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

(72) Inventors: DE BENEDITTIS, Rossella; SyrlinStrasse
18a, 89073 Ulm (DE). SEBIRE, Benoist Pierre; 2-20-5
Kagurazaka Shinjuku, Tokyo, 162-0825 (JP). HENT-
TONEN, Tero; Kivenlahdenkatu 3 B 22, FI-02320 Espoo
(FI).

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(54) Title: METHODS AND APPARATUSES FOR ENABLING/DISABLING A DRX MODE

Figure 3a

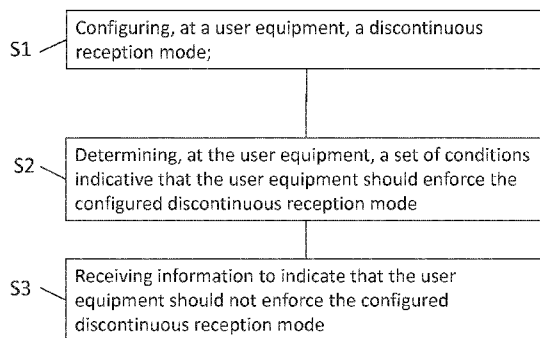
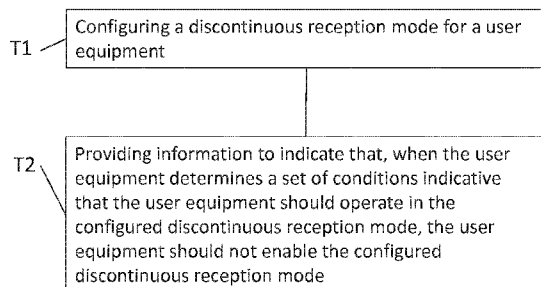


Figure 3b



(57) Abstract: There is provided a method comprising configuring, at a user equipment, a discontinuous reception mode, determining, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode and receiving information to indicate that the user equipment should not enable the configured discontinuous reception mode.

*Description**Title***METHODS AND APPARATUSES FOR ENABLING/DISABLING A DRX MODE**

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Field

The present application relates to a method, apparatus, system and computer program and in particular but not exclusively, to Dual Connectivity (DC) and Carrier Aggregation (CA) in
10 E-UTRAN/LTE communication systems.

Background

A communication system can be seen as a facility that enables communication sessions be-
15 tween 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
20 (email), text message, multimedia and/or content data and so on. Non-limiting examples of services provided comprise 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
25 stations occurs over a wireless link. Examples of wireless systems comprise 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.

30 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
35 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 a method comprising configuring, at a user equipment, a discontinuous reception mode, determining, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode and receiving information to indicate that the user equipment should not enable the configured discontinuous reception mode.

The method may comprise receiving information to indicate that the user equipment should enable the configured discontinuous reception mode and operating in the configured discontinuous reception mode.

The information may comprise an indication to revert the current state of operation of the configured discontinuous reception mode.

The information may comprise media access control elements.

The user equipment may be associated with a cell group.

The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

The information comprises the cell group identity information

The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

5 The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

Determining the set of conditions may comprise determining data inactivity from the cell.

10 In a second aspect there is provided a method comprising configuring a discontinuous reception mode for a user equipment and providing information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

15 The method may comprise providing information to indicate that the user equipment should enable the configured discontinuous reception mode.

The information may comprise an indication to revert the current state of operation of the configured discontinuous transmission mode.

20 The information may comprise media access control elements.

The user equipment may be associated with a cell group.

25 The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

30 The information may comprise cell group identity information

The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

35 The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

The set of conditions may comprise data inactivity from the cell.

In a third aspect there is provided an apparatus, said apparatus comprising means for configuring, at a user equipment, a discontinuous reception mode, means for determining, at the
5 user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode and means for receiving information to indicate that the user equipment should not enable the configured discontinuous reception mode.

The apparatus may means for receiving information to indicate that the user equipment
10 should enable the configured discontinuous reception mode and operating in the configured discontinuous reception mode.

The information may comprise an indication to revert the current state of operation of the configured discontinuous reception mode.

15 The information may comprise media access control elements.

The user equipment may be associated with a cell group.

20 The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

The information comprises the cell group identity information

25 The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

The user equipment may be configured for carrier aggregation and the cell group may be a
30 physical uplink control channel cell group.

Determining the set of conditions may comprise determining data inactivity from the cell.

In a fourth aspect there is provided an apparatus comprising means for configuring a discontinuous reception mode for a user equipment and means for providing information to indicate
35 that, when the user equipment determines a set of conditions indicative that the user equip-

ment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

5 The apparatus may comprise means for providing information to indicate that the user equipment should enable the configured discontinuous reception mode.

The information may comprise an indication to revert the current state of operation of the configured discontinuous transmission mode.

10 The information may comprise media access control elements.

The user equipment may be associated with a cell group.

15 The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

The information may comprise cell group identity information

20 The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

25 The set of conditions may comprise data inactivity from the cell.

30 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 configure, at a user equipment, a discontinuous reception mode, determine, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode and receive information to indicate that the user equipment should not enable the configured discontinuous reception mode.

