and may use the information indicated in the PDCCH in order to receive unicast transmission data on the corresponding PDSCH. Thus, in an aspect, unicast transmission may be C-RNTI based transmission. Various improvements may be made for such PTM transmission, as discussed *infra*.

[0067] The UE may be configured with one of several transmission modes for downlink transmission (e.g., to determine how to decode a PDCCH and a PDSCH for data transmission). In particular, the UE may initially send its transmission mode capability to a network, and the network may subsequently send the UE a transmission configuration message indicating which transmission mode the UE should be configured with. Then, the UE may configure downlink transmission with a transmission mode according to the transmission configuration message.

[0068] For a group call service where a single transmission targets multiple UEs, the different UEs may experience different geometry (e.g., signal-to-interference-plus-noise ratio). Thus, in order to accommodate the UEs having a wide geometry distribution, transmit diversity may be a preferred communication method to target multiple users via a PTM transmission. Therefore, according to a first approach of the disclosure, a downlink transmission mode for transmit diversity may be supported for the PTM transmission. Thus, the UE may be configured with the transmission mode for transmit diversity to receive the PTM transmission. For example, the downlink transmission mode for transmit diversity may be transmission mode 2 (TM2) for a PDSCH. Because the transmission scheme of the PDSCH for TM2 is transmit diversity, TM2 is suitable for transmission to multiple UEs having different geometry.

[0069] FIG. 8A is an example diagram 800 illustrating the first approach of the disclosure. In the example diagram 800, an eNB 802 is capable of performing a PTM transmission with multiple UEs. The UEs 812, 814, 816, and 818 are in the same group 810, and thus may receive the same service via PTM transmission from the eNB 802. The UEs 820 and 822 are not in the same group 810, and thus does not receive the same service via PTM transmission from the eNB 802 as the UEs 812, 814, 816, and 818. The eNB 802 may transmit the service via the PTM transmission using TM2 to the UEs 812, 814, and 818. In this example diagram, the eNB 802 may not transmit the service via TM2 to the UE 816 because UE 816 does not support TM2 for the PTM transmission.

[0070] According to a second approach of the disclosure, the UE may be configured with any one of the downlink transmission modes that is appropriate for receiving a service via PTM transmission. In the second approach, because multiple downlink transmission modes are available, each service is configured with a particular transmission mode that corresponds with the service. It is noted that the second approach does not mandate all UEs to support a particular transmission mode to receive a service via PTM transmission. In other words, some UEs may support a particular transmission mode, while other UEs may or may not support the same particular transmission mode. If a UE does not support a particular transmission mode, the UE may not be able to receive a corresponding service via PTM transmission, but may still be able to receive the corresponding service via unicast. For example, if a service is transmitted via transmission mode 7 (TM7) and the UE cannot support TM7, the UE may receive the service via unicast. In addition, in one aspect, certain transmission mode(s) for multi-user MIMO such as transmission mode 5 (TM5) may be excluded from available downlink transmission modes for PTM transmission because multi-user MIMO with a group of UEs may be difficult to enable with TM5.

[0071] In one aspect of the second approach, because different services may utilize different transmission modes, each UE may report a transmission mode capability to the network in order for the eNB to configure the PTM transmission to a respective UE. In one aspect, the UEs may report respective transmission mode capabilities to an application server (AS) when the UEs are initially set up for the PTM transmission, and the AS informs the eNB about the reported transmission mode capabilities. For example, if the majority of the UEs in a group support TM7, and report TM7 as the transmission mode capability to the AS, the AS determines that the majority of the UEs support TM7. Subsequently, the AS informs the eNB that the majority of the UEs support TM7, which may cause the eNB to utilize TM7 for the PTM transmission. In another aspect, when a UE first enters a connected mode with an eNB, the UE may report its transmission mode capability to the eNB in preparation for receiving a service via PTM transmission. After reporting the transmission mode capability to the eNB, the UE goes back to an idle mode to listen for the PTM transmission and receive a service via the PTM transmission. If the majority of the UEs report TM7 as the transmission mode capability to the eNB, the eNB may decide to utilize TM7 for the PTM transmission.

[0072] In another aspect of the second approach, the eNB may use a higher rank for PTM transmission based on the transmission mode and channel quality indicator (CQI) feedback from the UEs. If the eNB determines (e.g., based on the transmission mode capability reported from the UEs) to use a particular transmission mode for transmitting a particular service via PTM transmission, then the eNB may use CQI feedback from the UEs to decide whether to utilize rank 2 or higher, or rank 1 or lower for the group transmission. For example, the eNB may group high geometry UEs in a high geometry group and low geometry UEs in a low geometry group, based on the CQI feedback from the UEs, and use rank 2/high MCS for the high geometry group and rank 1/low MCS for the low geometry group. If a UE is in the connected mode, the network may determine how often the CQI feedback should be sent from the UE (periodically, e.g., once every 10ms or 80ms). The CQI feedback from the UE may be based on unicast transmission to the UE, and may not be based on the PTM transmission.

[0073] FIG. 8B is an example diagram 850 illustrating the second approach of the disclosure. In the example diagram 850, an eNB 852 is capable of performing a PTM transmission with multiple UEs. The UEs 862, 864, 866, and 868 are in the same group 860, and thus may receive the same service via PTM transmission from the eNB 852. The UEs 870 and 872 are not in the same group 860, and thus does not receive the same service via PTM transmission from the eNB 802 as the UEs 862, 864, 866, and 868. In the second approach, because a UE may be configured with any one of the downlink transmission modes that is appropriate for receiving a service via PTM transmission, the eNB 852 may transmit the service via the PTM transmission using transmission modes supported by the UE. Thus, in the example diagram 850, the eNB 852 transmits a particular service via PTM transmission using TM2 to the UEs 862, 864, and 868. In the example diagram 850, the eNB 852 transmits the particular service via unicast transmission using TM 7 to the UE 866. The UE 866 receives the particular service via unicast transmission because the UE 866 does not support TM2 that is associated with the particular service.

[0074] Various aspects are described for supporting C-RNTI based transmissions and/or G-RNTI based transmissions in the same subframe. According to a first method, the UE may support either a C-RNTI based PDSCH or G-RNTI based PDSCH on the same carrier in the same subframe, but not both the C-RNTI based PDSCH and the G-RNTI based PDSCH in the same subframe. Thus, according to the first method, a C-RNTI based PDSCH may be in one subframe, and a G-RNTI based PDSCH maybe in a different subframe. The C-RNTI may be used for unicast transmission and the G-RNTI may be used for the PTM transmission. Such method is similar to not supporting both PMCH and PDSCH on the same carrier in the same subframe. The UE may be signaled (e.g., by the eNB) with information about potential subframes that may be scheduled for the G-RNTI (e.g., subframes potentially having a PDCCH scrambled with the G-RNTI). For example, the eNB may provide the UE with PTM configuration information including the information about the potential subframes that may be scheduled for G-RNTI, where the eNB may send the PTM configuration via MCCH and/or MSI and/or SIB (system information block) and/or dedicated RRC signaling. Within those potential subframes, the UE monitors for a G-RNTI based transmission and may not monitor for a C-RNTI based transmission. Hence, the UE does not have to perform blind PDCCH decoding for both G-RNTI and C-RNTI, and thus there is no increase in a number of PDCCH blind decodes (thus no increase in complexity). It is noted that the first method may be implemented with the first approach discussed *supra*.

[0075] In a second method, the UE may support concurrent reception of a C-RNTI based PDSCH and a G-RNTI based PDSCH in the same subframe. It is noted that, in eMBMS, the UE may not support both unicast and multicast in the same subframe because different types of cyclic prefixes (CPs) are used for unicast transmission and multicast transmission. However, with implementation of a group bearer (e.g., via G-RNTI), the UE may support both unicast transmission and the PTM transmission via the same subframe using the C-RNTI for the unicast transmission and the G-RNTI for the PTM transmission because the same type of CP may be used for both the C-RNTI and the G-RNTI. As the UE supports concurrent reception of the C-RNTI based PDSCH and the G-RNTI based PDSCH in the same subframe, the UE also decodes a PDCCH using both the C-RNTI and the G-RNTI in the same subframe. It is noted that the second method may be implemented with the first approach or the second approach discussed *supra*.

[0076] It is noted that a total data rate with unicast transmission corresponding with the C-RNTI and PTM transmission corresponding with the G-RNTI should be consistent with UE capability. The UE may report the UE capability to the eNB when the UE connects to the eNB. The UE may send an MBMS interest indication message to the eNB, so that the eNB may configure the PTM transmission based on the MBMS interest indication message. Thus, the eNB may schedule the unicast transmission according to the UE capability and the MBMS interest indication message. For example, if the UE has UE capability to receive 1000 bits per subframe, and if the UE is configured to use 600 bits per subframe for the PTM transmission, the eNB may set the data rate for unicast transmission to the UE to a data rate that does not exceed 400 bits per subframe based on the MBMS interest indication message.

[0077] Typically, the MBMS interest indication message includes MBMS frequencies, but may not identify which particular service to receive. For example, unless the UE reports a specific TMGI associated with a particular service, the eNB may not be able to determine which particular service the UE is interested in receiving. It is noted that a TMGI uniquely identifies a group bearer that carries a particular service. If the UE does not indicate a specific PTM service (e.g., via the MBMS interest indication message), the eNB may set the data rate for the unicast transmission by considering the highest data rate among the data rates of all possible PTM services based on the MBMS interest indication message. For example, if the UE capability is 1000 bits per subframe and the highest data rate among the data rates of all PTM services is 600 bits per subframe, then the eNB may set the data rate for the unicast to be no higher than 400 bits per subframe. Thus, if the UE does not indicate a specific PTM service, the eNB may assume the worst case for the data rate for unicast transmission by considering highest rate for the PTM transmission.

[0078] In the second method, for better UE battery consumption, the UE can be signaled (e.g., by the eNB) about potential subframes which can be potentially scheduled for the G-RNTI. For example, the eNB may provide the UE with PTM configuration information including the information about the potential subframes that may be scheduled for G-RNTI, where the eNB may send the PTM configuration via MCCH and/or MSI and/or SIB (system information block) and/or dedicated RRC signaling. Subsequently, the UE may be configured to monitor for the G-RNTI based transmission on these potential subframes. Because the UE is configured to monitor for the G-RNTI based transmissions only on the potential subframes, not on all subframes, battery power of the UE may be saved. The UE may be configured to monitor for the C-RNTI based transmissions in all subframes. The UE may not monitor for C-RNTI based transmissions when the UE is not in a connected mode.

[0079] In a third method, the UE may monitor for both G-RNTI and C-RNTI in the same subframe, but may drop C-RNTI grant if the UE detects G-RNTI grant in the same subframe. Thus, in the third method, because the UE drops the C-RNTI grant upon detection of the G-RNTI grant in the same subframe, the UE ends up supporting either C-RNTI based PDSCH or G-RNTI based PDSCH in the same subframe.

[0080] Various aspects are now described to reduce the impact on PDCCH blind decodes with support for concurrent reception of C-RNTI based transmission and G-RNTI based transmission in same subframe on one carrier. In order to decode a PDCCH, a UE may blindly decode a PDCCH from several possible formats and control channel elements (CCEs) associated with the PDCCH. In an aspect, a number of PDCCH blind decodes is increased when the C-RNTI based transmissions and the G-RNTI based transmissions use different transmission modes. Typically, a UE-specific search space is associated with the C-RNTI or any other RNTI related to unicast transmission. Thus, it is noted that, typically, CCEs associated with the UE-specific search space are used to send the control information that is specific to a particular UE, whereas CCEs associated with the common search space are used to send the control information that is common for all the UEs.

[0081] In this aspect of the disclosure, the UE-specific search space may be associated with the G-RNTI. Further, in such an aspect, to limit the increase in the number of PDCCH blind decodes, a PDCCH associated with G-RNTI can be limited to a certain control channel element (CCE) aggregation level. Typically, in the UE specific search space, the CCE aggregation levels 1, 2, 4, and 8 may exist for each DCI format, and two DCI formats may be searched for each aggregation level. Thus, in the typical UE-specific search space, each DCI format will incur 16 blind decodes, with 6 blind decodes for each of aggregation levels 1 and 2 and 2 blind decodes for each of aggregation levels 4 and 8. In this aspect of the disclosure, For example, possible CCE aggregation levels may be limited to level 4 and level 8 for each DCI format for group transmission. Because two blind decodes may be performed for each of CCE aggregation levels 4 and 8, each DCI format will incur 4 blind decodes with the G-RNTI (two blind decodes for level 4 and two blind decodes for level 8). It is noted that the PTM transmission targets many UEs and thus the PTM transmission covering UEs with different geometry is desired. The UE may consider the CCE aggregation levels 4 and 8 to cover UEs with different geometry, without considering the CCE aggregation levels 1 and 2. In another aspect, the common search space may be associated with the G-RNTI. In the common search space, only CCE aggregation levels 4 and 8 are allowed with four blind decodes for aggregation level 4 and 2 blind decodes for aggregation level 8. Therefore, instead of performing two blind decodes for level 4 and two blind decodes for level 8 in the UE-specific search space, four blind decodes may be performed for level 4 and two blind decodes may be performed for level 8 in the common search space, which results in 6 blind decodes total. It is noted that the PDCCH with the G-RNTI in the UE-specific search space may be associated with DCI format 1A. It is further noted that the PDCCH associated with the G-RNTI is sent in a common search space.

[0082] In another aspect, no increase in the number of PDCCH blind decodes may be achieved by supporting DCI format 1A associated with a PDCCH with G-RNTI in a common search space. In particular, by supporting DCI format 1A associated with the PDCCH with G-RNTI in a common search space, without supporting other DCI formats, the number of PDCCH blind decodes may not be increased even when the UE supports concurrent reception of both the C-RNTI based PDSCH and the G-RNTI based PDSCH in the same subframe. If we use DCI format 1A which is common across all the UEs, then there is no blind decode increase. In such an aspect, the UE may further support DCI format 1A associated with a PDCCH with the G-RNTI in a UE-specific search space. In such an aspect, the transmission mode for transmit diversity (e.g. TM2) may be preferred for PTM transmission.

[0083] In another aspect, no increase in the number of PDCCH blind decodes may be achieved by introducing new DCI formats. For each transmission mode, there is a DCI format that is specific to a respective transmission mode. Each DCI format that is transmission mode specific may be modified to specify a new DCI format for the PTM transmission, where the size of the new DCI format is aligned with DCI format 1A. The UE defines that the new DCI format is supported in a common search space. For example, if the UE is in TM7 and DCI format 2D is specific to TM7, the UE may modify DCI format 2D to be DCI format 2D' that has the same size as DCI format 1A, and defines that the DCI format 2D' is supported in the common search space. Thus, when the UE searches DCI format 1A, the UE may find DCI format 2D'. The UE may define that the new DCI format is supported in a UE-specific search space, where the UE-specific search space is associated with a PDCCH associated with the G-RNTI.

[0084] Semi-persistent scheduling (SPS) for PTM transmission may be supported in certain aspects. SPS scheduling for PTM may be desirable because the PTM transmission may provide public safety, and unicast may use SPS for voice over IP (VoIP). The SPS G-RNTI (and/or SPS C-RNTI) may be signaled for each PTM service. However, if the UE receives a G-RNTI, the UE overwrites the SPS G-RNTI with the received G-RNTI. In one aspect, the UE may support SPS G-RNTI based PDSCH and C-RNTI/SPS C-RNTI PDSCH in the same subframe. In another aspect, the UE may support only a single SPS configuration, where SPS G-RNTI has higher priority over C-RNTI/SPS C-RNTI. In such an aspect, if the UE is signaled with information about the subframes that include the SPS G-RNTI based transmission, the UE monitors for G-RNTI/SPS G-RNTI in such subframes without monitoring for C-RNTI/SPS C-RNTI in such subframes (thus having no impact on the number of PDCCH blind decodes). If the UE is not signaled on the subframes where SPS G-RNTI is sent, the UE searches for a PDCCH with both G-RNTI/SPS G-RNTI and C-RNTI/SPS C-RNTI. If the UE finds a PDCCH with both G-RNTI/SPS G-RNTI and C-RNTI/SPS C-RNTI, the UE drops C-RNTI/SPS C-RNTI.

[0085] FIG. 9 is a flow chart 900 of a method of wireless communication according to the first approach of the disclosure. The method may be performed by a UE (e.g., the UE 812, the apparatus 1502/1502'). At 902, the UE receives, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes. At 904, the UE configures downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration. At 906, the UE receives a service via PTM downlink transmission based on the transmit diversity transmission mode. In an aspect, the transmit diversity downlink transmission mode is mode 2 for a PDSCH. For example, as discussed *supra*, the UE may be configured with one of several transmission modes for downlink transmission, and according to a first approach of the disclosure, the UE may be configured with the transmission mode for transmit diversity to receive the PTM transmission. For example, as discussed *supra*, the downlink transmission mode for transmit diversity may be TM2 for a PDSCH.

[0086] In an aspect, the UE is configured to support concurrent reception of both a PDSCH that is based on a C-RNTI and a PDSCH that is based on a G-RNTI in a same subframe. For example, as discussed *supra*, the UE may support concurrent reception of a C-RNTI based PDSCH and a G-RNTI based PDSCH in the same subframe. In an aspect, a PDCCH with the G-RNTI in a common search space is associated with DCI format 1A. In an aspect, a PDCCH with the G-RNTI in a UE-specific search space is associated with DCI format 1A. For example, as discussed *supra*, by supporting DCI format 1A associated with the PDCCH with G-RNTI in a common search space, without supporting other DCI formats, the number of PDCCH blind decodes may not be increased even when the UE supports concurrent reception of both the C-RNTI based PDSCH and the G-RNTI based PDSCH in the same subframe. For example, as discussed *supra*, the UE may further support DCI format 1A associated with a PDCCH with the G-RNTI in a UE-specific search space.

[0087] FIG. 10 is a flow chart 1000 of a method of wireless communication according to the second approach of the disclosure. The method may be performed by a UE (e.g., the UE 862, the apparatus 1702/1702'). At 1002, the UE reports a downlink transmission mode capability of the UE to a network. In an aspect, the reported downlink transmission mode capability enables the network to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability. For example, as discussed *supra*, each UE may report a transmission mode capability to the network in order for the eNB to configure the PTM transmission to a respective UE. In an aspect, the UE may report the downlink transmission capability by reporting the downlink transmission mode capability to an AS when the UE initially connects to the AS that is configured to indicate to the base station the downlink transmission mode capability. For example, as discussed *supra*, the UEs may report respective transmission mode capabilities to an AS when the UEs are initially set up for the PTM transmission, and the AS informs the eNB about the reported transmission mode capabilities. In another aspect, the UE may report the downlink transmission capability by entering a connected mode with a base station to report the downlink transmission mode capability to the base station when the UE determines to receive the PTM transmission, where the UE enters an idle mode to receive the PTM transmission after reporting the downlink transmission mode. For example, as discussed *supra*, when the UE first enters a connected mode with an eNB as the UE prepares to receive a service from the eNB via PTM transmission, the UE may report its transmission mode capability to the eNB. For example, as discussed *supra*, after reporting the transmission mode capability to the eNB, the UE goes back to an idle mode in order to listen for the PTM transmission and receive a service via PTM transmission.

