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(54) **Title**: DYNAMIC INDICATION OF TIME DIVISION (TDD) DUPLEX UPLINK/DOWNLINK SUBFRAME CONFIGURATIONS

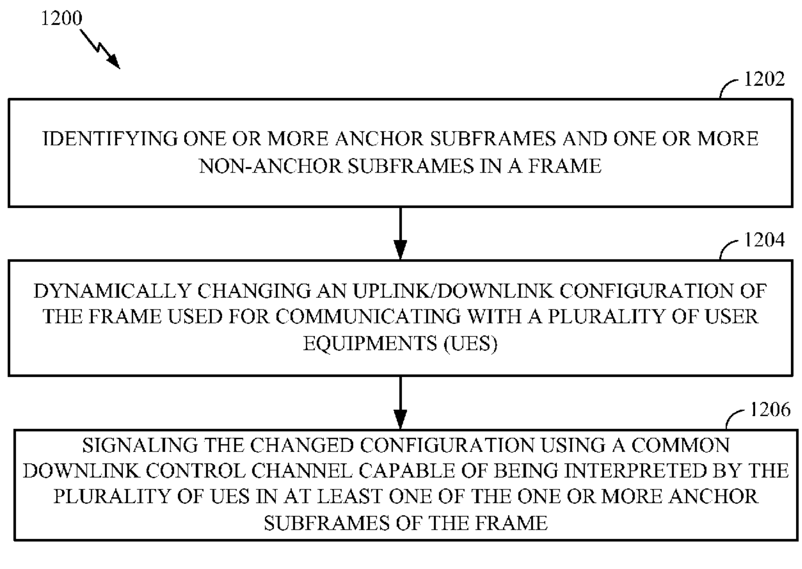

FIG. 12

(57) **Abstract**: Certain aspects of the present disclosure relate to techniques for dynamic indication of Time Division Duplex (TDD) Uplink (UL)/Downlink (DL) subframe configuration to User Equipments.

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DYNAMIC INDICATION OF TIME DIVISION (TDD) DUPLEX UPLINK/DOWNLINK SUBFRAME CONFIGURATIONS

BACKGROUND

Field

[0001] The present disclosure relates generally to wireless communication, and more particularly, to methods and apparatus for dynamic indication of Time Division Duplex (TDD) Uplink (UL)/Downlink (DL) subframe configurations.

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 divisional multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0003] These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example of an emerging telecommunication standard is Long Term Evolution (LTE). LTE/LTE-Advanced is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) mobile standard promulgated by Third Generation Partnership Project (3GPP). It is designed to better support mobile broadband Internet access by improving spectral efficiency, lower costs, improve services, make use of new spectrum, and better integrate 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] Certain aspects of the present disclosure provide a method for wireless communications by a base station. The method generally includes identifying one or more anchor subframes and one or more non-anchor subframes in a frame, dynamically changing an uplink/downlink configuration of the frame used for communicating with a plurality of user equipments (UEs), and signaling the changed configuration using a common downlink control channel capable of being interpreted by the plurality of UEs in at least one of the one or more anchor subframes of the frame.

[0005] Certain aspects of the present disclosure provide a method for wireless communications by a user equipment. The method generally includes monitoring one or more anchor subframes of a frame for a common downlink control channel capable of being interpreted by a plurality of UEs indicating a changed uplink/downlink configuration of subframes used for communication with the plurality of UEs, and decoding the common downlink control channel to determine the changed uplink/downlink configuration of subframes for use in subsequent communication.

[0006] Aspects generally include methods, apparatus, systems, computer program products, and processing systems, as substantially described herein with reference to and as illustrated by the accompanying drawings. “LTE” refers generally to LTE and LTE-Advanced (LTE-A).

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 plane.

[0012] FIG. 6 is a diagram illustrating an example of an evolved Node B and user equipment in an access network, in accordance with certain aspects of the disclosure.

[0013] FIG. 7 illustrates a list of uplink/downlink subframe configurations.

[0014] FIG. 8 illustrates an example subframe frame format.

[0015] FIG. 9 illustrates an example use of reference uplink/downlink subframe configurations.

[0016] FIG. 10 illustrates example transmission of common PDCCH, in accordance with aspects of the present disclosure.

[0017] FIG. 11 illustrates example transmission of common PDCCH at different locations in different cells, in accordance with aspects of the present disclosure.

[0018] FIG. 12 illustrates example operations performed, for example, by a base station (BS) for dynamic indication of TDD UL/DL subframe configuration, in accordance with aspect of the disclosure.

[0019] FIG. 13 illustrates example operations performed, for example, by a user equipment (UE) for dynamic indication of TDD UL/DL subframe configuration, in accordance with aspect of the disclosure.

DETAILED DESCRIPTION

[0020] The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0021] 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 hardware, software, or combinations thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0022] 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, firmware, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software/firmware, middleware, microcode, hardware description language, or otherwise.

[0023] Accordingly, in one or more exemplary embodiments, the functions described may be implemented in hardware, software, or combinations 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 RAM, ROM, EEPROM, PCM (phase change memory), flash memory, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers.

Combinations of the above should also be included within the scope of computer-readable media.

[0024] 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, a Home Subscriber Server (HSS) 120, and an Operator's IP Services 122. The EPS can interconnect with other access networks, but for simplicity those entities/interfaces are not shown. Exemplary other access networks may include an IP Multimedia Subsystem (IMS) PDN, Internet PDN, Administrative PDN (e.g., Provisioning PDN), carrier-specific PDN, operator-specific PDN, and/or GPS PDN. 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.

[0025] The E-UTRAN includes the evolved Node B (eNB) 106 and other eNBs 108. The eNB 106 provides user and control plane protocol terminations toward the UE 102. The eNB 106 may be connected to the other eNBs 108 via an X2 interface (e.g., backhaul). The eNB 106 may also be referred to as a base station, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), an access point, or some other suitable terminology. The eNB 106 may provide 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, a netbook, a smart book, an ultrabook, 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.

[0026] The eNB 106 is connected by an S1 interface to the EPC 110. The EPC 110 includes a Mobility Management Entity (MME) 112, other MMEs 114, a Serving Gateway 116, 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 is connected to the Operator's IP Services 122. The Operator's IP Services 122 may include, for example, the Internet, the Intranet, an IP Multimedia Subsystem (IMS), and a PS (packet-switched) Streaming Service (PSS). In this manner, the UE102 may be coupled to the PDN through the LTE network.

[0027] 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. A lower power class eNB 208 may be referred to as a remote radio head (RRH). The lower power class eNB 208 may be a femto cell (e.g., home eNB (HeNB)), pico cell, or micro cell. 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. The network 200 may also include one or more relays (not shown). According to one application, an UE may serve as a relay.

[0028] 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 duplexing (FDD) and time division duplexing (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), Ultra Mobile Broadband (UMB), 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.

[0029] 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 (e.g., 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.

[0030] 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.

[0031] 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).

[0032] 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 sub-frames with indices of 0 through 9. Each sub-frame 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, a resource block contains 12 consecutive subcarriers in the frequency domain and, for a normal cyclic prefix in each OFDM symbol, 7 consecutive OFDM symbols in the time domain, or 84 resource elements. For an extended cyclic prefix, a resource block contains 6 consecutive OFDM symbols in the time domain and has 72 resource elements. Some of the resource elements, as indicated as R 302, R 304, include DL reference signals (DL-RS). The DL-RS include Cell-specific RS (CRS) (also sometimes called common RS) 302 and UE-specific RS (UE-RS) 304. UE-RS 304 are transmitted only on the resource blocks upon which the corresponding physical DL shared channel (PDSCH) is mapped. The number of bits carried by each resource element depends on the modulation scheme. Thus, the more resource blocks that a UE receives and the higher the modulation scheme, the higher the data rate for the UE.

[0033] In LTE, an eNB may send a primary synchronization signal (PSS) and a secondary synchronization signal (SSS) for each cell in the eNB. The primary and secondary synchronization signals may be sent in symbol periods 6 and 5, respectively, in each of subframes 0 and 5 of each radio frame with the normal cyclic prefix (CP).

The synchronization signals may be used by UEs for cell detection and acquisition. The eNB may send a Physical Broadcast Channel (PBCH) in symbol periods 0 to 3 in slot 1 of subframe 0. The PBCH may carry certain system information.

[0034] The eNB may send a Physical Control Format Indicator Channel (PCFICH) in the first symbol period of each subframe. The PCFICH may convey the number of symbol periods (M) used for control channels, where M may be equal to 1, 2 or 3 and may change from subframe to subframe. M may also be equal to 4 for a small system bandwidth, e.g., with less than 10 resource blocks. The eNB may send a Physical HARQ Indicator Channel (PHICH) and a Physical Downlink Control Channel (PDCCH) in the first M symbol periods of each subframe. The PHICH may carry information to support hybrid automatic repeat request (HARQ). The PDCCH may carry information on resource allocation for UEs and control information for downlink channels. The eNB may send a Physical Downlink Shared Channel (PDSCH) in the remaining symbol periods of each subframe. The PDSCH may carry data for UEs scheduled for data transmission on the downlink.

[0035] The eNB may send the PSS, SSS, and PBCH in the center 1.08 MHz of the system bandwidth used by the eNB. The eNB may send the PCFICH and PHICH across the entire system bandwidth in each symbol period in which these channels are sent. The eNB may send the PDCCH to groups of UEs in certain portions of the system bandwidth. The eNB may send the PDSCH to specific UEs in specific portions of the system bandwidth. The eNB may send the PSS, SSS, PBCH, PCFICH, and PHICH in a broadcast manner to all UEs, may send the PDCCH in a unicast manner to specific UEs, and may also send the PDSCH in a unicast manner to specific UEs.