35

The apparatus may be configured to receive information to indicate that the user equipment should enable the configured discontinuous reception mode and operating in the configured discontinuous reception mode.

- 5 The information may comprise an indication to revert the current state of operation of the configured discontinuous reception mode.

The information may comprise media access control elements.

- 10 The user equipment may be associated with a cell group.

The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

15

The information comprises the cell group identity information

The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

20

The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

Determining the set of conditions may comprise determining data inactivity from the cell.

25

In a sixth aspect there is provided an apparatus, said 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 configure a discontinuous reception mode for a user equipment and provide information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

30

- 35 The apparatus may be configured to provide information to indicate that the user equipment should enable the configured discontinuous reception mode.

The information may comprise an indication to revert the current state of operation of the configured discontinuous transmission mode.

- 5 The information may comprise media access control elements.

The user equipment may be associated with a cell group.

The configured discontinuous reception mode may be associated with the cell group.

10

The information may be associated with the cell group.

The information may comprise cell group identity information

- 15 The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

20

The set of conditions may comprise data inactivity from the 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
25 controlling a process to execute a process, the process comprising configuring, at a user equipment, a discontinuous reception mode, determining, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode and receiving information to indicate that the user equipment should not enable the configured discontinuous reception mode.

30

The process may comprise receiving information to indicate that the user equipment should enable the configured discontinuous reception mode and operating in the configured discontinuous reception mode.

- 35 The information may comprise an indication to revert the current state of operation of the configured discontinuous reception mode.

The information may comprise media access control elements.

The user equipment may be associated with a cell group.

5

The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

10 The information comprises the cell group identity information

The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

15 The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

Determining the set of conditions may comprise determining data inactivity from the cell.

20 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 configuring a discontinuous reception mode for a user equipment and providing information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should
25 operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

The process may comprise providing information to indicate that the user equipment should enable the configured discontinuous reception mode.

30

The information may comprise an indication to revert the current state of operation of the configured discontinuous transmission mode.

The information may comprise media access control elements.

35

The user equipment may be associated with a cell group.

The configured discontinuous reception mode may be associated with the cell group.

The information may be associated with the cell group.

5

The information may comprise cell group identity information

The user equipment may be configured for dual connectivity, and the cell group may be a master cell group or a secondary cell group.

10

The user equipment may be configured for carrier aggregation and the cell group may be a physical uplink control channel cell group.

The set of conditions may comprise data inactivity from the cell.

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

20 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

25

Embodiments will now be described, by way of examples 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;

30

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

Figure 3a shows a flowchart of an example method;

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Figure 3b shows a flowchart of an example method;

Figure 4 shows a schematic diagram of an example control apparatus;

Figure 5 shows a schematic diagram of an apparatus;

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Figure 6 shows a schematic diagram of an apparatus;

Detailed description

10 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.

15 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.
20 wireless communication system 100) or in a core network (CN) (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 (RNC). In Figure 1 control apparatus 108 and 109 are shown to control the respective macro level base stations 106 and 107. The control
25 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.

30

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
35 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.

- 5 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.

10 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. Smaller base stations 116, 118 and 120 may be part of a second network,
15 for example WLAN and may be WLAN APs.

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
20 appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples comprise 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,
25 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 comprise two-way or multi-way calls, data communication or multimedia services or simply
30 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 comprise downloads, television and radio programs, videos, advertisements, various alerts and other information.

- 35 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.

5

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.

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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.

30

35

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 Packet Data Convergence/Radio Link Control/Medium Access Control/Physical layer protocol (PDCP/RLC/MAC/PHY) and control plane Radio Resource Control (RRC) protocol terminations towards the communication devices. Other examples of radio access sys-

tem comprise 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.

5

In dual Connectivity (DC) operation, a multi-transceiver UE is configured to utilise radio resources provided by two distinct eNBs, the Master eNB (MeNB) and the Secondary eNB (SeNB) respectively, connected via a non-ideal backhaul over the X2 interface.

10

One or more cells can serve the UE both from the MeNB and from the SeNB.

The set of UE serving cells located in the MeNB defines the Master Cell Group (MCG). The set of UE serving eNB located in the SeNB defines the Secondary Cell Group (SCG).

Within the SCG, at least one cell, named PSCell, should be configured with PUCCH resources.

15

The MeNB generates and terminates the final RRC messages towards the UE, after coordination of the RRM functions between MeNB and SeNB.

20

The UE RRC entity sees all messages coming only from one entity (in the MeNB) and the UE only replies back to that entity. Yet the UE is configured with two MAC entities: one MAC entity for MeNB and one MAC entity for SeNB.

25

Data activity through a cell may be suspended, for example because there is no data to send from that cell or the cell channel quality is such that that data transmission from that cell would result in too many retransmissions. 3GPP standard allows for an explicit deactivation of SCells, whereas for P(S)Cells it offers the enforcement of a configured discontinued reception (DRX) profile.