[0088] At 1004, the UE receives, from the network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes. At 1006, the UE configures downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration. At 1008, the UE receives a service via PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service. Further descriptions with regard to 1010 are provided *infra*. In an aspect, the plurality of downlink transmission modes are transmission modes for a PDSCH. For example, as discussed *supra*, the UE may be configured with any one of the downlink transmission modes that is appropriate for receiving a service via PTM transmission.

[0089] In an aspect, the UE receives the service via the PTM transmission based on a rank for PTM transmission. For example, as discussed *supra*, the eNB may use a higher rank for PTM transmission based on the transmission mode and CQI feedback from the UE. Thus, the UE may receive the PTM transmission based on the higher rank.

[0090] FIG. 11A is a flow chart 1100 of a method of wireless communication expanding from the flow chart 1000 of FIG. 10. In the flow chart 1100, the UE is configured to support reception of either a PDSCH that is based on a C-RNTI or a PDSCH that is based on a G-RNTI in a same subframe. For example, as discussed *supra*, the UE may support either a C-RNTI based PDSCH or G-RNTI based PDSCH on the same carrier in the same subframe. The method may be performed by the UE. At 1102, the UE receives information about subframes that are available for the G-RNTI to monitor for the G-RNTI. For example, as discussed *supra*, the UE is to be signaled (e.g., by the eNB) with information about potential subframes that may be scheduled for G-RNTI, and within those potential subframes, the UE monitors for a G-RNTI and may not monitor for a C-RNTI.

[0091] In an aspect, the G-RNTI is an SPS G-RNTI. In an aspect, the C-RNTI is an SPS C-RNTI. In an aspect, if the UE receives information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI, without monitoring for a C-RNTI or an SPS C-RNTI, and if the UE does not receive information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI. In an aspect, if the UE detects a PDCCH with at least one of a G-RNTI or an SPS G-RNTI after monitoring for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI, the UE stops monitoring a PDCCH with a C-RNTI and an SPS C-RNTI in the subframe. For example, as discussed *supra*, the SPS G-RNTI (and/or SPS C-RNTI) may be signaled for each PTM service. For example, as discussed *supra*, the UE may support SPS G-RNTI based PDSCH and C-RNTI/SPS C-RNTI PDSCH in the same subframe. For example, as discussed *supra*, if the UE is signaled on the subframes where SPS G-RNTI is sent, the UE monitors for G-RNTI/SPS G-RNTI in such subframes without monitoring for C-RNTI/SPS C-RNTI in such subframes (thus having no impact on the number of PDCCH blind decodes performed by the UE). For example, as discussed *supra*, if the UE is not signaled on the subframes where SPS G-RNTI is sent, the UE searches for a PDCCH with both G-RNTI/SPS G-RNTI and C-RNTI/SPS C-RNTI. If the UE finds a PDCCH with both G-RNTI/SPS G-RNTI and C-RNTI/SPS C-RNTI, the UE drops C-RNTI/SPS C-RNTI.

[0092] FIG. 11B is a flow chart 1150 of a method of wireless communication expanding from the flow chart 1000 of FIG. 10. In the flow chart 1150, the UE is configured to support concurrent reception of both a PDSCH that is based on a C-RNTI and a PDSCH that is based on a G-RNTI in a same subframe. For example, as discussed *supra*, the UE may support concurrent reception of a C-RNTI based PDSCH and a G-RNTI based PDSCH in the same subframe. The method may be performed by the UE. At 1152, the UE decodes a PDCCH with both the C-RNTI and the G-RNTI in the same subframe. For example, as discussed *supra*, as the UE supports concurrent reception of the C-RNTI based PDSCH and the G-RNTI based PDSCH in the same subframe, the UE also decodes a PDCCH with both the C-RNTI and the G-RNTI in the same subframe. At 1154, the UE sends an MBMS interest indication message to a base station. The base station may configure a unicast data rate associated with C-RNTI based on the MBMS interest indication for the PTM transmission. For example, as discussed *supra*, the UE may send an

MBMS interest indication message to the eNB, so that the eNB may configure the PTM transmission based on the MBMS interest indication message. In an aspect, the unicast data rate associated with the C-RNTI is set to be equal to a highest data rate for the PTM transmission if the MBMS interest indication message does not indicate a service. For example, as discussed *supra*, if the UE does not indicate a specific PTM service (e.g., via the MBMS interest indication message), the eNB may set the data rate for the unicast transmission by considering the highest data rate among the data rates of all possible PTM services based on the MBMS interest indication message. In an aspect, the G-RNTI is an SPS G-RNTI. In an aspect, the C-RNTI is an SPS C-RNTI. For example, as discussed *supra*, the SPS G-RNTI (and/or SPS C-RNTI) may be signaled for each PTM service.

[0093] FIG. 12A is a flow chart 1200 of a method of wireless communication expanding from the flow chart 1000 of FIG. 10. In the flow chart 1200, the UE is configured to support concurrent reception of both a PDSCH that is based on a C-RNTI and a PDSCH that is based on a G-RNTI in a same subframe. The method may be performed by the UE. At 1202, the UE receives information about subframes that are available for transmission of the PDSCH with the G-RNTI. At 1204, the UE monitors for a PDCCH with the G-RNTI in the subframes that are available for the G-RNTI. At 1206, the UE monitors for a PDCCH with the C-RNTI in all subframes. For example, as discussed *supra*, the UE can be signaled (e.g., by the eNB) about potential subframes which can be potentially scheduled for the G-RNTI, and then may be configured to monitor for the G-RNTI on these potential subframes. For example, as discussed *supra*, the UE may be configured to monitor for the C-RNTI on all subframes.

[0094] FIG. 12B is a flow chart 1250 of a method of wireless communication expanding from the flow chart 1000 of FIG. 10. In the flow chart 1250, the UE is configured to support concurrent reception of both a PDSCH that is based on a C-RNTI and a PDSCH that is based on a G-RNTI in a same subframe. The method may be performed by the UE. In an aspect, at 1252, the UE drops a PDCCH associated with the C-RNTI if the UE detects a PDCCH with the G-RNTI. For example, as discussed *supra*, the UE may monitor for both G-RNTI and C-RNTI in the same subframe, but may drop C-RNTI grant if the UE detects G-RNTI grant in the same subframe.

[0095] In an aspect, a PDCCH with the G-RNTI is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI. In such an aspect, in the UE-specific search space, the PDCCH with the G-RNTI is limited to a predetermined CCE aggregation level. In such an aspect, the PDCCH with the G-RNTI in the UE specific search space is associated with DCI format 1A. In an aspect, the PDCCH with the G-RNTI is sent in a common search space. For example, as discussed *supra*, the UE-specific search space may be associated with the G-RNTI. For example, as discussed *supra*, to limit the increase of PDCCH blind decodes, a PDCCH with G-RNTI can be limited to certain CCE aggregation level.

[0096] In an aspect, a PDCCH with the G-RNTI in a common search space is associated with DCI format 1A. For example, as discussed *supra*, by supporting DCI format 1A associated with the PDCCH with G-RNTI in a common search space, without supporting other DCI formats, the number of PDCCH blind decodes may not be increased even when the UE supports concurrent reception of both the C-RNTI based PDSCH and the G-RNTI based PDSCH in the same subframe.

[0097] In an aspect, for a downlink transmission mode supported by the UE for the PTM, a new DCI format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A. In such an aspect, the new DCI format is received in a common search space. In such an aspect, the new DCI format is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI. For example, as discussed *supra*, each DCI format that is transmission mode specific may be modified to be a new DCI format for the PTM transmission, where the size of the new DCI format is aligned with DCI format 1A. For example, as discussed *supra*, the UE defines that the new DCI format is supported in a common search space. For example, as discussed *supra*, the UE may define that the new DCI format is supported in a UE-specific search space, where the UE-specific search space is associated with a PDCCH associated with the G-RNTI.

[0098] FIG. 13A is a flow chart 1300 of a method of wireless communication according to the disclosure. The method may be performed by an eNB (e.g., the eNB 802 or the eNB 852, the apparatus 1902/1902'). At 1302, the eNB receives a downlink transmission mode capability of the UE from the UE. In an aspect, the downlink transmission mode capability enables the eNB to configure the PTM transmission with one of the plurality of downlink transmission modes based on the received downlink transmission mode capability. For example, as discussed *supra*, each UE may report a transmission mode capability to the network in order for the eNB to configure the PTM transmission to a respective UE. In an aspect, the eNB receives the downlink transmission mode capability by receiving an indication from an AS about the downlink transmission mode capability, where the downlink transmission mode capability is reported to the AS when the UE initially connects to the AS. For example, as discussed *supra*, the UEs may report respective transmission mode capabilities to an AS when the UEs are initially set up for the PTM transmission, and the AS informs the eNB about the reported transmission mode capabilities. In another aspect, the eNB receives the downlink transmission mode capability by receiving the downlink transmission mode capability from the UE after the UE enters a connected mode with the eNB when the UE determines to receive the PTM transmission, where the eNB is configured to send the PTM transmission to the UE when the UE enters an idle mode after the eNB receives the downlink transmission mode. For example, as discussed *supra*, when the UE first enters a connected mode with an eNB as the UE prepares to receive a service from the eNB via PTM transmission, the UE may report its transmission mode capability to the eNB. For example, as discussed *supra*, after reporting the transmission mode capability to the eNB, the UE goes back to an idle mode in order to listen for the PTM transmission and receive a service via PTM transmission.

[0099] At 1304, the eNB determines one of a plurality of downlink transmission modes for a service via PTM transmission. At 1306, the eNB transmits a service to a user equipment (UE) via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service. In an aspect, the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH). Further descriptions with regard to 1308 are provided *infra*. For example, as discussed *supra*, the UE may be configured with any one of the downlink transmission modes that is appropriate for receiving a service via PTM transmission.

[00100] FIG. 13B is a flow chart 1350 of a method of wireless communication expanding from the flow chart 1300 of FIG. 13A. The method may be performed by the eNB. At 1352, the eNB receives a CQI from the UE. At 1354, the eNB determines a rank for the PTM transmission based on the received downlink transmission mode capability and the CQI, wherein the PTM transmission is based on the rank. For example, as discussed *supra*, the eNB may use a higher rank for PTM transmission based on the transmission mode and CQI feedback from the UE.

[00101] FIG. 14A is a flow chart 1400 of a method of wireless communication expanding from the flow chart 1300 of FIG. 13A. The method may be performed by the eNB. In the flow chart 1400, the eNB utilizes either a PDSCH that is based on the C-RNTI or a PDSCH that is based on a G-RNTI to communicate with the UE. For example, as discussed *supra*, the UE may support either a C-RNTI based PDSCH or G-RNTI based PDSCH on the same carrier in the same subframe. At 1402, the eNB sends information on the subframes to be monitored for the G-RNTI to the UE. For example, as discussed *supra*, the UE is to be signaled (e.g., by the eNB) with information about potential subframes that may be scheduled for G-RNTI, and within those potential subframes, the UE monitors for a G-RNTI and may not monitor for a C-RNTI.

[00102] FIG. 14B is a flow chart 1450 of a method of wireless communication expanding from the flow chart 1400 of FIG. 13A. The method may be performed by the eNB. In the flow chart 1450, the eNB utilizes both a PDSCH that is based on the C-RNTI and a PDSCH that is based on a G-RNTI to communicate with the UE. For example, as discussed *supra*, the UE may support concurrent reception of a C-RNTI based PDSCH and a G-RNTI based PDSCH in the same subframe. At 1452, the eNB receives an MBMS interest indication message from the UE. At 1454, the eNB configures a unicast data rate associated with the C-RNTI based on the MBMS interest indication for the PTM transmission. For example, as discussed *supra*, the UE may send an MBMS interest indication message to the eNB, so that the eNB may configure the PTM transmission based on the MBMS interest indication message. At 1456, the eNB sets the unicast data rate associated with the C-RNTI to be equal to a highest data rate for the PTM transmission if the received MBMS interest indication message does not indicate a service. For example, as discussed *supra*, the UE does not indicate a specific PTM service (e.g., via the MBMS interest indication message), the eNB may set the data rate for the unicast transmission by

considering the highest data rate among the data rates of all possible PTM services based on the MBMS interest indication message.

[00103] In an aspect, for a downlink transmission mode supported by the UE for the PTM, a new DCI format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A. In such an aspect, the new DCI format is sent in a common search space. In such an aspect, the new DCI format is sent in a UE specific search space where the UE specific search space is associated with G-RNTI. For example, as discussed *supra*, each DCI format that is transmission mode specific may be modified to be a new DCI format for the PTM transmission, where the size of the new DCI format is aligned with DCI format 1A. The UE defines that the new DCI format is supported in a common search space. For example, as discussed *supra*, the UE may defines that the new DCI format is supported in a UE-specific search space, where the UE-specific search space is associated with a PDCCH associated with the G-RNTI.

[00104] FIG. 15 is a conceptual data flow diagram 1500 illustrating the data flow between different modules/means/components in an exemplary apparatus 1502. The apparatus may be a UE. The apparatus includes a reception module 1504, a transmission module 1506, and a communication configuration module 1508.

[00105] The communication receives via the reception module 1504, from a network (e.g., eNB 1550), a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes. The communication configuration module 1508 configures downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration. The reception module 1504 receives a service via PTM downlink transmission based on the transmit diversity transmission mode. In an aspect, the transmit diversity downlink transmission mode is mode 2 for a PDSCH.

[00106] In an aspect, the UE is configured via the communication configuration module 1508 to support concurrent reception of both a PDSCH that is based on a C-RNTI and a PDSCH that is based on a G-RNTI in a same subframe. In an aspect, a PDCCH with the G-RNTI in a common search space is associated with DCI format 1A. In an aspect, a PDCCH with the G-RNTI in a UE-specific search space is associated with DCI format 1A.

[00107] The apparatus may include additional modules that perform each of the blocks of the algorithm in the aforementioned flow charts of FIG. 9. As such, each block in the aforementioned flow charts of FIG. 9 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.

[00108] FIG. 16 is a diagram 1600 illustrating an example of a hardware implementation for an apparatus 1502' employing a processing system 1614. The processing system 1614 may be implemented with a bus architecture, represented generally by the bus 1624. The bus 1624 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 1614 and the overall design constraints. The bus 1624 links together various circuits including one or more processors and/or hardware modules, represented by the processor 1604, the modules 1504, 1506, 1508, and the computer-readable medium / memory 1606. The bus 1624 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.

[00109] The processing system 1614 may be coupled to a transceiver 1610. The transceiver 1610 is coupled to one or more antennas 1620. The transceiver 1610 provides a means for communicating with various other apparatus over a transmission medium. The transceiver 1610 receives a signal from the one or more antennas 1620, extracts information from the received signal, and provides the extracted information to the processing system 1614, specifically the reception module 1504. In addition, the transceiver 1610 receives information from the processing system 1614, specifically the transmission module 1506, and based on the received information, generates a signal to be applied to the one or more antennas 1620. The processing system 1614 includes a processor 1604 coupled to a computer-readable medium / memory 1606. The processor 1604 is responsible for general processing, including the execution of software stored on the computer-readable medium / memory 1606. The software, when executed by the processor 1604, causes the processing system 1614 to perform the various functions described

supra for any particular apparatus. The computer-readable medium / memory 1606 may also be used for storing data that is manipulated by the processor 1604 when executing software. The processing system further includes at least one of the modules 1504, 1506, 1508. The modules may be software modules running in the processor 1604, resident/stored in the computer readable medium / memory 1606, one or more hardware modules coupled to the processor 1604, or some combination thereof. The processing system 1614 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.

[00110] In one configuration, the apparatus 1502/1502' for wireless communication includes means for receiving , from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes, means for configuring downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration, and means for receiving a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode. The aforementioned means may be one or more of the aforementioned modules of the apparatus 1502 and/or the processing system 1614 of the apparatus 1502' configured to perform the functions recited by the aforementioned means. As described *supra*, the processing system 1614 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.

[00111] FIG. 17 is a conceptual data flow diagram 1700 illustrating the data flow between different modules/means/components in an exemplary apparatus 1702. The apparatus may be a UE. The apparatus includes a reception module 1704, a transmission module 1706, a communication configuration module 1708, a transmission mode capability management module 1710, an RNTI management module 1712, a channel management module 1714, and an information reporting module 1716.

[00112] The transmission mode capability management module 1710 reports via the transmission module 1706 a downlink transmission mode capability of the UE to a

network. In an aspect, the reported downlink transmission mode capability enables the network to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability. In an aspect, the transmission mode capability management module 1710 may report the downlink transmission capability by reporting the downlink transmission mode capability to an AS when the UE initially connects to the AS that is configured to indicate to the eNB 1750 about the downlink transmission mode capability. In another aspect, the transmission mode capability management module 1710 may report the downlink transmission capability by entering a connected mode with a eNB 1750 to report the downlink transmission mode capability to the eNB 1750 when the UE determines to receive the PTM transmission, where the UE enters an idle mode to receive the PTM transmission after reporting the downlink transmission mode.

[00113] The communication configuration module 1708 receives via the reception module 1704, from a network (e.g., the eNB 1750), a downlink transmission configuration indicating one of a plurality of downlink transmission modes. The communication configuration module 1708 configures downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration. The reception module 1704 receives a service via PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service. In an aspect, the plurality of downlink transmission modes are transmission modes for a PDSCH. In an aspect, the UE receives the service via the PTM transmission based on a rank for PTM transmission.

[00114] According to the first method, the UE is configured to support reception of either a PDSCH that is based on a C-RNTI or a PDSCH that is based on a G-RNTI in a same subframe. The RNTI management module 1712 receives via the reception module 1704 information about subframes that are available for the G-RNTI to monitor for the G-RNTI.

[00115] In an aspect, the G-RNTI is an SPS G-RNTI. In an aspect, the C-RNTI is an SPS C-RNTI. In an aspect, if the RNTI management module 1712 receives information on the subframes to be monitored for the G-RNTI, the RNTI management module 1712 monitors for at least one of a G-RNTI or an SPS G-RNTI, without monitoring for a C-RNTI or an SPS C-RNTI, and if the RNTI management

module 1712 does not receive information on the subframes to be monitored for the G-RNTI, the RNTI management module 1712 monitors for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI. In an aspect, if the RNTI management module 1712 detects a PDCCH with at least one of a G-RNTI or an SPS G-RNTI after monitoring for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI, the RNTI management module 1712 stops monitoring a PDCCH with a C-RNTI and an SPS C-RNTI in the subframe.

[00116] According to the second method, the UE is configured to support concurrent reception of both a PDSCH that is based on a C-RNTI and a PDSCH that is based on a G-RNTI in a same subframe. At 1152, the channel management module 1714 decodes a PDCCH with both the C-RNTI and the G-RNTI in the same subframe. At 1154, the information reporting module 1716 sends an MBMS interest indication message to the eNB 1750 via the transmission module 1706. The eNB 1750may configure a unicast data rate associated with C-RNTI based on the MBMS interest indication for the PTM transmission. In an aspect, the unicast data rate associated with the C-RNTI is set to be equal to a highest data rate for the PTM transmission if the MBMS interest indication message does not indicate a service. In an aspect, the G-RNTI is an SPS G-RNTI. In an aspect, the C-RNTI is an SPS C-RNTI.

