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(71) Applicant: **NOKIA SOLUTIONS AND NETWORKS OY** [FI/FI]; Karaportti 3, FI-02610 Espoo (FI).

(72) Inventors: **TIIROLA, Esa, Tapani**; Porttikellonkuja 12, FI-90450 Kempele (FI). **HOOLI, Kari, Juhani**; Paloniemenranta 5 C 6, FI-90540 Oulu (FI). **LUNTTILA, Timo, Erkki**; Tontunmäentie 34 F, FI-02200 Espoo (FI). **HUGL, Klaus**; Kaiserstrasse 71/1/12, A-1070 Wien (AT).

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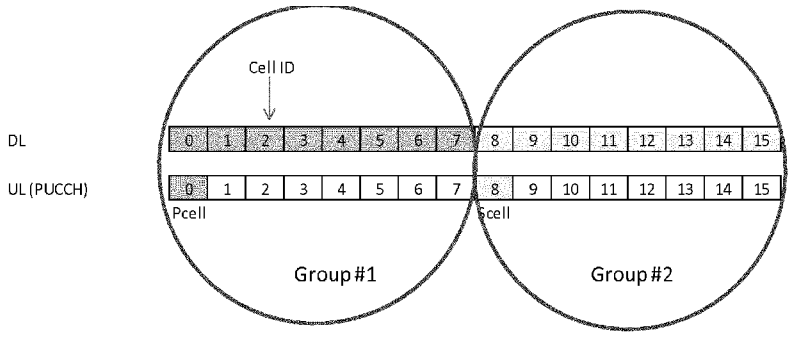
(54) Title: METHOD, APPARATUS AND SYSTEM FOR THE CONFIGURATION OF AN UPLINK CONTROL CHANNEL

Figure 5



(57) Abstract: A method comprising receiving at least one first information element at a user equipment, from said at least one first information element, determining, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

DESCRIPTION

TITLE

METHOD, APPARATUS AND SYSTEM FOR THE CONFIGURATION OF AN UPLINK CONTROL CHANNEL

Field

The present application relates to a method, apparatus and system and in particular but not exclusively, to LTE carrier aggregation.

Background

A communication system can be seen as a facility that enables communication sessions between two or more entities such as user terminals, base stations and/or other nodes by providing carriers between the various entities involved in the communications path. A communication system can be provided for example by means of a communication network and one or more compatible communication devices. The communications may comprise, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and/or content data and so on. Non-limiting examples of services provided include two-way or multi-way calls, data communication or multimedia services and access to a data network system, such as the Internet.

In a wireless communication system at least a part of communications between at least two stations occurs over a wireless link. Examples of wireless systems include public land mobile networks (PLMN), satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). The wireless systems can typically be divided into cells, and are therefore often referred to as cellular systems. A user can access the communication system by means of an appropriate communication device or terminal. A communication device of a user is often referred to as user equipment (UE). A communication device is provided with an appropriate signal receiving and transmitting apparatus for enabling communications, for example enabling access to a communication network or communications directly with other users. The communication device may access a carrier provided by a station, for example a base station of a cell, and transmit and/or receive communications on the carrier.

The communication system and associated devices typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. Communication protocols and/or parameters which shall be used for the connection are also typically defined. An example of attempts to solve the problems associated with the increased demands for capacity is an architecture that is known as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. The LTE is being standardized by the 3rd Generation Partnership Project (3GPP). The various development stages of the 3GPP LTE specifications are referred to as releases.

Summary

In a first aspect there is provided a method comprising receiving at least one first information element at a user equipment, from said at least one first information element, determining, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

The first cell may comprise a primary cell and the second cell may comprise a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

The method may comprise determining which of the control channels associated with first cell and the second cell to use in dependence on priority information.

The method may comprise determining which of the control channels associated with the first cell and second cell to use in dependence on said at least one first information element.

Each said at least one first information element may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The first group of cells may be associated with one of a primary cell and a secondary cell.

The at least one first information element may comprise first information received from at least one of a primary cell and a secondary cell.

In a second aspect there is provided a method comprising causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and receiving uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

The first cell may be a primary cell and the second cell may be a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

Said at least one first information element may indicate control channel associated with the first cell or the control channel associated with the second cell.

Said at least one first information element may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The respective cell may be the first cell or the second cell.

The first group of cells may be associated with one of a primary cell and a secondary cell.

In a third aspect there is provided an apparatus, said apparatus comprising means for receiving at least one first information element at a user equipment, means for determining, from said first information, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and means for causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

The first cell may comprise a primary cell and the second cell may comprise a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information

The apparatus may comprise means for determining which of the control channels associated with first cell and the second cell to use in dependence on priority information.

The apparatus may comprise means for determining which of the control channels associated with the first cell and second cell to use in dependence on said at least one first information element.

Said at least one first information may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The first group of cells may be associated with one of a primary cell and a secondary cell.

The at least one first information element may comprise first information received from at least one of a primary cell and a secondary cell.

In a fourth aspect there is provided an apparatus, said apparatus comprising means for causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and means for receiving uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

The first cell may be a primary cell and the second cell may be a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

Said at least one first information element may indicate the control channel associated with the first cell or the control channel associated with the second cell.

Said at least one first information element may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The respective cell may be the first cell or the second cell.

The first group of cells may be associated with one of a primary cell and a secondary cell.

In a fifth aspect there is provided an apparatus comprising at least one processor and at least one memory including a 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 receive at least one first information at a user equipment, from said at least one first information element , determine at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and cause uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

The first cell may comprise a primary cell and the second cell may comprise a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information

The apparatus may be configured to determine which of the control channels associated with first cell and the second cell to use in dependence on priority information.

The apparatus may be configured to determine which of the control channels associated with the first cell and second cell to use in dependence on said at least one first information element.

Said at least one first information element may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The first group of cells may be associated with one of a primary cell and a secondary cell.

The at least one first information element may comprise first information received from at least one of a primary cell and a secondary cell.

In a sixth aspect there is provided an apparatus comprising at least one processor and at least one memory including a 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 cause at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and receive uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

The first cell may be a primary cell and the second cell may be a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

Said at least one first information element may indicate the control channel associated with the first cell or the control channel associated with the second cell.

Said at least one first information element may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The respective cell may be the first cell or the second cell.

The first group of cells may be associated with one of a primary cell and a secondary cell.

In a seventh aspect there is provided a computer program embodied on a non-transitory computer-readable storage medium, the computer program comprising program code for controlling a process to execute a process, the process comprising receiving at least one first information element at a user equipment, from said at least one first information

element, determining, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

The first cell may comprise a primary cell and the second cell may comprise a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information

The process may comprise determining which of the control channels associated with first cell and the second cell to use in dependence on priority information.

The process may comprise determining which of the control channels associated with the first cell and second cell to use in dependence on said at least one first information element .

Each said first information may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The first group of cells may be associated with one of a primary cell and a secondary cell.

The at least one first information element may comprise first information received from at least one of a primary cell and a secondary cell.

In an eighth aspect there is provided a computer program embodied on a non-transitory computer-readable storage medium, the computer program comprising program code for controlling a process to execute a process, the process comprising causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and receiving uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

The first cell may be a primary cell and the second cell may be a secondary cell.

A configuration may comprise an uplink control information profile.

The uplink control information profile may define at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.
Said at least one first information element may indicate the control channel associated with the first cell or the control channel associated with the second cell.

Said at least one first information element may comprise at least one bit of a downlink assignment message.

The first cell may be associated with a first group of cells, and the second cell may be associated with a second group of cells.

The respective cell may be the first cell or the second cell.

The first group of cells may be associated with one of a primary cell and a secondary cell.

In a ninth aspect there is provided a computer program product for a computer, comprising software code portions for performing the steps of any one of the first and second aspects when said product is run on the computer.

In the above, many different embodiments have been described. It should be appreciated that further embodiments may be provided by the combination of any two or more of the embodiments described above.

Description of figures

Embodiments will now be described, by way of example only, with reference to the accompanying Figures in which:

Figure 1 shows a schematic diagram of an example communication system comprising a base station and a plurality of communication devices;

Figure 2 shows a schematic diagram, of an example mobile communication device;

Figure 3 shows a flowchart of an example method of providing flexible PUCCH configuration in carrier aggregation;

Figure 4 shows a flowchart of an example method of providing flexible PUCCH configuration in carrier aggregation;

Figure 5 shows an example of cell grouping in terms of PUCCH allocation;

Figure 6 shows a an example of priority handling in case of two PUCCH configurations;

Figure 7 shows an example of UCI (uplink control information) configurations that a UE may be configured with;

Figure 8 shows an example of UCI (uplink control information) configurations that a UE may be configured with;

Figure 9 shows a schematic diagram of an example control apparatus;

Figure 10 shows a schematic diagram of an example apparatus;

Figure 11 shows a schematic diagram of an example apparatus;

Detailed description

Before explaining in detail the examples, certain general principles of a wireless communication system and mobile communication devices are briefly explained with reference to Figures 1 to 2 to assist in understanding the technology underlying the described examples.