[0036] A number of resource elements may be available in each symbol period. Each resource element (RE) may cover one subcarrier in one symbol period and may be used to send one modulation symbol, which may be a real or complex value. Resource elements not used for a reference signal in each symbol period may be arranged into resource element groups (REGs). Each REG may include four resource elements in one symbol period. The PCFICH may occupy four REGs, which may be spaced approximately equally across frequency, in symbol period 0. The PHICH may occupy three REGs, which may be spread across frequency, in one or more configurable symbol periods. For example, the three REGs for the PHICH may all belong in symbol period 0 or may be spread in symbol periods 0, 1, and 2. The PDCCH may occupy 9, 18, 36, or 72 REGs, which may be selected from the available REGs, in the first M symbol periods, for example. Only certain combinations of REGs may be allowed for the PDCCH. In aspects of the present methods and apparatus, a subframe may include more than one PDCCH.

[0037] A UE may know the specific REGs used for the PHICH and the PCFICH. The UE may search different combinations of REGs for the PDCCH. The number of combinations to search is typically less than the number of allowed combinations for the PDCCH. An eNB may send the PDCCH to the UE in any of the combinations that the UE will search.

[0038] 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.

[0039] A UE may be assigned resource blocks 410a, 410b in the control section to transmit control information to an eNB. The UE may also be assigned resource blocks 420a, 420b in the data section to transmit data to the eNB. The UE may transmit control information in a physical UL control channel (PUCCH) on the assigned resource blocks in the control section. The UE may transmit only data or both data and control information in a physical UL shared channel (PUSCH) on the assigned resource blocks in the data section. A UL transmission may span both slots of a subframe and may hop across frequency.

[0040] A set of resource blocks may be used to perform initial system access and achieve UL synchronization in a physical random access channel (PRACH) 430. The PRACH 430 carries a random sequence and cannot carry any UL data/signaling. Each random access preamble occupies a bandwidth corresponding to six consecutive resource blocks. The starting frequency is specified by the network. That is, the transmission of the random access preamble is restricted to certain time and frequency resources. There is no frequency hopping for the PRACH. The PRACH attempt is carried in a single subframe (1 ms) or in a sequence of few contiguous subframes and a UE can make only a single PRACH attempt per frame (10 ms).

[0041] 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.

[0042] 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.).

[0043] 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.

[0044] 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 (i.e., radio bearers) and for configuring the lower layers using RRC signaling between the eNB and the UE.

[0045] 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.

[0046] The TX processor 616 implements various signal processing functions for the L1 layer (i.e., physical layer). The signal processing functions includes 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 is then provided to a different antenna 620 via a separate transmitter 618TX. Each transmitter 618TX modulates an RF carrier with a respective spatial stream for transmission.

[0047] 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 receiver (RX) processor 656. The RX processor 656 implements various signal processing functions of the L1 layer. The RX processor 656 performs 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, is 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.

[0048] 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 control/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.

[0049] 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.

[0050] 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 are provided to different antenna 652 via separate transmitters 654TX. Each transmitter 654TX modulates an RF carrier with a respective spatial stream for transmission.

[0051] 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.

[0052] The controller/processor 675 implements the L2 layer. The controller/processor 675 can be associated with a memory 676 that stores program codes and data. The memory 676 may be referred to as a computer-readable medium. In the UL, the control/processor 675 provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover upper layer packets from the UE 650. Upper layer packets from the controller/processor 675 may be provided to the core network. The controller/processor 675 is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations. The controllers/processors 675, 659 may direct the operation at the eNB 610 and the UE 650, respectively. The controller/processor 659 and/or other processors and modules at the UE 650 may perform or direct operations for example operations 1300 in FIG. 13, and/or other processes for the techniques described herein, for example. The controller/processor 675 and/or other processors and modules at the eNB 610 may perform or direct operations for example operations 1200 in FIG 12, and/or other processes for the techniques described herein, for example. In aspects, one or more of any of the components shown in FIG. 6 may be employed to perform example operations 1200 and 1300 and/or other processes for the techniques described herein.

EVOLVED INTERFERENCE MANAGEMENT FOR TRAFFIC ADAPTATION (EIMTA)

[0053] In certain wireless communications networks, such as LTE networks, both Frequency Division Duplex (FDD) and (TDD) frame structures are supported. For TDD, 7 possible DL and UL subframe configurations are supported, as shown in FIG. 7. It may be noted that there are 2 switching periodicities, 5ms and 10ms. For 5ms, there are two special subframes in one frame (10ms) – as illustrated in FIG. 8. For 10ms, there is one special subframe in one frame. The present methods and apparatus may be employed when a larger or smaller number of subframe configurations are supported.

[0054] In LTE Rel-12, it is possible to dynamically adapt TDD DL/UL subframe configurations based on the actual traffic needs, also known as evolved interference management for traffic adaptation (eIMTA). For example, if during a short duration, a large data burst on downlink is needed, the subframe configuration may be changed, for example, from config #1 (6 DL : 4 UL) to config #5 (9 DL : 1 UL). In some cases, the adaptation of TDD configuration is expected to be no slower than 640ms. In an extreme case, the adaptation may be expected to be as fast as 10ms, although this may not desirable.

[0055] In certain aspects, the adaptation, however, may cause overwhelming interference to both downlink and uplink when two or more cells have different downlink and uplink subframes. In addition, the adaptation may cause some complexity in DL and UL HARQ timing management. In certain aspects, each of the seven DL/UL subframe configurations has its own DL/UL HARQ timing. The DL/UL HARQ timing is optimized for each configuration (e.g., in terms of HARQ operation efficiency). For example, the timing from PDSCH to the corresponding ACK/NAK may be different for different TDD DL/UL subframe configurations (e.g., depending on when the next available uplink subframe occurs for sending the ACK/NAK).

[0056] Dynamical switching among the 7 configurations (or even more, if more flexible adaptation is deemed as necessary) implies that if current DL/UL HARQ timing is kept, there may be missed ACK/NAK transmission opportunities for some of the DL or UL transmissions.

[0057] In certain aspects, in order to simplify the operations for enhanced (or evolved) interference mitigation with traffic adaptation (eIMTA), it is possible to define a single DL/UL configuration as a reference for many physical layer operations. For instance, DL HARQ operations may be based on DL/UL subframe configuration #5, regardless of the actual DL/UL subframe configuration in use in a frame (or half a frame).

[0058] That is, if dynamic DL/UL subframe configuration is enabled, the DL HARQ timing may be always based on the 9:1 DL/UL subframe configuration. Similarly, UL HARQ operation can be based, for example, on DL/UL subframe configuration #0, regardless of the actual DL/UL subframe configuration in use in a frame (or half a frame). That is, if dynamic DL/UL subframe configuration is enabled, the UL HARQ timing may be always based on the 4:6 DL/UL subframe configuration, as illustrated in FIG. 9.

[0059] As shown in FIG. 9, the actual usage of a subframe may be subject to eNB scheduling. For example, Subframes 3/4/5/7/8/9 may either be DL or UL subframes, while subframe 6 may either be DL or special subframe.

ENABLING COMMON (e)PDCCH TO DYNAMICALLY INDICATE TDD DL/UL SUBFRAME CONFIGURATION

[0060] Aspects of the present disclosure discuss techniques for dynamic indication of the TDD UL/DL subframe configuration to UEs. In certain aspects common PDCCH or ePDCCH capable of being interpreted by a plurality of UEs may be used for indicating the TDD DL/UL configuration to one or more UEs.

[0061] In certain aspects, dynamic indication of TDD DL/UL subframe configuration is expected for UEs in RRC_CONNECTED state only. Therefore, in certain aspects, dynamic indication via common PDCCH may be enabled via a common Radio Network Temporary Identifier, for example, DTC (Dynamic TDD DL/UL configuration)-RNTI. In an aspect, the selection of a 16-bit DTC-RNTI may follow the same rules as C-RNTI (Cell-RNTI) and avoiding RNTIs used by P-RNTI, SI-RNTI, RA-RNTI, TPC RNTI etc. In an aspect, a corresponding PDCCH CRC (Cyclic Redundancy Check) may be scrambled by the DTC-RNTI.

[0062] In certain aspects, the size of the common PDCCH may either match an existing DCI format or may be a new format. For example, the size of common PDCCH may be small or similar to that of DCI format 1C. In an aspect, the common PDCCH may include 3-bits indicating the configuration, 5 bits reserved, 16-bit CRC, for a total of 24 bits, which is that same size as DCI format 1C under 1.4MHz or 6-RB system bandwidth. In an aspect the size of the common PDCCH may be bandwidth independent. Hereinafter, the DCI format for the common PDCCH will be referred to as DCI format 5.

[0063] In certain aspects, the common PDCCH may only be carried in DL anchor subframes. In an aspect, the common PDCCH may not have to be carried in all DL anchor subframes.

[0064] In certain aspects, the common PDCCH indicating a TDD DL/UL subframe configuration may be transmitted in early subframes of a frame, or even earlier, for example in a previous frame to allow both eNB and UE to react to the new configuration. For example, to give UE enough time to decode the common PDCCH and determine the TDD UL/DL subframe configuration. FIG. 10 illustrates transmission of the common PDCCH in subframe 5 of frame n-1 indicating TDD DL/UL subframe configuration of frame n.

[0065] In certain aspects, a set of subframes for UE to monitor DCI format 5 may be pre-determined, or indicated by signaling (e.g., broadcast or unicast). For example, subframe 5 of all frames may be predetermined to carry the common PDCCH. In an aspect, one of the SIBs, may indicate which subframes/frames carry DCI format 5. In an aspect, dedicated signaling may be used to indicate which subframes/frames carry DCI format 5. In certain aspects, a same subframe configuration indication may be transmitted in multiple subframes. UEs may monitor the multiple subframes for the same TDD DL/UL subframe configuration indication, in order to facilitate eNB control load balancing and Discontinuous Reception (DRX) operation for the UEs. For example, UEs may monitor the common PDCCH in both subframes 5 and 6.