[00117] In the second method, the RNTI management module 1712 receives via the reception module 1704 information about subframes that are available for transmission of the PDSCH with the G-RNTI. The RNTI management module 1712 monitors for a PDCCH with the G-RNTI in the subframes that are available for the G-RNTI. The RNTI management module 1712 UE monitors for a PDCCH with the C-RNTI in all subframes.

[00118] In the second method, the RNTI management module 1712 drops a PDCCH associated with the C-RNTI if the RNTI management module 1712 detects a PDCCH with the G-RNTI.

[00119] In an aspect, a PDCCH with the G-RNTI is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI. In such an aspect, in the UE-specific search space, the PDCCH with the G-RNTI is limited to a predetermined CCE aggregation level. In such an aspect, the PDCCH with the G-RNTI in the UE specific search space is associated with DCI format 1A. In an aspect, the PDCCH with the G-RNTI is sent in a common search space. In an aspect, a PDCCH with the G-RNTI in a common search space is associated with DCI format 1A.

[00120] In an aspect, for a downlink transmission mode supported by the UE for the PTM, a new DCI format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A. In such an aspect, the new DCI format is received in a common search space. In such an aspect, the new DCI format is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

[00121] The apparatus may include additional modules that perform each of the blocks of the algorithm in the aforementioned flow charts of FIGs. 10-12. As such, each block in the aforementioned flow charts of FIGs. 10-12 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.

[00122] FIG. 16 is a diagram 1600 illustrating an example of a hardware implementation for an apparatus 1702' employing a processing system 1814. The processing system 1814 may be implemented with a bus architecture, represented generally by the bus 1824. The bus 1824 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 1814 and the overall design constraints. The bus 1824 links together various circuits including one or more processors and/or hardware modules, represented by the processor 1804, the modules 1704, 1706, 1708, 1710, 1712, 1714, 1716, and the computer-readable medium / memory 1806. The bus 1824 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.

[00123] The processing system 1814 may be coupled to a transceiver 1810. The transceiver 1810 is coupled to one or more antennas 1820. The transceiver 1810 provides a means for communicating with various other apparatus over a transmission medium. The transceiver 1810 receives a signal from the one or more antennas 1820, extracts information from the received signal, and provides the

extracted information to the processing system 1814, specifically the reception module 1704. In addition, the transceiver 1810 receives information from the processing system 1814, specifically the transmission module 1706, and based on the received information, generates a signal to be applied to the one or more antennas 1820. The processing system 1814 includes a processor 1804 coupled to a computer-readable medium / memory 1806. The processor 1804 is responsible for general processing, including the execution of software stored on the computer-readable medium / memory 1806. The software, when executed by the processor 1804, causes the processing system 1814 to perform the various functions described *supra* for any particular apparatus. The computer-readable medium / memory 1806 may also be used for storing data that is manipulated by the processor 1804 when executing software. The processing system further includes at least one of the modules 1704, 1706, 1708, 1710, 1712, 1714, and 1716. The modules may be software modules running in the processor 1804, resident/stored in the computer readable medium / memory 1806, one or more hardware modules coupled to the processor 1804, or some combination thereof. The processing system 1814 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.

[00124] In one configuration, the apparatus 1702/1702' for wireless communication includes means for receiving, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes, means for configuring downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration, and means for receiving a service via PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service. The apparatus 1702/1702' further includes means for reporting a downlink transmission mode capability of the UE to a network, where the reported downlink transmission mode capability enables the network to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability. The apparatus 1702/1702' further includes means for receiving information about subframes that are available for the G-RNTI to monitor for the G-RNTI. The apparatus 1702/1702' further includes means for decoding a PDCCH with both the C-RNTI and the G-RNTI in the same subframe. The apparatus 1702/1702' further includes means for sending an MBMS interest indication message to a base station. The apparatus 1702/1702' further includes means for receiving information about subframes that are available for transmission of the PDSCH with the G-RNTI, means for monitoring for a PDCCH with the G-RNTI in the subframes that are available for the G-RNTI, and means for monitoring for a PDCCH with the C-RNTI in all subframes. The apparatus 1702/1702' further includes means for dropping a PDCCH associated with the C-RNTI if the UE detects a PDCCH with the G-RNTI. The aforementioned means may be one or more of the aforementioned modules of the apparatus 1702 and/or the processing system 1814 of the apparatus 1702' configured to perform the functions recited by the aforementioned means. As described *supra*, the processing system 1814 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.

[00125] FIG. 19 is a conceptual data flow diagram 1900 illustrating the data flow between different modules/means/components in an exemplary apparatus 1902. The apparatus may be an eNB. The apparatus includes a reception module 1904, a transmission module 1906, a transmission mode capability management module 1908, a PTM transmission management module 1910, and unicast management module 1912.

[00126] The transmission mode capability management module 1908 receives via the reception module 1904 a downlink transmission mode capability of the UE 1950 from the UE 1950. In an aspect, the downlink transmission mode capability enables the eNB to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability. In an aspect, the eNB receives the downlink transmission mode capability by receiving an indication from an AS about the downlink transmission mode capability, where the downlink transmission mode capability is reported to the AS when the UE 1950 initially connects to the AS. In another aspect, the eNB receives the downlink transmission mode capability by receiving the downlink transmission mode capability from the UE 1950 after the UE enters a connected mode with the eNB when the UE 1950 determines to receive the PTM transmission, where the eNB is configured to send the PTM transmission to the UE 1950 when the UE 1950 enters an idle mode after the eNB receives the downlink transmission mode.

[00127] The transmission mode capability management module 1908 determines one of a plurality of downlink transmission modes for a service via PTM transmission. The PTM transmission management module 1910 transmits a service to the UE via 1950 the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service. In an aspect, the plurality of downlink transmission modes are transmission modes for a PDSCH.

[00128] The PTM transmission management module 1910 receives via the reception module 1904 a CQI from the UE 1950. The PTM transmission management module 1910 determines a rank for the PTM transmission based on the received downlink transmission mode capability and the CQI, where the PTM transmission is based on the rank.

[00129] In the first method, the eNB utilizes either a PDSCH that is based on the C-RNTI or a PDSCH that is based on a G-RNTI in a subframe to communicate with the UE 1950. At 1402, the eNB sends information on the subframes to be monitored for the G-RNTI to the UE.

[00130] In the second method, the eNB utilizes both a PDSCH that is based on the C-RNTI and a PDSCH that is based on a G-RNTI to communicate in a subframe with the UE 1950. The unicast management module 1912 receives an MBMS interest indication message from the UE 1950. The unicast management module 1912 configures a unicast data rate associated with the C-RNTI based on the MBMS interest indication for the PTM transmission. The unicast management module 1912 sets the unicast data rate associated with the C-RNTI to be equal to a highest data rate for the PTM transmission if the received MBMS interest indication message does not indicate a service.

[00131] In an aspect, for a downlink transmission mode supported by the UE 1950 for the PTM, a new DCI format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A. In such an aspect, the new DCI format is sent in a common search space. In such an aspect, the new DCI format is sent in a UE specific search space where the UE specific search space is associated with G-RNTI.

[00132] The apparatus may include additional modules that perform each of the blocks of the algorithm in the aforementioned flow charts of FIGs. 13 and 14. As such, each block in the aforementioned flow charts of FIGs. 13 and 14 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.

[00133] FIG. 20 is a diagram 2000 illustrating an example of a hardware implementation for an apparatus 1902' employing a processing system 2014. The processing system 2014 may be implemented with a bus architecture, represented generally by the bus 2024. The bus 2024 may include any number of interconnecting buses and bridges depending on the specific application of the processing system 2014 and the overall design constraints. The bus 2024 links together various circuits including one or more processors and/or hardware modules, represented by the processor 2004, the modules 1904, 1906, 1908, 1910, 1912, and the computer-readable medium / memory 2006. The bus 2024 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.

[00134] The processing system 2014 may be coupled to a transceiver 2010. The transceiver 2010 is coupled to one or more antennas 2020. The transceiver 2010 provides a means for communicating with various other apparatus over a transmission medium. The transceiver 2010 receives a signal from the one or more antennas 2020, extracts information from the received signal, and provides the extracted information to the processing system 2014, specifically the reception module 1904. In addition, the transceiver 2010 receives information from the processing system 2014, specifically the transmission module 1906, and based on the received information, generates a signal to be applied to the one or more antennas 2020. The processing system 2014 includes a processor 2004 coupled to a computer-readable medium / memory 2006. The processor 2004 is responsible for general processing, including the execution of software stored on the computer-readable medium / memory 2006. The software, when executed by the processor 2004, causes the processing system 2014 to perform the various functions described

supra for any particular apparatus. The computer-readable medium / memory 2006 may also be used for storing data that is manipulated by the processor 2004 when executing software. The processing system further includes at least one of the modules 1904, 1906, 1908, 1910, and 1912. The modules may be software modules running in the processor 2004, resident/stored in the computer readable medium / memory 2006, one or more hardware modules coupled to the processor 2004, or some combination thereof. The processing system 2014 may be a component of the eNB 610 and may include the memory 676 and/or at least one of the TX processor 616, the RX processor 670, and the controller/processor 675.

[00135] In one configuration, the apparatus 1902/1902' for wireless communication includes means for means for determining one of a plurality of downlink transmission modes for a service via PTM transmission, and means for transmitting a service to a UE via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service. The apparatus 1902/1902' further includes means for receiving a downlink transmission mode capability of the UE from the UE, where the downlink transmission mode capability enables the base station to configure the PTM transmission with one of the plurality of downlink transmission modes based on the received downlink transmission mode capability. The apparatus 1902/1902' further includes means for receiving a CQI from the UE, and means for determining a rank for the PTM transmission based on the received downlink transmission mode capability and the CQI, wherein the PTM transmission is based on the rank. The apparatus 1902/1902' further includes means for sending information on the subframes to be monitored for the G-RNTI to the UE. The apparatus 1902/1902' further includes means for receiving an MBMS interest indication message from the UE, and means for configuring a unicast data rate associated with the C-RNTI based on the MBMS interest indication for the PTM transmission. The apparatus 1902/1902' further includes means for setting the unicast data rate associated with the C-RNTI to be equal to a highest data rate for the PTM transmission if the received MBMS interest indication message does not indicate a service. The aforementioned means may be one or more of the aforementioned modules of the apparatus 1902 and/or the processing system 2014 of the apparatus 1902' configured to perform the functions recited by the aforementioned means. As described *supra*, the processing system 2014 may

include the TX Processor 616, the RX Processor 670, and the controller/processor 675. As such, in one configuration, the aforementioned means may be the TX Processor 616, the RX Processor 670, and the controller/processor 675 configured to perform the functions recited by the aforementioned means.

[00136] It is understood that the specific order or hierarchy of blocks 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 blocks in the processes / flow charts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[00137] 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.”

WHAT IS CLAIMED IS:

CLAIMS

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

receiving, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes;

configuring downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration; and

receiving a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode.

2. The method of claim 1, wherein the transmit diversity downlink transmission mode is mode 2 for a physical downlink shared channel (PDSCH).

3. The method of claim 1, wherein the UE is configured to support concurrent reception of both a physical layer downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) and a physical downlink shared channel (PDSCH) that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

4. The method of claim 3, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a common search space is associated with downlink control information (DCI) format 1A.

5. The method of claim 3, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a UE-specific search space is associated with downlink control information (DCI) format 1A.

6. A method of wireless communication performed by a user equipment (UE), comprising:

receiving, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes;

configuring downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration; and

receiving a service via point-to-multiple (PTM) transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

7. The method of claim 6, wherein the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH).

8. The method of claim 6, further comprising:

reporting a downlink transmission mode capability of the UE to a network, wherein the reported downlink transmission mode capability enables the network to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability.

9. The method of claim 8, wherein the reporting the downlink transmission mode capability includes:

reporting the downlink transmission mode capability to an application server (AS) when the UE initially connects to the AS that is configured to indicate to the base station the downlink transmission mode capability.

10. The method of claim 8, wherein the reporting the downlink transmission mode capability includes:

entering a connected mode with a base station to report the downlink transmission mode capability to the base station when the UE determines to receive the PTM transmission,

wherein the UE enters an idle mode to receive the PTM transmission after reporting the downlink transmission mode.

11. The method of claim 8, wherein the UE receives the service via the PTM transmission based on a rank for PTM transmission.

12. The method of claim 6, wherein the UE is configured to support reception of either a physical downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) or a PDSCH that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

13. The method of claim 12, further comprising:

receiving information about subframes that are available for the G-RNTI to monitor for the G-RNTI.

14. The method of claim 12, wherein the G-RNTI is a semi-persistent scheduling (SPS) G-RNTI.

15. The method of claim 12, wherein the C-RNTI is a semi-persistent scheduling (SPS) C-RNTI.

16. The method of claim 12, wherein if the UE receives information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI, without monitoring for a C-RNTI or an SPS C-RNTI, and wherein if the UE does not receive information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI.

17. The method of claim 16, wherein if the UE detects a physical downlink control channel (PDCCH) with at least one of a G-RNTI or an SPS G-RNTI after monitoring for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI, the UE stops monitoring a PDCCH with a C-RNTI and an SPS C-RNTI in the subframe.

18. The method of claim 6, wherein the UE is configured to support concurrent reception of both a physical downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) and a PDSCH that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

19. The method of claim 18, further comprising:

decoding a physical downlink control channel (PDCCH) with both the C-RNTI and the G-RNTI in the same subframe.

20. The method of claim 18, further comprising:

sending a multimedia broadcast multicast services (MBMS) interest indication message to a base station.

21. The method of claim 18, further comprising:

receiving information about subframes that are available for transmission of the PDSCH with the G-RNTI;

monitoring for a physical downlink control channel (PDCCH) with the G-RNTI in the subframes that are available for the G-RNTI; and

monitoring for a PDCCH with the C-RNTI in all subframes.

22. The method of claim 18, wherein the G-RNTI is a semi-persistent scheduling (SPS) G-RNTI.

23. The method of claim 18, wherein the C-RNTI is a semi-persistent scheduling (SPS) C-RNTI.

24. The method of claim 18, further comprising:

dropping a physical downlink control channel (PDCCH) associated with the C-RNTI if the UE detects a PDCCH with the G-RNTI.

25. The method of claim 18, wherein a physical downlink control channel (PDCCH) with the G-RNTI is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

26. The method of claim 25, wherein, in the UE-specific search space, the PDCCH with the G-RNTI is limited to a predetermined control channel element (CCE) aggregation level.

27. The method of claim 25, wherein the PDCCH with the G-RNTI in the UE specific search space is associated with downlink control information (DCI) format 1A.

28. The method of claim 18, wherein the PDCCH with the G-RNTI is received in a common search space.

29. The method of claim 18, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a common search space is associated with downlink control information (DCI) format 1A.

30. The method of claim 18, wherein for a downlink transmission mode supported by the UE for the PTM, a new downlink control information (DCI) format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A.

31. The method of claim 30, wherein the new DCI format is received in a common search space.

32. The method of claim 30, wherein the new DCI format is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

33. A method of wireless communication performed by a base station, comprising:

determining one of a plurality of downlink transmission modes for a service via point-to-multiple (PTM) transmission; and

transmitting a service to a user equipment (UE) via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

34. The method of claim 33, wherein the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH).

35. The method of claim 33, further comprising:

receiving a downlink transmission mode capability of the UE from the UE, wherein the downlink transmission mode capability enables the base station to configure the PTM transmission with one of the plurality of downlink transmission modes based on the received downlink transmission mode capability.

36. The method of claim 35, wherein the receiving the downlink transmission mode capability includes:

receiving an indication from an application server (AS) about the downlink transmission mode capability, wherein the downlink transmission mode capability is reported to the AS when the UE initially connects to the AS.

37. The method of claim 35, wherein the receiving the downlink transmission mode capability includes:

receiving the downlink transmission mode capability from the UE after the UE enters a connected mode with a base station when the UE determines to receive the PTM transmission,

wherein the base station is configured to send the PTM transmission to the UE when the UE enters an idle mode after the base station receives the downlink transmission mode.

38. The method of claim 35, further comprising:

receiving a channel quality indication (CQI) from the UE; and

determining a rank for the PTM transmission based on the received downlink transmission mode capability and the CQI, wherein the PTM transmission is based on the rank.

39. The method of claim 33, wherein the base station utilizes either a physical downlink shared channel (PDSCH) that is based on the cell radio network temporary identifier (C-RNTI) or a PDSCH that is based on a group radio network temporary identifier (G-RNTI) to communicate with the UE.

40. The method of claim 39, further comprising:

sending information on the subframes to be monitored for the G-RNTI to the UE.

41. The method of claim 33, wherein the base station utilizes both a physical downlink shared channel (PDSCH) that is based on the cell radio network temporary identifier (C-RNTI) and a PDSCH that is based on a group radio network temporary identifier (G-RNTI) to communicate with the UE.

42. The method of claim 41, further comprising:

receiving a multimedia broadcast multicast services (MBMS) interest indication message from the UE; and

configuring a unicast data rate associated with the C-RNTI based on the MBMS interest indication for the PTM transmission.

43. The method of claim 42, further comprising:

setting the unicast data rate associated with the C-RNTI to be equal to a highest data rate for the PTM transmission if the received MBMS interest indication message does not indicate a service.

44. The method of claim 41, wherein for a downlink transmission mode supported by the UE for the PTM, a new downlink control information (DCI) format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A.

45. The method of claim 44, wherein the new DCI format is sent in a common search space.

46. The method of claim 44, wherein the new DCI format is sent in a UE specific search space where the UE specific search space is associated with G-RNTI.

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

a memory; and

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

receive, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes;

configure downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration; and

receive a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode.

48. The UE of claim 47, wherein the transmit diversity downlink transmission mode is mode 2 for a physical downlink shared channel (PDSCH).

49. The UE of claim 47, wherein the UE is configured to support concurrent reception of both a physical layer downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) and a physical downlink shared channel (PDSCH) that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

50. The UE of claim 49, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a common search space is associated with downlink control information (DCI) format 1A.

51. The UE of claim 49, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a UE-specific search space is associated with downlink control information (DCI) format 1A.

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

a memory; and

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

receive, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes;

configure downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration ; and

receive a service via point-to-multiple (PTM) transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

53. The UE of claim 52, wherein the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH).

54. The UE of claim 52, wherein the at least one processor is further configured to:

report a downlink transmission mode capability of the UE to a network, wherein the reported downlink transmission mode capability enables the network to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability.

55. The UE of claim 54, wherein the at least one processor configured to report the downlink transmission mode capability is configured to:

report the downlink transmission mode capability to an application server (AS) when the UE initially connects to the AS that is configured to indicate to the base station the downlink transmission mode capability.

56. The UE of claim 54, wherein the at least one processor configured to report the downlink transmission mode capability is configured to:

enter a connected mode with a base station to report the downlink transmission mode capability to the base station when the UE determines to receive the PTM transmission,

wherein the UE enters an idle mode to receive the PTM transmission after reporting the downlink transmission mode.