In a wireless communication system 100, such as that shown in figure 1, mobile communication devices or user equipment (UE) 102, 104, 105 are provided wireless access via at least one base station or similar wireless transmitting and/or receiving node or point. Base stations are typically controlled by at least one appropriate controller apparatus, so as to enable operation thereof and management of mobile communication devices in communication with the base stations. The controller apparatus may be located in a radio access network (e.g. wireless communication system 100) or in a core network (not shown) and may be implemented as one central apparatus or its functionality may be distributed over several apparatus. The controller apparatus may be part of the base station and/or provided by a separate entity such as a Radio Network Controller. In Figure 1 control apparatus 108 and 109 are shown to control the respective macro level base stations 106 and 107. The control apparatus of a base station can be interconnected with other control entities. The control apparatus is typically provided with memory capacity and at least one data processor. The control apparatus and functions may be distributed between a plurality of control units. In some systems, the control apparatus may additionally or alternatively be provided in a radio network controller. The control apparatus may provide an apparatus such as that discussed in relation to figure 8.

LTE systems may however be considered to have a so-called “flat” architecture, without the provision of RNCs; rather the (e)NB is in communication with a system architecture evolution gateway (SAE-GW) and a mobility management entity (MME), which entities may also be pooled meaning that a plurality of these nodes may serve a plurality (set) of (e)NBs. Each UE is served by only one MME and/or S-GW at a time and the (e)NB keeps track of current association. SAE-GW is a “high-level” user plane core network element in LTE, which may consist of the S-GW and the P-GW (serving gateway and packet data network gateway, respectively). The functionalities of the S-GW and P-GW are separated and they are not required to be co-located.

In Figure 1 base stations 106 and 107 are shown as connected to a wider communications network 113 via gateway 112. A further gateway function may be provided to connect to another network.

The smaller base stations 116, 118 and 120 may also be connected to the network 113, for example by a separate gateway function and/or via the controllers of the macro level stations. The base stations 116, 118 and 120 may be pico or femto level base stations or the like. In the example, stations 116 and 118 are connected via a gateway 111 whilst station 120 connects via the controller apparatus 108. In some embodiments, the smaller stations may not be provided.

A possible mobile communication device will now be described in more detail with reference to Figure 2 showing a schematic, partially sectioned view of a communication device 200. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples include a mobile station (MS) or mobile device such as a mobile phone or what is known as a 'smart phone', a computer provided with a wireless interface card or other wireless interface facility (e.g., USB dongle), personal data assistant (PDA) or a tablet provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services include two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. Users may also be provided broadcast or multicast data. Non-limiting examples of the content include downloads, television and radio programs, videos, advertisements, various alerts and other information.

The mobile device 200 may receive signals over an air or radio interface 207 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 transceiver apparatus is designated schematically by block 206. The transceiver apparatus 206 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the mobile device.

A mobile device is typically provided with at least one data processing entity 201, at least one memory 202 and other possible components 203 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 204. The user may control the operation of the mobile device by means of a suitable user interface such as key pad 205, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 208, a speaker and a microphone can be also provided. Furthermore, a mobile communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

The communication devices 102, 104, 105 may access the communication system based on various access techniques, such as code division multiple access (CDMA), or wideband CDMA (WCDMA). Other non-limiting examples comprise time division multiple access (TDMA), frequency division multiple access (FDMA) and various schemes thereof such as the interleaved frequency division multiple access (IFDMA), single carrier frequency division multiple access (SC-FDMA) and orthogonal frequency division multiple access (OFDMA), space division multiple access (SDMA) and so on.

An example of wireless communication systems are architectures standardized by the 3rd Generation Partnership Project (3GPP). A latest 3GPP based development is often referred to as the long term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. The various development stages of the 3GPP specifications are referred to as releases. More recent developments of the LTE are often referred to as LTE Advanced (LTE-A). The LTE employs a mobile architecture known as the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). Base stations of such systems are known as evolved or enhanced Node Bs (eNBs) and provide E-UTRAN features such as user plane Radio Link Control/Medium Access Control/Physical layer protocol (RLC/MAC/PHY) and control plane Radio Resource Control (RRC) protocol terminations towards the communication devices. Other examples of radio access system include those provided by base stations of systems that are based on technologies such as wireless local area network (WLAN) and/or WiMax (Worldwide Interoperability for Microwave Access). A base station can provide coverage for an entire cell or similar radio service area.

The LTE Carrier Aggregation (CA) framework supporting carrier aggregation of up to 5 component carriers in UL and/or DL of the same frame structure (FDD-FDD or TDD-TDD) has been introduced in LTE-Advanced (LTE Rel. 10), where it is assumed that the cells/carriers do have a fast (close to ideal) backhaul connection.

In Rel. 11, the CA framework has been extended by supporting inter-band TDD carrier aggregation with different UL-DL configurations and moreover, which may enable different timing advance values for carriers belonging to different timing advance groups (TAGs) and may improve the UL carrier aggregation support.

In Rel. 12, TDD-FDD carrier aggregation has been introduced which may enable the support of aggregation of carriers with different frame structures, i.e. it may be possible for a single user to aggregate resources of FDD & TDD carriers.

Dual-connectivity support has been introduced in Rel. 12 which may enable the aggregation of resources of cells which do not have an ideal (fast) backhaul connectivity between the different cells or cell groups. One of the cell groups may be supported by a primary or master eNB (MeNB) and the other cell group by a secondary eNB (SeNB). Here, additional support for dual-PUCCH operation may be provided, where separate UL control channels (PUCCHs) are provided for the master eNB (MeNB) and secondary eNB (SeNB). Within the MeNB and SeNB cell groups normal carrier aggregation operation as such may be possible.

A 5 component carrier limit may limit future LTE CA configurations, especially for DL carrier aggregation operation. Therefore, the CA framework needs to be extended to support a larger number of component carriers.

The extension of the CA framework beyond 5 carriers may give operators an opportunity to more efficiently utilize the available spectrum for communication needs.

Not all CA aspects scale directly with an increasing number of component carriers. As an example, if the number of CA capable UEs and/or the aggregated CCs is increased, the cell used as the PCell may be highly loaded especially in UL. This is because there are key features which are applied to the PCell only, such as the PUCCH transmission. The increase in the number of supported component carriers may call for rather large increase

in the required PUCCH payload size per CA UE, which may impact on PCell UL load with increasing number of CA UEs. Accommodating all the PUCCH transmissions in the PCell UL may significantly increase UL overhead and may impact performance, especially for the non-CA UEs.

In this case, the PCell change between the macro cell and a small cell served by an RRH may distribute the PUCCH resources of UEs in the network and may resolve the overload issue. However, more careful cell planning is needed for the small cell deployment, as UE mobility will then be managed via the small cell. This may reduce the benefit of installation of the small cell equipment such as RRH in a simple manner.

In Rel-12, Dual Connectivity (DC) was developed, in which the UE may be required to be capable of supporting UL-CA with simultaneous PUCCH/PUCCH and PUCCH/PUSCH transmissions across cell-groups (CGs).

As such, support of PUCCH on SCell for CA may be deemed as essential for the deployment in carrier aggregation. From physical layer viewpoints, it may be possible to reuse dual connectivity UCI feedback mechanism for CA. Moreover, PUCCH on SCell for CA may ease the burden in terms of PUCCH considering an increase in the number of DL carriers that can be aggregated.

Despite the introduction of PUCCH on SCell or Dual PUCCH, CA extension to support a larger number of component carriers (e.g. up to 32) may call also for enhancements on HARQ-ACK feedback and CSI feedback carried on a single UL carrier. Such enhancements may improve CA operation especially with TDD PCell, which may already face limitations on PDSCH HARQ-ACK feedback even with 3 component carriers.

Since Rel-10, the basic assumption in LTE Carrier aggregation has been that HARQ-ACK feedback is provided for all the configured DL carriers, regardless of whether those carriers are actually scheduled, or even activated, or not. The only exception to this may be when UE has PDSCH scheduled only on the PCell: in such case the HARQ-ACK feedback is provided for PCell only using PUCCH format 1a/b.