30

The serving cells of the MCG other than the PCell may be activated (and deactivated) by a MAC Control Element (MAC CE) received on MCG. Similarly, the serving cells of the SCG other than PSCell can be activated (and deactivated) by a MAC CE received on SCG.

35

In DC, the PSCell and the PCell can never be deactivated at the UE. With these cells, DRX is the only way to minimize the UE power consumption when there is no data to send. The MeNB and SeNB can set the DRX parameters independently, but it is expected that the DRX cycles would be coordinated to provide maximal benefits.

When cell channel quality is such that that data transmission from that cell would result in too many retransmissions, it may be more efficient from throughput viewpoint to use just the other cells with sufficient channel quality for serving the UE. Once cell channel quality improves, data transmission should be resumed as fast as possible to benefit all the configured radio resources. For this to happen, the cell channel quality should be constantly monitored, even when data transmission has been suspended.

E-UTRAN may derive the cell channel quality from the UE from the UE's layer 3 measurement reports and/or from the UE's layer 2 indicators (e.g. CQI reports, HARQ ack/nack).

However, layer 3 measurements may not be very fast. The measurement itself may take some time (both L1 filtering and L3 filtering is applied), results are communicated via an RRC procedure and the signaling is exchanged between the UE and the MeNB, and MeNB would need to forward the result/requested action to the SeNB

Layer 2 measurements (at eNB) may be faster and can be handled locally in the affected cell. However, with the current DC concept defined by 3GPP, when data transmission from a PSCell (and similarly from a PCell) is suspended, the UE enforces the DRX mode according to DRX mode configuration received from the eNB, and while inactive, does neither the PDCCH monitoring nor uplink transmission (e.g. CQI reports). The UE is only monitoring PDCCH and performing UL transmissions during the "active" times. Hence, with reduced CQI reports from UE to the eNB, layer 2 channel quality monitoring may become slower and less efficient.

A possibility offered by 3GPP would be to configure a DRX profile composed both by a short and by a long DRX cycle: the short DRX cycle would work at the beginning of data inactivity assuring sufficient CQI reports, whereas the long cycle will be applied only if the status of no data transmission persists. However, if the short DRX cycle is too short (e.g. 20 ms) and the fading last for more than 500 ms, the long DRX cycle will apply before the channel quality resumes (max repetition of the short cycle is 16, i.e. $16 \times 20 = 320$ ms). On the other hand, if short DRX cycle is too long (e.g. 160 ms), it may take too long to resume the connection with the UE.

In an example, the UE is in DC with Cell1 as Pcell in the MeNB and with Cell2 as PSCell SeNB. The data bearer in the SeNB may be from a split bearer (i.e. split between the MeNB

and the SeNB) or from a SCG bearer (i.e. only served by the SeNB). When configured in DC, the UE also gets the DRX configuration to apply in the SeNB and MCG respectively.

SeNB may suspend data transmission from Cell2, if it finds out that its DL channel quality is bad.

As there is no data activity through Cell2, UE enforces DRX, slowing down the CQI transmission according to the configured DRX profile. When DRX is enforced, the UE can send CQI reports only in the DRX On Duration time intervals which occur with a frequency that depends on the configured DRX cycle size

Later on, the Cell2 channel quality may improve. However, due the reduced CQI report rate, it takes time for the SeNB to realize that the channel quality is improved and, due to the enforcement of DRX inactive periods, it takes some time to resume data transmission from this cell. For resuming data transmission, the eNB must wait for the next DRX on duration period. The wait time depends again on the configured DRX cycle. The UE throughput may stay affected for quite some time, although it could benefit from Cell2 radio resources.

If DRX is not configured, when there is no traffic to convey via the SCG (or MCG) cells, the UE does not go into idle and therefore its power consumption may not be optimised. If a DRX profile with both a short and a long DRX cycle is configured, the short DRX cycle is enforced first with its inactive periods where no CQI can be reported by the UE and after a while (i.e. after the pre-configured max repetition of the short DRX cycle) the UE will enforce the long DRX cycle if it has still no data to transmit or receive which has even longer inactive periods and therefore even less opportunities for the UE to send CQI reports.

When data transmission from the PSCell (PCell) is suspended for bad channel quality, DRX should be released in order not to reduce the UE opportunities to send CQI, therefore not to slow down channel quality estimation at the eNB. However, as the DRX release requires a layer 3 procedure between the UE and the MeNB, this solution may not be as fast as required. On the other hand, sending dummy DL packets (for instance Timing Advance Command MAC Control Element only) to cause the UE to stay active may increase both DL and UL overhead unnecessarily.

US patent publication no. 20140241227 proposes that a UE, configured with two different DRX profiles or with one single DRX profile composed both of a short and of a long DRX cy-

cle, changes from one DRX profile to the other, or enforces either the short or the long DRX cycle of the single DRX profile respectively, according to the actual data traffic. The UE always enforces one of, or part of, the provided DRX configuration, with the consequence that CQI opportunities will decrease, if there is no data activity.

5

Another proposal is that an eNB dynamically controls when the UE should stay active and when it can go to sleep mode, according to the actual traffic needs. The eNB provides to the UE the active period length and the sleeping period length to use, at the beginning and at the end of the current active period respectively, resulting in a so-called "dynamic" DRX profile.

