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(54) Title: METHOD AND APPARATUS FOR ADAPTED CARRIER AGGREGATION SIGNALING TO SUPPORT FLEXIBLE TDD UL/DL RECONFIGURATION

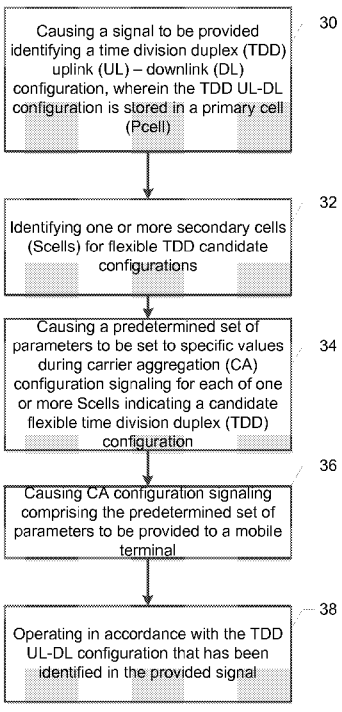


FIG. 3

(57) Abstract: A method, apparatus and computer program product are provided to support TDD UL/DL reconfiguration, such as to adapt to traffic within a respective cell. The method, apparatus and computer program product may identify one or more secondary cells (Scells) for flexible TDD configuration, cause a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration, and cause CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal. To change TDD configuration, an activation signal may be provided, activating a Scell associated with a second TDD UL-DL configuration. For a second change, a deactivation signal may be provided deactivating the Scell associated with the second TDD UL-DL configuration and a new activation signal may be provided.

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METHOD AND APPARATUS FOR ADAPTED CARRIER AGGREGATION SIGNALING TO SUPPORT FLEXIBLE TDD UL/DL RECONFIGURATION

TECHNOLOGICAL FIELD

[0001] A method, apparatus and computer program product are provided in accordance with an example embodiment for facilitating time division duplex (TDD) uplink and downlink (UL-DL) reconfiguration via an adapted carrier aggregation (CA) signal.

BACKGROUND

[0002] One benefit of deploying a time division duplex (TDD) system is the allowance for asymmetric uplink (UL) and downlink (DL) allocations. According to the 3GPP specification, the asymmetric resource allocation in LTE provides seven different semi-statically configured uplink-downlink (UL-DL) configurations. In current LTE deployment, same TDD configuration in each cell is assumed, since otherwise interference between UL and DL including both basestation-to-basestation and UE-to-UE interference needs to be considered. However, in local area (LA) network, due to small number of active user equipment (UE) per cell, the traffic situation may fluctuate frequently. TDD reconfiguration may be used to adapt to the traffic and provide improved resource efficiency and power savings.

[0003] In regard to TDD UL/DL reconfiguration, several different time scales for such reconfiguration have been considered in support of different time scales. For example, SIB signaling supports a minimum 640ms time scale for TDD reconfiguration. RRC level signaling – support minimum 200ms time scale for TDD reconfiguration. MAC level signaling supports a dozens of millisecond (ms) time scale for TDD reconfiguration, and PHY level signaling supports a minimum 10ms time scale for TDD reconfiguration. Among RRC signaling, MAC signaling and PHY signaling, MAC signaling can support much smaller time scale than RRC

signaling and be more reliable than PHY signaling because of HARQ functionality. Current CA activation/deactivation is in MAC signaling format.

[0004] In small cell scenario, the number of mobile terminals per cell is relatively small which results in variable DL/UL traffic for the small cell. By flexible TDD, i.e. flexible adjustment of the number of DL/UL subframes number in the cell, ideally an access point (e.g., radio resource) can adapt to traffic variant so that the radio resource can be fully utilized. Based on a study in 3GPP, it was observed more frequent TDD UL/DL resource reconfiguration can achieve more gains on DL/UL throughput. However, in the current specification, TDD UL/DL resource is reconfigured by SIB1 signaling, which may only support larger than a 640ms time scale for TDD reconfiguration. This time scale is rather long and the gains of flexible TDD cannot be fully exploited.

BRIEF SUMMARY

[0005] A method, apparatus and computer program product are provided in accordance with an example embodiment of the present invention in order to support TDD UL/DL reconfiguration, such as to adapt to traffic within a respective cell, utilizing adapted CA signaling. Mobile devices capable of flexible TDD may initially be configured with TDD UL/DL configuration indicated in, for example, SIB1 signaling. The base station, for example, eNB, may then use MAC signaling to indicate a TDD UL-DL configuration change.

[0006] In one embodiment, a method is provided that includes causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell). The method of this embodiment also identifies one or more secondary cells (Scells) for flexible TDD configuration and causes a predetermined set of parameters to be set to specific values during carrier

aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. In this embodiment, the method also causes CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal and thereafter operates in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0007] In another embodiment, an apparatus is provided that includes at least one processor and at least one memory including computer program code with the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to cause a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell). The at least one memory and the computer program code are also configured to, with the at least one processor, cause the apparatus of this embodiment to identify one or more secondary cells (Scells) for flexible TDD configuration and to cause a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. In this embodiment, the at least one memory and the computer program code are also configured to, with the at least one processor, cause the apparatus to cause CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal and to thereafter operate in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0008] In a further embodiment, a computer program product is provided that includes at least one non-transitory computer-readable storage medium having computer-executable program code portions stored therein with the computer-executable program code portions including program code instructions for causing a signal to be provided identifying a time

division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell). The computer-executable program code portions of this embodiment also include program code instructions for identifying one or more secondary cells (Scells) for flexible TDD configuration and for causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. In this embodiment, the computer-executable program code portions also include program code instructions for causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal and for thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0009] In yet another embodiment, an apparatus is provided that includes means for causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell). The apparatus of this embodiment also includes means for identifying one or more secondary cells (Scells) for flexible TDD configuration and means for causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. I n this embodiment, the apparatus also includes means for causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal and means for thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0010] In one embodiment, a method is provided that includes receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration and causing the TDD UL-DL configuration to be stored in a primary cell (Pcell). The method of this embodiment also

includes receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. In this embodiment, the method also includes causing the candidate flexible TDD configurations to be stored with the associated Scells and thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0011] In another embodiment, an apparatus is provided that includes at least one processor and at least one memory including computer program code with the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to receive a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration and to cause the TDD UL-DL configuration to be stored in a primary cell (Pcell). The at least one memory and the computer program code are also configured to, with the at least one processor, cause the apparatus of this embodiment to receive carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. In this embodiment, the at least one memory and the computer program code are also configured to, with the at least one processor, cause the apparatus to cause the candidate flexible TDD configurations to be stored with the associated Scells and to thereafter operate in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0012] In a further embodiment, a computer program product is provided that includes at least one non-transitory computer-readable storage medium having computer-executable program code portions stored therein with the computer-executable program code portions including program code instructions for receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration and for causing the TDD UL-DL

configuration to be stored in a primary cell (Pcell). The computer-executable program code portions of this embodiment also include program code instructions for receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. In this embodiment, the computer-executable program code portions also include program code instructions for causing the candidate flexible TDD configurations to be stored with the associated Scells and program code instructions for thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0013] In yet another embodiment, an apparatus is provided that includes means for receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration and means for causing the TDD UL-DL configuration to be stored in a primary cell (Pcell). The apparatus of this embodiment also includes means for receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. The apparatus may further include means for causing the candidate flexible TDD configurations to be stored with the associated Scells and means for thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Having thus described certain embodiments of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[0015] Figure 1 is a schematic representation of a system including access point and one or more mobile terminals that may be specifically configured in accordance with an example embodiment of the present invention;