57. The UE of claim 54, wherein the UE receives the service via the PTM transmission based on a rank for PTM transmission.

58. The UE of claim 52, wherein the UE is configured to support reception of either a physical downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) or a PDSCH that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

59. The UE of claim 58, the at least one processor is further configured to:

receive information about subframes that are available for the G-RNTI to monitor for the G-RNTI.

60. The UE of claim 58, wherein the G-RNTI is a semi-persistent scheduling (SPS) G-RNTI.

61. The UE of claim 58, wherein the C-RNTI is a semi-persistent scheduling (SPS) C-RNTI.

62. The UE of claim 58, wherein if the UE receives information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI, without monitoring for a C-RNTI or an SPS C-RNTI, and wherein if the UE does not receive information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI.

63. The UE of claim 62, wherein if the UE detects a physical downlink control channel (PDCCH) with at least one of a G-RNTI or an SPS G-RNTI after monitoring for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI, the UE stops monitoring a PDCCH with a C-RNTI and an SPS C-RNTI in the subframe.

64. The UE of claim 52, wherein the UE is configured to support concurrent reception of both a physical downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) and a PDSCH that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

65. The UE of claim 64, wherein the at least one processor is further configured to:
decode a physical downlink control channel (PDCCH) with both the C-RNTI and the G-RNTI in the same subframe.

66. The UE of claim 64, wherein the at least one processor is further configured to:
send a multimedia broadcast multicast services (MBMS) interest indication message to a base station.

67. The UE of claim 64, wherein the at least one processor is further configured to:
receive information about subframes that are available for transmission of the PDSCH with the G-RNTI;
monitor for a physical downlink control channel (PDCCH) with the G-RNTI in the subframes that are available for the G-RNTI; and
monitor for a PDCCH with the C-RNTI in all subframes.

68. The UE of claim 64, wherein the G-RNTI is a semi-persistent scheduling (SPS) G-RNTI.

69. The UE of claim 64, wherein the C-RNTI is a semi-persistent scheduling (SPS) C-RNTI.

70. The UE of claim 64, wherein the at least one processor is further configured to:
drop a physical downlink control channel (PDCCH) associated with the C-RNTI if the UE detects a PDCCH with the G-RNTI.

71. The UE of claim 64, wherein a physical downlink control channel (PDCCH) with the G-RNTI is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

72. The UE of claim 71, wherein, in the UE-specific search space, the PDCCH with the G-RNTI is limited to a predetermined control channel element (CCE) aggregation level.

73. The UE of claim 71, wherein the PDCCH with the G-RNTI in the UE specific search space is associated with downlink control information (DCI) format 1A.

74. The UE of claim 64, wherein the PDCCH with the G-RNTI is sent in a common search space.

75. The UE of claim 64, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a common search space is associated with downlink control information (DCI) format 1A.

76. The UE of claim 64, wherein for a downlink transmission mode supported by the UE for the PTM, a new downlink control information (DCI) format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A..

77. The UE of claim 76, wherein the new DCI format is received in a common search space.

78. The UE of claim 76, wherein the new DCI format is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

79. A base station for wireless communication, comprising:

a memory; and

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

determining one of a plurality of downlink transmission modes for a service via point-to-multiple (PTM) transmission; and

transmitting a service to a user equipment (UE) via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

80. The base station of claim 79, wherein the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH).

81. The base station of claim 79, wherein the at least one processor is further configured to:

receive a downlink transmission mode capability of the UE from the UE, wherein the downlink transmission mode capability enables the base station to configure the PTM transmission with one of the plurality of downlink transmission modes based on the received downlink transmission mode capability.

82. The base station of claim 81, wherein the at least one processor configured to receive the downlink transmission mode capability is configured to:

receive an indication from an application server (AS) about the downlink transmission mode capability, wherein the downlink transmission mode capability is reported to the AS when the UE initially connects to the AS.

83. The base station of claim 81, wherein the at least one processor configured to receive the downlink transmission mode capability is configured to:

receive the downlink transmission mode capability from the UE after the UE enters a connected mode with a base station when the UE determines to receive the PTM transmission,

wherein the base station is configured to send the PTM transmission to the UE when the UE enters an idle mode after the base station receives the downlink transmission mode.

84. The base station of claim 81, wherein the at least one processor is further configured to:

receive a channel quality indication (CQI) from the UE; and

determine a rank for the PTM transmission based on the received downlink transmission mode capability and the CQI, wherein the PTM transmission is based on the rank.

85. The base station of claim 79, wherein the base station utilizes either a physical downlink shared channel (PDSCH) that is based on the cell radio network temporary identifier (C-RNTI) or a PDSCH that is based on a group radio network temporary identifier (G-RNTI) to communicate with the UE.

86. The base station of claim 85, wherein the at least one processor is further configured to:

send information on the subframes to be monitored for the G-RNTI to the UE.

87. The base station of claim 79, wherein the base station utilizes both a physical downlink shared channel (PDSCH) that is based on the cell radio network temporary identifier (C-RNTI) and a PDSCH that is based on a group radio network temporary identifier (G-RNTI) to communicate with the UE.

88. The base station of claim 87, wherein the at least one processor is further configured to:

receive a multimedia broadcast multicast services (MBMS) interest indication message from the UE; and

configure a unicast data rate associated with the C-RNTI based on the MBMS interest indication for the PTM transmission.

89. The base station of claim 88, wherein the at least one processor is further configured to:

set the unicast data rate associated with the C-RNTI to be equal to a highest data rate for the PTM transmission if the received MBMS interest indication message does not indicate a service.

90. The base station of claim 87, wherein for a downlink transmission mode supported by the UE for the PTM, a new downlink control information (DCI) format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A.

91. The base station of claim 90, wherein the new DCI format is sent in a common search space.

92. The base station of claim 90, wherein the new DCI format is sent in a UE specific search space where the UE specific search space is associated with G-RNTI.

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

means for receiving, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes;

means for configuring downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration; and

means for receiving a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode.

94. The UE of claim 93, wherein the transmit diversity downlink transmission mode is mode 2 for a physical downlink shared channel (PDSCH).

95. The UE of claim 93, wherein the UE is configured to support concurrent reception of both a physical layer downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) and a physical downlink shared channel (PDSCH) that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

96. The UE of claim 93, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a common search space is associated with downlink control information (DCI) format 1A.

97. The UE of claim 96, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a UE-specific search space is associated with downlink control information (DCI) format 1A.

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

means for receiving, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes;

means for configuring downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration; and means for receiving a service via point-to-multiple (PTM) transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

99. The UE of claim 98, wherein the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH).

100. The UE of claim 98, further comprising:

means for reporting a downlink transmission mode capability of the UE to a network, wherein the reported downlink transmission mode capability enables the network to configure the PTM transmission with one of the plurality of downlink transmission modes based on the reported downlink transmission mode capability.

101. The UE of claim 100, wherein the means for reporting the downlink transmission mode capability is configured to:

report the downlink transmission mode capability to an application server (AS) when the UE initially connects to the AS that is configured to indicate to the base station the downlink transmission mode capability.

102. The UE of claim 100, wherein the means for reporting the downlink transmission mode capability is configured to:

enter a connected mode with a base station to report the downlink transmission mode capability to the base station when the UE determines to receive the PTM transmission,

wherein the UE enters an idle mode to receive the PTM transmission after reporting the downlink transmission mode.

103. The UE of claim 100, wherein the UE receives the service via the PTM transmission based on a rank for PTM transmission.

104. The UE of claim 98, wherein the UE is configured to support reception of either a physical downlink shared channel (PDSCH) that is based on a cell radio network

temporary identifier (C-RNTI) or a PDSCH that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

105. The UE of claim 104, further comprising:

means for receiving information about subframes that are available for the G-RNTI to monitor for the G-RNTI.

106. The UE of claim 104, wherein the G-RNTI is a semi-persistent scheduling (SPS) G-RNTI.

107. The UE of claim 104, wherein the C-RNTI is a semi-persistent scheduling (SPS) C-RNTI.

108. The UE of claim 104, wherein if the UE receives information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI, without monitoring for a C-RNTI or an SPS C-RNTI, and wherein if the UE does not receive information on the subframes to be monitored for the G-RNTI, the UE monitors for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI.

109. The UE of claim 108, wherein if the UE detects a physical downlink control channel (PDCCH) with at least one of a G-RNTI or an SPS G-RNTI after monitoring for at least one of a G-RNTI or an SPS G-RNTI and for at least one of a C-RNTI or an SPS C-RNTI, the UE stops monitoring a PDCCH with a C-RNTI and an SPS C-RNTI in the subframe.

110. The UE of claim 98, wherein the UE is configured to support concurrent reception of both a physical downlink shared channel (PDSCH) that is based on a cell radio network temporary identifier (C-RNTI) and a PDSCH that is based on a group radio network temporary identifier (G-RNTI) in a same subframe.

111. The UE of claim 110, further comprising:

means for decoding a physical downlink control channel (PDCCH) with both the C-RNTI and the G-RNTI in the same subframe.

112. The UE of claim 110, further comprising:

means for sending a multimedia broadcast multicast services (MBMS) interest indication message to a base station.

113. The UE of claim 110, further comprising:

means for receiving information about subframes that are available for transmission of the PDSCH with the G-RNTI;

means for monitoring for a physical downlink control channel (PDCCH) with the G-RNTI in the subframes that are available for the G-RNTI; and

means for monitoring for a PDCCH with the C-RNTI in all subframes.

114. The UE of claim 110, wherein the G-RNTI is a semi-persistent scheduling (SPS) G-RNTI.

115. The UE of claim 110, wherein the C-RNTI is a semi-persistent scheduling (SPS) C-RNTI.

116. The UE of claim 110, further comprising:

means for dropping a physical downlink control channel (PDCCH) associated with the C-RNTI if the UE detects a PDCCH with the G-RNTI.

117. The UE of claim 110, wherein a physical downlink control channel (PDCCH) with the G-RNTI is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

118. The UE of claim 117, wherein, in the UE-specific search space, the PDCCH with the G-RNTI is limited to a predetermined control channel element (CCE) aggregation level.

119. The UE of claim 117, wherein the PDCCH with the G-RNTI in the UE specific search space is associated with downlink control information (DCI) format 1A.

120. The UE of claim 110, wherein the PDCCH with the G-RNTI is sent in a common search space.

121. The UE of claim 110, wherein a physical downlink control channel (PDCCH) with the G-RNTI in a common search space is associated with downlink control information (DCI) format 1A.

122. The UE of claim 110, wherein for a downlink transmission mode supported by the UE for the PTM, a new downlink control information (DCI) format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A..

123. The UE of claim 122, wherein the new DCI format is received in a common search space.

124. The UE of claim 122, wherein the new DCI format is received in a UE-specific search space where the UE-specific search space is associated with the G-RNTI.

125. A base station for wireless communication, comprising:

means for determining one of a plurality of downlink transmission modes for a service via point-to-multiple (PTM) transmission; and

means for transmitting a service to a user equipment (UE) via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

126. The base station of claim 125, wherein the plurality of downlink transmission modes are transmission modes for a physical downlink shared channel (PDSCH).

127. The base station of claim 125, further comprising:

means for receiving a downlink transmission mode capability of the UE from the UE, wherein the downlink transmission mode capability enables the base station to configure the PTM transmission with one of the plurality of downlink transmission modes based on the received downlink transmission mode capability.

128. The base station of claim 127, wherein the means for receiving the downlink transmission mode capability is configured to:

receive an indication from an application server (AS) about the downlink transmission mode capability, wherein the downlink transmission mode capability is reported to the AS when the UE initially connects to the AS.

129. The base station of claim 127, wherein the means for receiving the downlink transmission mode capability is configured to:

receive the downlink transmission mode capability from the UE after the UE enters a connected mode with a base station when the UE determines to receive the PTM transmission,

wherein the base station is configured to send the PTM transmission to the UE when the UE enters an idle mode after the base station receives the downlink transmission mode.

130. The base station of claim 127, further comprising:

means for receiving a channel quality indication (CQI) from the UE; and

means for determining a rank for the PTM transmission based on the received downlink transmission mode capability and the CQI, wherein the PTM transmission is based on the rank.

131. The base station of claim 125, wherein the base station utilizes either a physical downlink shared channel (PDSCH) that is based on the cell radio network temporary identifier (C-RNTI) or a PDSCH that is based on a group radio network temporary identifier (G-RNTI) to communicate with the UE.

132. The base station of claim 131, further comprising:

means for sending information on the subframes to be monitored for the G-RNTI to the UE.

133. The base station of claim 125, wherein the base station utilizes both a physical downlink shared channel (PDSCH) that is based on the cell radio network temporary identifier (C-RNTI) and a PDSCH that is based on a group radio network temporary identifier (G-RNTI) to communicate with the UE.

134. The base station of claim 133, further comprising:

means for receiving a multimedia broadcast multicast services (MBMS) interest indication message from the UE; and

means for configuring a unicast data rate associated with the C-RNTI based on the MBMS interest indication for the PTM transmission.

135. The base station of claim 134, further comprising:

means for setting the unicast data rate associated with the C-RNTI to be equal to a highest data rate for the PTM transmission if the received MBMS interest indication message does not indicate a service.

136. The base station of claim 133, wherein for a downlink transmission mode supported by the UE for the PTM, a new downlink control information (DCI) format corresponding to a DCI format supported by the downlink transmission mode is generated and the new DCI format has a size aligned with DCI format 1A..

137. The base station of claim 136, wherein the new DCI format is sent in a common search space.

138. The base station of claim 136, wherein the new DCI format is sent in a UE specific search space where the UE specific search space is associated with G-RNTI.

139. A computer-readable medium storing computer executable code for wireless communication, comprising code for:

receiving, from a network, a downlink transmission configuration indicating a transmit diversity downlink transmission mode of a plurality of downlink transmission modes;

configuring downlink communication based on the transmit diversity downlink transmission mode according to the downlink transmission configuration; and

receiving a service via point-to-multiple (PTM) downlink transmission based on the transmit diversity transmission mode.

140. A computer-readable medium storing computer executable code for wireless communication, comprising code for:

receiving, from a network, a downlink transmission configuration indicating one of a plurality of downlink transmission modes;

configuring downlink communication based on the one of the plurality of downlink transmission modes according to the downlink transmission configuration; and

receiving a service via point-to-multiple (PTM) transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

141. A computer-readable medium storing computer executable code for wireless communication, comprising code for:

determining one of a plurality of downlink transmission modes for a service via point-to-multiple (PTM) transmission; and

transmitting a service to a user equipment (UE) via the PTM transmission based on the one of the plurality of downlink transmission modes that corresponds with the service.

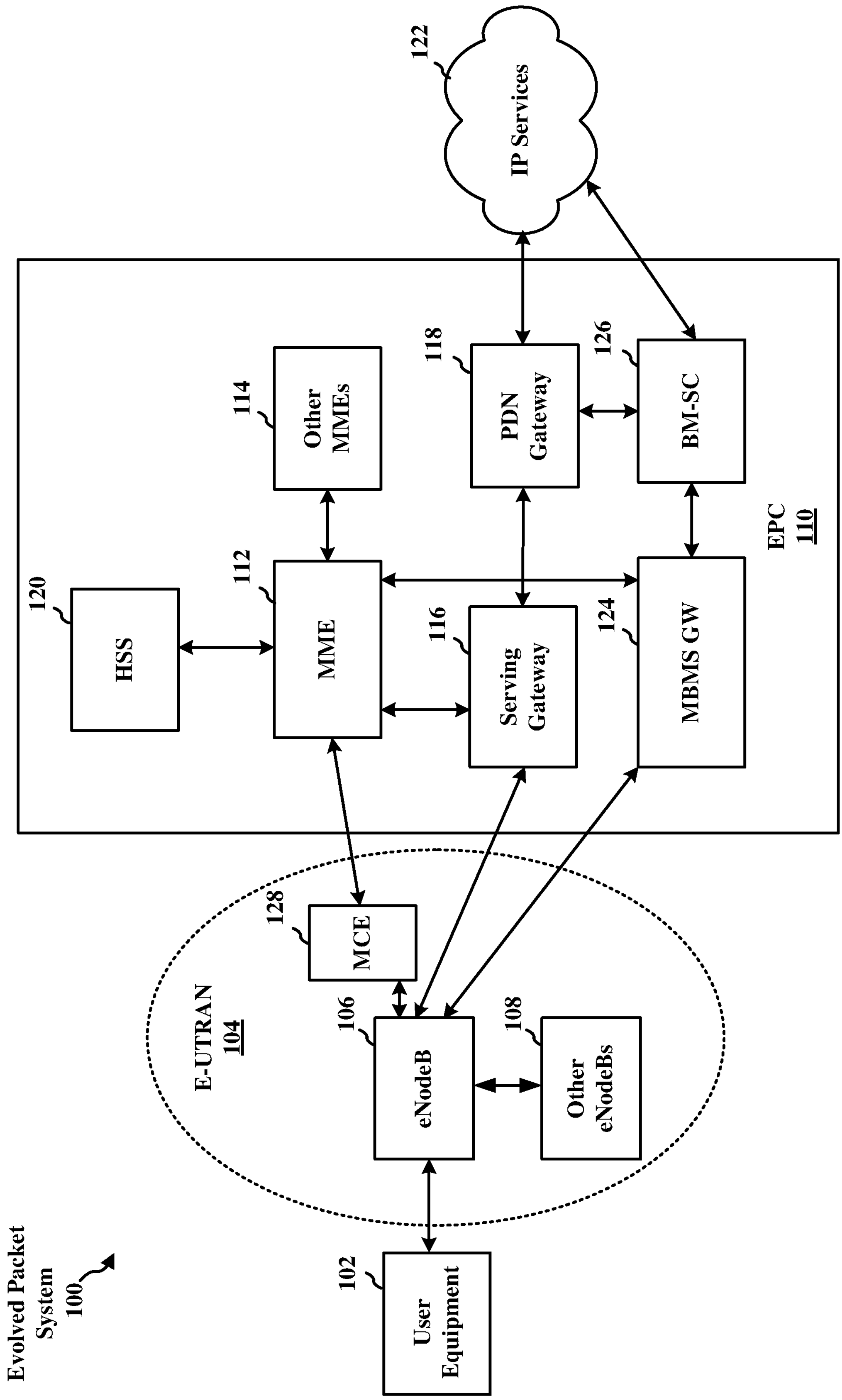
Evolved Packet System
100
User Equipment
102
eNodeB
106
Other eNodeBs
108
E-UTRAN
104
MCE
128
MME
112
HSS
120
Other MMEs
114
Serving Gateway
116
MBMS GW
124
PDN Gateway
118
BM-SC
126
EPC
110
IP Services
122