[0066] In certain aspexcts, different UEs may have different DRX operation. For example, a UE1 may monitor subframe 5 and another UE2 may monitor 6 due to the DRX operation being subframe specific. Therefore, in an aspect, the set of subframes for a UE to monitor DCI format 5 may be tied with its DRX operation. This, for example, may ensure that there is at least one subframe carrying DCI format 5 in certain duration. In an aspect, a UE may need to pre-wake-up to monitor DCI format 5 before ON duration, especially during long DRX. In an aspect, if a UE cannot detect the common PDCCH, it may fall back to a legacy or reference configuration.

[0067] In certain aspects, the eNB may consider transmitting the common PDCCH in at least two DL anchor subframes to increase reliability. From UE perspective, it may monitor the common PDCCH in at least two DL subframes and may also combine the two DL subframes for joint decoding (TTI bundling for PDCCH) for more time diversity. For example, compared with one level 4 PDCCH transmission in one subframe, there may be 2 level 2 PDCCH transmissions in two subframes.

[0068] In an aspect, reliability of the common PDCCH may further be increased by power control.

[0069] In certain aspects, there may be restriction on the sets of usable subframes. For example, some subframes may experience interference on UL or DL and thus an eNB may use only certain subframes (e.g., subframes when interfering cell(s) is configured with almost blank subframes). As a result,the set of subframes for use may be restricted. Thus, in an aspect, the time location of the common PDCCH may be different for different cells. For example, as shown in FIG. 11, cell 1 uses subframe 5 while cell 2 uses subframe 6 for transmitting the common PDCCH.

[0070] In certain aspects, for the purposes of blind decoding, in subframes where the common PDCCH is transmitted, the UE may not be required to decode DCI format 1C. In an aspect, the set of decoding candidates originally monitored for DCI format 1C may be used for DCI format 5, thus maintaining the same number of blind decodes as DCI format 5. Hence, the new DCI format may replace DCI format 1C for UEs to monitor certain subframes. As a result, there is no increase of the number of DCI sizes to monitor.

[0071] In certain aspects, in order to maintain the same number of maximum number of blind decodes, the number of decoding candidates for DCI format 5 should be the same as DCI format 1C. However, the set of aggregation levels for DCI format 5 may be may be revised to be different from that of DCI format 1C (which has 4 decoding candidates for level 4, and 2 decoding candidates for level 8 – total of 6 decoding candidates) in order to accommodate DCI format 5. In an aspect, the motivation is that for a payload size of 24 bits, 2 CCEs (or 72 REs) results in a coding rate of 24/2(QPSK)/72 = 1/6, which should be enough to cover the majority of cases especially considering the small cell context. An example set of aggregation levels are {1, 2, 2, 1} for aggregation levels {1, 2, 4, 8}, respectively. i.e. we can still support original aggregation levels {1, 2, 4, 8} for DCI format 5, but in order to maintain same decoding candidates aggregation levels {1, 2, 2, 1} may be used for aggregation levels {1, 2, 4, 8}.

[0072] For DCI format 1C, the common search space always starts from CCE 0. In an aspect, for DCI format 5 the common search space may also start with CCE 0. But this may be restrictive as it may collide with common search space transmissions. That is, for DCI format 5 the starting CCE of each aggregation level may be the same common search space for the same aggregation levels and within the common search space for other new aggregation levels, but restrictive given that it may collide with common search space related operations (e.g., paging, RAR response, system information broadcast, etc.). As a result, two alternatives may be designed to address this concern.

[0073] In a first alternative, starting CCE may be configured via RRC signaling. The RRC configuration may be aggregation level dependent and/or subframe dependent. It may be common to all UEs of a cell, or common to a group of UEs of a cell, but different for different groups (two or more groups) of UEs of the cell.

[0074] In a second alternative, the starting CCE may be derived based on DTC-RNTI, similar to C-RNTI. This approach is simple and at the same time effective. Further simplification may be possible, e.g., the starting CCE for all aggregation levels may be the same (e.g., based on level 8).

[0075] In certain aspects, dynamic indication of the TDD UL/DL subframe configuration may be supported via ePDCCH. In an aspect, the discussions earlier for the common PDCCH may be largely applied for ePDCCH, but with some differences. For instance, distributed ePDCCH may preferably be used for the common EPDCCH DCI format 5. In an aspect, it is sufficient that the common EPDCCH is located in one resource set, if the UE is configured with two ePDCCH resource sets. In certain aspects, if the UE is configured with localized ePDCCH resource set(s) only, dynamic indication may be conveyed via some localized ePDCCH.

[0076] In certain aspects, the UE may monitor only one of common PDCCH or common ePDCCH for dynamic indication of TDD subframe configuration. Alternatively, the UE may monitor both common PDCCH or common ePDCCH for dynamic indication of TDD subframe configuration if the UE is configured to monitor PDCCH and ePDCCH over different subframes.

[0077] In certain aspects, if it is assumed that DCI format 5 replaces DCI format 1C, there may be concerns of reduced paging opportunities due to loss of DCI format 1C in some subframes. In certain aspects, UEs may be allowed to monitor both DCI format 5 and DCI format 1C in the same subframe. In an aspect, the size of DCI format 5 may be the same or different from that of DCI format 1C. In the case of same size, some bit(s) inside the payload may be used to differentiate 1C from 5. However, if the sizes of the formats 5 and 1C are different, in order to maintain the same number of blind decodes (or to minimize the total number of blind decodes), splitting the decoding candidates may be considered between 1C and 5 in one subframe for the UE to monitor. For example, 3 decoding candidates for 5 (2 level 2 and 1 level 4), and 3 decoding candidates for DCI format 1C (2 level 4 and 1 level 8). In an aspect, there may also be an uneven split of decoding candidates between the two formats.

[0078] In CoMP scenario 4, a macro cell and its associated small cells may have the same PCI. As a result, if the search space for DCI format 5 is only dependent on PCI, search space for DCI format 5 may collide. Thus, in an aspect, differentiation of DCI format 5 for macro cell and its associated small cells of the same PCI should be supported. In an aspect, this may be accomplished by non-overlapping DCI format 5 search spaces for macro and small cells, e.g., by configuring different starting CCEs or ECCEs. In alternative aspects, same search space may be used, but within each DCI format, an index may be included identifying a small cell within the same cluster of the same PCI (e.g., similar to DCI 3/3A based group power control, where each TPC_index corresponds to a particular UE). In an aspect, UEs may be further indicated the mapping between the indices and the small cells.

[0079] In certain aspects, DTC-RNTI may be configured differently for different small cells of the same PCI. That is, for a same PCI, UEs may be required to monitor two or more DTC-RNTIs. The corresponding search spaces for the two or more DTC-RNTIs may be the same or separately defined (e.g., based on each individual DTC-RNTI).

[0080] FIG. 12 illustrates example operations 1200 performed, for example, by a base station (BS) for dynamic indication of TDD UL/DL subframe configuration, in accordance with aspect of the disclosure. Operations 1200 may begin, at 1202, by identifying one or more anchor subframes and one or more non-anchor subframes in a frame. At 1204 the BS may dynamically change an uplink/downlink configuration of the frame used for communicating with a plurality of UEs. At 1206, the BS may signal the changed configuration using a common downlink control channel capable of being interpreted by the plurality of UEs in at least one of the one or more anchor subframes of the frame.

[0081] FIG. 13 illustrates example operations 1300 performed, for example, by a user equipment (UE) for dynamic indication of TDD UL/DL subframe configuration, in accordance with aspect of the disclosure. Operations 1300 may begin, at 1302, by monitoring one or more anchor subframes of a frame for a common downlink control channel capable of being interpreted by a plurality of UEs indicating a changed uplink/downlink configuration of subframes used for communication with the plurality of UEs. At 1304, the UE may decode the common downlink control channel to determine the changed uplink/downlink configuration of subframes for use in subsequent communication.

[0082] It is understood that the specific order or hierarchy of steps in the processes disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged. Further, some steps may be combined or omitted. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0083] Moreover, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or." That is, unless specified otherwise, or clear from the context, the phrase, for example, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, for example the phrase "X employs A or B" is satisfied by any of the following instances: X employs A; X employs B; or X employs both A and B. In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from the context to be directed to a singular form. A phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of: *a*, *b*, or *c*" is intended to cover: *a, b, c, a-b, a-c, b-c, and a-b-c*.

[0084] 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." Unless specifically stated otherwise, the term "some" refers to one or more. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

CLAIMS

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

identifying one or more anchor subframes and one or more non-anchor subframes in a frame;

dynamically changing an uplink/downlink configuration of the frame used for communicating with a plurality of user equipments (UEs); and

signaling the changed configuration using a common downlink control channel capable of being interpreted by the plurality of UEs in at least one of the one or more anchor subframes of the frame.

2. The method of claim 1, wherein the size of the common downlink control channel is same as the size defined for a legacy Long Term Evolution (LTE) Downlink Control Information (DCI) format.

3. The method of claim 2, wherein the legacy LTE DCI format comprises DCI format 1C.

4. The method of claim 1, wherein the size of the common downlink control channel is independent of a downlink system bandwidth.

5. The method of claim 1, further comprising scrambling Cyclic Redundancy Check (CRC) code of the common downlink control channel by Radio Network Temporary Identifier (RNTI) specific to the common downlink control channel.

6 The method of claim 1, further comprising configuring two or more RNTI values for cells of a same physical cell identity (PCI), wherein each of the plurality of UEs is indicated to monitor only one of the two or more RNTI values.

7. The method of claim 1, wherein the signaling comprises transmitting the common downlink control channel only in a subset of the one or more anchor subframes of the frame.

8. The method of claim 1, wherein the signaling comprises transmitting the common downlink control channel in the one or more anchor subframes of the frame for indicating the uplink/downlink configuration for another subsequent frame.