10

This proposal may keep a UE active when a bad channel condition is detected, however it defines a new concept for DRX that is not defined so far by 3GPP, and more information may be needed to be exchanged between the UE and the eNB, which may be inefficient..

15

A flowchart of an example method in accordance with an embodiment is shown in figure 3a. The method comprises, in a first step S1, configuring, at a user equipment, a discontinuous reception mode.

20

In a second step S2, the method comprises determining, at the user equipment, a set of conditions indicative that the user equipment should enforce the configured discontinuous reception mode, i.e. that it should enable the configured DRX profile according to the actual data activity.

25

In a third step S3, the method comprises receiving information to indicate that the user equipment should not enforce the configured discontinuous reception mode, i.e. it should operate as if it was not configured with DRX independent from the actual data activity.

A flowchart of an example method in accordance with an embodiment is shown in figure 3b.

30

In a first step T1, the method comprises configuring a discontinuous reception mode for a user equipment. In a second step, T2, the method comprises providing information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

35

The UE may be associated with a cell of a cell group. For example, the UE may be configured with DC in the E-UTRAN/LTE. The configured discontinuous reception mode (DRX) may be a DRX profile configured at the UE. The configured DRX mode may be associated with a first cell group, e.g. MCG, SCG or PUCCH cell group. The configured DRX mode may
5 comprise a short DRX cycle inside a long DRX cycle.

The information that indicates to the UE whether it should or it should not enforce a configured DRX profile may be conveyed to the UE via e a MAC CE.

10 For example, in an embodiment, the information may comprise two MAC Control Elements (MAC CE), which may be referred to as DRX Enable MAC CE and DRX Disable MAC CE, by which the base station (e.g. SeNB and/or MeNB) can respectively enable and disable the enforcement at the UE of a configured DRX profile in a respective cell group (SCG and/or MCG). The "DRX Disable" disables the DRX configuration in the UE, while the "DRX Enable"
15 enables it again if it has been disabled. While a DRX configuration is disabled, UE acts as if no DRX was configured.

The information may comprise an indication to revert the state of operation of the first DRX. For example, the information may comprise one MAC CE which reverts the command of the
20 previous one, assuming a default starting condition e.g. "DRX Enabled".

The information, e.g. the MAC CEs, may be associated with a UE cell group and may be sent from any cell of the respective Cell Group.

For a UE in DC, the cell group can identify the Master Cell Group (MCG) or a Secondary
25 Cell Group (SCG), whereas for a UE in CA the cell group can identify a PUCCH Cell Group.

The information may comprise the cell group identity information. For example, the MAC CEs may be used with a payload, which identifies the CG (for DC) or PUCCH group (for enhanced CA) to which the command refers. This way, the information may be sent from a cell
30 of a different group from the one to which the command applies. In DC X2 signalling may be enhanced in order to signal the DRX status ordered from one cell group of the UE to the other cell group to allow the transmission of the information from a different cell group from the one it refers. If the information does not include the cell group, e.g. the CG or PUCCH group, identify information, the information applies to the cell group, CG or PUCCH group,
35 on which it is sent.

The base station, e.g. eNB, may specify via RRC signaling how the information, e.g. MAC CEs, should be interpreted by the UE. For example, the eNB may specify via RRC signalling whether the MAC Disable switches off completely the DRX profile or it allows only the small DRX cycles if configured.

5

Example implementations will now be described in which a UE is in DC with Cell1 as Pcell in the MeNB and with Cell2 as PSCell SeNB. The data bearer in the SeNB may be from a split bearer (i.e. split between the MeNB and the SeNB) and/or from a SCG bearer (i.e. only served by the SeNB).

10

When configured in DC, the UE may also receive the DRX configuration to apply in the SCG and MCG respectively.

In one embodiment, if the SeNB determines that the Cell2 DL channel quality is not good enough for efficient scheduling, the SeNB suspends data transmission from Cell2, and sends a "DRX Disable" MAC CE to the UE.

15

Although the UE receives no data from Cell2, the UE does not enter in DRX inactive mode as it has been instructed to not enforce DRX by the "DRX disable" MAC CE. The UE will therefore continue to send CQI bits as if there were data activity.

20

Once the channel quality improves sufficiently, the SeNB may resume data transmission from Cell2. At the same time, SeNB sends the "DRX Enable" MAC CE to the UE.

In one embodiment, when starting data transmission with a UE, SeNB sends the "DRX Disable" MAC CE to the UE.

25

When the SeNB finds out that Cell2 DL channel quality is not good enough for efficient scheduling, SeNB suspends data transmission from Cell2.

30

Although it receives no data from Cell2, the UE does not enter in DRX inactive mode as it has been instructed to not enforce DRX. The UE will therefore continue to send CQI bits as if there were data activity.

As soon as the channel quality improves sufficiently, SeNB quickly resumes data transmission from Cell2.

35

When there is no data to send to the UE, eNB sends the "DRX Enable" MAC CE to the UE, by which the UE can enforce DRX.