FIG. 1

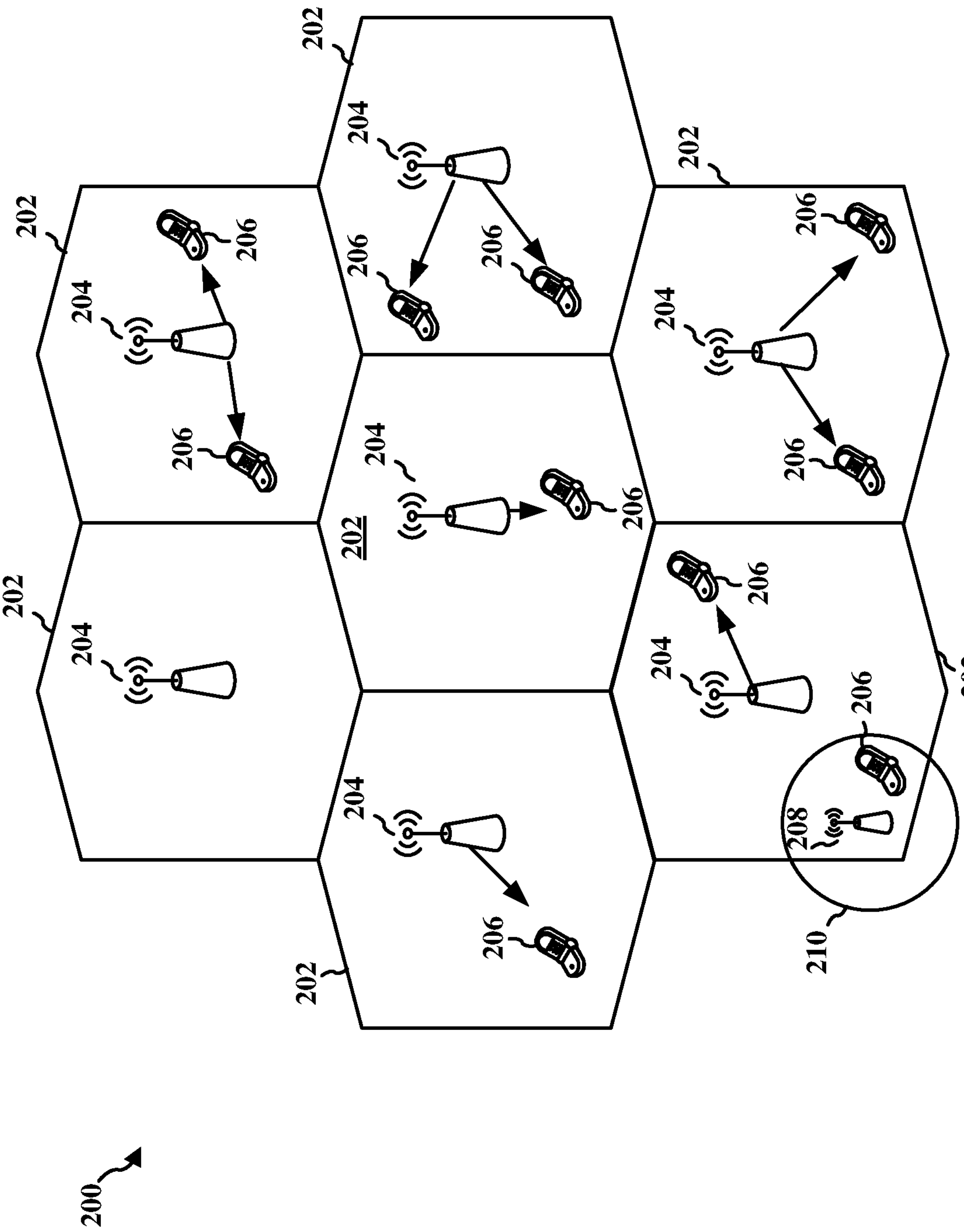
202
202
202
202
202
202
202
202
204
204
204
204
204
204
204
206
206
206
206
206
206
206
206
206
206
208
210
200

FIG. 2

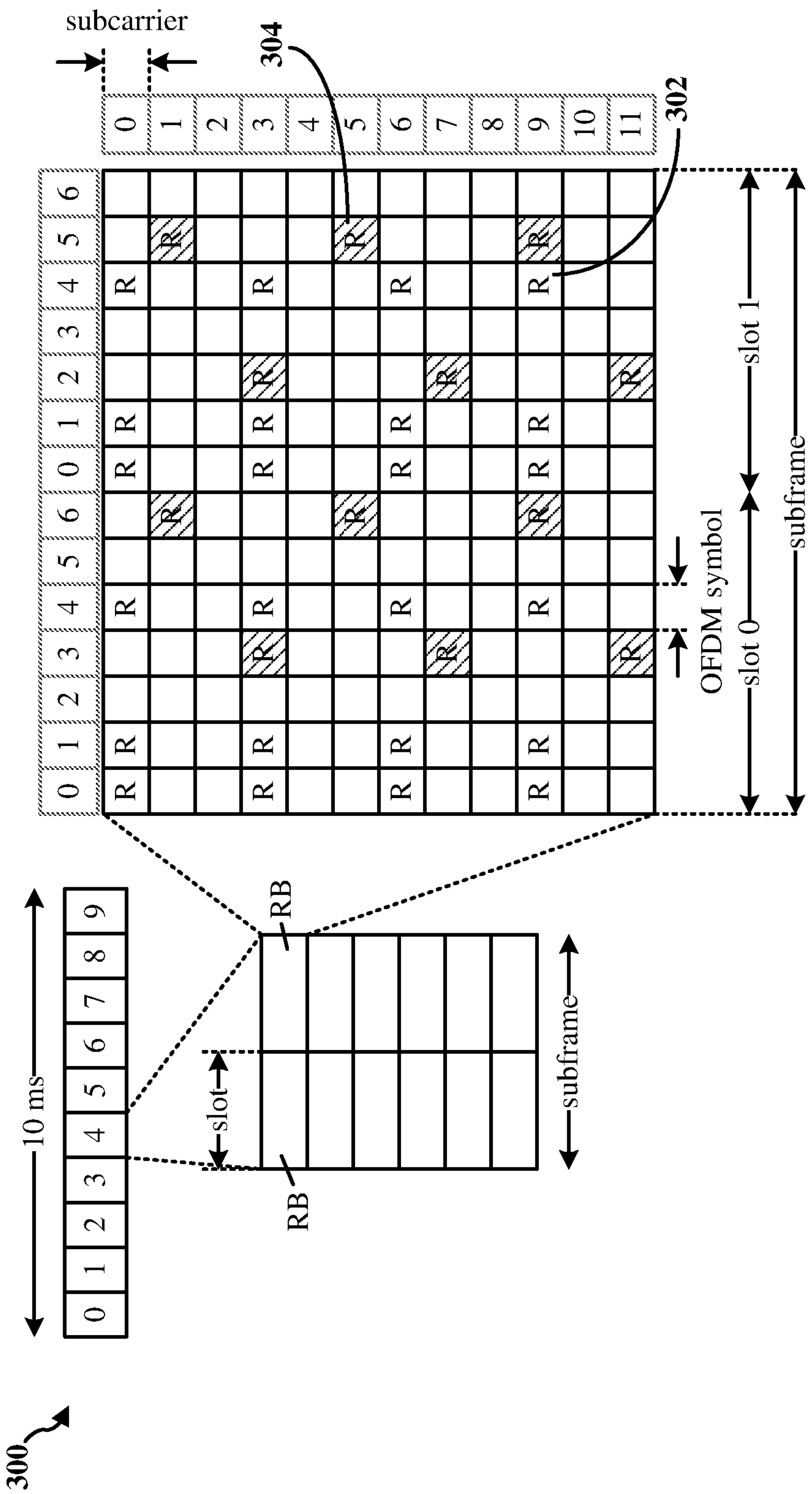
subcarrier
304
302
R
OFDM symbol
slot 0
slot 1
subframe
10 ms
RB
RB
slot
subframe
300

FIG. 3

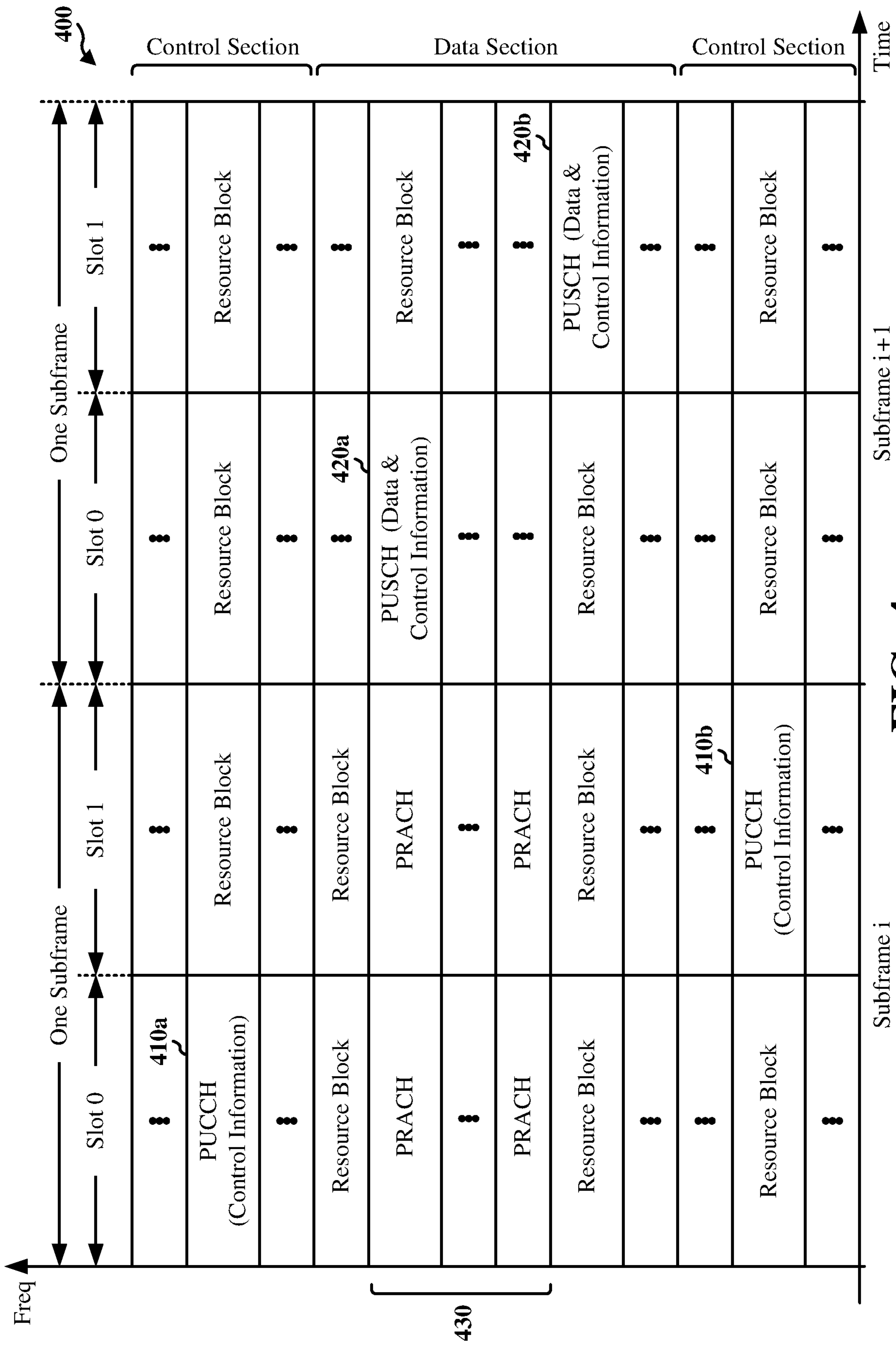
400
Control Section
Data Section
Control Section
Time
Freq
One Subframe
One Subframe
Slot 0
Slot 1
Slot 0
Slot 1
410a
PUCCH (Control Information)
410b
PUCCH (Control Information)
420a
PUSCH (Data & Control Information)
420b
PUSCH (Data & Control Information)
Resource Block
PRACH
430
Subframe i
Subframe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

FIG. 4

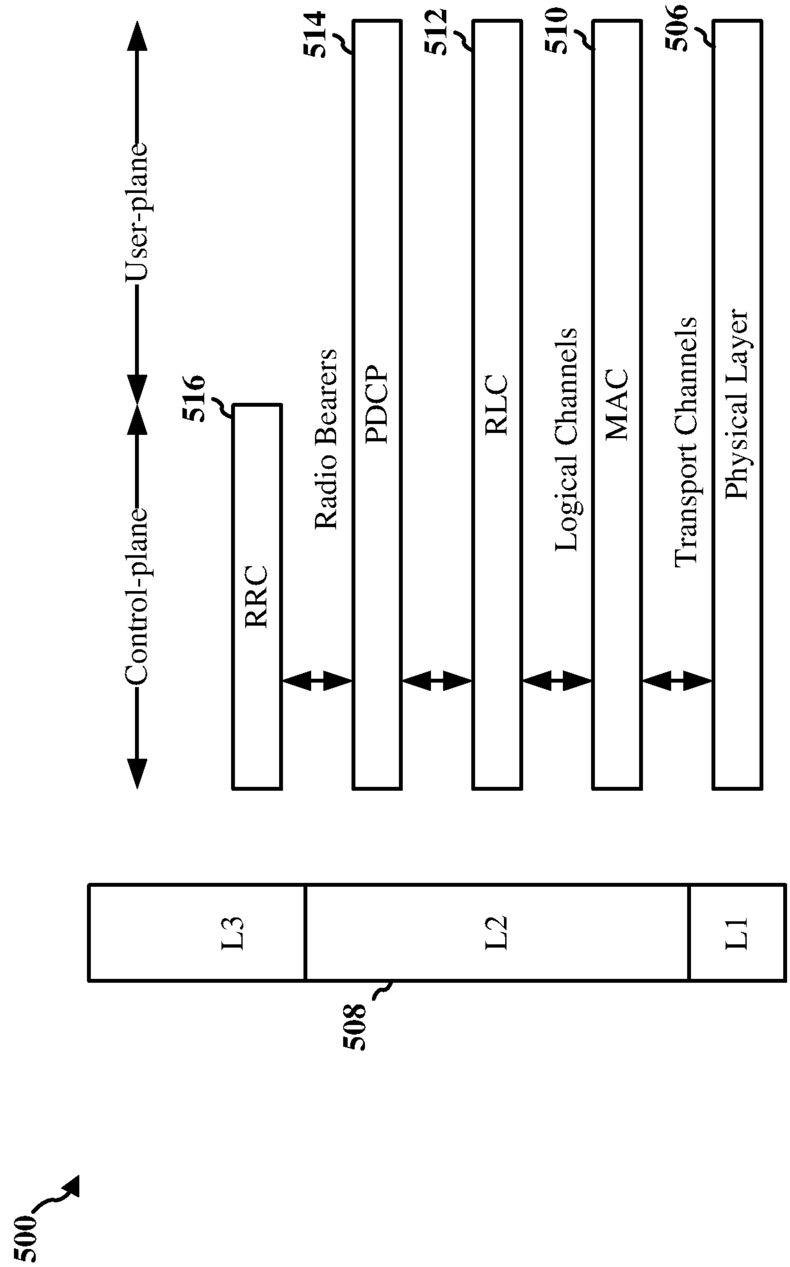
500
508
L3
L2
L1
Control-plane
User-plane
516
RRC
Radio Bearers
514
PDCP
512
RLC
Logical Channels
510
MAC
Transport Channels
506
Physical Layer

FIG. 5

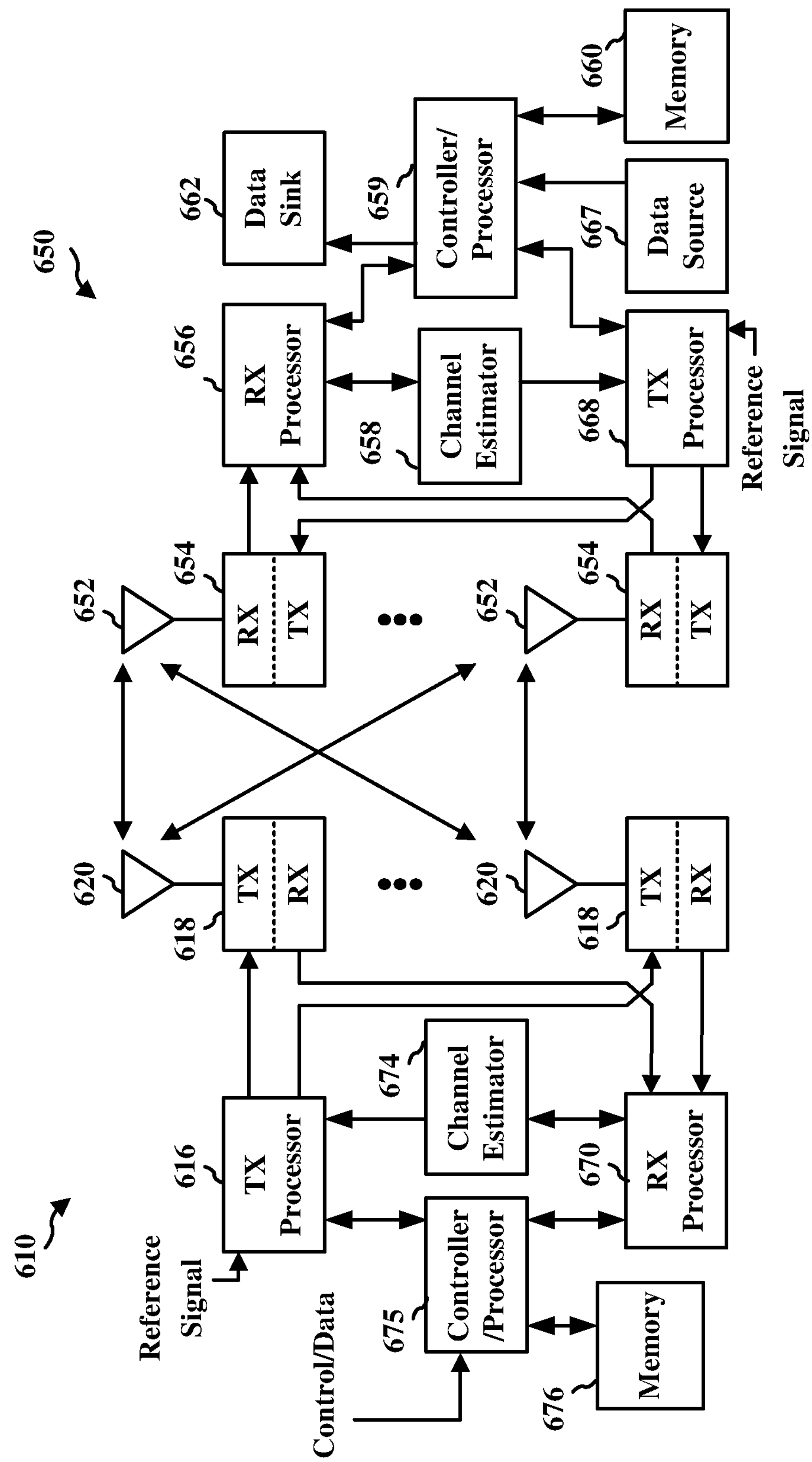
610
Reference Signal
616
TX Processor
Control/Data
675
Controller /Processor
676
Memory
674
Channel Estimator
670
RX Processor
618
TX
RX
620
650
652
654
RX
TX
656
RX Processor
658
Channel Estimator
659
Controller/ Processor
662
Data Sink
660
Memory
667
Data Source
668
TX Processor
Reference Signal