As a result, PUCCH overhead is always maximized even if the eNodeB chooses to schedule e.g. one (SCell) or two DL cells at the time. This may not be significant when the number of carriers is only up to 5. However, as the number of configured DL carriers

increases, for example, up to 32 carriers, the UL/PUCCH overhead also increases. On the other hand, it may still be likely that a base station will not simultaneously schedule all the DL carriers at the same time. This highlights the need for enhancing the PUCCH resource usage.

Carrier aggregation was introduced in LTE Rel-10. As part of the solution a new PUCCH format 3 based on block spread DFT-S-OFDMA was introduced. The main features of PUCCH Format 3 are:

- Payload depends on the number of configured cells and the corresponding transmission modes (i.e. not the number of scheduled DL cells).
- Explicit resource allocation
    - TPC field (2 bits) in the PDCCH corresponding to PDSCH on Scell is used as an ARI (ACK/NACK Resource Indicator)
    - The 4 values in the ARI point to 4 semi-statically configured values of PUCCH resources
    - In the case of PCell-only scheduling, PUCCH Format 1a/1b resource derived implicitly is applied.

The current ARI functionality may not be flexible enough to support a larger number, e.g. up to 32, component carriers. Furthermore, it may not cover the scenario with Scell PUCCH. The following relates to LTE carrier aggregation enhancements beyond 5 component carriers including support for PUCCH on Scell.

A method is shown in figure 3 of providing flexible PUCCH configuration in carrier aggregation. The method comprises at step S1, receiving at least one first information element, from said at least one first information element, at step S2, determining at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and, at step S3, causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

The method may be performed at a user equipment. The at least one first information element may be received from at least one of the first cell and the second cell. The first cell may be a primary cell and the second cell may be a secondary cell (Scell), such as a

specific Scell (i.e. the only SCell supporting PUCCH), referred to as a PScell. Alternatively, the at least one first information element may be received from a cell that is in a cell group associated with the first cell and/or the second cell.

A method such as that shown in figure 4 may be implemented at a first cell or a second cell. The method comprises at step T1, causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and at step T2, receiving uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

The respective cell may be one of the first and second cell.The first cell may be a primary cell and the second cell may be a secondary cell, for use for example in CA. The secondary cell may be a specific Scell (i.e. the only Scell supporting PUCCH) and may be referred to as a PSCell. Alternatively, the first cell and/or the second cell may be a cell that is in a cell group associated with the respective cell (e.g. with a Pcell or PSCell).

Uplink control channel transmission may comprise uplink control information (UCI) transmission.

The configurations for a control channel may be a UCI profile for a PUCCH configuration. The association of a configuration with a first or second cell may comprise a mapping of the PUCCH configuration to the respective first or second cell.

A UE may transmit according to both control channel configurations. A UE may transmit UCI via predefined control channel configuration, e.g. according to configuration associated with Pscell and drop another configuration, e.g. the configuration relating to Pcell.

More than one PUCCH configurations may be provided for CA UE. In some embodiments, CA operation follows a predefined grouping of 16 cells as shown in figure 5 for the specific example of two groups each having one PUCCH configuration and each group containing 8 DL component carriers. The grouping of cells shown in figure 5 is an example; there may be any number of cells configured in DL side, and two or more cells in

UL side, respectively.Grouping may involve certain limitations, for example, DL cross-carrier scheduling may take place only within a group. One of the PUCCH configurations may be associated with, or mapped to, a first cell, e.g. a Pcell (Group #1). Another PUCCH configuration may be associated with, e.g. mapped to, a second cell, e.g. a predefined Scell. The predefined Scell may be referred to as PSCell. The PScell may be located in Group #2. The first information element may be received from the PCell or the PScell or from a cell that is in a cell group associated with the first cell or the second cell (e.g. with a Pcell or PSCell).

In a situation where CA is configured for the UE for the first time, then the at least one first information element come from the PCell, since a configuration over an SCell may not be transmitted before CA is to configured. On the other hand, a potential reconfiguration of the PUCCH association (PUCCH profile) could be transmitted over the PDSCH of any SCell.

Figure 6 shows example UCI configurations for Pcell and PSCell having two fixed PUCCH configurations with a single fixed UCI profile for each configuration.In the examples below, the first cell is the PCell and the second cell is the PScell. Each PUCCH configuration may have multiple (e.g. four or eight) configurations, or UCI profiles, defined. The at least one first information element may be a predefined bit in a DL resource allocation grant, e.g. ARI. eNB may indicates the selected UCI profile to UE via ARI (or some other predefined bits included in DL resource allocation grants). The UE can thus determine, from said at least one information element, a selected UCI profile for a PUCCH configuration for a respective cell, i.e. one of a plurality of configurations associated with the first cell and one of a plurality of configurations associated with a second cell. Figure 7 shows example UCI configurations for PCell and PSCell, for the example of using the 2bit ARI to indicate one of 4 different UCI profiles in addition to the Format 1a/1b fallback in case only the PUCCH carrying cell is scheduled in that PUCCH profile.

A UCI profile may define e.g. PUCCH Format type (e.g. existing LTE PUCCH formats such as Format 1a/1b, Format 3 – as well as potential additional new and/or larger PUCCH format types, referred to as Format x, for example format 4 as shown in figure 7), resource index for the given PUCCH format type, possible bundling scheme e.g. spatial bundling and/or carrier/time domain bundling.

UCI profile may define involved DL cells. Involved DL cells are DL Cells for which ACK/NACK is transmitted in that UCI profile. One DL cell can be part of multiple UCI

profiles/PUCCH configurations. This may facilitate dynamic adaptation of the UCI payload size. This may require that different UCI profiles have different cell combinations configured. This may facilitate dynamic selection of the PUCCH Cell according to eNB's scheduling decision. This may require that certain cell(s) are part of two (both) PUCCH configurations. This may facilitate UCI diversity transmission via both PUCCH Cells (again depending on PUCCH configuration).

A cell may be part of both first control channel configuration and the second control channel configuration. For example, DL cell association may be defined according to at least one of the following principles:

- One-to-one mapping wherein one DL cell is part of just one configuration (i.e. Pcell configuration or Scell configuration)

- One-to-many mapping wherein one DL cell can be part of both Pcell configuration and Scell configuration.

There may be different options available for conveying UCI. For example, both Pcell PUCCH and PScell PUCCH may be transmitted according to current UCI profiles defined by ARI.

An alternative is to transmit according to just one UCI profile defined by ARI, e.g. PSCell PUCCH. Another PUCCH may be dropped (Pcell in the case).

The number of ARI bits may be e.g., 2 or 3. ARI may use TPC bits or some other bits included in the DL assignments. Alternatively or in addition, additional bits may be introduced into the PDCCH/EPDCCH DL assignment.

Having cell groups configured may provide flexible configuration options for eNB (as the ARI bits or other bits included in the DL resource allocation grant indicating the UCI profile for each of the, in the example of Figure 6, two PUCCH configurations),

The ARI bits/field may be extended, although ARI would use 2 TPC bits per grant. TPC bits on scheduling grants for certain Scells provide certain ARI bits. An association between ARI bits and DL Scells may be configured via higher layers. ARI field is composed from TPC bits of multiple scheduling grants. Default value for ARI bits is

predefined. In the cases where ARI bit value is not signaled / received, default value may be used. If the eNB wants to minimize error cases, it may change the signaled ARI bit value from default value only when the ARI bit is signaled via multiple DL scheduling grants.

A resource pool of each PUCCH configuration may be configured via higher layer signaling (RRC). Cell association for each UCI profile/PUCCH configuration may be signaled e.g. via bitmap or indicating the involved cells explicitly.
The configuration of UCI profile(s) and PUCCH configuration(s) may be UE-specific.

Prioritization rules may be needed to improve the resource efficiency esp. when one cell is part of multiple UCI configurations (as shown in Figures 7 and 8). Prioritization rules may be applied when ARI on the first cell group scheduling grant(s) indicates one UCI profile from the first PUCCH configuration and ARI on the second cell group scheduling grant(s) indicates another UCI profile from the second PUCCH configuration. In the example depicted in Figure 7, it is possible that even if UE receives PDSCH via both groups (see Figure 6) it may transmit UCI via Scell (or PCell) only. This makes since one of the UCI profiles involved (i.e. UCI profile SCell_Y in this example) is capable to convey HARQ-ACK corresponding to all involved DL cells. This option may be seen as a way to offload UCI from PCell to Scell.

Some (if not all) of the prioritization rules may be defined by the specification.

For example, PSCell may be prioritized with respect to Pcell which may facilitate PUCCH offload aspect. An alternative may be to make (at last some of) the priority rules configurable by eNB.