[0016] Figure 2 is a block diagram of an apparatus that may be embodied by an access or a mobile terminal and that may be specifically configured in accordance with an example embodiment of the present invention;

[0017] Figure 3 a flow chart illustrating operations (performed e.g. by an example base station) in accordance with some example embodiments of the present invention;

[0018] Figure 4 is a flow chart illustrating operations (performed e.g. by an example base station) in accordance with some example embodiments of the present invention; and

[0019] Figure 5 is a flow chart illustrating example operations (performed e.g. by an example mobile terminal) in accordance with some example embodiments of the present invention.

DETAILED DESCRIPTION

[0020] The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the inventions are shown. Indeed, these inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0021] As used in this application, the term “circuitry” refers to all of the following: (a)hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software

(including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

[0022] This definition of "circuitry" applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or application specific integrated circuit for a mobile phone or a similar integrated circuit in server, a cellular network device, or other network device.

[0023] A method, apparatus and computer program product are provided in accordance with an example embodiment of the present invention in order to support TDD UL/DL reconfiguration. For example, the TDD UL/DL reconfiguration supported by embodiments of the present invention may permit the TDD UL/DL configuration to adapt to traffic within a respective cell. In one embodiment, a method, apparatus and computer program product are provided in order to facilitate TDD UL-DL reconfiguration via an adapted CA signal. The method, apparatus and computer program product of this embodiment avoid designing a new signaling method and may fully reuse HARQ agreements of CC specific TDD configuration, thereby avoiding hard and long discussion for HARQ timeline and procedure.

[0024] Referring now to Figure 1, a system that supports communications between a plurality of mobile terminals 10 (one of which is illustrated by way of example) and a network 14, such as an 802.11 network, a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, a Global Systems for Mobile communications (GSM) network, a Code Division

Multiple Access (CDMA) network, e.g., a Wideband CDMA (WCDMA) network, a CDMA2000 network or the like, a General Packet Radio Service (GPRS) network or other type of network, via an access point 12 is shown. The network may be a non-uniform network, such as a non-uniform universal mobile telecommunications systems (UMTS) terrestrial radio access network (UTRAN) LTE network that may include one or more macro, pico and/or femto cells. Various types of mobile terminals may be employed including, for example, mobile communication devices or user equipment such as, for example, mobile telephones, smartphones, personal digital assistants (PDAs), pagers, laptop computers, tablet computers or any of numerous other hand held or portable communication devices, computation devices, content generation devices, content consumption devices, or combinations thereof. Regardless of the type of mobile terminal, the mobile terminal may communicate with the network via an access point, such as a base station, a Node B, an evolved Node B (eNB), a relay node or other type of access point.

[0025] The mobile terminal 10 and a network entity, such as the access point 12, may each embody or otherwise be associated with an apparatus 20 that is generally depicted in Figure 2 and that may be configured to perform various operations in accordance with an example embodiment of the present invention as described below, such as in conjunction with Figures 6 and 8 from the perspective of the mobile terminal and Figures 3 and 7 from the perspective of a network entity, such as the access point. However, it should be noted that the components, devices or elements described below may not be mandatory and thus some may be omitted in certain embodiments. Additionally, some embodiments may include further or different components, devices or elements beyond those shown and described herein.

[0026] As shown in Figure 2, the apparatus 20 may include or otherwise be in communication with a processing system including, for example, processing circuitry 22 that is

configurable to perform actions in accordance with example embodiments described herein. The processing circuitry may be configured to perform data processing, application execution and/or other processing and management services according to an example embodiment of the present invention. In some embodiments, the apparatus or the processing circuitry may be embodied as a chip or chip set. In other words, the apparatus or the processing circuitry may comprise one or more physical packages (e.g., chips) including materials, components and/or wires on a structural assembly (e.g., a baseboard). The structural assembly may provide physical strength, conservation of size, and/or limitation of electrical interaction for component circuitry included thereon. The apparatus or the processing circuitry may therefore, in some cases, be configured to implement an embodiment of the present invention on a single chip or as a single "system on a chip." As such, in some cases, a chip or chipset may constitute means for performing one or more operations for providing the functionalities described herein.

[0027] In an example embodiment, the processing circuitry 22 may include a processor 24 and memory 26 that may be in communication with or otherwise control a communication interface 28 and, in some cases in which the apparatus is embodied by the mobile terminal 10, a user interface 30. As such, the processing circuitry may be embodied as a circuit chip (e.g., an integrated circuit chip) configured (e.g., with hardware, software or a combination of hardware and software) to perform operations described herein. However, in some embodiments, the processing circuitry may be embodied as a portion of mobile terminal or the access point.

[0028] The user interface 30 (if implemented in embodiments of the apparatus 20 embodied by the mobile terminal 10) may be in communication with the processing circuitry 22 to receive an indication of a user input at the user interface and/or to provide an audible, visual, mechanical or other output to the user. As such, the user interface may include, for example, a keyboard, a mouse, a joystick, a display, a touch screen, a microphone, a speaker, and/or other input/output

mechanisms. In one embodiment, the user interface includes user interface circuitry configured to facilitate at least some functions of the station by receiving user input and providing output.

[0029] The communication interface 28 may include one or more interface mechanisms for enabling communication with other devices and/or networks. In some cases, the communication interface may be any means such as a device or circuitry embodied in either hardware, or a combination of hardware and software that is configured to receive and/or transmit data from/to a network 14 and/or any other device or module in communication with the processing circuitry 22, such as between the mobile terminal 10 and the access point 12. In this regard, the communication interface may include, for example, an antenna (or multiple antennas) and supporting hardware and/or software for enabling communications with a wireless communication network and/or a communication modem or other hardware/software for supporting communication via cable, digital subscriber line (DSL), universal serial bus (USB), Ethernet or other methods.

[0030] In an example embodiment, the memory 26 may include one or more non-transitory memory devices such as, for example, volatile and/or non-volatile memory that may be either fixed or removable. The memory may be configured to store information, data, applications, instructions or the like for enabling the apparatus 20 to carry out various functions in accordance with example embodiments of the present invention. For example, the memory could be configured to buffer input data for processing by the processor 24. Additionally or alternatively, the memory could be configured to store instructions for execution by the processor. As yet another alternative, the memory may include one of a plurality of databases that may store a variety of files, contents or data sets. Among the contents of the memory, applications may be stored for execution by the processor in order to carry out the functionality associated with each

respective application. In some cases, the memory may be in communication with the processor via a bus for passing information among components of the apparatus.