9. The method of claim 1, further comprising indicating to at least one UE of the plurality of UEs via explicit signaling a set of subframes configured to carry the common downlink control channel.

10. The method of claim 9, wherein the explicit signaling comprises signaling via a System Information Block (SIB).

11. The method of claim 9, wherein the explicit signaling comprises dedicated signaling for the indication.

12. The method of claim 9, wherein a set of subframes configured to carry the common downlink control channel is pre-determined.

13. The method of claim 1, further comprising determining a set of subframes to carry the common downlink control channel for each UE based on a Discontinuous Reception (DRX) operation of the UE such that at least one subframe carries the downlink control channel in a DRX ON duration.

14. The method of claim 1, wherein the signaling comprises transmitting the common downlink control channel in at least two downlink anchor subframes.

15. The method of claim 1, wherein the time location of a subframe carrying the common downlink control channel is different for different cells.

16. The method of claim 1, wherein the signaling comprises transmitting the common downlink control channel in a subframe originally configured for transmission of a legacy downlink control channel such that a number of decoding candidates for blind decoding the common downlink control channel is same as a number of decoding candidates for blind decoding the legacy downlink control channel.

17. The method of claim 16, wherein transmission of the common downlink control channel replaces the transmission of the legacy downlink control channel in the subframe.

18. The method of claim 16, wherein starting CCEs of search spaces for blind decoding of the common downlink control channel and the legacy downlink control channel are the same.

19. The method of claim 16, wherein the starting CCE of a search space for blind decoding of the common downlink control channel is configured via Radio Resource Control (RRC) signaling.

20 The method of claim 16, wherein the RRC signaling is UE-specific.

21. The method of claim 16, wherein the starting CCE of a search space for blind decoding of the common downlink control channel is derived based on a Radio Network Temporary Identifier (RNTI) specific to the common downlink control channel.

22. The method of claim 16, further comprising transmitting the common downlink control channel and the legacy downlink control channel simultaneously in the subframe.

23. The method of claim 22, wherein the sizes of the common downlink control channel and the legacy downlink control channel are the same.

24. The method of claim 23, further comprising transmitting a bit to differentiate between the common downlink control channel and the legacy downlink control channel.

25. The method of claim 1, wherein the uplink/downlink configuration of the subframes comprises a Time Division Duplex (TDD) Uplink-Downlink configuration.

26. The method of claim 1, wherein the common downlink control channel comprises Physical Downlink Control Channel (PDCCH) or enhanced PDCCH (ePDCCH).

27. The method of claim 1, wherein a search space for blind decoding of the common downlink control channel comprises candidates of at least one of aggregation level 1, aggregation level 2, aggregation level 4, or aggregation level 8.

28. A method of wireless communication by a User Equipment (UE), comprising:

monitoring one or more anchor subframes of a frame for a common downlink control channel capable of being interpreted by a plurality of UEs indicating a changed uplink/downlink configuration of subframes used for communication with the plurality of UEs; and

decoding the common downlink control channel to determine the changed uplink/downlink configuration of subframes for use in subsequent communication.

29. The method of claim 28, wherein the size of the common downlink control channel is same as the size defined for a legacy Long Term Evolution (LTE) Downlink Control Information (DCI) format.

30. The method of claim 29, wherein the legacy LTE DCI format comprises DCI format 1C.

31 The method of claim 28, wherein the size of the common downlink control channel is independent of a downlink system bandwidth.

32. The method of claim 28, wherein the Cyclic Redundancy Check (CRC) code of the common downlink control channel is scrambled by Radio Network Temporary Identifier (RNTI) specific to the common downlink control channel.

33. The method of claim 28, wherein two or more RNTI values are configured for cells of a same physical cell identity (PCI), wherein the UE monitors only one of the two or more RNTI values.

34. The method of claim 28, wherein the signaling comprises the common downlink control channel only in a subset of the one or more anchor subframes of the frame.

35. The method of claim 28, wherein the signaling comprises the common downlink control channel in the one or more anchor subframes of the frame indicating the uplink/downlink configuration for another subsequent frame.

36. The method of claim 28, further comprising receiving indication via explicit signaling of a set of subframes configured to carry the common downlink control channel.

37. The method of claim 36, wherein the explicit signaling comprises signaling via a System Information Block (SIB).

38. The method of claim 36, wherein the explicit signaling comprises dedicated signaling for the indication.

39. The method of claim 36, wherein a set of subframes configured to carry the common downlink control channel is pre-determined.

40. The method of claim 28, wherein a set of subframes carrying the common downlink control channel for each UE is based on a Discontinuous Reception (DRX) operation of the UE such that at least one subframe carries the downlink control channel in a DRX ON duration.

41. The method of claim 28, wherein the signaling comprises the common downlink control channel in at least two downlink anchor subframes.

42. The method of claim 28, wherein the time location of a subframe carrying the common downlink control channel is different for different cells.

43. The method of claim 28, wherein the signaling comprises the common downlink control channel in a subframe originally configured for transmission of a legacy downlink control channel such that a number of decoding candidates for blind decoding

the common downlink control channel is same as a number of decoding candidates for blind decoding the legacy downlink control channel.

44. The method of claim 43, wherein the common downlink control channel replaces the legacy downlink control channel in the subframe.

45. The method of claim 43, wherein starting CCEs of search spaces for blind decoding of the common downlink control channel and the legacy downlink control channel are the same.

46. The method of claim 43, wherein the starting CCE of a search space for blind decoding of the common downlink control channel was configured via Radio Resource Control (RRC) signaling.

47 The method of claim 46, wherein the RRC signaling is UE-specific.

48. The method of claim 43, wherein the starting CCE of a search space for blind decoding of the common downlink control channel was derived based on a Radio Network Temporary Identifier (RNTI) specific to the common downlink control channel.

49. The method of claim 43, wherein the common downlink control channel and the legacy downlink control channel are received simultaneously in the subframe.

50. The method of claim 49, wherein the sizes of the common downlink control channel and the legacy downlink control channel are the same.

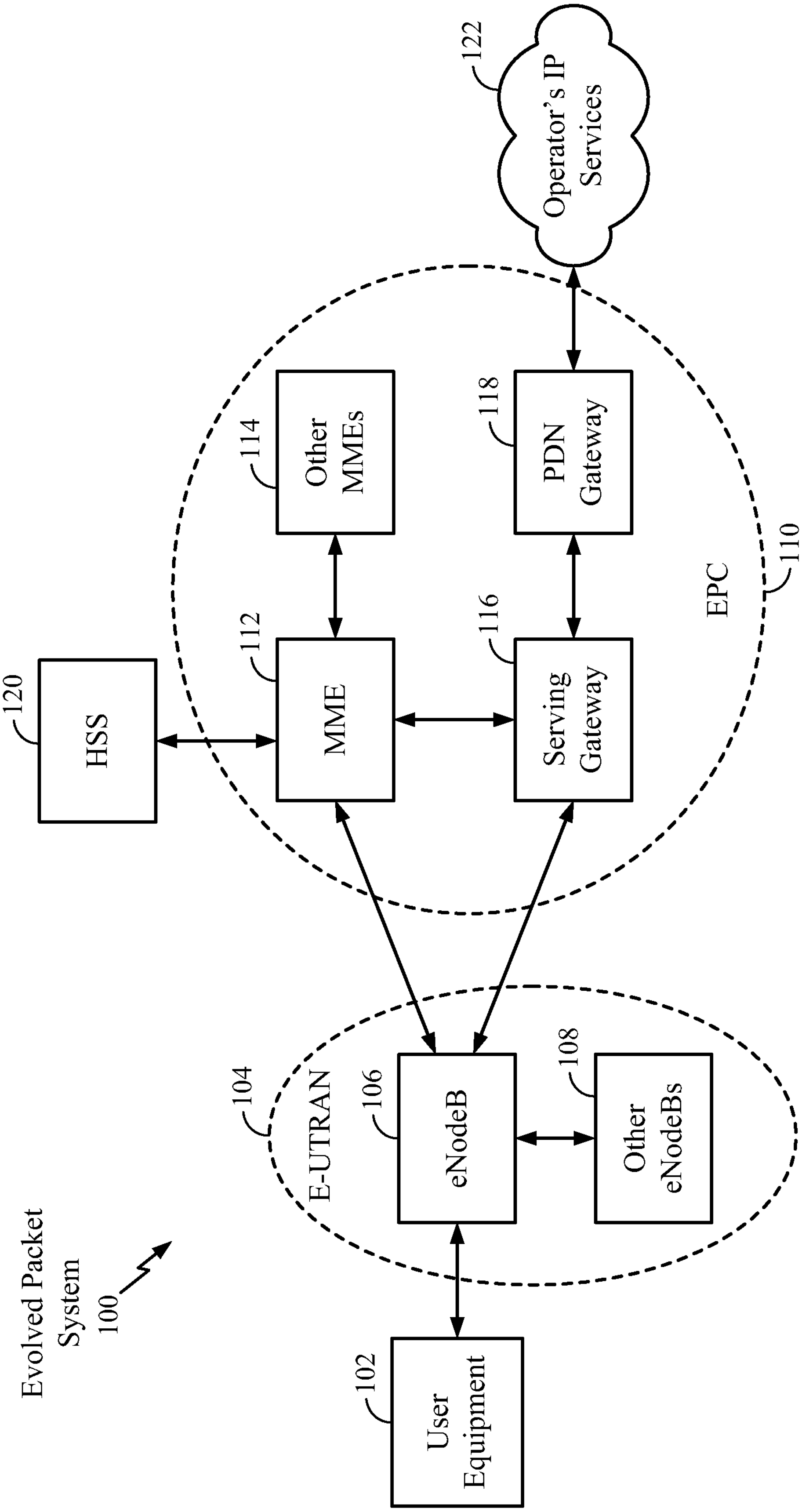
51. The method of claim 50, wherein the signaling comprises a bit to differentiate between the common downlink control channel and the legacy downlink control channel.