In one embodiment, said configuration for the at last one control channel is dependent on predefined priority rules. Priority rules may apply only when certain criteria are met: for example if the prioritized PUCCH configuration can convey HARQ-ACK for all scheduled cells, then another PUCCH can be dropped. Another exemplary criterion for applying the priority rule is that all scheduled DL cells are listed as Involved DL Cell in the prioritized UCI profile. (If not, both PUCCH configurations defined by ARI are used in UCI transmission). Priority rules may take into account also other signals to be transmitted via the same subframe (e.g. different priorities with and without simultaneous periodic CSI).

An example of possible configuration using priority rules is shown in figure 7.

In these example, there are up to two Cell groups; Group #1: Cell 0 – Cell 7 and Group #2: Cell 8 – 15. There are two PUCCH configurations in this example; Pcell PUCCH configuration is mapped to uplink of Cell 0 and PSCell PUCCH configuration is mapped to uplink of Cell 8.

There are four UCI profiles in each PUCCH configuration (the number of ARI bits equals to two)

The eNodeB includes into every DL assignment scheduling cells #0 … #15 the ARI, which indicates the UCI profile to be applied. The ARI may not be present in the PDCCH assignment corresponding to the Pcell (or the PSCell). Those bits may be used as TPC bits. The UE may assume that the eNodeB signals the same ARI value in the PDCCH assignment corresponding the Cells that belong to the same Group.

In a first example, the eNodeB schedules all 16 cells (0 – 15). The ARI in the PDCCH assignments transmitted on the cells belonging to Group #1 is set to “11”. The ARI in the PDCCH assignments transmitted on the cells belonging to Group #2 is set to “11”. Predefined priority rules define that it is sufficient to transmit according to UCI profile 1 on PSCell (Pcell is dropped).

In a second example, the eNodeB schedules only 4 cells (e.g. #0, #1, #3, #5) from Group #1, and no cells from Group #2. The eNodeB selects the ARI as follows: the ARI in the PDCCH assignments transmitted on the cells belonging to Group #1 is set to “10”. The UE reserves space for HARQ Ack/Nack of 6 cells, but sends HARQ only for the scheduled four cells. For the rest of the DL cells being part of the indicated UCI profile’, the UE signals “NACK”. PUCCH format 3 and resource “B” is used on PCell.

In a third example, the eNodeB schedules cells #1, and #8. The eNodeB selects the ARI as follows: the ARI in the PDCCH assignments transmitted on the cell #1 is set to “00”. Correspondingly, PUCCH Format 3 (on resource D) is transmitted on PCell PUCCH. Since the Cell #8 is a PSCell, there is no ARI in the PDCCH DL assignment. As PSCell is not part of UCI profile indicated by ARI on cell #1, implicitly determined PUCCH format 1a/b resource on PSCell PUCCH is used for Cell #8 HARQ-ACK feedback.

Additionally, or as an alternative to using priority rules, the at least one first information element may indicate a control channel. An eNB may select the PUCCH configuration and UCI profile to be used by UE and signal the PUCCH configuration and UCI profile to the UE via ARI. This option may not require predefined grouping of the cells between Pcell and Pscell. PUCCH configuration and UCI profile is associated for each ARI value via higher layer signaling. More than one PUCCH configuration and UCI profiles may be associated for a ARI value or some other predefined bits included in DL resource allocation grants, in which case UE transmits PUCCH both on PCell and PSCell according to the UCI profiles associated to the ARI value (or value determined by some other predefined bits included in DL resource allocation grants).

An example of the possible implementation of this embodiment is illustrated in Figure 8. In this example, there are two PUCCH configurations; PCell PUCCH configuration is mapped to uplink of Cell 0, PSCell PUCCH configuration is mapped to uplink of Cell 8. There are two UCI profiles in PCell PUCCH configuration and six UCI configurations in PSCell PUCCH configuration (which may provide more flexible support for PUCCH offloading). In this example, the at least one first information element is ARI. The eNodeB includes into every DL assignment scheduling cells #0 … #15 the ARI extended to 3 bits, which indicates the UCI profile and PUCCH configuration to be applied. ARI may not be present in the PDCCH assignment corresponding to the Pcell (or the PSCell).

The proposed solution provides a reasonable way for more dynamic HARQ-ACK codebook adaptation, which can be seen as a performance booster compared to current solution. Better PUCCH reliability can be achieved when a smaller number of DL cells is scheduled.

Embodiments may facilitate more efficient PUCCH resource usage. Furthermore, they may maximize similarity with current solutions. For example, the method may be compatible with current PUCCH formats. The method may be compatible with current PUCCH Format 3 resource allocation.

Embodiments may support new PUCCH format(s) developed when extending the CA capabilities. Embodiments maybe applied for both TDD and FDD.

Various eNB implementation options may be supported, for example one with completely independent processing between Group#1 and Group#2. This maximizes implementation

synergy with Dual Connectivity. Another implementation option is optimized UCI for Carrier Aggregation. In this approach there is overlapping in UCI between Group#1 and Group #2.

Embodiments described above by means of figures 1 to 8 may be implemented on an apparatus, such as a node, host or server, or in a unit, module, etc. providing control functions as shown in figure 9 or on a mobile device (or in a unit, module etc. in the mobile device) such as that of figure 2. Figure 9 shows an example of such an apparatus. In some embodiments, a base station comprises a separate unit or module for carrying out control functions. In other embodiments, the control functions may be provided by another network element such as a radio network controller or a spectrum controller. The apparatus 300 may be arranged to provide control on communications in the service area of the system. The apparatus 300 comprises at least one memory 301, at least one data processing unit 302, 303 and an input/output interface 304. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The receiver and/or the transmitter may be implemented as a radio front end or a remote radio head. For example the apparatus 300 may be configured to execute an appropriate software code to provide the control functions. Control functions may include at least receiving at least one first information element at a user equipment, from said at least one first information element, determining, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell and causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination. Alternatively, or in addition, control functions may include causing at least one first information element to be sent to a user equipment from one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and receiving uplink control channel transmission using the control channels associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication

An example of an apparatus 1000, as shown in figure 10 may comprise means 1010 for receiving at least one first information element at a user equipment, means 1030 for determining, from said at least one first information element, at least one of, one of a plurality of configurations for a control channel associated with a first cell and one of a

plurality of configurations for a control channel associated with a second cell and means 1020 for causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination. The apparatus may be suitable for inclusion in a user equipment.

An example of an apparatus 1100, as shown in figure 11, may comprise means 1110 for causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell and means 1120 for receiving uplink control channel transmission using the control channels associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication. The apparatus may be suitable for inclusion in a base station.

It should be understood that the apparatuses may include or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. Although the apparatuses have been described as one entity, different modules and memory may be implemented in one or more physical or logical entities.

It is noted that whilst embodiments have been described in relation to LTE, similar principles can be applied to any other communication system or radio access technology. Embodiments are generally applicable where carrier aggregation is supported. Therefore, although certain embodiments were described above by way of example with reference to certain example architectures for wireless networks, technologies and standards, embodiments may be applied to any other suitable forms of communication systems than those illustrated and described herein.

It is also noted herein that while the above describes example embodiments, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention.

In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing

device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

Embodiments as described above by means of figures 1 to 8 may be implemented by computer software executable by a data processor, at least one data processing unit or process of a device, such as a base station, e.g. eNB, or a UE, in, e.g., the processor entity, or by hardware, or by a combination of software and hardware. Computer software or program, also called program product, including software routines, applets and/or macros, may be stored in any apparatus-readable data storage medium or distribution medium and they include program instructions to perform particular tasks. An apparatus-readable data storage medium or distribution medium may be a non-transitory medium. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to carry out embodiments. The one or more computer-executable components may be at least one software code or portions of it.

Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. The software may be stored on such physical media as memory chips, or memory blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example DVD and the data variants thereof, CD. The physical media is a non-transitory media.

The memory may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), FPGA, gate level

circuits and processors based on multi-core processor architecture, as non-limiting examples.

Embodiments described above in relation to figures 1 to 8 may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

The foregoing description has provided by way of non-limiting examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention as defined in the appended claims. Indeed there is a further embodiment comprising a combination of one or more embodiments with any of the other embodiments previously discussed.

CLAIMS

1. A method comprising:

receiving at least one first information element at a user equipment;

from said at least one first information element, determining, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell; and

causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

2. A method according to claim 1, wherein a configuration comprises an uplink control information profile.

3. A method according to claim 2 wherein the uplink control information profile defines at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

4. A method according to any preceding claim, comprising determining which of the control channels associated with first cell and the second cell to use in dependence on priority information.

5. A method according to any one of claims 1 to 3, comprising determining which of the control channels associated with the first cell and second cell to use in dependence on said at least one first information element.

6. A method according to any preceding claim, wherein said at least one first information element comprises at least one bit of a downlink assignment message.