- 5 When there is again data to send from Cell2, eNB sending the "DRX Disable" MAC CE to the UE.

Sending "DRX Disable" when starting data transmission, may result in the MAC CE being sent in radio channel conditions in which there is a has higher probability to be successfully
10 received by the UE.

Data transmission from Cell2 is quickly suspended when its channel condition deteriorates, but can be quickly resumed once the channel quality improves again.

- 15 When there is no more data to send, the UE is enabled to enforce DRX.

It should be understood that each block of the flowchart of Figures x and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry. Although the blocks are shown
20 in a first order, the steps may be performed in any order, and/or may be performed as part of a single calculation/determination.

The method may be implemented on a mobile device as described with respect to figure 2 or control apparatus as shown in figure 4. Figure 4 shows an example of a control apparatus
25 for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station or (e) node B, or a node of a core network such as an MME, or a server or host, or a control node of a WLAN network, e.g. a WIG. The method may be implanted in a single control apparatus or across more than one control apparatus. The control apparatus may be integrated with or external to a node
30 or module of a core network or RAN. In some embodiments, base stations comprise a separate control apparatus unit or module. In other embodiments, the control apparatus can be another network element such as a radio network controller or a spectrum controller. In some embodiments, each base station may have such a control apparatus as well as a control apparatus being provided in a radio network controller. The control apparatus 300 can be
35 arranged to provide control on communications in the service area of the system. The control 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 control apparatus 300 can be configured to execute an appropriate software code to provide the control functions. Control functions may comprise configuring a discontinuous reception mode for a user equipment and providing information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode

An example of an apparatus 500 shown in figure 5 comprises means 510 for configuring, at a user equipment, a discontinuous reception mode, means 520 for determining, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode and means 530 for receiving information to indicate that the user equipment should not enable the configured discontinuous reception mode.

An example of an apparatus 600 shown in figure 6 comprises means 610 for configuring a discontinuous reception mode for a user equipment and means 620 for providing information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

It should be understood that the apparatuses may comprise 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 in relation to other cellular networks and wireless local area networks and to any other communication system where dual connectivity and/or 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.

5 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.

15

The embodiments of this invention may be implemented by computer software executable by a data processor of the mobile device, such as in 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 and they comprise program instructions to perform particular tasks. 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.

25

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.

35 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 comprise 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 of the inventions 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.

In an embodiment at least some of the functionalities of the apparatus of Figures 4 and 5 may be shared between two physically separate devices forming one operational entity. Therefore, the apparatus may be seen to depict the operational entity comprising one or more physically separate devices for executing at least some of the described processes. The apparatus utilizing such shared architecture, may comprise a remote control unit (RCU), such as a host computer or a server computer, operatively coupled (e.g. via a wireless or wired network) to a remote radio head (RRH) located in the base station, in the access point, or in the WIG, for example. In an embodiment, at least some of the described processes may be performed by the RCU. In an embodiment, the execution of at least some of the described processes may be shared among the RRH and the RCU.

In an embodiment, the RCU may generate a virtual network through which the RCU communicates with the RRH. In general, virtual networking may involve a process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Network virtualization may involve platform virtualization, often combined with resource virtualization. Network virtualization may be categorized as external virtual networking which combines many networks, or parts of networks, into the server computer or the host computer (i.e. to the RCU). External network virtualization is targeted to optimized network sharing. Another category is internal virtual networking which provides network-like functionality to the software containers on a single system. Virtual networking may also be used for testing the terminal device.

In an embodiment, the virtual network may provide flexible distribution of operations between the RRH and the RCU. In practice, any digital signal processing task may be performed in

either the RRH or the RCU and the boundary where the responsibility is shifted between the RRH and the RCU may be selected according to implementation.

5 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
10 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:
configuring, at a user equipment, a discontinuous reception mode;
5 determining, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode; and
receiving information to indicate that the user equipment should not enable the configured discontinuous reception mode.
- 10 2. A method according to claim 1, comprising:
receiving information to indicate that the user equipment should enable the configured discontinuous reception mode; and
operating in the configured discontinuous reception mode.
- 15 3. A method according to any preceding claim, wherein the information comprises an indication to revert the current state of operation of the configured discontinuous reception mode.
4. A method according to any preceding claim, wherein the information comprises media access control elements.
20
5. A method according to any preceding claim, wherein the user equipment is associated with a cell group.
- 25 6. A method according to claim 5, wherein the configured discontinuous reception mode is associated with the cell group.
7. A method according to claim 5 or claim 6, wherein the information is associated with the cell group.
30
8. A method according to any one of claims 5 to 7, wherein the information comprises the cell group identity information
9. A method according to one of claims 5 to 8, wherein the user equipment is
35 configured for dual connectivity, and the cell group is a master cell group or a secondary cell group.

10. A method according to one of claims 5 to 9, wherein the user equipment is configured for carrier aggregation and the cell group is a physical uplink control channel cell group.

11. A method according to any one of claims 5 to 10, wherein determining the set of conditions comprises determining data inactivity from the cell.