[0031] The processor 24 may be embodied in a number of different ways. For example, the processor may be embodied as various processing means such as one or more of a microprocessor or other processing element, a coprocessor, a controller or various other computing or processing devices including integrated circuits such as, for example, an ASIC (application specific integrated circuit), an FPGA (field programmable gate array), or the like. In an example embodiment, the processor may be configured to execute instructions stored in the memory 26 or otherwise accessible to the processor. As such, whether configured by hardware or by a combination of hardware and software, the processor may represent an entity (e.g., physically embodied in circuitry – in the form of processing circuitry) capable of performing operations according to embodiments of the present invention while configured accordingly. Thus, for example, when the processor is embodied as an ASIC, FPGA or the like, the processor may be specifically configured hardware for conducting the operations described herein. Alternatively, as another example, when the processor is embodied as an executor of software instructions, the instructions may specifically configure the processor to perform the operations described herein.

[0032] An access point 12 and a mobile terminal 10 may initially be configured to communicate in accordance with a first Time Division Duplex (TDD) uplink (UL) / downlink (DL) configuration that defines the link direction of the various subframes such that the subframes are identified as being either an UL subframe or a DL subframe. The first TDD UL/DL configuration may be established based upon system information that is transmitted from the access point to the mobile terminal that identifies the first TDD UL/DL configuration. Although the system information may be provided in a variety of different manners, the system

information that defines the first TDD UL/DL configuration may be provided by the system information block 1 (SIB 1). Although the first TDD UL/DL configuration may be defined in various manners, the first TDD UL/DL configuration may be defined by the system information to be one of a plurality of predefined TDD UL/DL configurations, such as TDD UL/DL configuration 0, TDD UL/DL configuration 1, ... TDD UL/DL configuration 7. Each of the predefined TDD UL/DL configurations has one or more TDD UL/DL configuration candidates that share the same, e.g., have common, DL subframes to facilitate backwards compatibility, as indicated above in Table 1.

[0033] Figure 3 depicts the operations performed in order to facilitate TDD UL-DL reconfiguration via an adapted CA signal, such as between a mobile terminal 10 and the access point 12 as shown in solid lines in Figure 1. The method may be performed by a processing means, such as the processor 22, a processing system, a processing system and/or processing circuitry described above with respect to Figure 2.

[0034] Referring now to Figure 3, the operations performed by a method, apparatus and computer program product of an example embodiment are illustrated from the perspective of an apparatus 20 that may be embodied by or otherwise associated with an access point 12.

[0035] As shown in block 30 of Figure 3, the apparatus 20 embodied by the access point 12 may be configured to cause a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration.

[0036] The one or more second TDD UL/DL configurations may be signaled to the mobile terminal in various manners including with higher layer signaling, such as RRC, master

information block (MIB) or SIB signaling. In one embodiment, the TDD UL-DL configuration that is indicated in SIB1 may be stored in a primary cell (Pcell).

[0037] As shown in block 32 of Figure 3, the apparatus 20 embodied by the access point 12 may be configured to identify one or more secondary cells (Scells) for flexible TDD candidate configurations. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for identifying one or more secondary cells (Scells) for flexible TDD candidate configurations.

[0038] As shown in block 34 of Figure 3, the apparatus 20 embodied by the access point 12 may be configured to cause a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration.

[0039] In one embodiment of the present invention, the causing of a predetermined set of parameters to be set to specific values further comprises, for each of the one or more Scells identified, causing a value of a physical cell identifier (ID) and a downlink carrier frequency to be set to a value of a Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal. Additionally or alternatively, the causing of a predetermined set of parameters to be set to specific values may further comprise for each of the one or more Scells identified, causing the TDD UL-DL configuration to be set to one of a plurality of candidate TDD configurations.

[0040] In a specific embodiment, and for exemplary purposes only, currently in LTE specification, CA configuration is via RRC signaling and CA activation/deactivation is via MAC signaling. CA signaling may be defined 3GPP TS 36.331. The Activation/Deactivation MAC control element may be identified by a MAC PDU subheader with LCID and may have a fixed size and consist of a single octet containing seven C-fields and one R-field. The Activation/Deactivation MAC control element may be defined as follows: C_i: if there is an Scell configured with SCellIndex i, this field indicates the activation/deactivation status of the SCell with SCellIndex i , else the UE shall ignore the C_i field. The C_i field is set to "1" to indicate that the SCell with SCellIndex i shall be activated. The C_i field is set to "0" to indicate that the SCell with SCellIndex i shall be deactivated; and R: Reserved bit, set to “0”.

[0041] Continuing the above example, in SCellToAddMod-r10, for cellIdentification-r10, the value of physCellId-r10 and dl-CarrierFreq-r10 may be set to the same value of a UE’s Pcell physical cell ID and carrier frequency. In RadioResourceConfigCommonSCell-r10, tdd-Config-r10 may be one of the candidate TDD configurations. More specifically, in one embodiment, SIB1 may indicate TDD configuration is 0, and a candidate flexible TDD configuration may be 1, 2, 6. The mobile device may then regard TDD configuration 0 indicated in SIB1 as Pcell. The access point, may then configure a number of, for example, three Scells, for candidate flexible TDD configurations. In one embodiment, physCellId-r10 and dl-CarrierFreq-r10 of all three Scells may be set to the physical cell ID and DL frequency of Pcell. Additionally, tdd-Config-r10 of Scell 1, 2, 3 may be set to TDD UL/DL configuration 1, 2, 6 respectively.

[0042] As shown in block 36 of Figure 3, the apparatus 20 embodied by the access point 12 may be configured to cause CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a

processing system, the communication interface 26 or the like, for causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal.

[0043] With regard to the above example, when the mobile device receives such CA configuration signaling, the three Scell configurations may be saved as the candidate flexible TDD configurations. In one embodiment, if the mobile device not configured with a normal CA, there may be maximally 5 candidate flexible TDD configurations. In above-mentioned example, a mobile device's serving cell may be:

	TDD UL/DL configuration	How to configure
Pcell	0	By SIB1
Scell 1	1	By CA configuration signaling
Scell 2	2	By CA configuration signaling
Scell 3	6	By CA configuration signaling

[0044] As shown in block 38 of Figure 3, the apparatus 20 embodied by the access point 12 may be configured to operate operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0045] Figure 4 depicts the operations performed in order to facilitate a change in TDD UL-DL configuration. The method may be performed by a processing means, such as the processor 22, a processing system, a processing system and/or processing circuitry described above with respect to Figure 2.

[0046] Referring now to Figure 4, the operations performed by a method, apparatus and computer program product of an example embodiment are illustrated from the perspective of an apparatus 20 that may be embodied by or otherwise associated with an access point 12.