FIG. 6

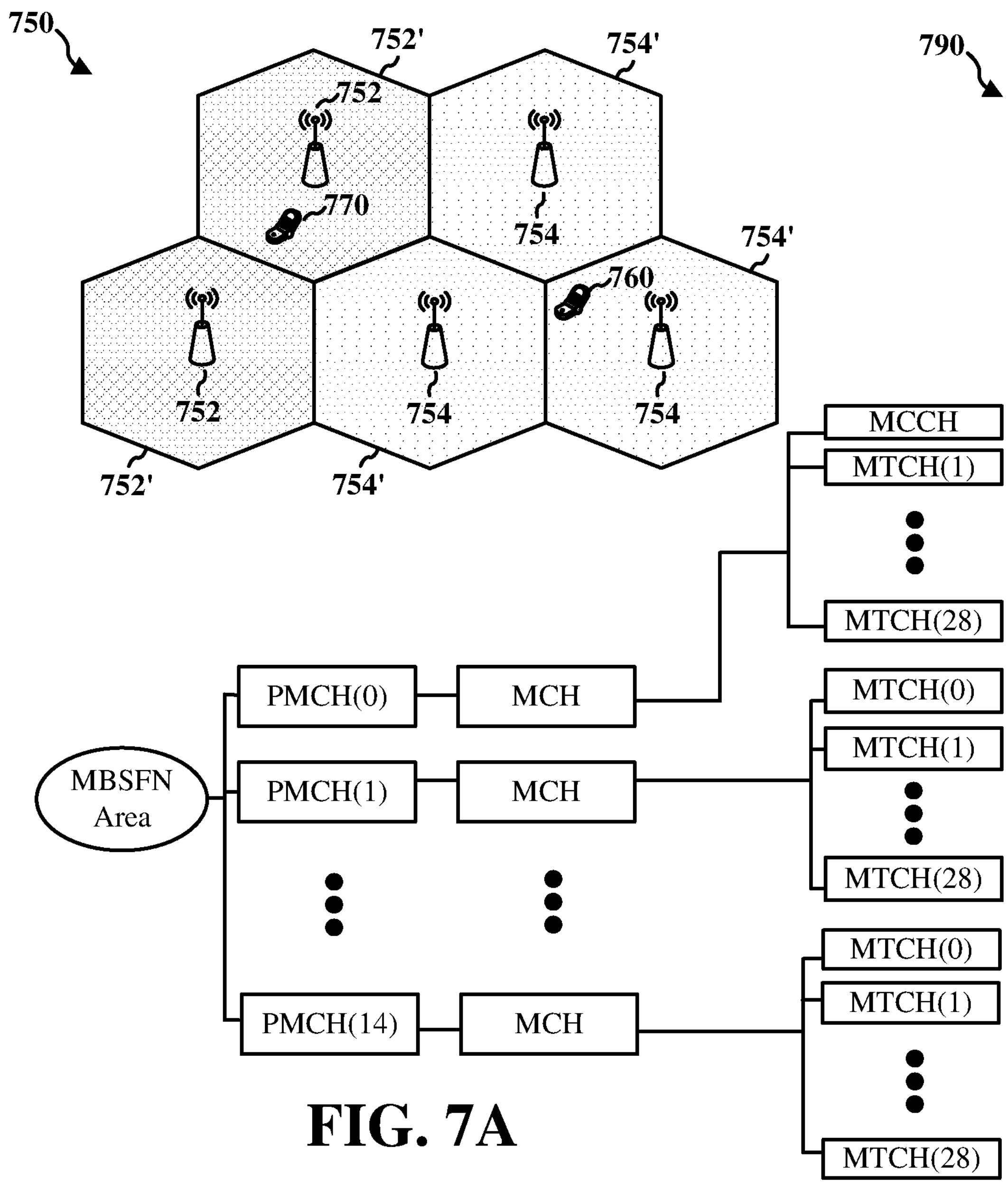
750
752'
754'
752
770
754
754'
760
752
754
754
752'
754'
MBSFN Area
PMCH(0)
PMCH(1)
PMCH(14)
MCH
MCH
MCH
MCCH
MTCH(1)
MTCH(28)
MTCH(0)
MTCH(1)
MTCH(28)
MTCH(0)
MTCH(1)
MTCH(28)

FIG. 7A

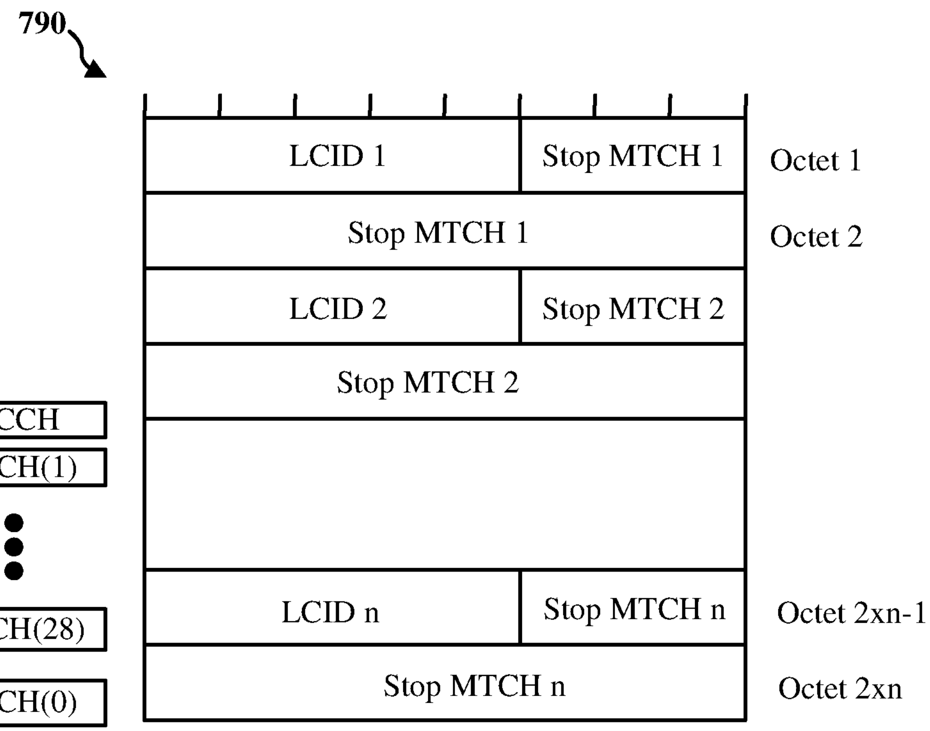
790
LCID 1
Stop MTCH 1
Octet 1
Stop MTCH 1
Octet 2
LCID 2
Stop MTCH 2
Stop MTCH 2
LCID n
Stop MTCH n
Octet 2xn-1
Stop MTCH n
Octet 2xn

FIG. 7B

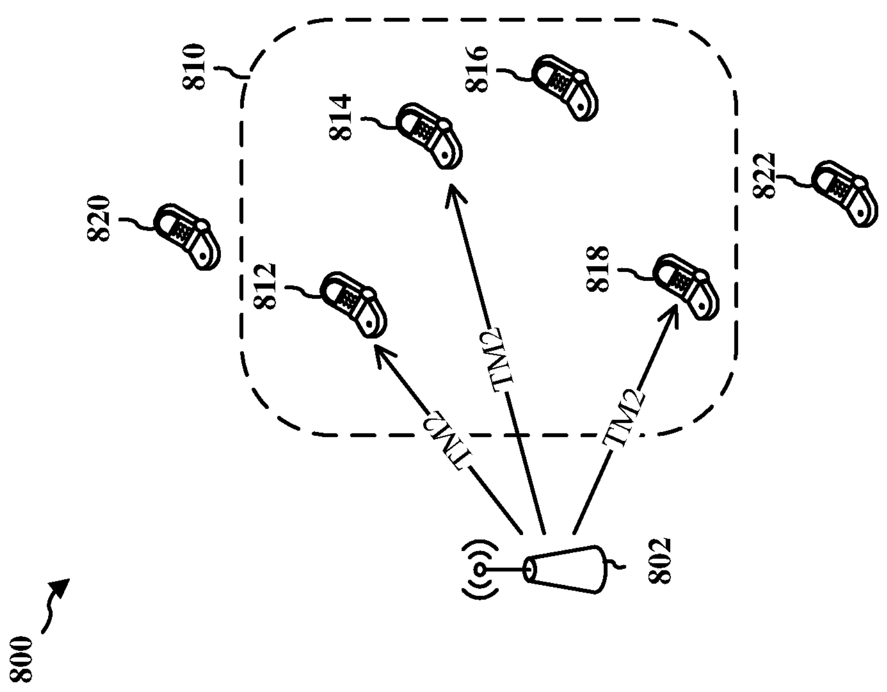
800
802
810
812
814
816
818
820
822
TM2
TM2
TM2

FIG. 8A

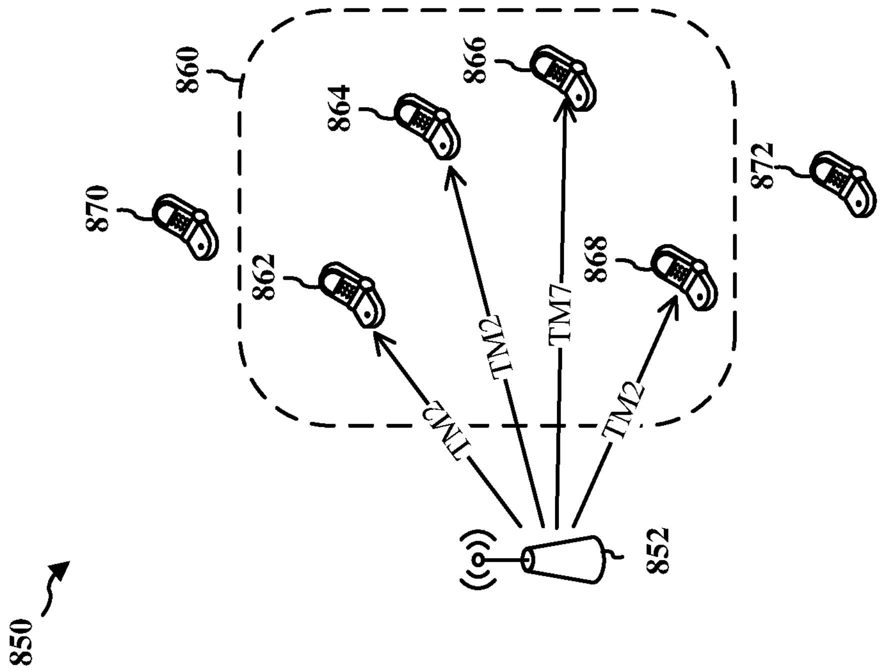
850
852
860
862
864
866
868
870
872
TM2
TM1
TM7
TM2

FIG. 8B

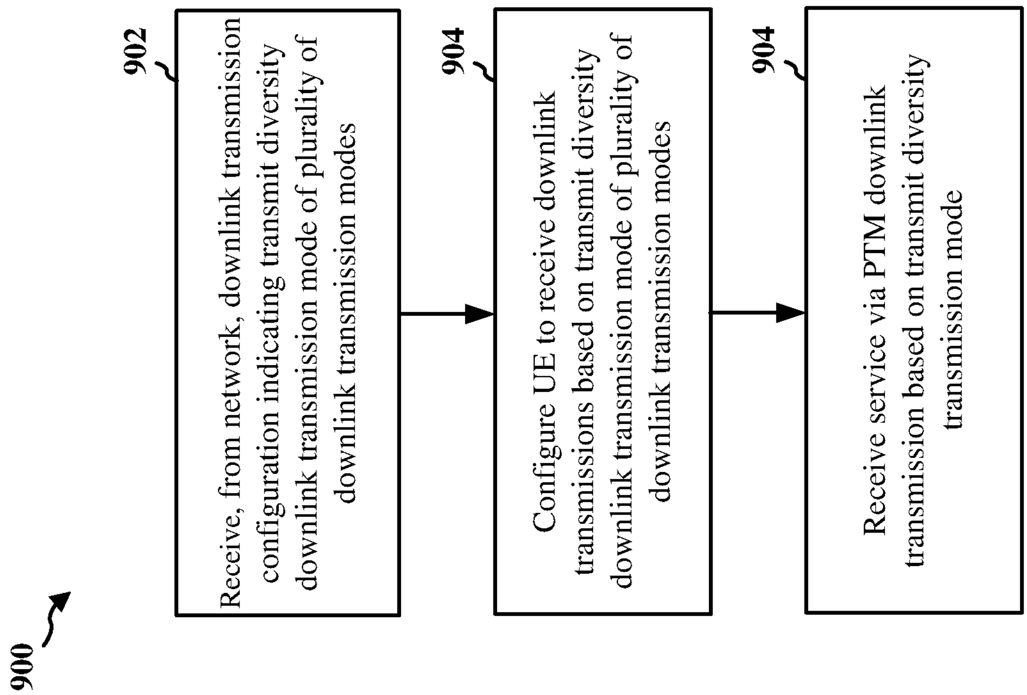
900
902
Receive, from network, downlink transmission configuration indicating transmit diversity downlink transmission mode of plurality of downlink transmission modes
904
Configure UE to receive downlink transmissions based on transmit diversity downlink transmission mode of plurality of downlink transmission modes
904
Receive service via PTM downlink transmission based on transmit diversity transmission mode

FIG. 9

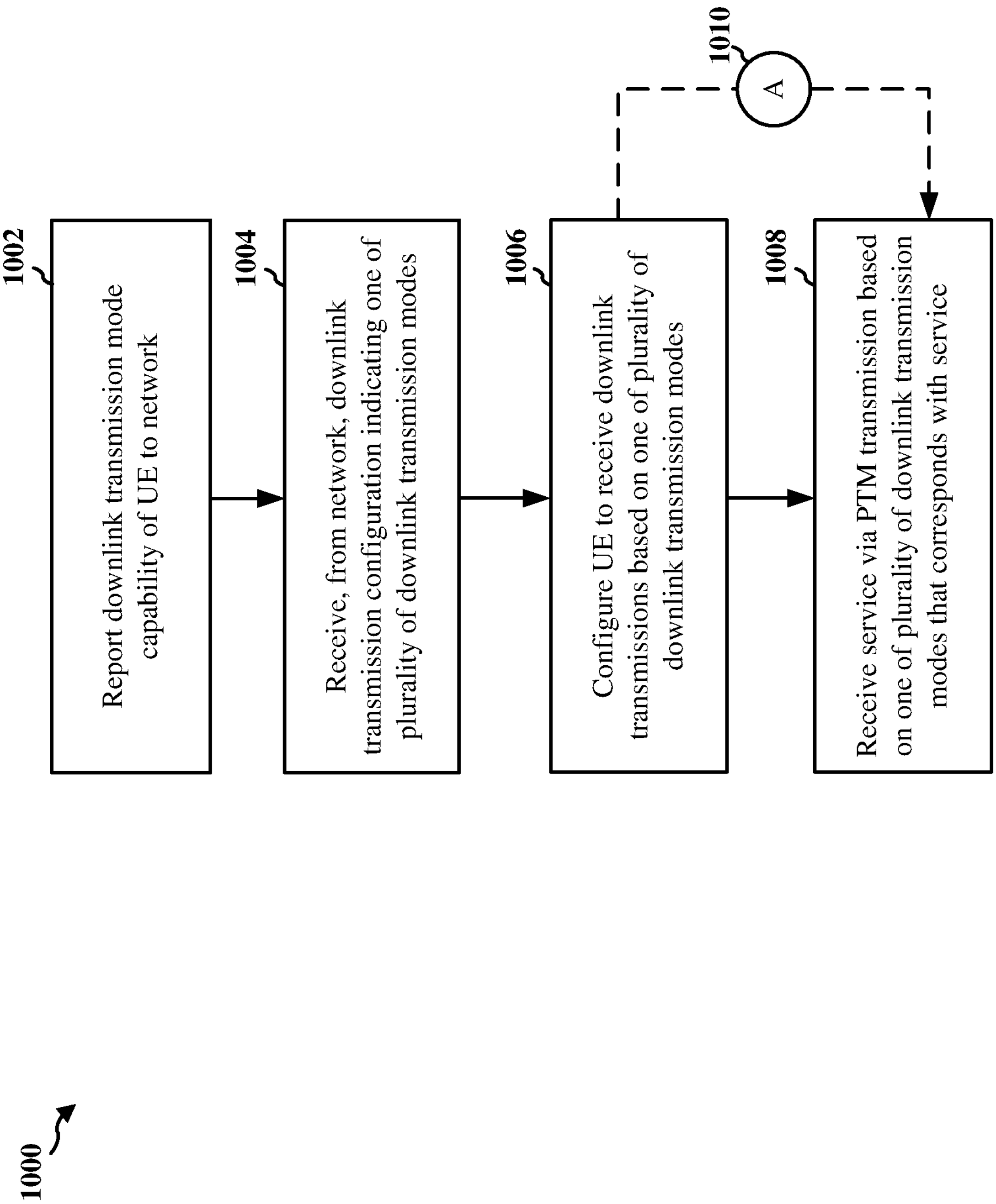
1000
1002
Report downlink transmission mode capability of UE to network
1004
Receive, from network, downlink transmission configuration indicating one of plurality of downlink transmission modes
1006
Configure UE to receive downlink transmissions based on one of plurality of downlink transmission modes
1008
Receive service via PTM transmission based on one of plurality of downlink transmission modes that corresponds with service
1010
A