12. A method comprising:
configuring a discontinuous reception mode for a user equipment; and
providing information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous reception mode, the user equipment should not enable the configured discontinuous reception mode.

13. A method according to claim 12, comprising providing information to indicate that the user equipment should enable the configured discontinuous reception mode.

14. A method according to any one of claims 12 and 13, wherein the information comprises an indication to revert the current state of operation of the configured discontinuous transmission mode.

15. A method according to any one of claims 11 to 14, wherein the information comprises media access control elements.

16. A method according to any one of claims 11 to 15, wherein the user equipment is associated with a cell group.

17. A method according to claim 16, wherein the configured discontinuous reception mode is associated with the cell group.

18. A method according to claim 16 or claim 17, wherein the information is associated with the cell group.

19. A method according to any one of claims 16 to 18, wherein the information comprises cell group identity information

20. A method according to one of claims 16 to 19, wherein the user equipment is configured for dual connectivity, and the cell group is a master cell group or a secondary cell group.

21. A method according to one of claims 16 to 19, wherein the user equipment is configured for carrier aggregation and the cell group is a physical uplink control channel cell group.

22. A method according to any one of claims 16 to 21, wherein the set of conditions comprises data inactivity from the cell.

23. A computer program product for a computer, comprising software code portions for performing the steps of any of claims 1 to 22 when said product is run on the computer.

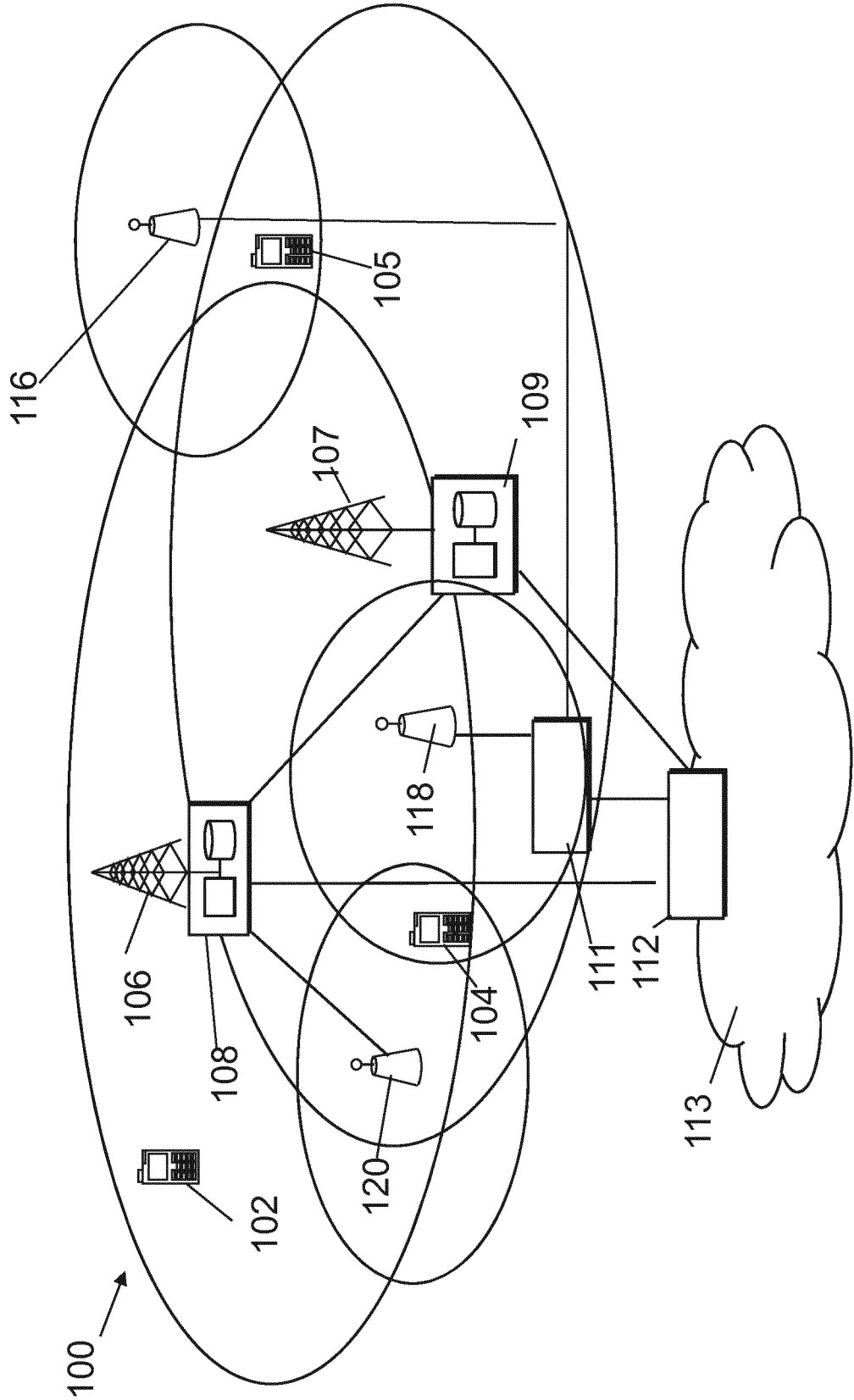
24. An apparatus comprising means for performing a method according to any one of claims 1 to 22.