[0047] As shown in block 40 of Figure 4, the apparatus 20 embodied by the access point 12 may be configured to determine that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for determining that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration.

[0048] As shown in block 42 of Figure 4, the apparatus 20 embodied by the access point 12 may be configured to identify the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for identifying the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration.

[0049] For example, if an access point, or eNB, an Scell activation command may be provided to the mobile device. For example, a mobile device may be initially configured as TDD configuration 0 and a change to TDD configuration 1 may be facilitated. The access point may send an Scell activation command to activate Scell 1. When the mobile device receives such activation command, current CA activation procedures, (e.g., 3GPP Release 10), may be followed to activate Scell 1, i.e. to change to TDD configuration 1. Additionally or alternatively, current CA activation procedures may be followed and one or more new behaviors may be followed. For example, in one embodiment, if there are equal or more than two activated Scells in the activation command, the mobile device may regard this as an error and abandon the

activation signaling. Additionally or alternatively, the mobile device may regard Pcell to be still running on the same frequency with same physical cell id.

[0050] Additionally or alternatively, in one embodiment, when the mobile device receives control signaling scrambled with RA-RNTI, SI-RNTI, P-RNTI, M-RNTI, (SPS C-RNTI), the mobile device may receive these RNTIs and corresponding data on Pcell. HARQ timing for above data may follow Pcell's timing that may be agreed for CC specific TDD configuration.

[0051] Additionally or alternatively, in one embodiment, when the mobile device receives C-RNTI, Temporary C-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, (SPS C-RNTI), the mobile device may receive these RNTIs and corresponding data on Scell. HARQ timing for above data may follow Scell's timing that may be agreed for CC specific TDD configuration.

[0052] As shown in block 44 of Figure 4, the apparatus 20 embodied by the access point 12 may be configured to determine that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for determining that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration.

[0053] As shown in block 46 of Figure 4, the apparatus 20 embodied by the access point 12 may be configured to identify the third TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for identifying the third TDD UL-DL configuration by

providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration.

[0054] As shown in block 48 of Figure 4, the apparatus 20 embodied by the access point 12 may be configured to cause an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for causing an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration.

[0055] With regard to the above example, where a change at the mobile device from TDD configuration 1 to TDD configuration 2 may be facilitated, then the access point may send the activation/deactivation command to deactivate Scell 1 and activate Scell 2. In one embodiment, when the mobile device receives such command, the mobile device may change the TDD configuration from 1 to 2. The activation procedure may be the same as above. Additionally or alternatively, for deactivation procedure, the mobile device may follow existing deactivation procedure, (e.g., 3GPP Release 10). Alternatively, for deactivation procedure, the mobile device may follow existing deactivation procedure, (e.g., 3GPP Release 10), except for the mobile device may not flush the HARQ buffer and/or if no other Scell is activated, the mobile device may continue all DL reception and UL transmission in Pcell, i.e. on TDD UL-DL configuration indicated in SIB1.

[0056] Figure 5 depicts the operations performed in order to facilitate TDD UL-DL reconfiguration at a mobile device via a received adapted CA signal, such as between a mobile terminal 10 and the access point 12 as shown in solid lines in Figure 1. The method may be

performed by a processing means, such as the processor 22, a processing system, a processing system and/or processing circuitry described above with respect to Figure 2.

[0057] Referring now to Figure 5, the operations performed by a method, apparatus and computer program product of an example embodiment are illustrated from the perspective of an apparatus 20 that may be embodied by or otherwise associated with a mobile terminal 10.

[0058] As shown in block 50 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to receive a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration.

[0059] As shown in block 52 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to cause the TDD UL-DL configuration that may be indicated in SIB1 to be stored in a primary cell (Pcell). The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for causing the TDD UL-DL configuration that may be indicated in SIB1 to be stored in a primary cell (Pcell).

[0060] As shown in block 54 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to receive carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of

parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration.

[0061] As shown in block 56 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to cause the candidate flexible TDD configurations to be stored with the associated Scells. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for causing the candidate flexible TDD configurations to be stored with the associated Scells.

[0062] As shown in block 58 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to operate in accordance with the TDD UL-DL configuration that has been identified in the provided signal. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

[0063] As shown in block 60 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to receive an Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for receiving a Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration.

[0064] As shown in block 62 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to receive an Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a

processing system, the communication interface 26 or the like, for receiving a Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration.

[0065] As shown in block 64 of Figure 5, the apparatus 20 embodied by the mobile terminal may be configured to receive an Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration. The apparatus embodied by the access point may therefore include means, such as the processor 22, a processing system, processing circuitry, a processing system, the communication interface 26 or the like, for receiving a Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration.

[0066] Figures 3, 4 and 5 are flowcharts illustrating the operations performed by a method, apparatus and computer program product, such as apparatus 20 of Figure 2, in accordance with one embodiment of the present invention. It will be understood that each block of the flowcharts, and combinations of blocks in the flowcharts, may be implemented by various means, such as hardware, firmware, processor, circuitry and/or other device associated with execution of software including one or more computer program instructions. For example, one or more of the procedures described above may be embodied by computer program instructions. In this regard, the computer program instructions which embody the procedures described above may be stored by a non-transitory memory 24 of an apparatus employing an embodiment of the present invention and executed by a processor 22 in the apparatus. As will be appreciated, any such computer program instructions may be loaded onto a computer or other programmable apparatus (e.g., hardware) to produce a machine, such that the resulting computer or other programmable apparatus provides for implementation of the functions specified in the flowchart blocks. These computer program instructions may also be stored in a non-transitory computer-readable storage memory that may direct a computer or other programmable apparatus to function in a particular manner, such that the instructions stored in the computer-readable storage memory produce an

article of manufacture, the execution of which implements the function specified in the flowchart blocks. The computer program instructions may also be loaded onto a computer or other programmable apparatus to cause a series of operations to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions which execute on the computer or other programmable apparatus provide operations for implementing the functions specified in the flowchart blocks. As such, the operations of Figures 4 and 5, when executed, convert a computer or processing circuitry into a particular machine configured to perform an example embodiment of the present invention. Accordingly, the operations of Figures 3, 4 and 5 define an algorithm for configuring a computer or processing circuitry, e.g., processor, to perform an example embodiment. In some cases, a general purpose computer may be provided with an instance of the processor which performs the algorithm of Figures 3, 4 and 5 to transform the general purpose computer into a particular machine configured to perform an example embodiment.

[0067] Accordingly, blocks of the flowcharts support combinations of means for performing the specified functions and combinations of operations for performing the specified functions. It will also be understood that one or more blocks of the flowcharts, and combinations of blocks in the flowcharts, can be implemented by special purpose hardware-based computer systems which perform the specified functions, or combinations of special purpose hardware and computer instructions.

[0068] In some embodiments, certain ones of the operations above may be modified or further amplified as described below. It should be appreciated that each of the modifications, optional additions or amplifications below may be included with the operations above either alone or in combination with any others among the features described herein.