7. A method according to claim any preceding claim, wherein the first cell is associated with a first group of cells, and the second cell is associated with a second group of cells.

8. A method according to claim 7, wherein the first group of cells is associated with one of a primary cell and a secondary cell.

9. A method according to any preceding claim, wherein the at least one first information element comprises first information received from at least one of a primary cell and a secondary cell.

10. A method comprising: causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell; and

receiving uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

11. A method according to claim 10, wherein a configuration comprises an uplink control information profile.

12. A method according to claim 11, wherein the uplink control information profile defines at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

13. A method according to any one of claims 10 to 12, wherein said at least one first information element indicates the control channel associated with the first cell or the control channel associated with the second cell.

14. A method according to any one of claims 10 to 13, wherein the first cell is associated with a first group of cells, and the second cell is associated with a second group of cells.

15. A method according to claim 14, wherein the first group of cells is associated with one of a primary cell and a secondary cell.

16. An apparatus comprising means for carrying out the method according to any one of claims 1 to 15.

17. A computer program product for a computer, comprising software code portions for performing the steps of any one of claims 1 to 15 when said product is run on the computer.

18. An apparatus comprising:
at least one processor and at least one memory including a 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:

receive at least one first information element;

from said at least one first information element, determine, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell; and

cause uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination.

19. An apparatus according to claim 18, wherein a configuration comprises an uplink control information profile.

20. An apparatus according to claim 19, wherein the uplink control information profile defines at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information

21. An apparatus according to any one of claims 18 to 20, configured to determine which of the control channels associated with first cell and the second cell to use in dependence on priority information.

22. An apparatus according to any one of claims 18 to 20, configured to determine which of the control channels associated with the first cell and second cell to use in dependence on said at least one first information element.

23. An apparatus according to any one of claims 18 to 22, wherein said at least one first information element comprises at least one bit of a downlink assignment message.

24. An apparatus according to claim 23, wherein the first cell is associated with a first group of cells, and the second cell is associated with a second group of cells.

25. An apparatus according to claim 24, wherein the first group of cells is associated with one of a primary cell and a secondary cell.

26. An apparatus according to any one of claims 17 to 25, wherein the at least one first information element comprises first information received from at least one of a primary cell and a secondary cell.

27. An apparatus comprising:

at least one processor and at least one memory including a 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:

cause at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell; and

receive uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication.

28. An apparatus according to claim 27, wherein a configuration comprises an uplink control information profile.

29. An apparatus according to claim 28, wherein the uplink control information profile defines at least one of control channel format type, resource index associated with a control channel format type, spatial bundling information, carrier bundling information, time domain bundling information and involved downlink cell information.

30. An apparatus according to any one of claims 27 to 29, wherein said at least one first information element indicates the control channel associated with the first cell or the control channel associated with the second cell.

31. An apparatus according to any one of claims 27 to 30, wherein the first cell is associated with a first group of cells, and the second cell is associated with a second group of cells.

32. An apparatus according to claim 31, wherein the first group of cells is associated with one of a primary cell and a secondary cell.