FIG. 10

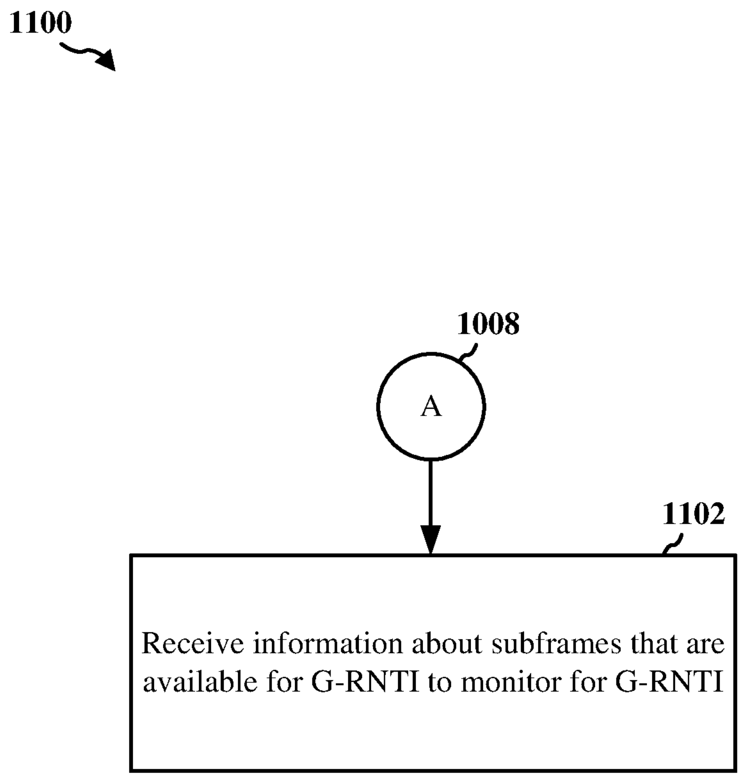

FIG. 11A

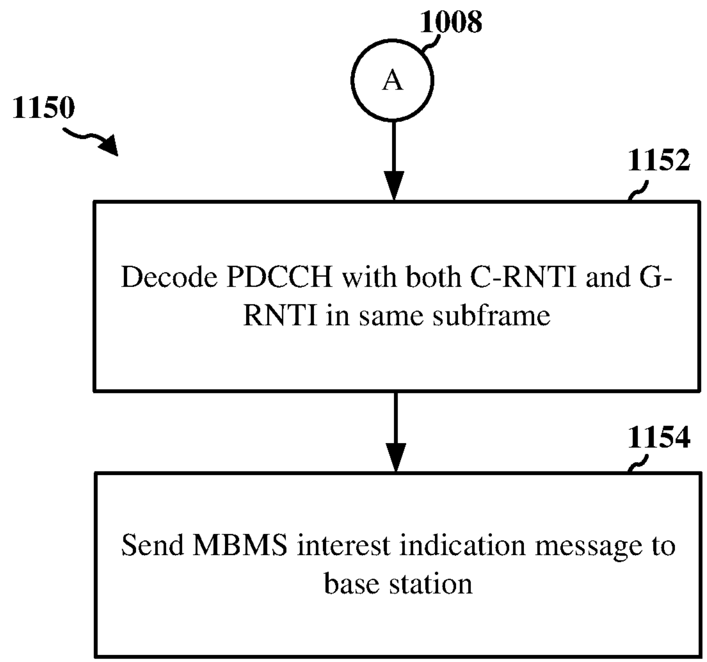

FIG. 11B

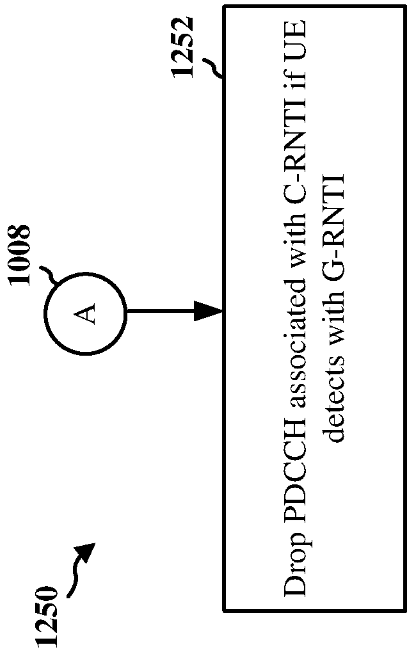

FIG. 12B

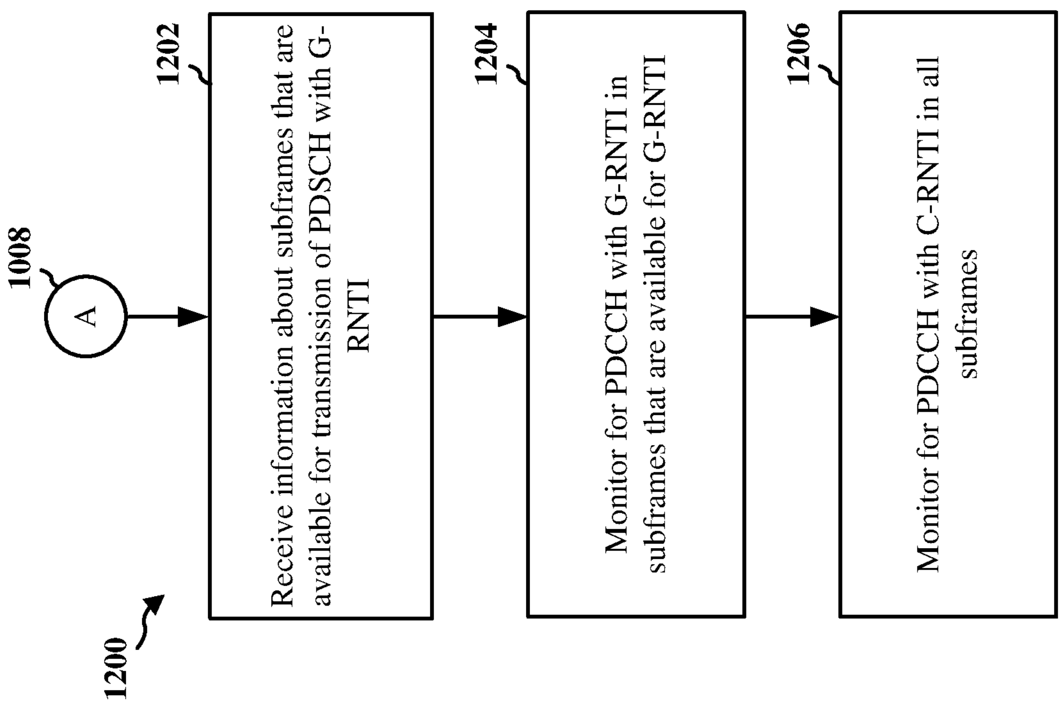

FIG. 12A

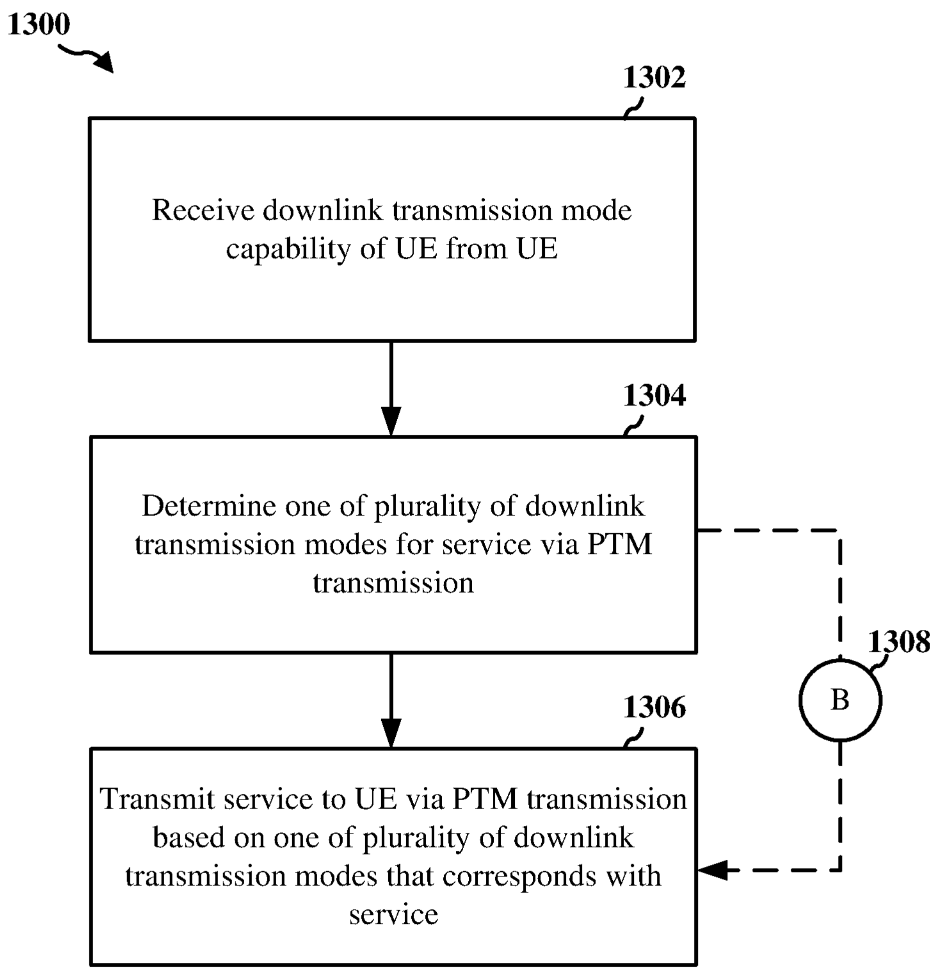

FIG. 13A

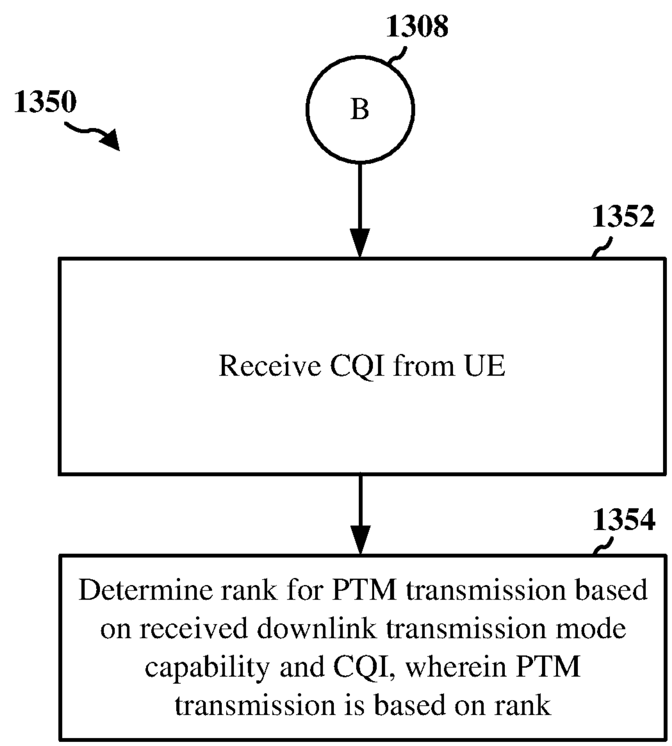

FIG. 13B

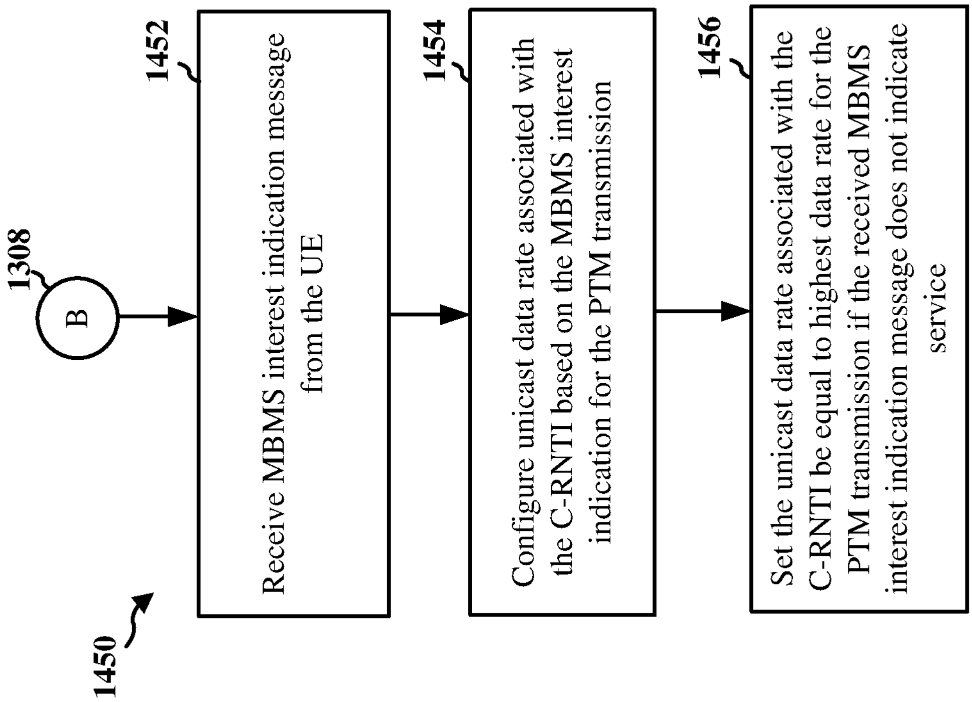

FIG. 14B

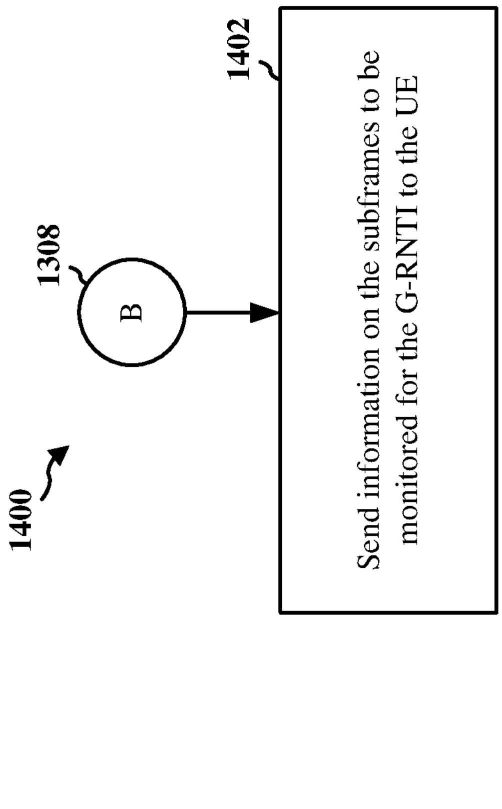

FIG. 14A

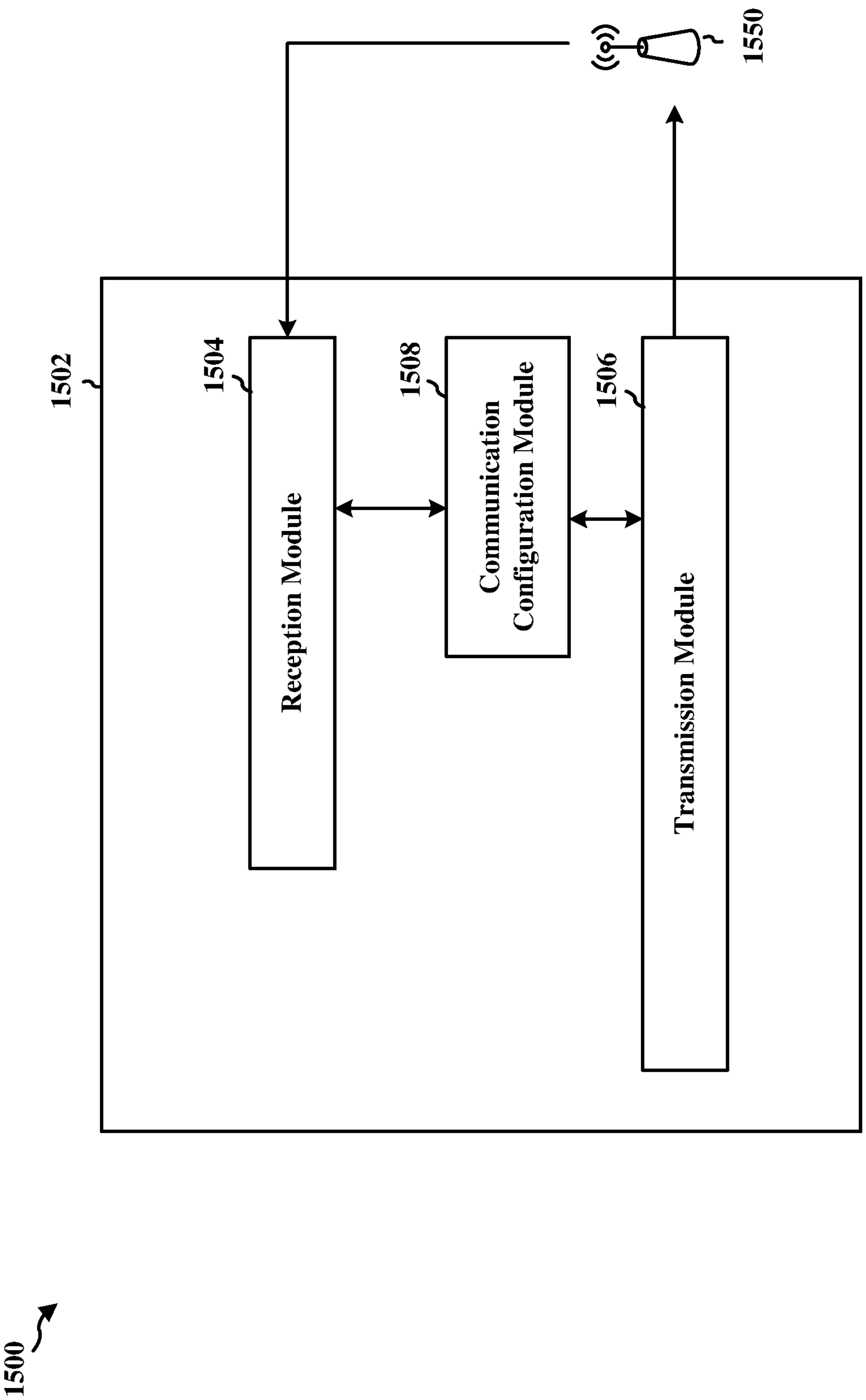
1550
1502
1504
Reception Module
1508
Communication
Configuration Module
1506
Transmission Module
1500

FIG. 15

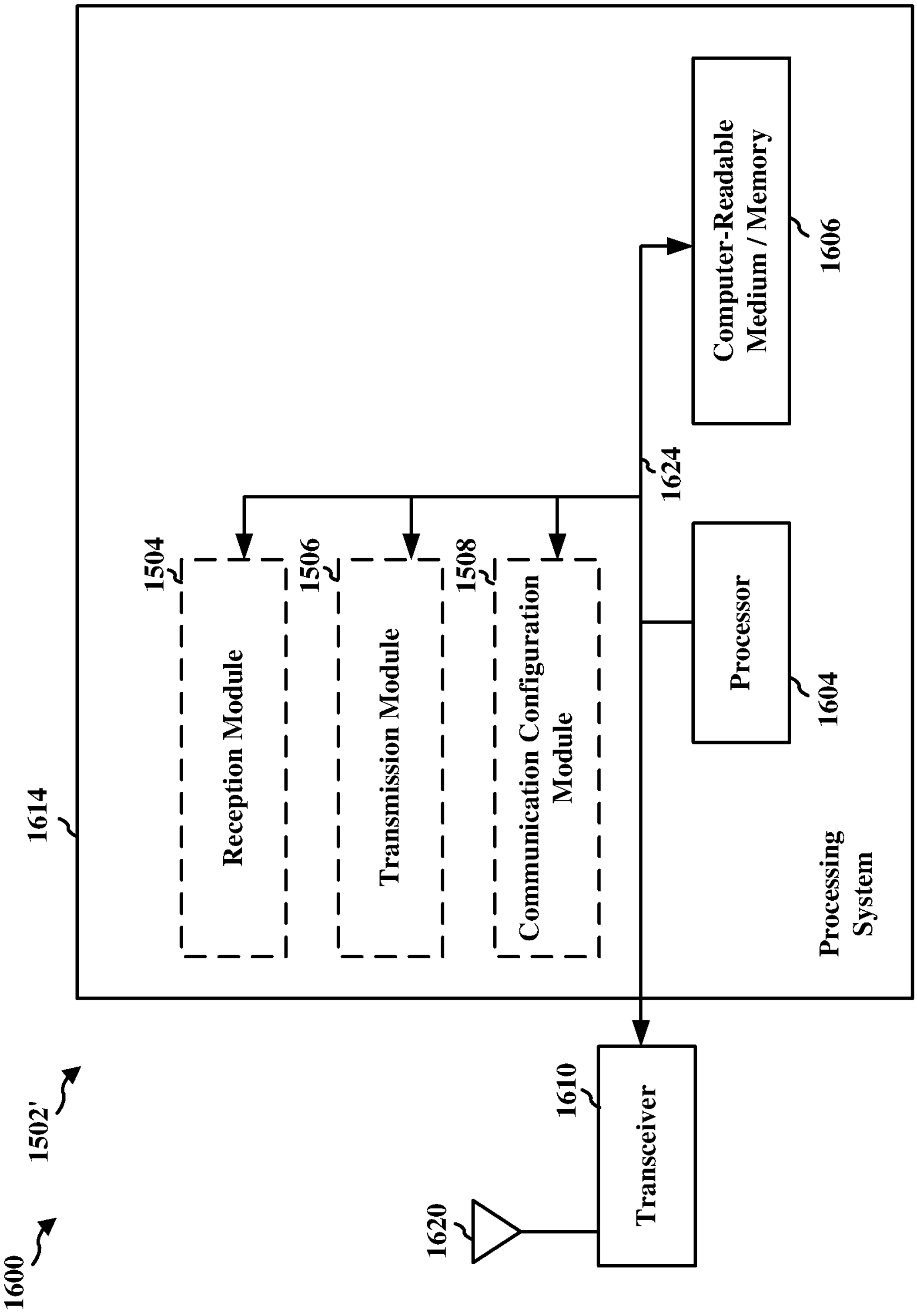
1600
1502'
1614
1504
Reception Module
1506
Transmission Module
1508
Communication Configuration Module
1624
Processor
1604
Computer-Readable Medium / Memory
1606
Processing System
1610
Transceiver
1620