25. 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:
configure, at a user equipment, a discontinuous reception mode;
determine, at the user equipment, a set of conditions indicative that the user equipment should operate using the configured discontinuous reception mode; and
receive information to indicate that the user equipment should not enable the configured discontinuous reception mode.

26. 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:
configure a discontinuous reception mode for a user equipment; and
provide information to indicate that, when the user equipment determines a set of conditions indicative that the user equipment should operate in the configured discontinuous

reception mode, the user equipment should not enable the configured discontinuous reception mode

Figure 1



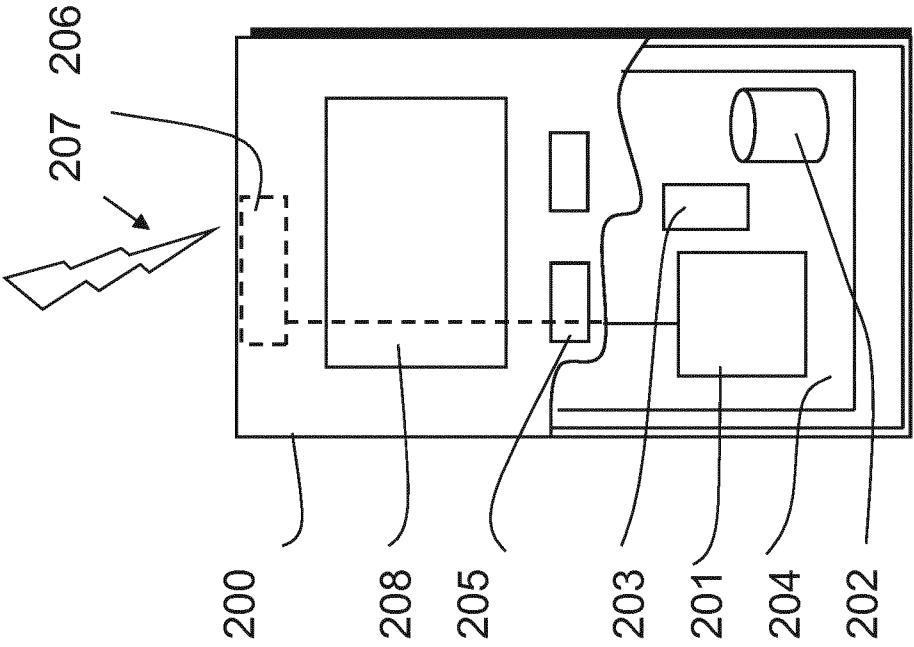