52. The method of claim 28, wherein the uplink/downlink configuration of the subframes comprises a Time Division Duplex (TDD) Uplink-Downlink configuration.

53. The method of claim 28, wherein the common downlink control channel comprises Physical Downlink Control Channel (PDCCH) or enhanced PDCCH (ePDCCH).

54. The method of claim 28, wherein a search space for blind decoding of the common downlink control channel comprises candidates of at least one of aggregation level 1, aggregation level 2, aggregation level 4, or aggregation level 8.

55. A method, apparatus, system, computer program product, and processing system as substantially described herein with reference to and as illustrated by the accompanying drawings.


Evolved Packet System
100
User Equipment
102
E-UTRAN
104
eNodeB
106
Other eNodeBs
108
EPC
110
MME
112
Other MMEs
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Serving Gateway
116
PDN Gateway
118
HSS
120
Operator's IP Services
122

FIG. 1

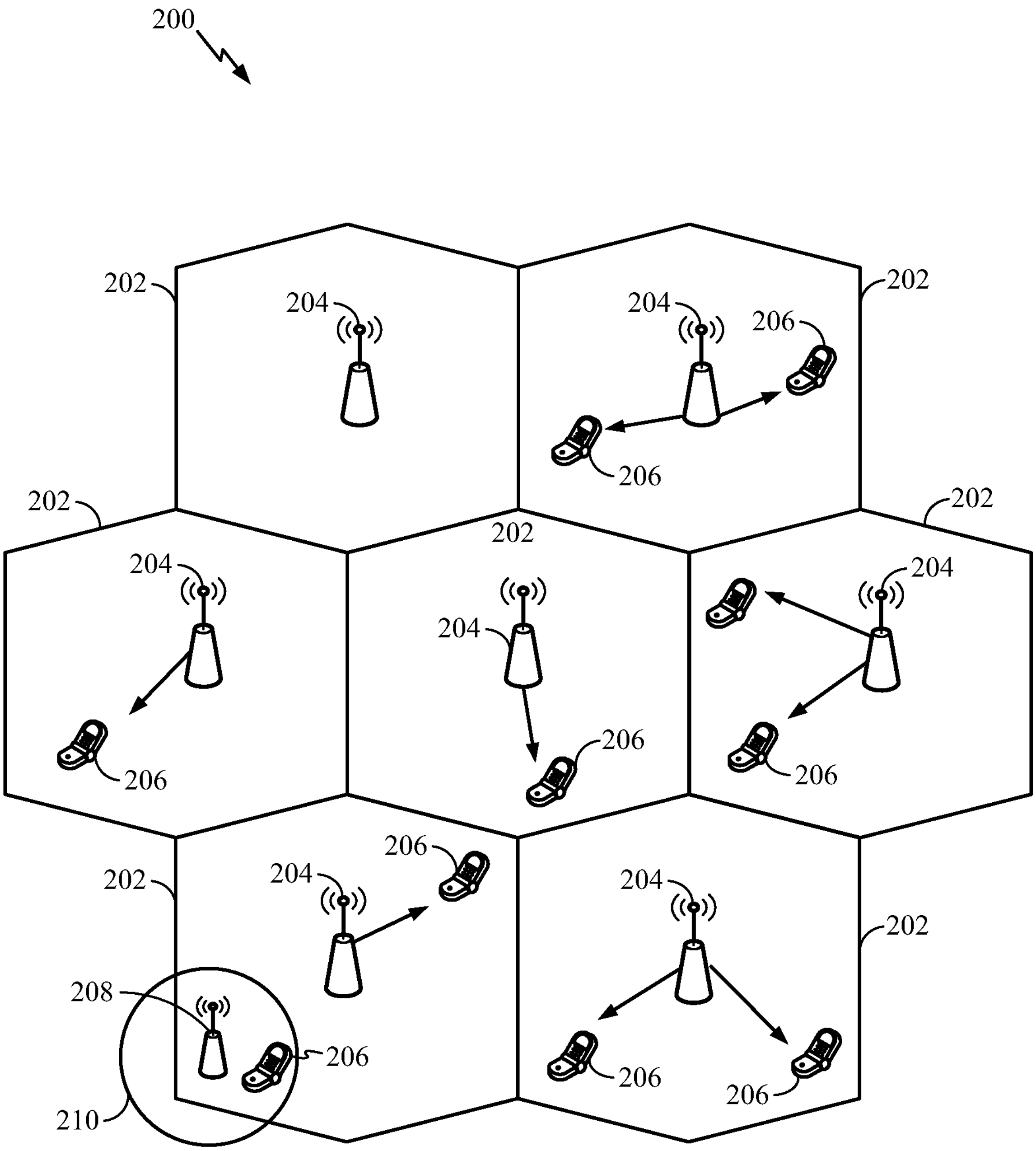
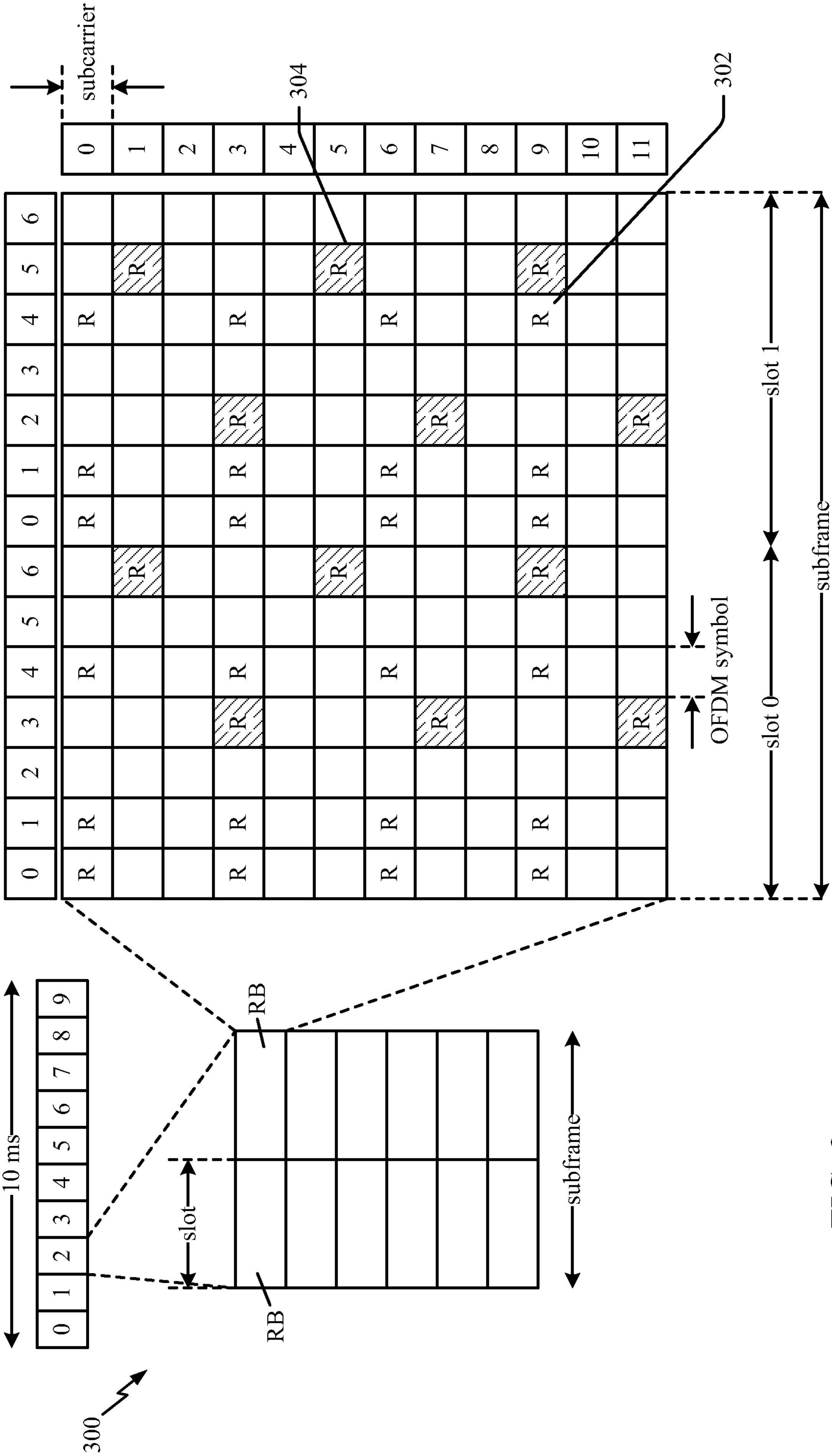


FIG. 2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304
302
OFDM symbol
slot 0
slot 1
subframe
10 ms
RB
RB
slot
subframe
300