FIG. 16

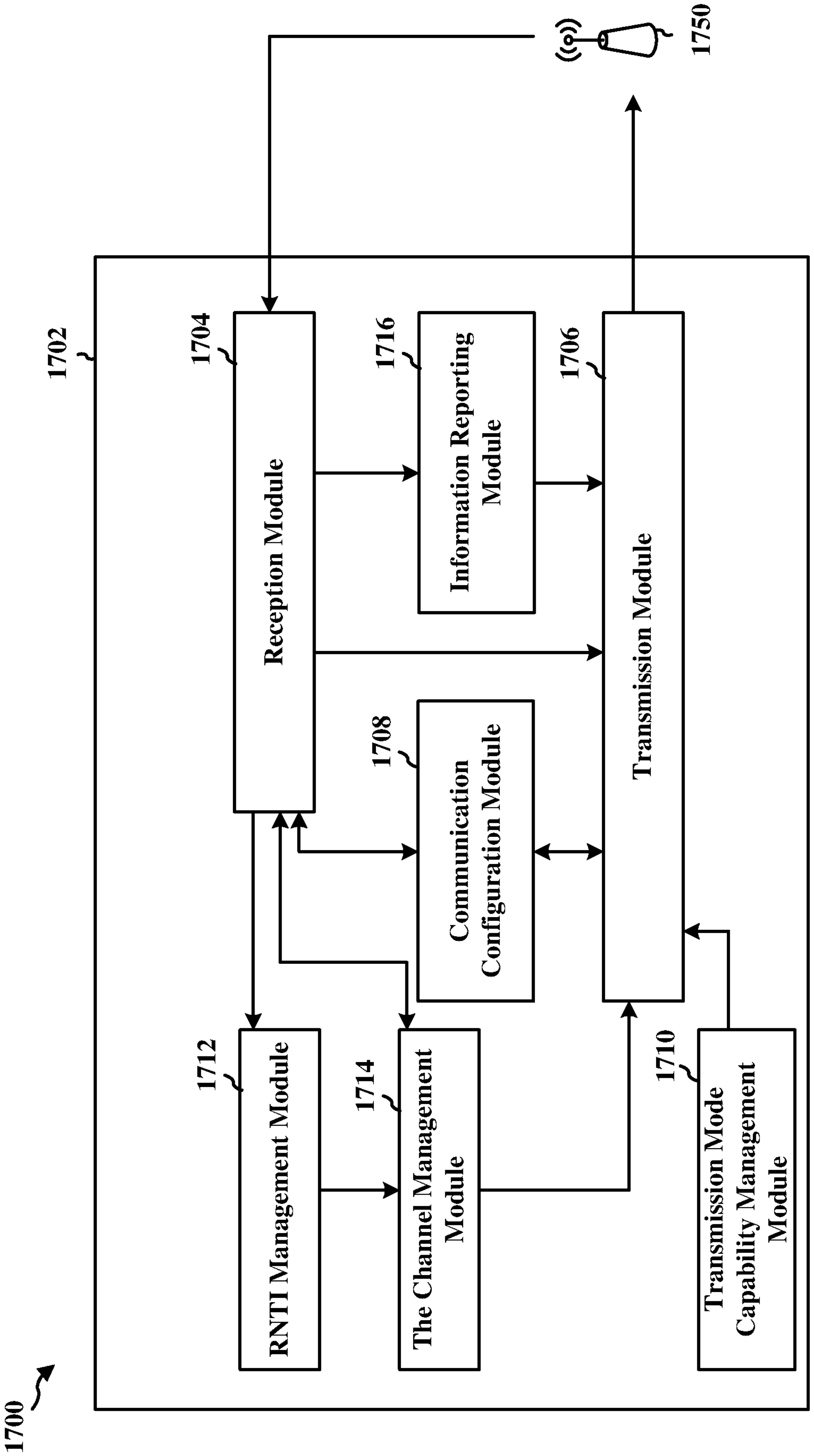
1700
1702
1704
Reception Module
1716
Information Reporting Module
1706
Transmission Module
1708
Communication Configuration Module
1712
RNTI Management Module
1714
The Channel Management Module
1710
Transmission Mode Capability Management Module
1750

FIG. 17

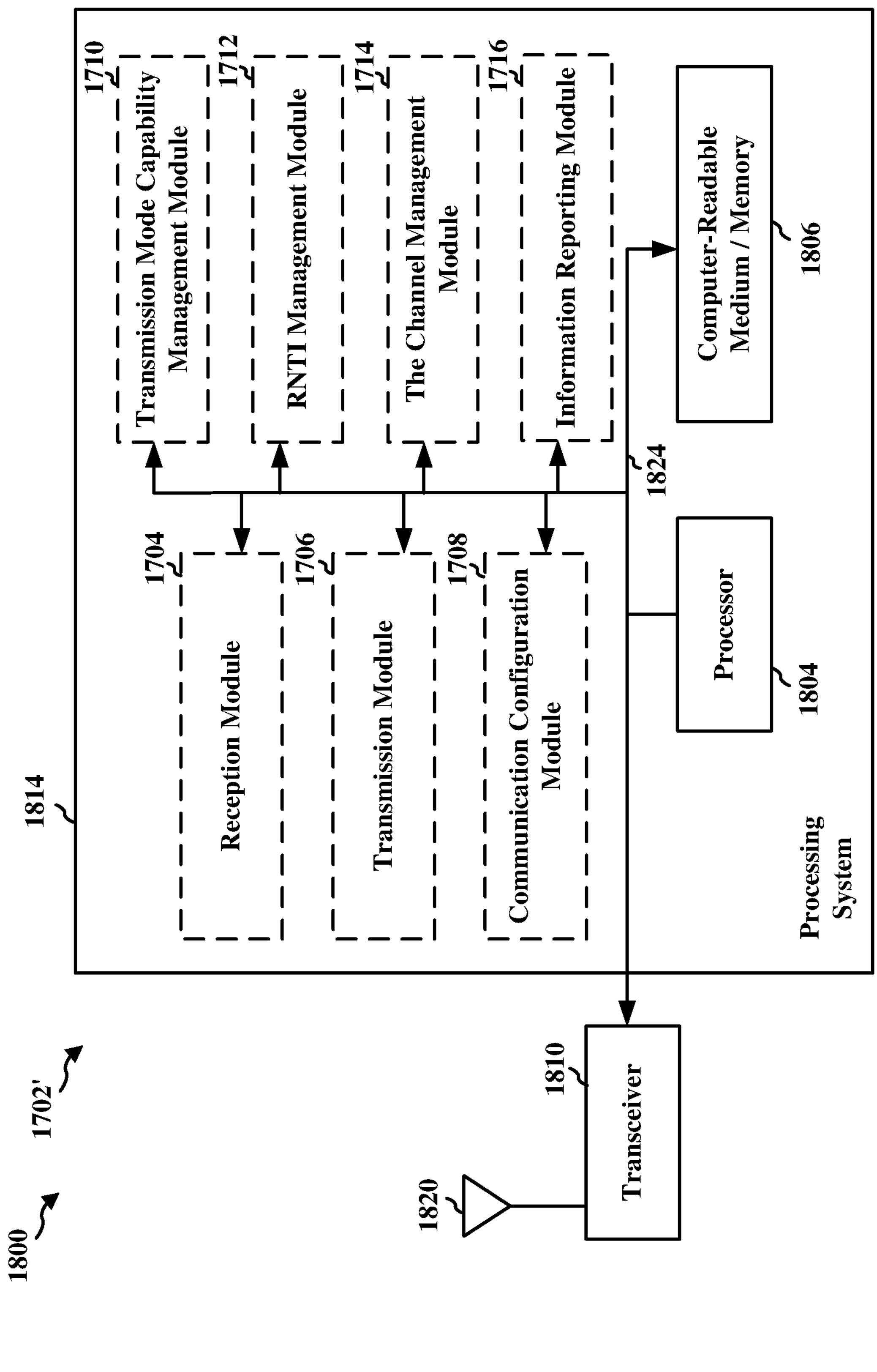
1800
1702'
1814
Processing System
1704
Reception Module
1706
Transmission Module
1708
Communication Configuration Module
1710
Transmission Mode Capability Management Module
1712
RNTI Management Module
1714
The Channel Management Module
1716
Information Reporting Module
1824
Computer-Readable Medium / Memory
1806
Processor
1804
1810
Transceiver
1820

FIG. 18

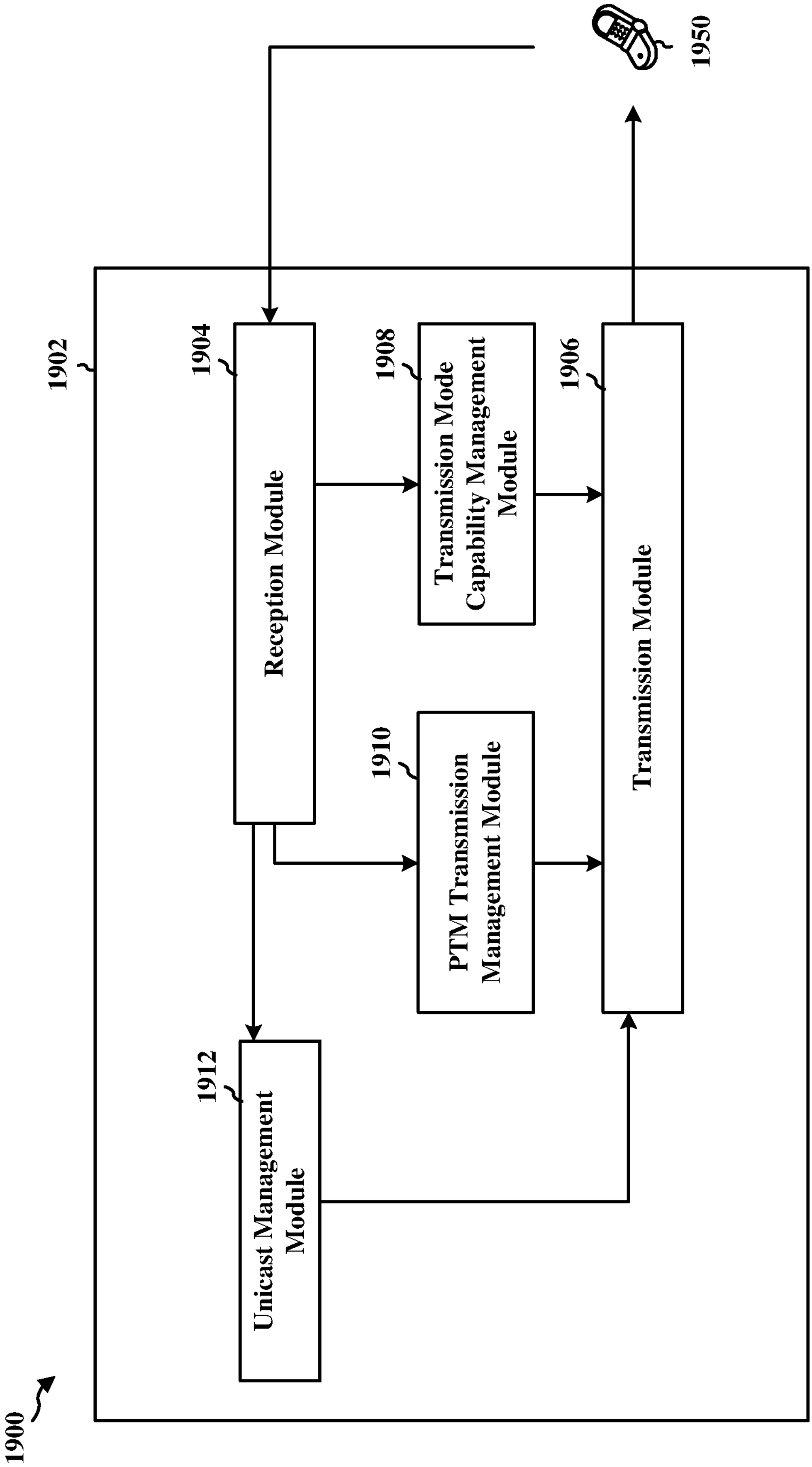
1950
1902
1904
Reception Module
1908
Transmission Mode Capability Management Module
1906
Transmission Module
1910
PTM Transmission Management Module
1912
Unicast Management Module
1900

FIG. 19

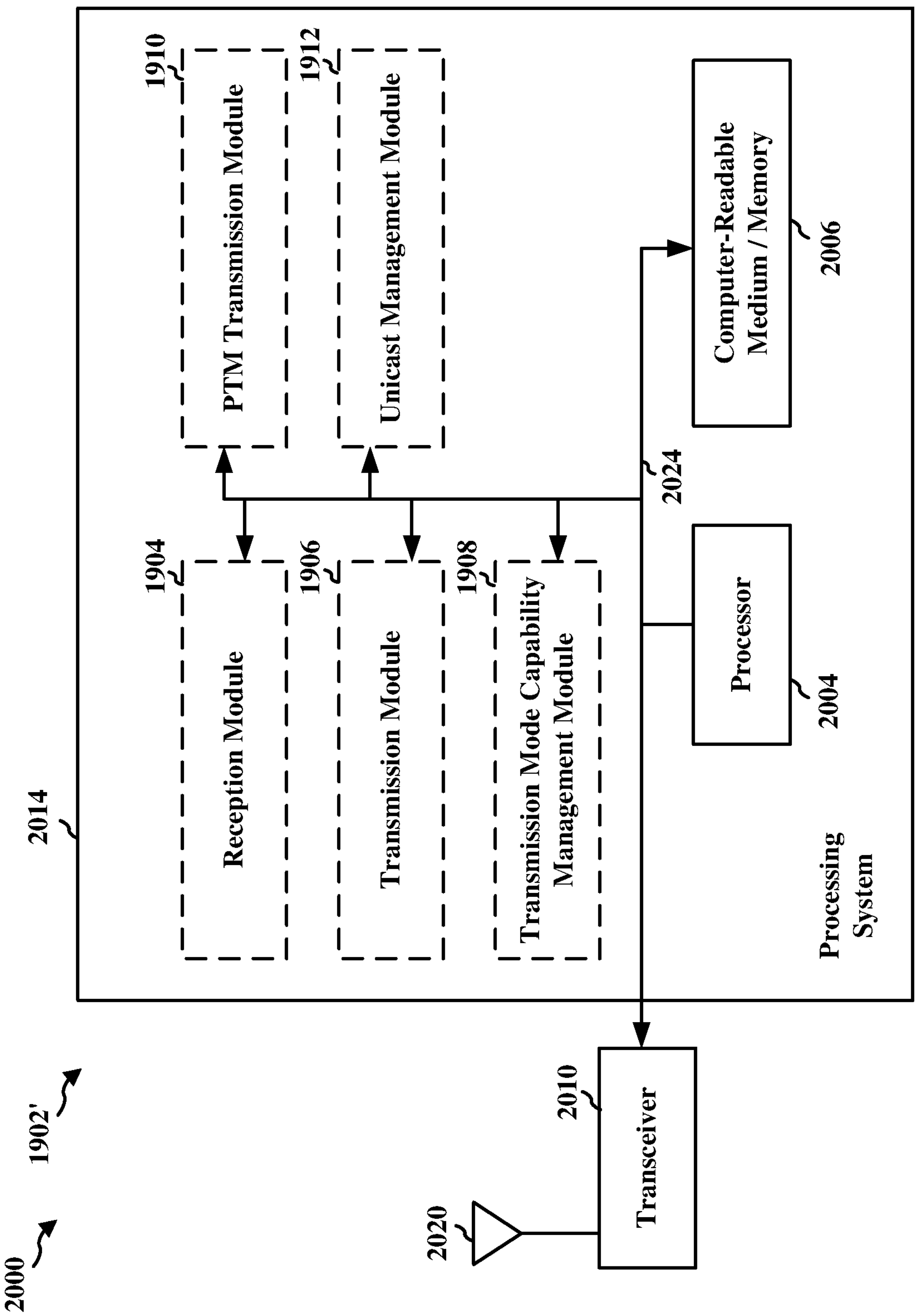
2000
1902'
2014
1904
Reception Module
1906
Transmission Module
1908
Transmission Mode Capability Management Module
1910
PTM Transmission Module
1912
Unicast Management Module
2024
Computer-Readable Medium / Memory
2006
Processor
2004
Processing System
2010
Transceiver
2020

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/071911

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(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)

H04L; H04W; H04Q

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

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

CNPAT,CNKI,WPI,EPODOC: terminal, wireless, ptm, point, multipl+, PDSCH,PDCCH, DCI ,RNTI, downlink,config+, diversity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014073671 A1 (SHARP KABUSHIKI KAISHA) 15 May 2014 (2014-05-15) description, pages 2-4, 18-19, figures 8-16	1-141
A	EP 2765723 A1 (LG ELECTRONICS INC.) 13 August 2014 (2014-08-13) the whole document	1-141

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

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Date of the actual completion of the international search	Date of mailing of the international search report
17 September 2015	**24 September 2015**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/071911

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2014073671 A1	15 May 2014	CA 2890712 A1	15 May 2014
		CN 104782206 A	15 July 2015
		CN 104769868 A	08 July 2015
		WO 2014069601 A1	08 May 2014
		EP 2919538 A1	16 September 2015
EP 2765723 A1	13 August 2014	US 2015003425 A1	01 January 2015
		WO 2013051856 A1	11 April 2013