[0069] Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Moreover, although the foregoing descriptions and the associated drawings describe example embodiments in the context of certain example combinations of elements and/or functions, it should be appreciated that different combinations of elements and/or functions may be provided by alternative embodiments without departing from the scope of the appended claims. In this regard, for example, different combinations of elements and/or functions than those explicitly described above are also contemplated as may be set forth in some of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

WHAT IS CLAIMED IS:

1. A method comprising:

causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell);

identifying one or more secondary cells (Scells) for flexible TDD configuration;

causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal; and

thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

2. A method according to Claim 1 wherein the causing of a predetermined set of parameters to be set to specific values further comprises:

for each of the one or more Scells identified, causing a value of a physical cell identifier (ID) and a downlink carrier frequency to be set to a value of a Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

3. A method according to any one of Claims 1 or 2, wherein the causing of a predetermined set of parameters to be set to specific values further comprises:

for each of the one or more Scells identified, causing the TDD UL-DL configuration to be set to one of a plurality of candidate TDD configurations.

4. A method according to any of one Claims 1 to 3 further comprising:

determining that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration; and

identifying the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration.

5. A method according to any of one Claims 1 to 4, wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

6. A method according to any of one Claims 1 to 5, further comprising:

determining that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration;

identifying the third TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration; and

causing an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration.

7. An apparatus comprising:

at least one processor; and

at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform:

causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell);

identifying one or more secondary cells (Scells) for flexible TDD configuration;

causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal; and

thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

8. An apparatus according to Claim 7 wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to cause of a predetermined set of parameters to be set to specific values by:

for each of the one or more Scells identified, causing a value of a physical cell identifier (ID) and a downlink carrier frequency to be set to a value of a Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

9. An apparatus according to any one of Claims 7 or 8, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to cause of a predetermined set of parameters to be set to specific values by:

for each of the one or more Scells identified, causing the TDD UL-DL configuration to be set to one of a plurality of candidate TDD configurations.

10. An apparatus according to any of one Claims 7 to 9 wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:

determine that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration; and

identify the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration.

11. An apparatus according to any of one Claims 7 to 10, wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

12. An apparatus according to any of one Claims 7 to 11, wherien the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:

determine that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration;

identify the third TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration; and

cause an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration.

13. An apparatus according to any one of Claims 7 to 12 wherein the apparatus is embodied as an access point.

14. An apparatus according to any one of Claims 7 to 13 wherein the apparatus is configured for use in an Long Term Evolution (LTE) system.

15. An apparatus according to any one of Claims 7 to 14 further comprising a communications interface configured to communicate with the mobile terminal.

16. A computer program product comprising at least one non-transitory computer-readable storage medium having computer-executable program code portions stored therein, the computer-executable program code portions comprising program code instructions for:

causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell);

identifying one or more secondary cells (Scells) for flexible TDD configuration;

causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal; and

thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

17. A computer program product according to Claim 16 wherein the program code instructions for causing of a predetermined set of parameters to be set to specific values further comprise program instructions for:

for each of the one or more Scells identified, causing a value of a physical cell identifier (ID) and a downlink carrier frequency to be set to a value of a Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

18. A computer program product according to any one of Claims 16 or 17, wherein program code instructions for the causing of a predetermined set of parameters to be set to specific values further comprise program code instructions for:

for each of the one or more Scells identified, causing the TDD UL-DL configuration to be set to one of a plurality of candidate TDD configurations.

19. A computer program product according to any of one Claims 16 to 18 wherein the computer-executable program code portions further comprise program code instructions for:

determining that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration; and

identifying the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration.

20. A computer program product according to any of one Claims 16 to 19, wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

21. A computer program product according to any of one Claims 16 to 20, wherein the computer-executable program code portions further comprise program code instructions for:

determining that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration;

identifying the third TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration; and

causing an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration.

22. An apparatus comprising:

means for causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell);

means for identifying one or more secondary cells (Scells) for flexible TDD configuration;

means for causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

means for causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal; and

means for thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

23. An apparatus according to Claim 22 wherein the means for causing of a predetermined set of parameters to be set to specific values further comprises:

for each of the one or more Scells identified, means for causing a value of a physical cell identifier (ID) and a downlink carrier frequency to be set to a value of a Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

24. An apparatus according to any one of Claims 22 or 23, wherein the means for causing of a predetermined set of parameters to be set to specific values further comprises:

for each of the one or more Scells identified, means for causing the TDD UL-DL configuration to be set to one of a plurality of candidate TDD configurations.

25. An apparatus according to any of one Claims 22 to 24 further comprising:

means for determining that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration; and

means for identifying the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration.

26. An apparatus according to any of one Claims 22 to 25, wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

27. An apparatus according to any of one Claims 22 to 26, further comprising:

means for determining that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration;

means for identifying the third TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration; and

means for causing an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration.

28. A method comprising:

receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration;

causing the TDD UL-DL configuration to be stored in a primary cell (Pcell);

receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

causing the candidate flexible TDD configurations to be stored with the associated Scells; and

thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

29. A method according to Claim 28, wherein the receiving of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values further comprises: for each of the one or more Scells identified, receiving a value of a physical cell identifier (ID) and a downlink carrier frequency set to a value of the Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

30. A method according to any one of Claims 28 or 29, wherein the receiving of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values further comprises: for each of the one or more Scells identified, receiving a TDD UL-DL configuration set to one of a plurality of candidate TDD configurations.

31. A method according to any one of Claims 28 to 30, further comprising:

receiving an Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration.

32. A method according to any one of Claims 28 to 31, further comprising:

receiving an Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration; and

receiving an Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration.

33. A method according to any one of Claims 28 to 32,

wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

34. An apparatus comprising:

at least one processor; and

at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform:

receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration;

causing the TDD UL-DL configuration to be stored in a primary cell (Pcell);

receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

causing the candidate flexible TDD configurations to be stored with the associated Scells; and

thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

35. An apparatus according to Claim 34, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to receive of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values by: for each of the one or more Scells identified, receiving a value of a physical cell identifier (ID) and a downlink carrier frequency set to a value of the Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

36. An apparatus according to any one of Claims 34 or 35, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to receive of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values by: for each of the one or more Scells identified, receiving a TDD UL-DL configuration set to one of a plurality of candidate TDD configurations.

37. An apparatus according to any one of Claims 34 to 36, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:

receive an Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration.

38. An apparatus according to any one of Claims 34 to 37, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:

receive an Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration; and

receive an Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration.

39. An apparatus according to any one of Claims 34 to 38,

wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

40. An apparatus according to any one of Claims 34 to 39 wherein the apparatus is embodied as a mobile terminal.

41. An apparatus according to any one of Claims 34 to 40 wherein the apparatus is configured for use in an Long Term Evolution (LTE) system.