FIG. 3

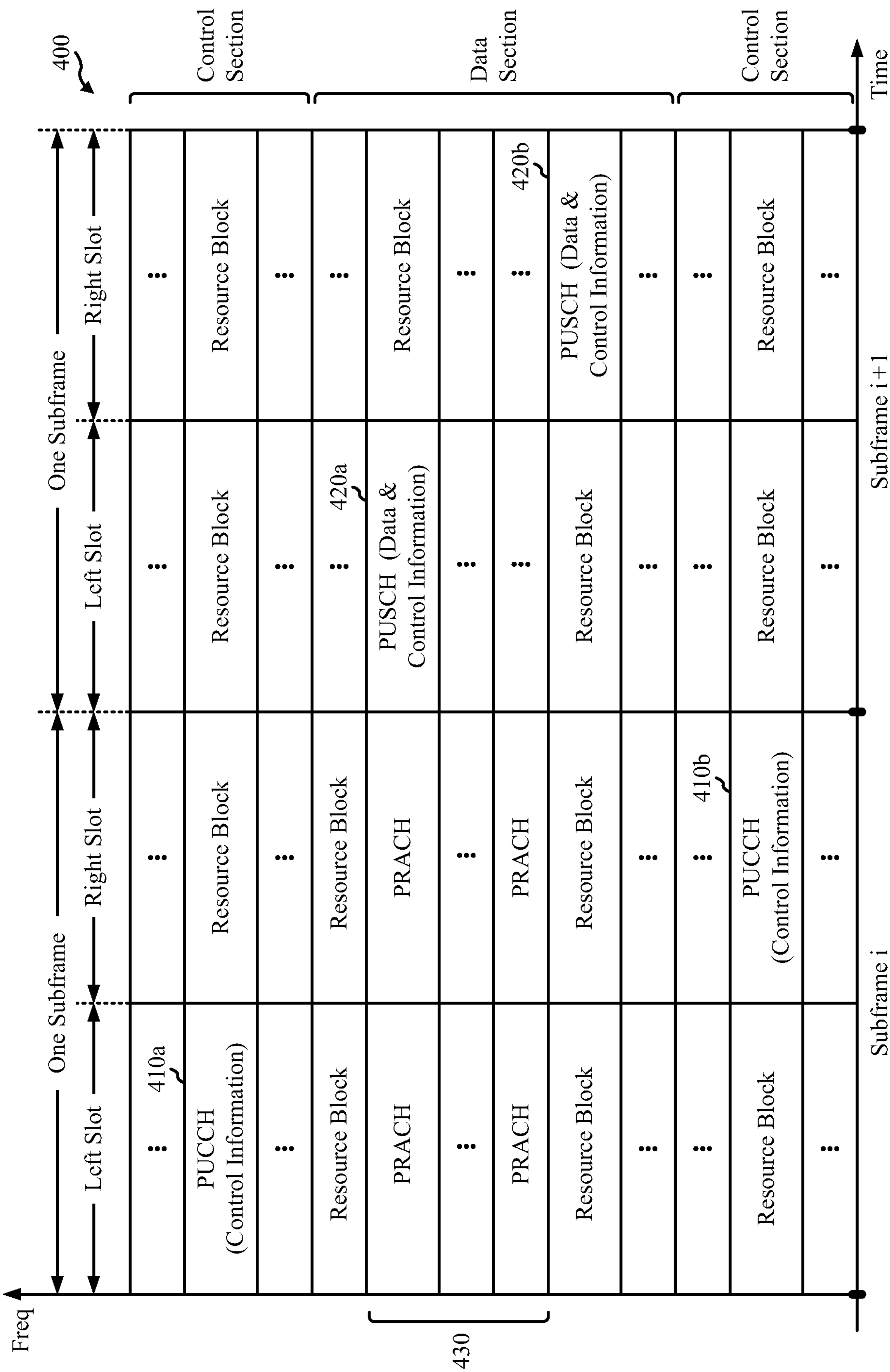

400
Control Section
Data Section
Control Section
Time
Freq
One Subframe
One Subframe
Left Slot
Right Slot
Left Slot
Right Slot
PUCCH (Control Information)
410a
Resource Block
PRACH
PRACH
Resource Block
Resource Block
PUCCH (Control Information)
410b
PUSCH (Data & Control Information)
420a
PUSCH (Data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

FIG. 4

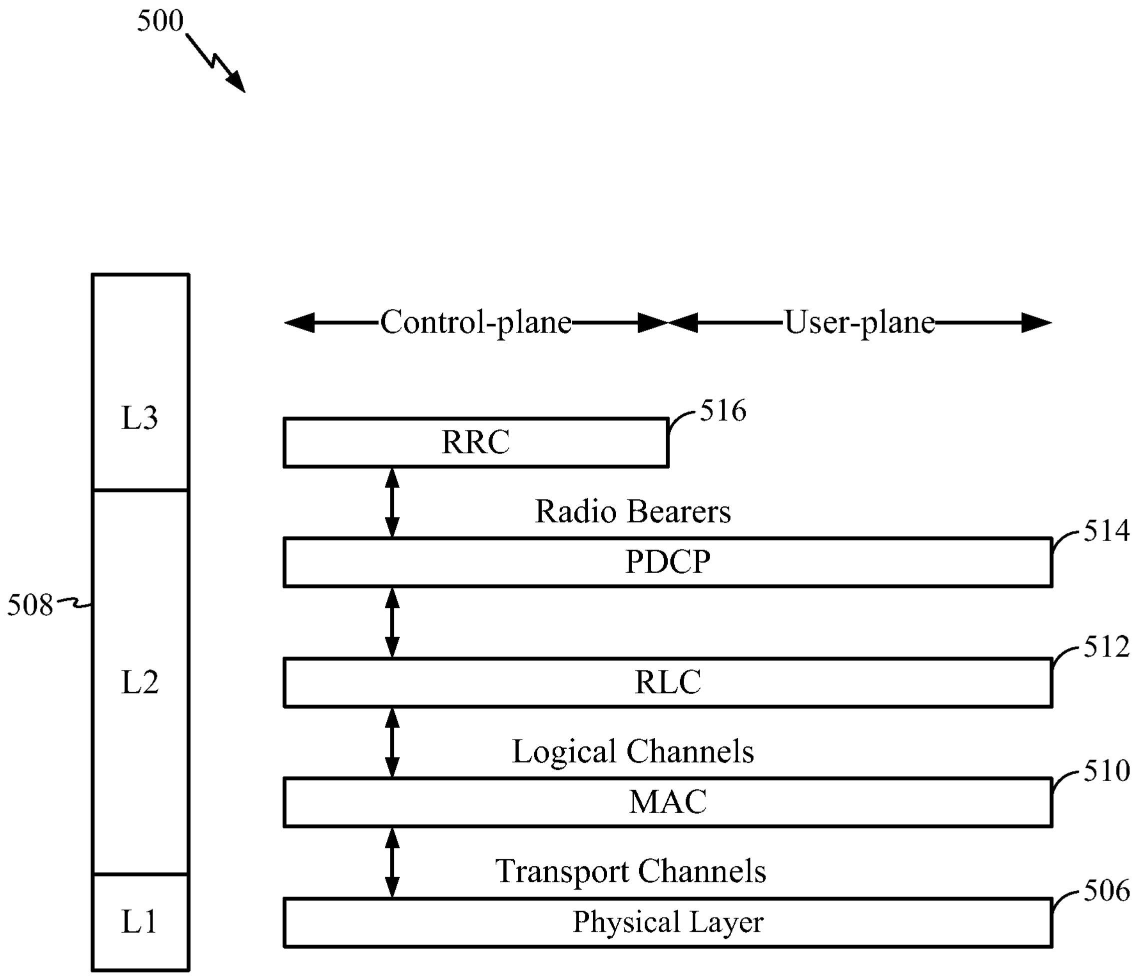

500
Control-plane
User-plane
L3
L2
L1
508
RRC
516
Radio Bearers
PDCP
514
RLC
512
Logical Channels
MAC
510
Transport Channels
Physical Layer
506