Figure 2

Figure 3a

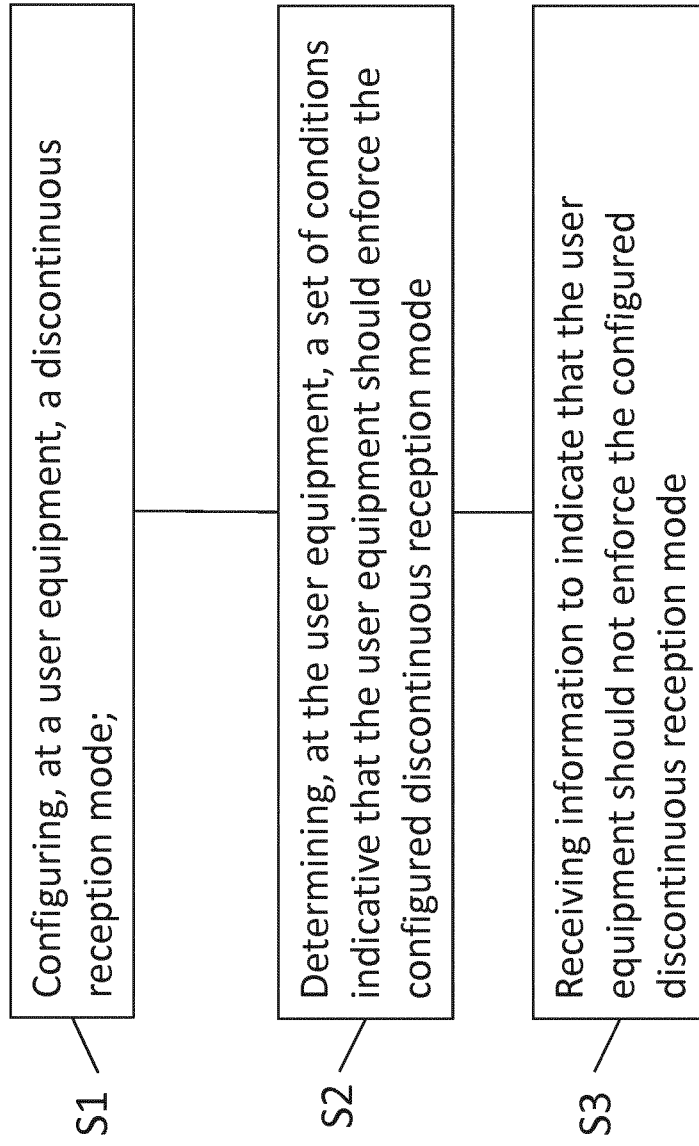
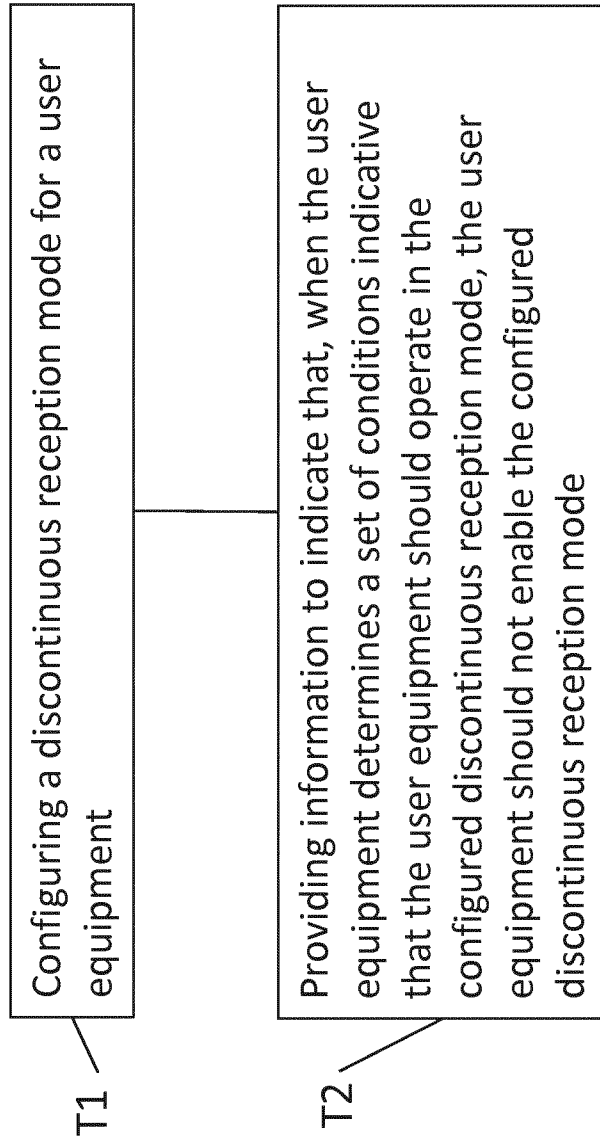


Figure 3b



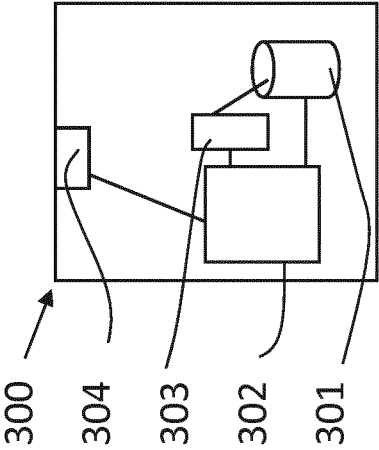
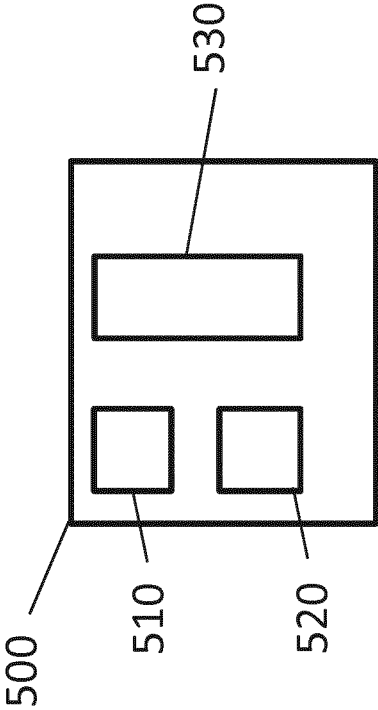


Figure 4

Figure 5



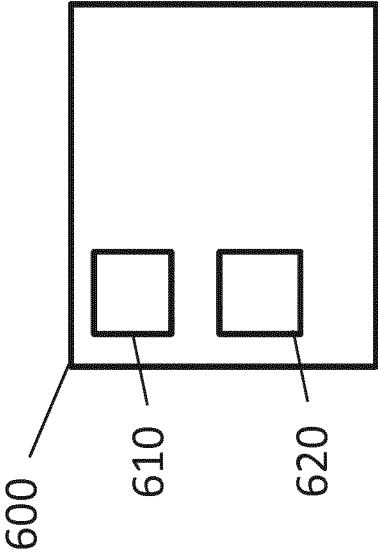


Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/060330

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W76/04
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, WPI Data

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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

26 January 2016

Date of mailing of the international search report

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Tous Fajardo, Juan

INTERNATIONAL SEARCH REPORT

International application No

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