42. An apparatus according to any one of Claims 34 to 41 further comprising user interface circuitry configured to facilitate user control of at least some functions based upon user input.

43. A computer program product comprising at least one non-transitory computer-readable storage medium having computer-executable program code portions stored therein, the computer-executable program code portions comprising program code instructions for:

receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration;

causing the TDD UL-DL configuration to be stored in a primary cell (Pcell);

receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

causing the candidate flexible TDD configurations to be stored with the associated Scells; and

thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

44. A computer program product according to Claim 43, wherein the program code instructions for receiving of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values further comprise program code instructions for: for each of the one or more Scells identified, receiving a value of a physical cell identifier (ID) and a downlink carrier frequency set to a value of the Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

45. A computer program product according to any one of Claims 43 or 44, wherein the program code instructions for receiving of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values further comprise program code instructions for: for each of the one or more Scells identified, receiving a TDD UL-DL configuration set to one of a plurality of candidate TDD configurations.

46. A computer program product according to any one of Claims 43 to 45, wherein the computer-executable program code portions further comprise program code instructions for:

receiving an Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration.

47. A computer program product according to any one of Claims 43 to 46, wherein the computer-executable program code portions further comprise program code instructions for:

receiving an Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration; and

receiving an Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration.

48. A computer program product according to any one of Claims 43 to 47,

wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

49. An apparatus comprising:

means for receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration;

means for causing the TDD UL-DL configuration to be stored in a primary cell (Pcell);

means for receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration;

means for causing the candidate flexible TDD configurations to be stored with the associated Scells; and

means for thereafter operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal.

50. An apparatus according to Claim 49, wherein the means for receiving of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values further comprise, for each of the one or more Scells identified, means for receiving a value of a physical cell identifier (ID) and a downlink carrier frequency set to a value of the Pcell physical cell ID and a carrier frequency, respectively, of the mobile terminal.

51. An apparatus according to any one of Claims 49 or 50, wherein the means for receiving of the carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values further comprise, for each of the one or more Scells identified, means for receiving a TDD UL-DL configuration set to one of a plurality of candidate TDD configurations.

52. An apparatus according to any one of Claims 49 to 51, further comprising:
means for receiving an Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration.

53. An apparatus according to any one of Claims 49 to 51, further comprising:
means for receiving an Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration; and
means for receiving an Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration.

54. An apparatus according to any one of Claims 49 to 53,
wherein the Pcell maintains the Pcell physical cell ID and continues running on the carrier frequency.