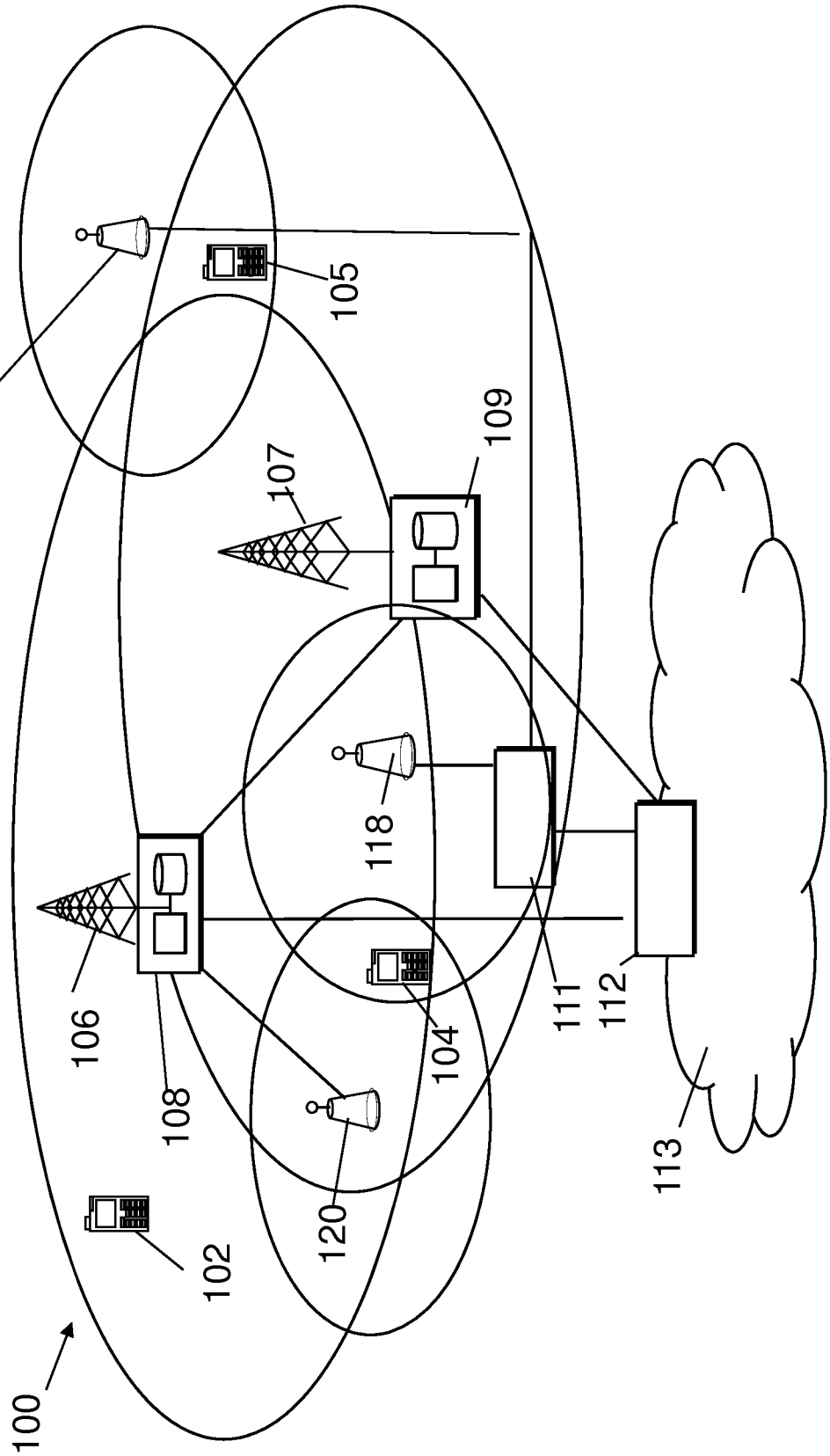


Figure 1

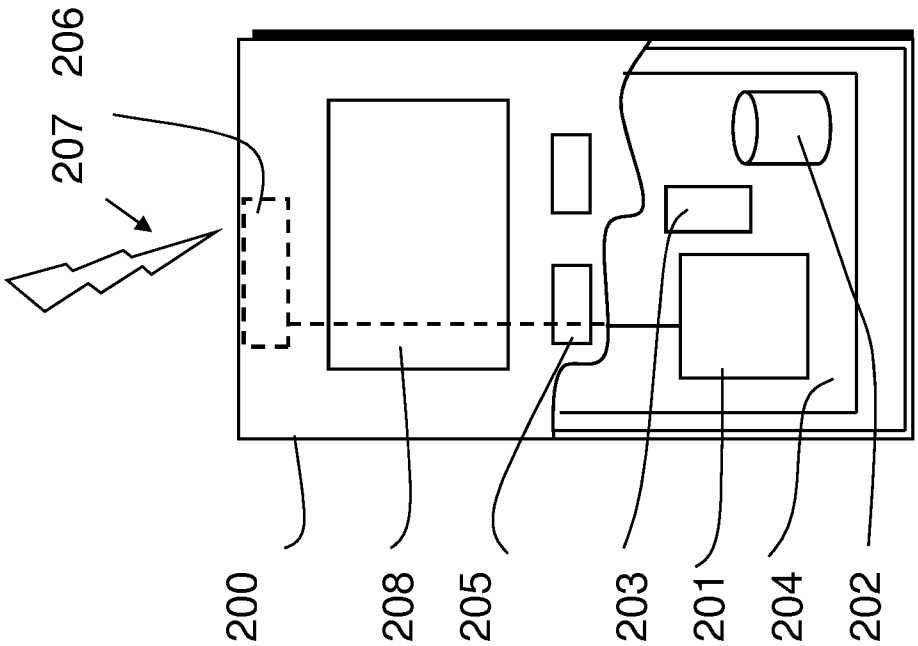


Figure 2

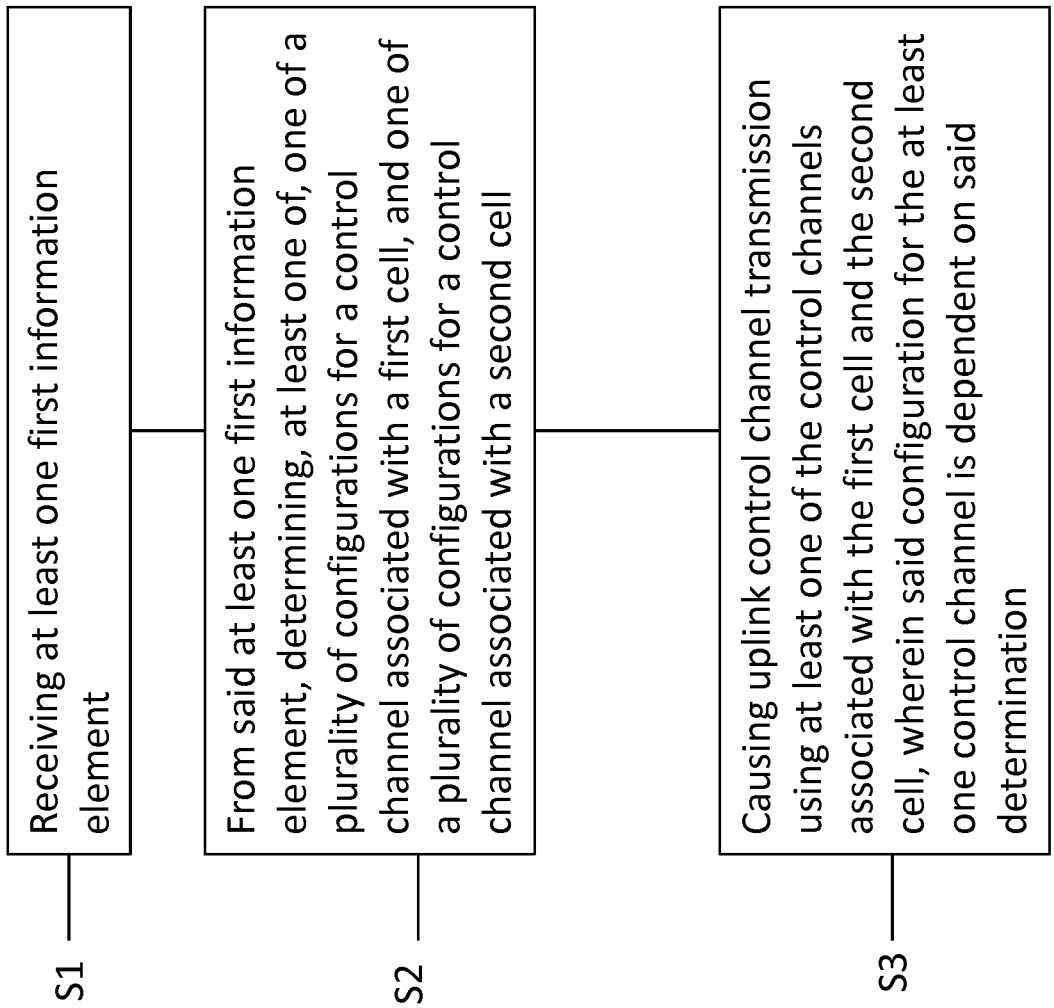

S1
Receiving at least one first information element
S2
From said at least one first information element, determining, at least one of, one of a plurality of configurations for a control channel associated with a first cell, and one of a plurality of configurations for a control channel associated with a second cell
S3
Causing uplink control channel transmission using at least one of the control channels associated with the first cell and the second cell, wherein said configuration for the at least one control channel is dependent on said determination

Figure 3

Figure 4

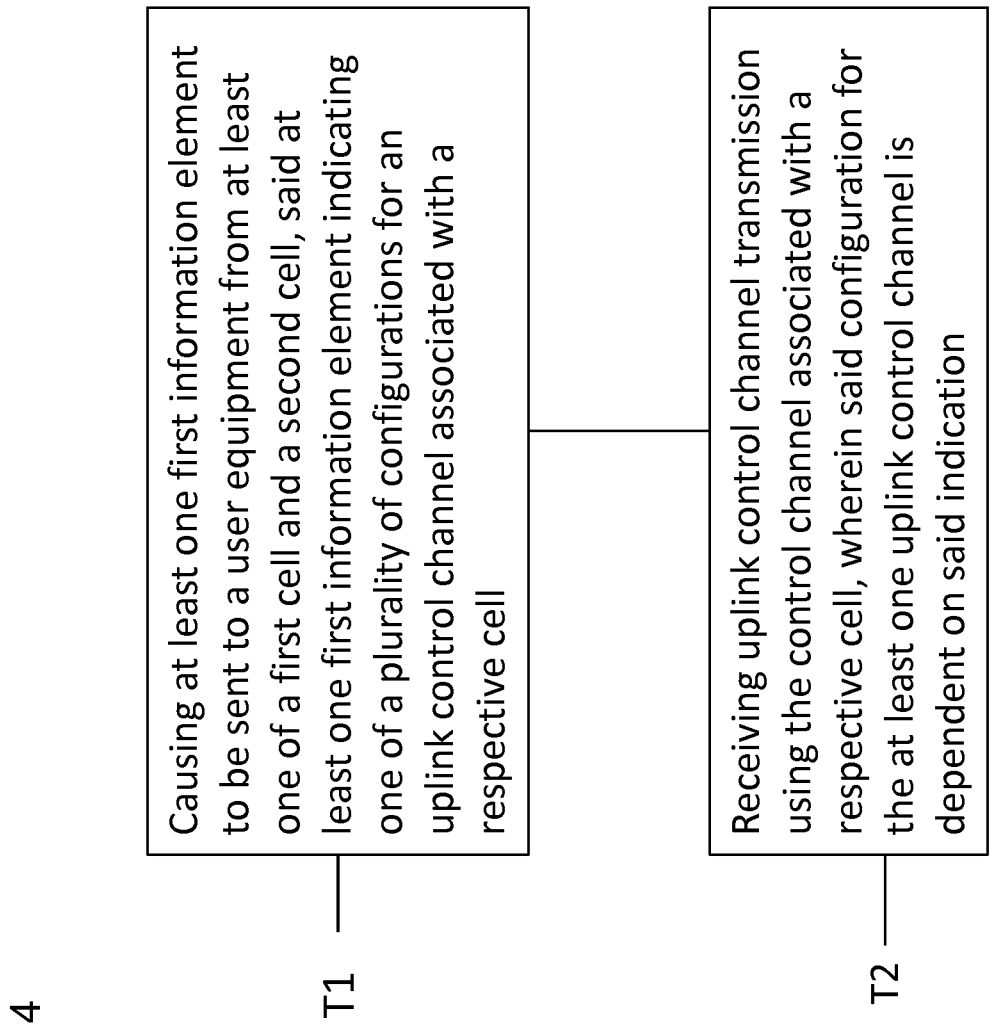

Causing at least one first information element to be sent to a user equipment from at least one of a first cell and a second cell, said at least one first information element indicating one of a plurality of configurations for an uplink control channel associated with a respective cell
T1
Receiving uplink control channel transmission using the control channel associated with a respective cell, wherein said configuration for the at least one uplink control channel is dependent on said indication
T2