FIG. 5

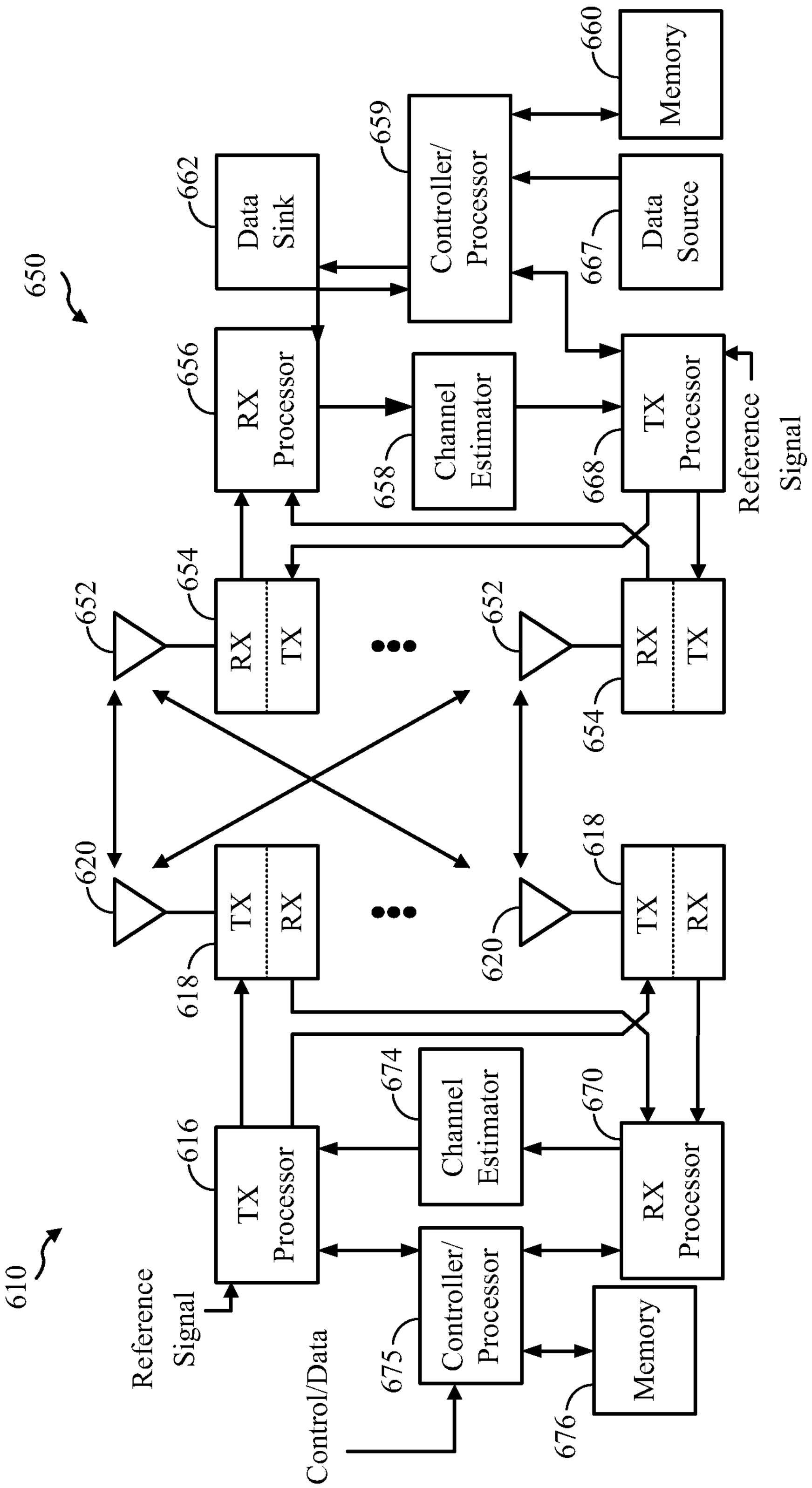
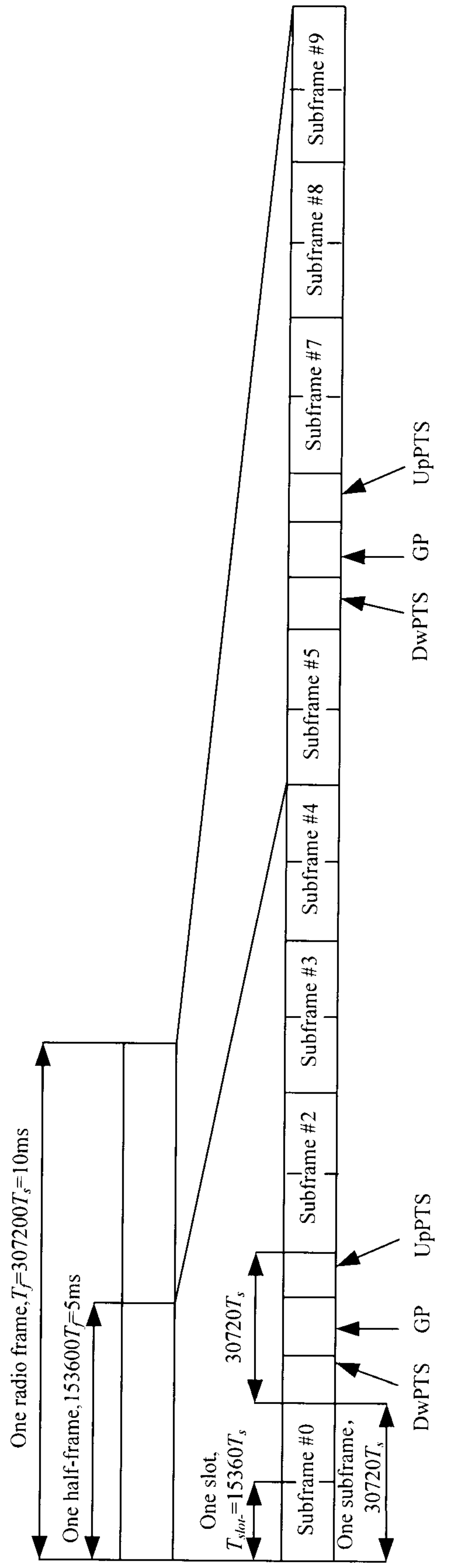

610
650
Reference Signal
616
TX Processor
674
Channel Estimator
670
RX Processor
675
Controller/ Processor
Control/Data
676
Memory
618
TX
RX
620
652
654
RX
TX
656
RX Processor
658
Channel Estimator
668
TX Processor
Reference Signal
662
Data Sink
659
Controller/ Processor
667
Data Source
660
Memory

FIG. 6

Uplink-downlink configurations.

Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

FIG. 7


One radio frame, T_f=307200T_s=10ms
One half-frame, 153600T_s=5ms
One slot, T_{slot}=15360T_s
30720T_s
Subframe #0
One subframe, 30720T_s
DwPTS
GP
UpPTS
Subframe #2
Subframe #3
Subframe #4
Subframe #5
DwPTS
GP
UpPTS
Subframe #7
Subframe #8
Subframe #9

FLG.8

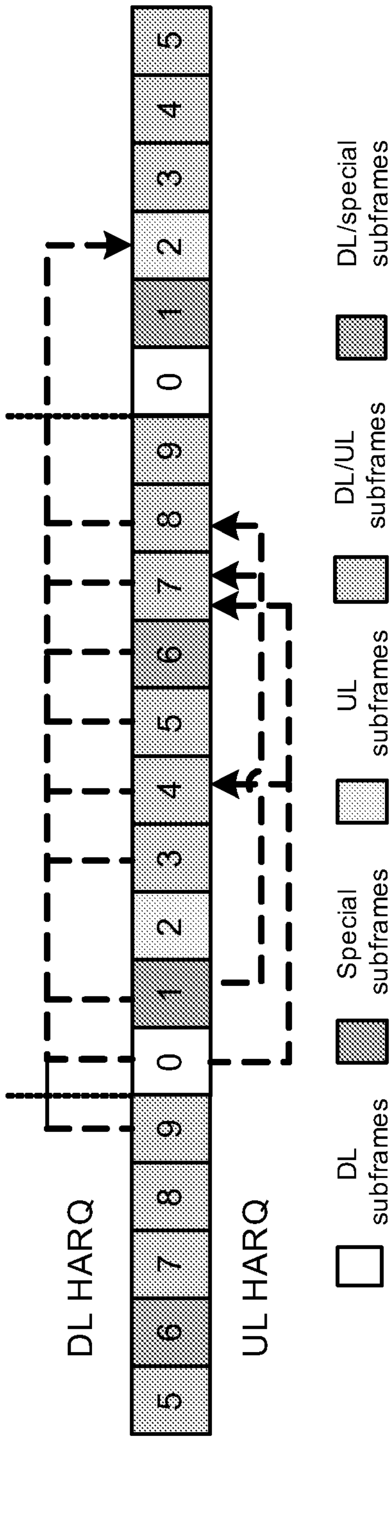

DL HARQ
UL HARQ
5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
DL subframes
Special subframes
UL subframes
DL/UL subframes
DL/special subframes

FIG. 9

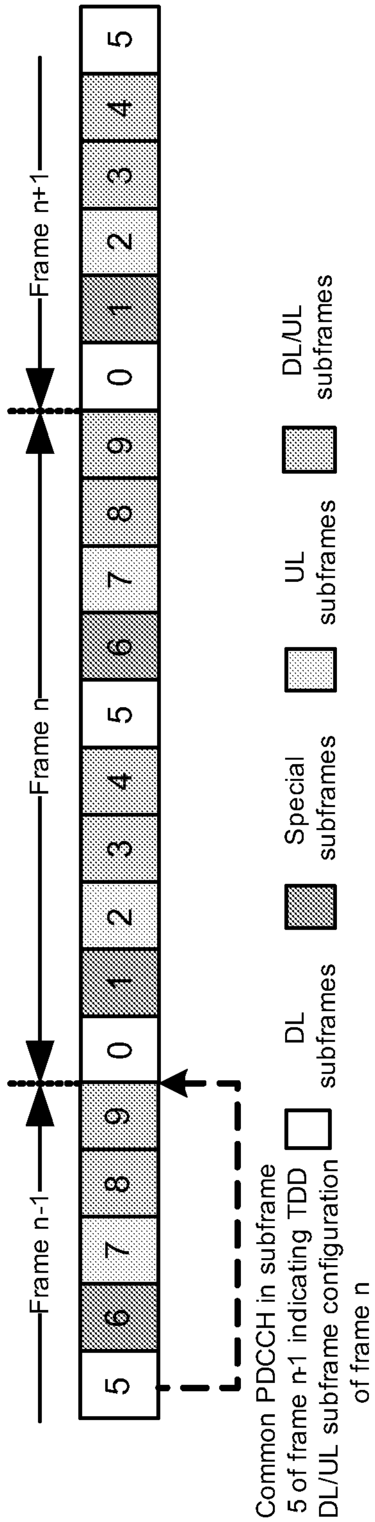

Frame n-1
Frame n
Frame n+1
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
Common PDCCH in subframe 5 of frame n-1 indicating TDD DL/UL subframe configuration of frame n
DL subframes
Special subframes
UL subframes
DL/UL subframes