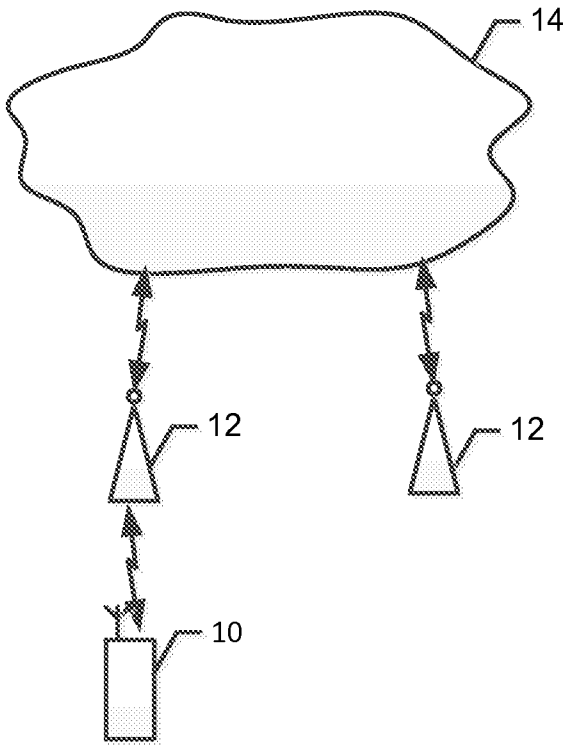


FIG. 1

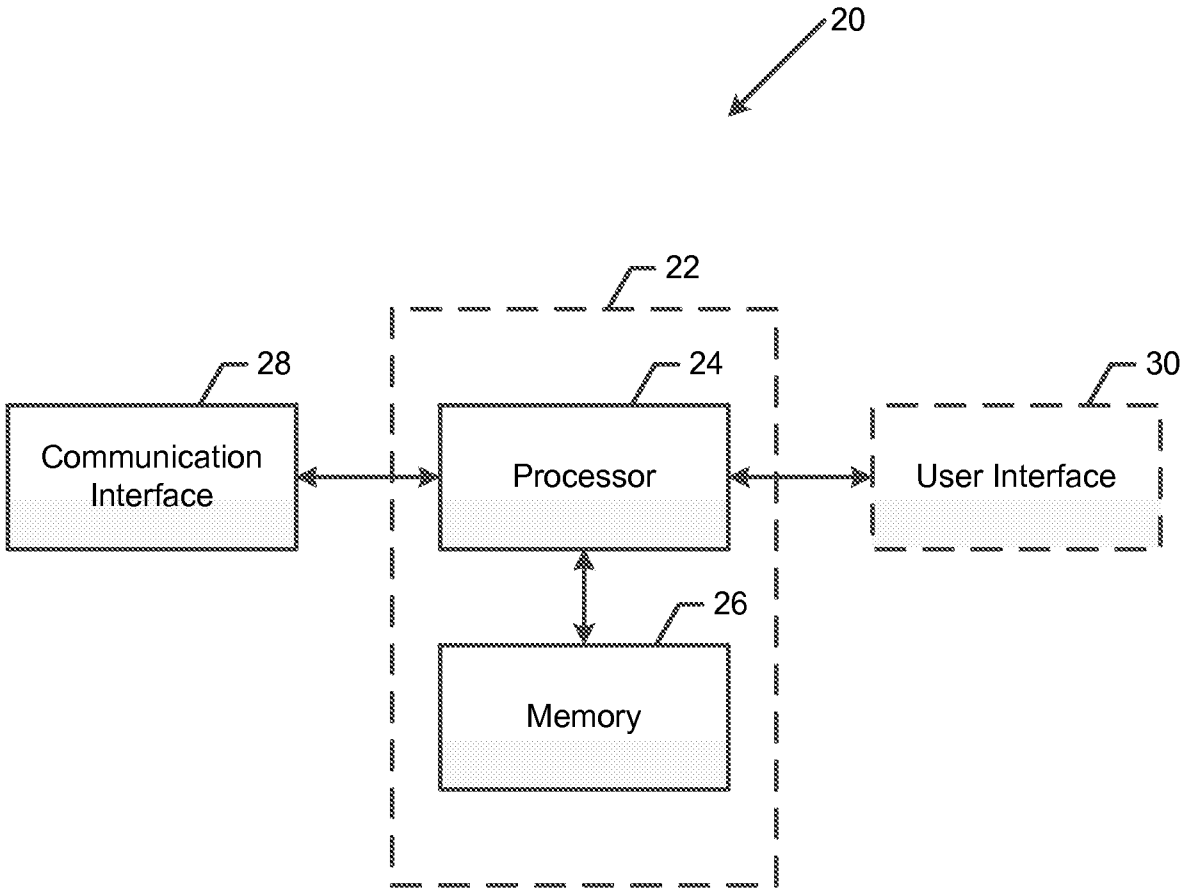

20
22
28
24
30
Communication Interface
Processor
User Interface
26
Memory

FIG. 2

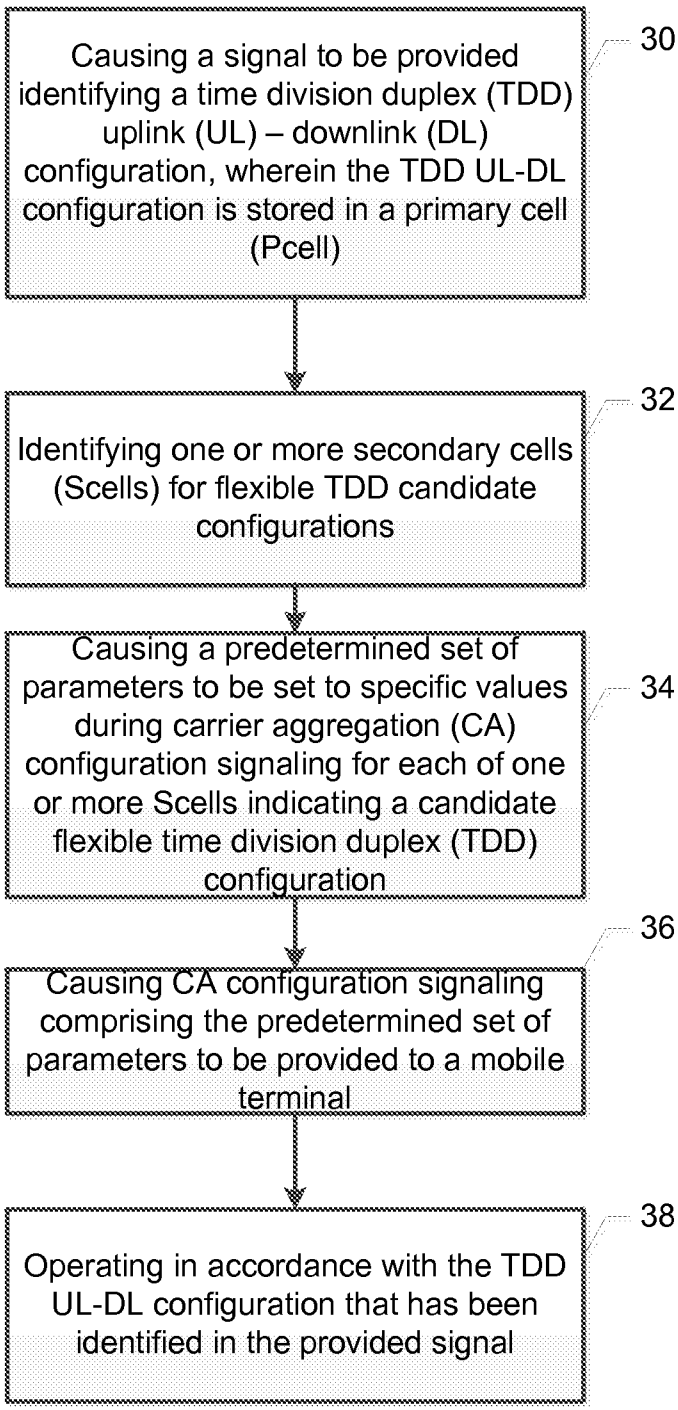

Causing a signal to be provided identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration, wherein the TDD UL-DL configuration is stored in a primary cell (Pcell)
30
Identifying one or more secondary cells (Scells) for flexible TDD candidate configurations
32
Causing a predetermined set of parameters to be set to specific values during carrier aggregation (CA) configuration signaling for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration
34
Causing CA configuration signaling comprising the predetermined set of parameters to be provided to a mobile terminal
36
Operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal
38

FIG. 3

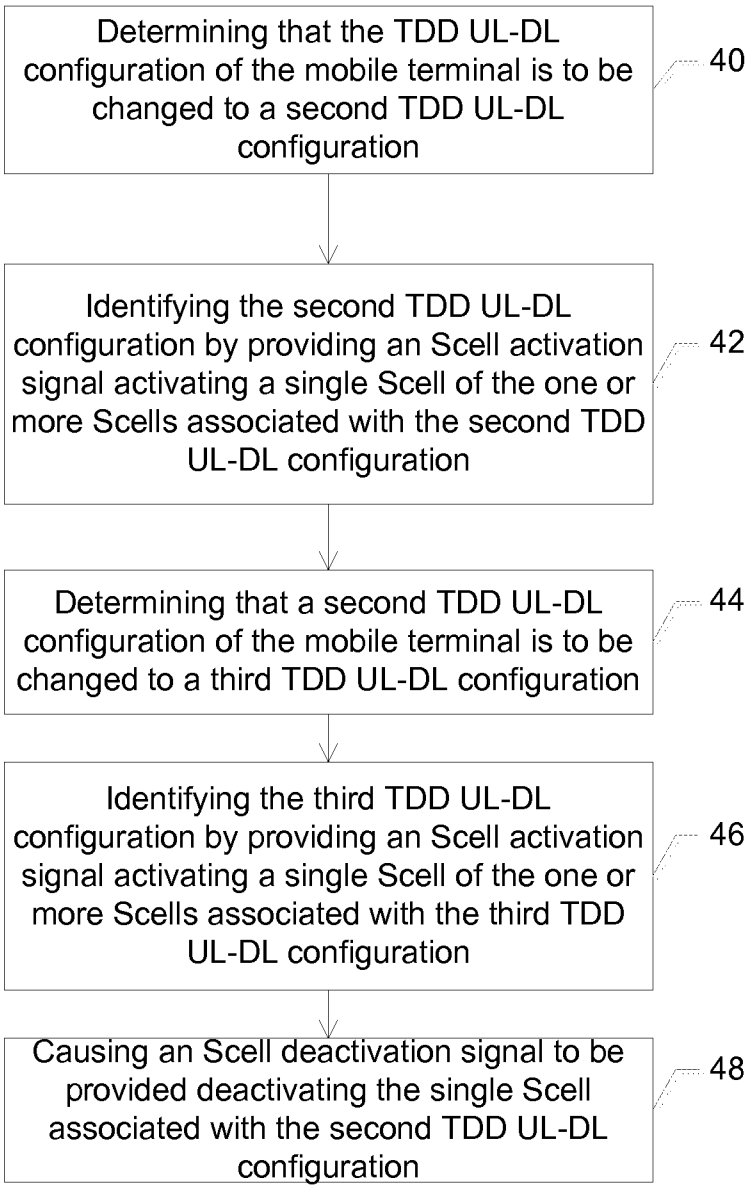

Determining that the TDD UL-DL configuration of the mobile terminal is to be changed to a second TDD UL-DL configuration
40
Identifying the second TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the second TDD UL-DL configuration
42
Determining that a second TDD UL-DL configuration of the mobile terminal is to be changed to a third TDD UL-DL configuration
44
Identifying the third TDD UL-DL configuration by providing an Scell activation signal activating a single Scell of the one or more Scells associated with the third TDD UL-DL configuration
46
Causing an Scell deactivation signal to be provided deactivating the single Scell associated with the second TDD UL-DL configuration
48