Figure 5

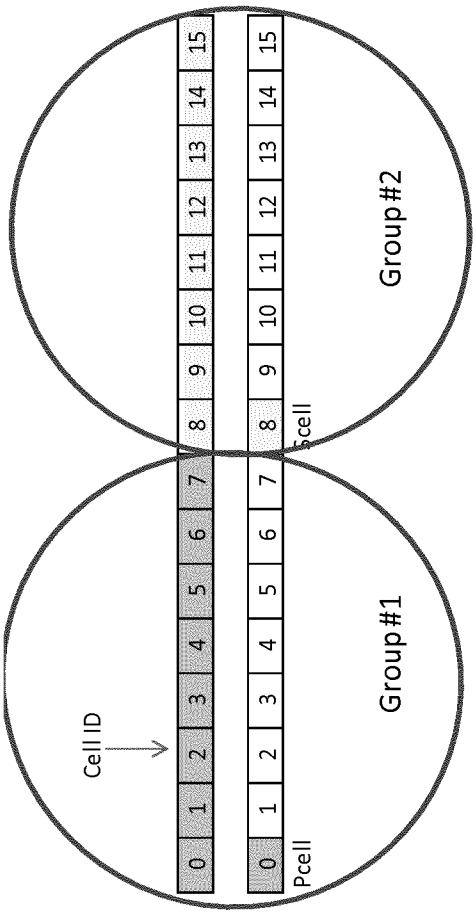
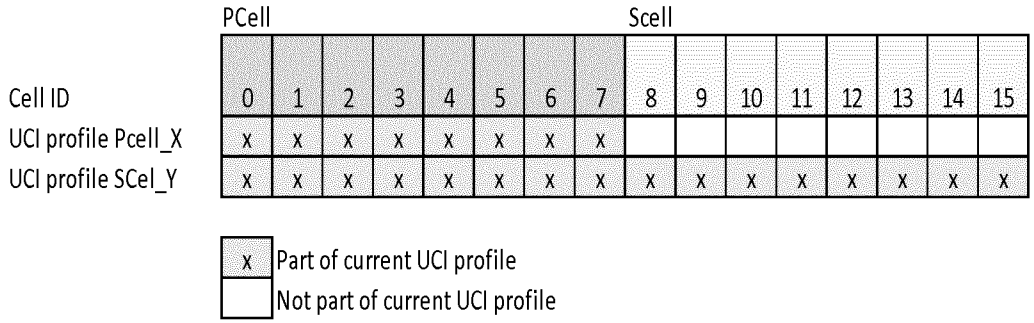

Cell ID
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DL
UL (PUCCH)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Pcell
Scell
Group#1
Group#2

Figure 6



configuration

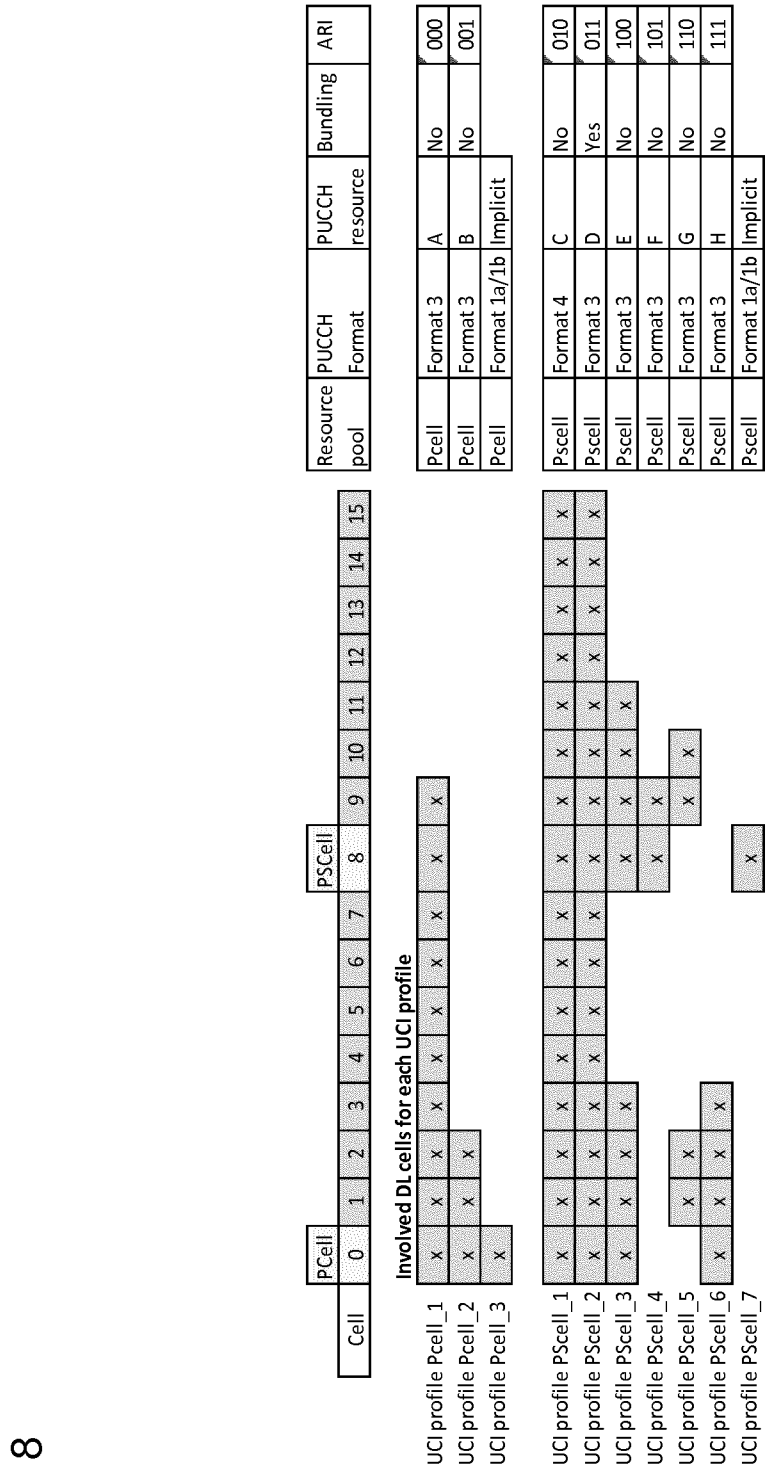
Resource pool	PUCCH Format	PUCCH resource
Pcell	Format 3	1_X
Scell	Format 3	2_Y

Figure 7

	Pcell								Pscell							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
UCI profile Pcell_1	x	x	x	x	x	x	x	x								
UCI profile Pcell_2	x	x	x	x	x	x										
UCI profile Pcell_3	x	x	x	x												
UCI profile Pcell_4	x	x														
UCI profile Pcell_5	x															
UCI profile PScell_1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
UCI profile PScell_2									x	x	x	x	x	x	x	x
UCI profile PScell_3									x	x						
UCI profile PScell_4									x	x						
UCI profile PScell_5									x							

Resource pool	PUCCH Format	PUCCH resource	ARI
Pcell	Format 3	A	11
Pcell	Format 3	B	10
Pcell	Format 3	C	01
Pcell	Format 3	D	00
Pcell	Format 1a/1b	implicit	
Scell	Format 4	E	11
Scell	Format 3	F	10
Scell	Format 3	G	01
Scell	Format 3	H	00
Scell	Format 1a/1b	implicit	

Figure 8


Cell
PCell
PSCell
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Involved DL cells for each UCI profile
UCI profile Pcell_1
UCI profile Pcell_2
UCI profile Pcell_3
UCI profile PScell_1
UCI profile PScell_2
UCI profile PScell_3
UCI profile PScell_4
UCI profile PScell_5
UCI profile PScell_6
UCI profile PScell_7
Resource pool
PUCCH Format
PUCCH resource
Bundling
ARI
Pcell Format 3 A No 000
Pcell Format 3 B No 001
Pcell Format 1a/1b Implicit
Pscell Format 4 C No 010
Pscell Format 3 D Yes 011
Pscell Format 3 E No 100
Pscell Format 3 F No 101
Pscell Format 3 G No 110
Pscell Format 3 H No 111
Pscell Format 1a/1b Implicit