FIG. 10

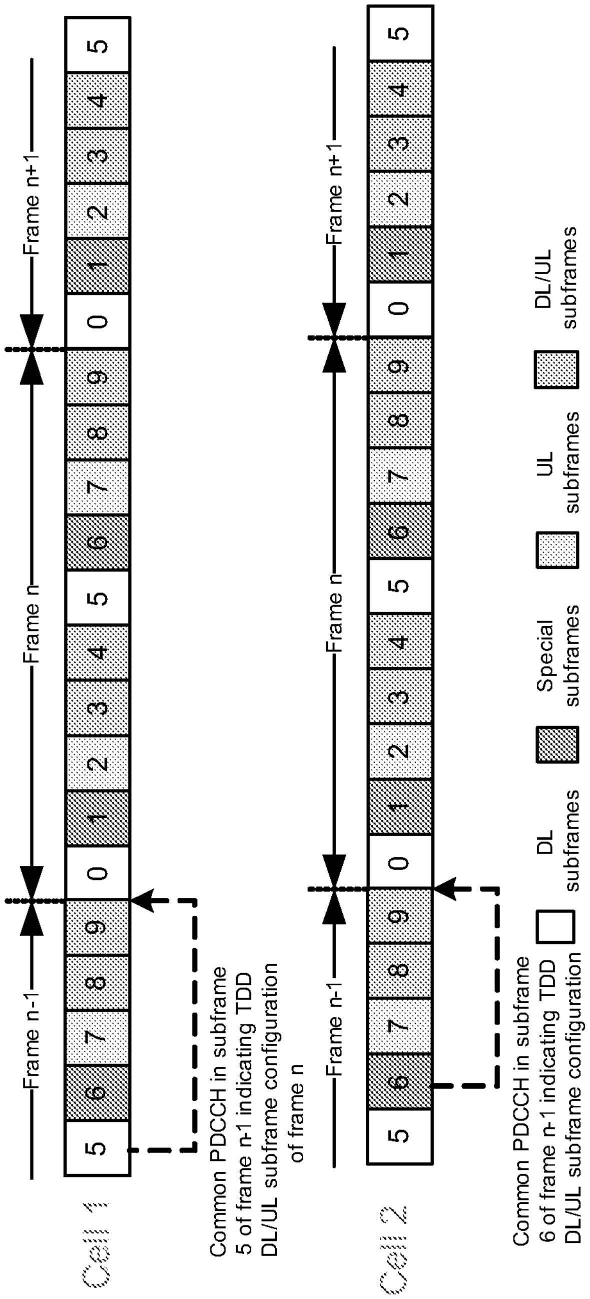

Cell 1
Cell 2
Frame n-1
Frame n
Frame n+1
Common PDCCH in subframe 5 of frame n-1 indicating TDD DL/UL subframe configuration of frame n
Common PDCCH in subframe 6 of frame n-1 indicating TDD DL/UL subframe configuration of frame n
DL subframes
Special subframes
UL subframes
DL/UL subframes

FIG. 11

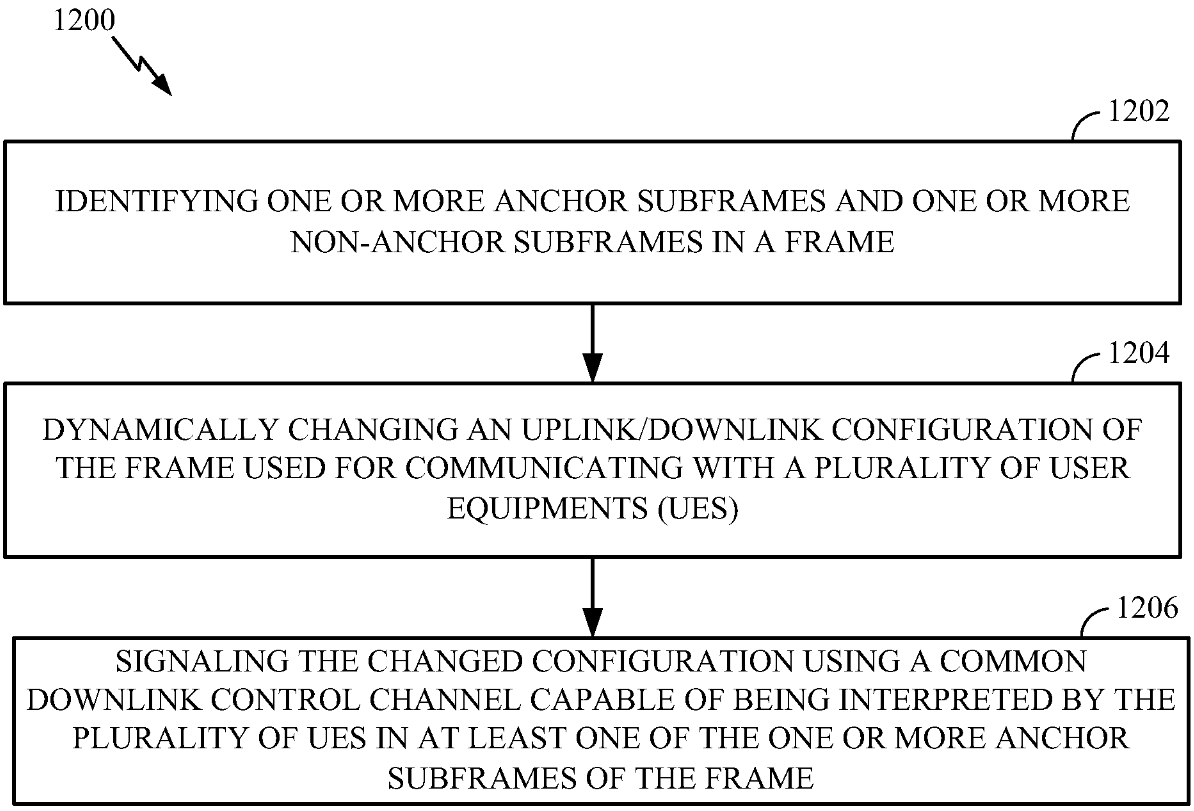

1200
1202
IDENTIFYING ONE OR MORE ANCHOR SUBFRAMES AND ONE OR MORE NON-ANCHOR SUBFRAMES IN A FRAME
1204
DYNAMICALLY CHANGING AN UPLINK/DOWNLINK CONFIGURATION OF THE FRAME USED FOR COMMUNICATING WITH A PLURALITY OF USER EQUIPMENTS (UES)
1206
SIGNALING THE CHANGED CONFIGURATION USING A COMMON DOWNLINK CONTROL CHANNEL CAPABLE OF BEING INTERPRETED BY THE PLURALITY OF UES IN AT LEAST ONE OF THE ONE OR MORE ANCHOR SUBFRAMES OF THE FRAME

FIG. 12

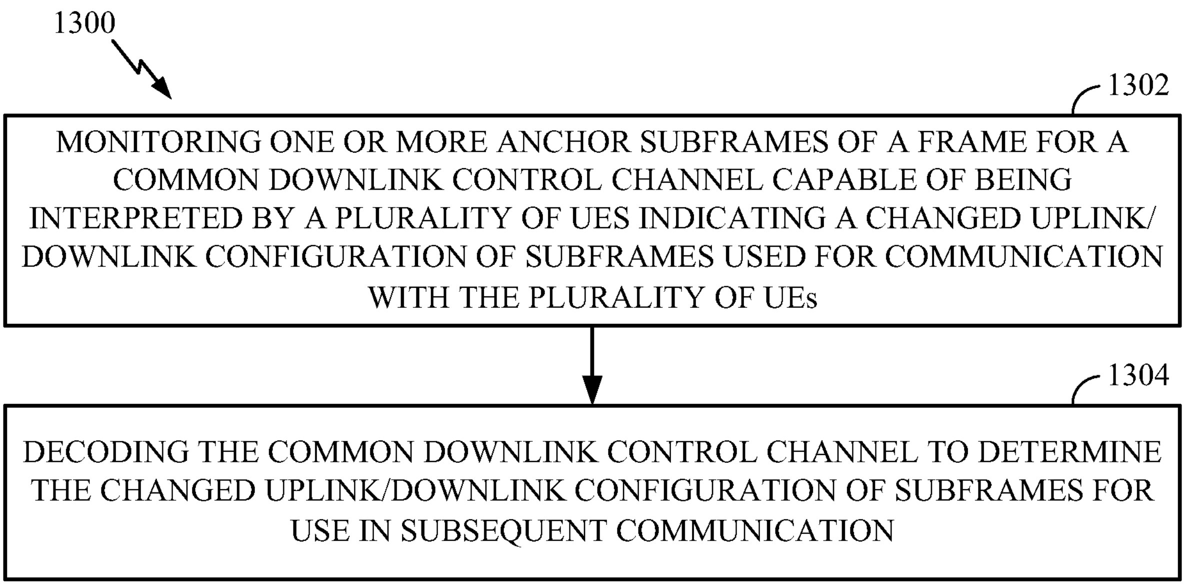

1300
1302
MONITORING ONE OR MORE ANCHOR SUBFRAMES OF A FRAME FOR A COMMON DOWNLINK CONTROL CHANNEL CAPABLE OF BEING INTERPRETED BY A PLURALITY OF UES INDICATING A CHANGED UPLINK/ DOWNLINK CONFIGURATION OF SUBFRAMES USED FOR COMMUNICATION WITH THE PLURALITY OF UEs
1304
DECODING THE COMMON DOWNLINK CONTROL CHANNEL TO DETERMINE THE CHANGED UPLINK/DOWNLINK CONFIGURATION OF SUBFRAMES FOR USE IN SUBSEQUENT COMMUNICATION

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/080330

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)

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, EPODOC, WPI: wireless, anchor, subframe, frame, dynamic, change, adjust, config, configure, downlink, DL, uplink, UL, DCI, CRC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103023614A (NEW POST COMMUNICATION EQUIPMENT CO., LTD.) 03 April 2013 (2013-04-03) the abstract, description, paragraphs [0008] to [0015], [0022] to [0051]	28-55
Y	CN 103023614A (NEW POST COMMUNICATION EQUIPMENT CO., LTD.) 03 April 2013 (2013-04-03) the abstract, description, paragraphs [0008] to [0015], [0022] to [0051]	1-27
Y	US 2013044651A1 (WANG, YIPING ET AL.) 21 February 2013 (2013-02-21) the abstract, description, paragraphs [0017] to [0021], [0035] to [0069]	1-27
A	WO 2012148222A2 (LG ELECTRONICS INC. ET AL.) 01 November 2012 (2012-11-01) the whole document	1-55
A	CN 102594438A (ZTE CORPORATION) 18 July 2012 (2012-07-18) the whole document	1-55

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 April 2014	**12 May 2014**

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

International application No.
PCT/CN2013/080330

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 103023614A	03 April 2013	None	
US 2013044651A1	21 February 2013	TW 201318391A	01 May 2013
		WO 2013025290A1	21 February 2013
		CA 2844857A1	21 February 2013
WO 2012148222A2	01 November 2012	US 2014003381A1	02 January 2014
		CN 103503344A	08 January 2014
		KR 20140012675A	03 February 2014
		EP 2702713A2	05 March 2014
CN 102594438A	18 July 2012	WO 2012094922A1	19 July 2012