FIG. 4

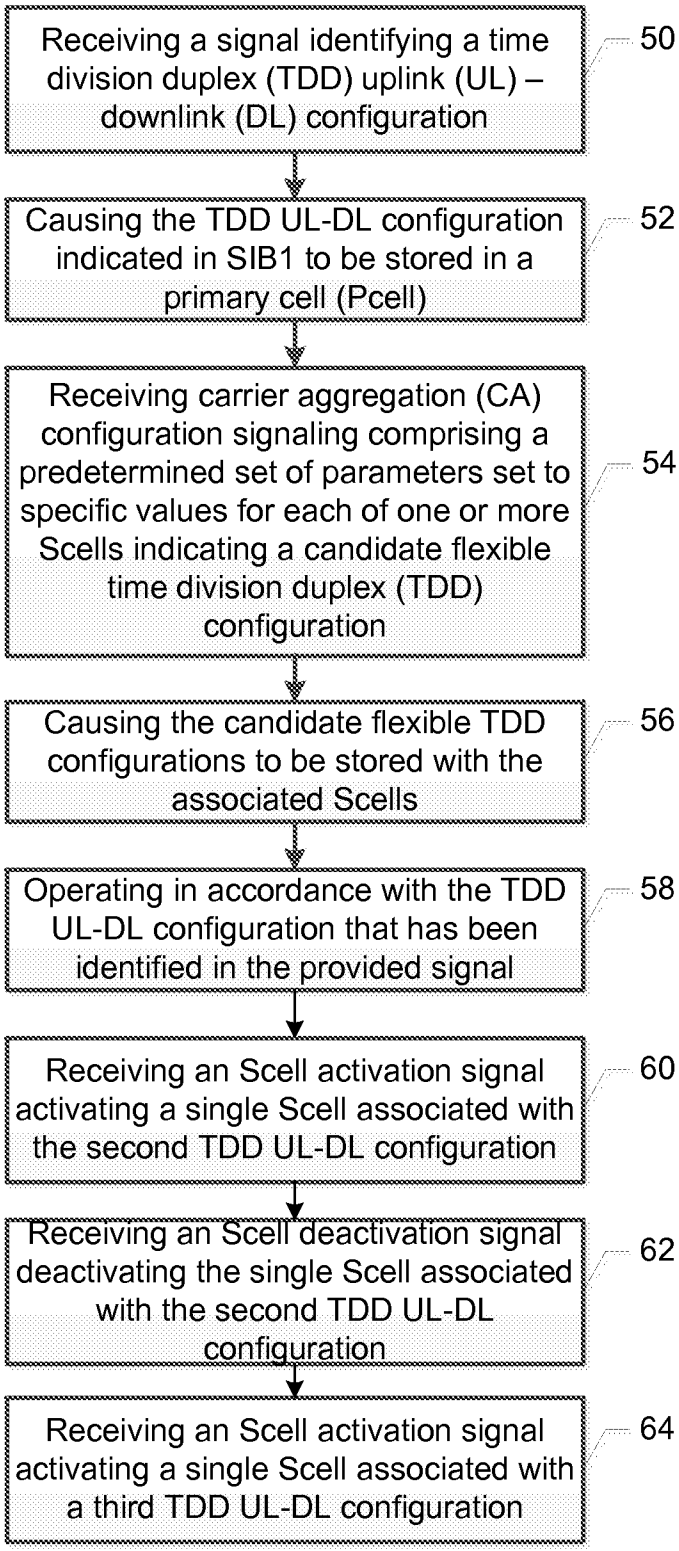

Receiving a signal identifying a time division duplex (TDD) uplink (UL) – downlink (DL) configuration
50
Causing the TDD UL-DL configuration indicated in SIB1 to be stored in a primary cell (Pcell)
52
Receiving carrier aggregation (CA) configuration signaling comprising a predetermined set of parameters set to specific values for each of one or more Scells indicating a candidate flexible time division duplex (TDD) configuration
54
Causing the candidate flexible TDD configurations to be stored with the associated Scells
56
Operating in accordance with the TDD UL-DL configuration that has been identified in the provided signal
58
Receiving an Scell activation signal activating a single Scell associated with the second TDD UL-DL configuration
60
Receiving an Scell deactivation signal deactivating the single Scell associated with the second TDD UL-DL configuration
62
Receiving an Scell activation signal activating a single Scell associated with a third TDD UL-DL configuration
64

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/070664

A. CLASSIFICATION OF SUBJECT MATTER

H04W 16/14 (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)

IPC: H04W 16/-, H04W 72/-, H04W 74/-

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)

CNABS, CNKI, VEN, 3GPP: CA, carrier aggregation, TDD, time division duplex, UL, DL, configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102075949 A(DATANG MOBILE COMMUNICATION EQUIP CO., LTD.) 25 May 2011(25.05.2011) paragraphs 0005-0006, 0055-0103 of the description and figures 1, 5-9	1-54
X	CN 102026208 A (DATANG MOBILE COMMUNICATION EQUIP CO., LTD.) 20 April 2011(20.04.2011) paragraphs 0033-0150 of the description and figures 1-8	1-54
A	WO 2012139291 A1(RENESAS MOBILE CORPORATION) 18 October 2012(18.10.2012) the whole document	1-54

☒ 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
30 September 2013(30.09.2013)	**24 Oct. 2013 (24.10.2013)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer LV, He Telephone No. (86-10)62411400

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/070664

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	3GPP TSG RAN Meeting #51, RP-110451 "LTE Carrier Aggregation Enhancements-Performance" 18 March 2011(18.03.2011) the whole document	1-54
A	3GPP TS 36.300 version 11.3.0 Release 11 "LTE;Evolved Universal Terrestrial Radio Access (E-UTRA)and Evolved Universal Terrestrial Radio Access Network (E-UTRAN);Overall description; Stage 2" 30 November 2012 (30.11.2012) part 5.5, 7.5	1-54
A	3GPP TS 36.321 version 11.0.0 Release 11 "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA);Medium Access Control (MAC) protocol specification" 31 October 2012(31.10.2012) part 3.1	1-54

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/070664

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102075949 A	25.05.2011	CN 102075949 B	20.03.2013
		WO 2012083811 A1	28.06.2012
CN 102026208 A	20.04.2011	WO 2012079476 A1	21.06.2012
WO 2012139291 A1	18.10.2012	None	