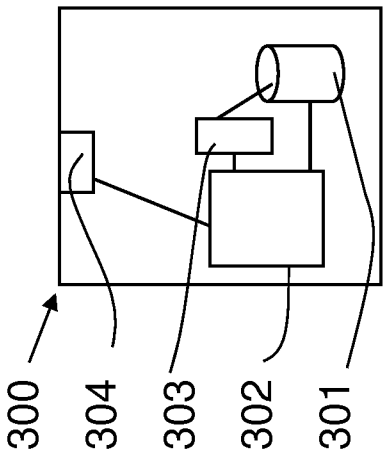


Figure 9

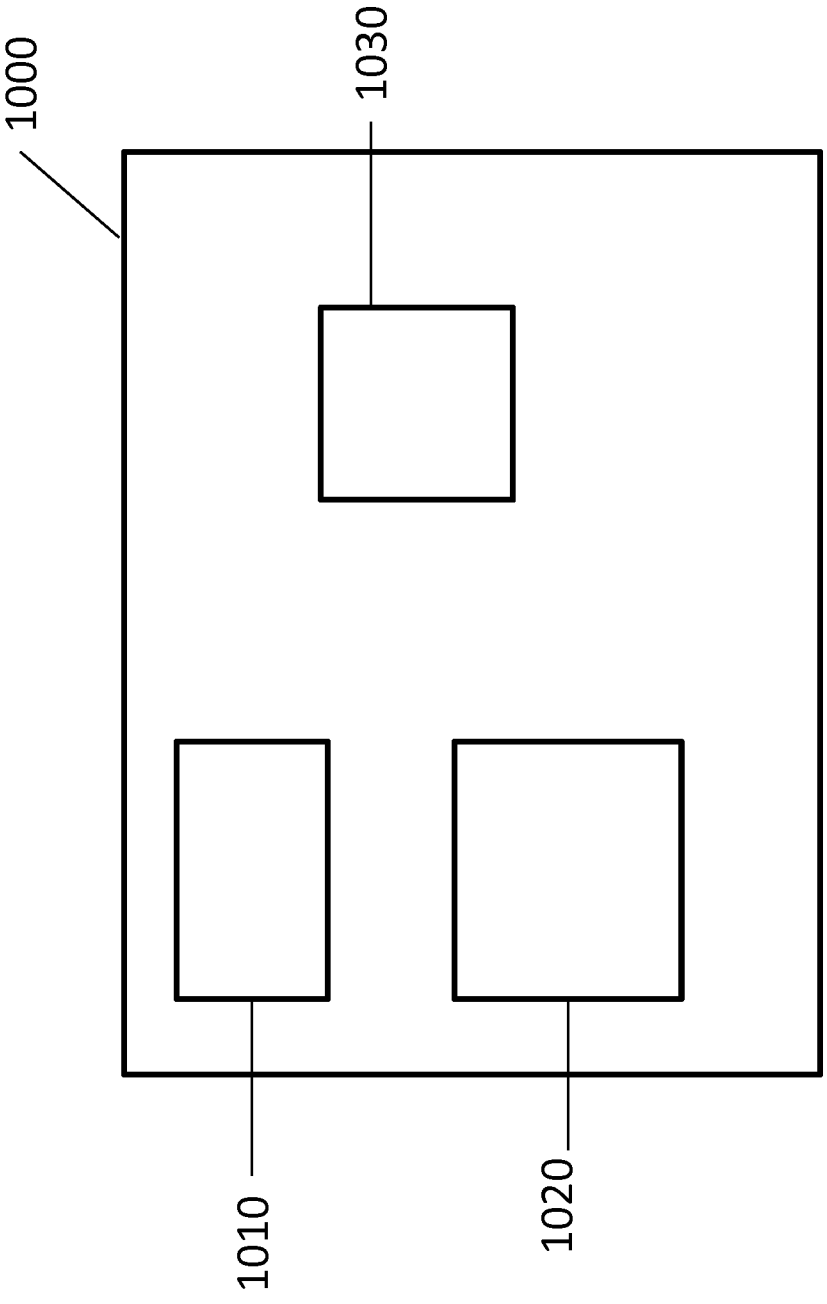


Figure 10

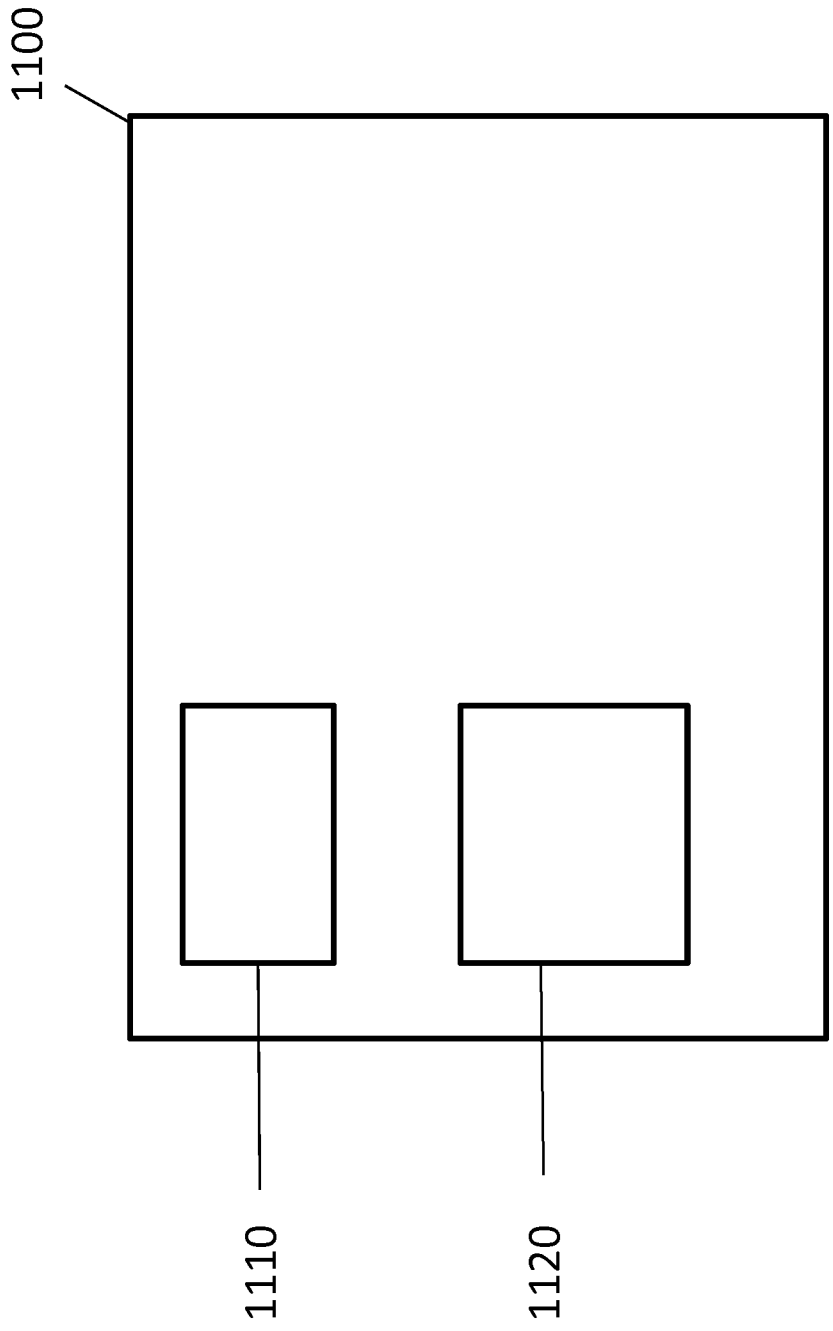


Figure 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/051315

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W72/12 H04W72/04
ADD.

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

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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NTT DOCOMO ET AL: "Support of PUCCH on SCell for CA - RAN2 asp", 3GPP DRAFT; R2-143073, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Dresden, Germany; 20140818 - 20140822 17 August 2014 (2014-08-17), XP050794200, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2014-08-17]	1,7-10, 14-18, 26,27, 31,32
Y	the whole document	6,23-25
A		2-5, 11-13, 19-22,

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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
25 September 2015	02/10/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Papanikolaou, Eleni

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2014/192738 A1 (NAM YOUNG-HAN [US] ET AL) 10 July 2014 (2014-07-10)	1,4,5, 10,13, 16-18, 21,22, 27,30
Y	paragraphs [0004] - [0010]	6,23
A	paragraphs [0060], [0065] paragraphs [0089] - [0092] paragraphs [0099] - [0135] paragraphs [0142] - [0179] paragraphs [0223] - [0229] figure 9	2,3,7-9, 11,12, 14,15, 19,20, 24-26, 28,29, 31,32

X	WO 2014/075043 A2 (QUALCOMM INC [US]) 15 May 2014 (2014-05-15)	1,2,10, 11, 16-19, 27,28
Y	paragraph [0042] paragraphs [0052] - [0053]	3,12,20, 29
A	paragraphs [0056] - [0069] paragraphs [0098] - [0099] figures 8A,12	4-9, 13-15, 21-26, 30-32

X	HUAWEI ET AL: "Extending PUCCH on PCell and pSCell to Carrier Aggregation", [Online] 10 May 2014 (2014-05-10), 3GPP DRAFT; R1-142337, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, XP050814787, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_77/Docs/> [retrieved on 2014-05-10]	1,10, 16-18,27
Y	1-Introduction 2-Motivation to extend PUCCH on PCell and	3,12,20, 29
A	PSCell to CA 3-Additionnal work to extend PUCCH on PCell and pSCell to CA	2,4-9, 11, 13-15, 19, 21-26, 28,30-32

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SAMSUNG: "UL DAI for DL CA", 3GPP DRAFT; R1-110727 UL DAI, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Taipei, Taiwan; 20110221, 15 February 2011 (2011-02-15), XP050490532, [retrieved on 2011-02-15]	6,23-25
A	2-DAI in UL Scheduling Assignments for CA and FDD -----	1-5, 7-22, 26-32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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