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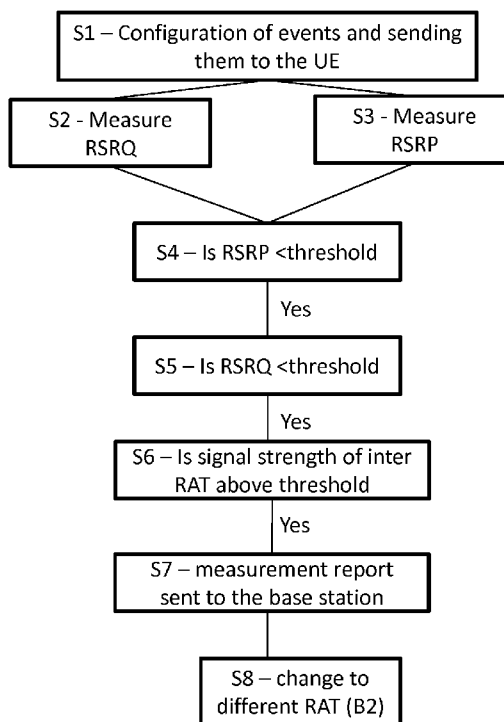
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(54) Title: METHOD AND APPARATUS

Figure 5



[Continued on next page]



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**(57) Abstract:** A method comprises using information about a power with which a signal is received by a user equipment and information about a quality with which the signal is received by a user equipment to provide information used to change said user equipment to a different cell.

## DESCRIPTION

Title

## METHOD AND APPARATUS

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Some embodiments relate to methods and apparatus and in particular but not exclusively to methods and apparatus and in particular but not exclusively for use when determining if a change is to be made from one cell to another.

10 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  
15 voice, electronic mail (email), text messages, 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.

20 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.

25 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  
30 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 3<sup>rd</sup> Generation Partnership Project (3GPP). The various development stages of the 3GPP LTE specifications are referred to as releases. A further development of the LTE is referred to as LTE-Advanced (LTE-A).

It has been proposed to have co-channel deployment where two different radio technologies share a carrier band.

According to an aspect, there is provided a method comprising: using information about a power with which a signal is received by a user equipment and information about a quality with which the signal is received by a user equipment to provide information used to change said user equipment to a different cell.

The signal received by said user equipment may comprise a reference signal.

The using may comprise comparing said information about said power with which said signal is received to a first threshold.

The using may comprise comparing said information about said quality with which said signal is received to a second threshold.

In some methods, if said information about said power with which said signal is received is less than said first threshold and the information about the quality with which said signal is received is less than said second threshold then said information used to change said user equipment to a different cell is provided.

The different cell may be a cell of a different radio access technology to a current cell of said user equipment or a same radio access technology to a said current cell.

The using may comprise further using information about a signal strength of a signal of said different cell of said different radio access technology to provide said information used to change said user equipment to a different cell.

The using may comprise comparing said information about said signal strength to a third threshold.

In some methods, if the information about said signal strength is above said third threshold then said information used to change said user equipment to said different cell  
5 of said different radio access technology is provided.

The method may comprise receiving threshold information defined at least one of said first, second and third thresholds.

The method may comprise providing said information used to change said user  
10 equipment to a different cell.

According to another aspect, there may be provided a method comprising: causing information to be sent to a user equipment, said information comprising first threshold information associated with a power with which a signal is received by a user equipment and second threshold information associated with a quality with which the signal is re-  
15 ceived by a user equipment, said thresholds being used to determine when said user equipment is to be provided to a different cell.

According to an aspect there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one proces-  
20 sor, to cause the apparatus at least to: use information about a power with which a signal is received by a user equipment and information about a quality with which the signal is received by a user equipment to provide information used to change said user equipment to a different cell.

The signal received by said user equipment may comprise a reference signal.

The at least one memory and the computer code may be configured with the at  
25 least one processor to cause the apparatus to compare said information about said power with which said signal is received to a first threshold.

The at least one memory and the computer code may be configured with the at  
30 least one processor to cause the apparatus to compare said information about said quality with which said signal is received to a second threshold.

The at least one memory and the computer code may be configured with the at least one processor to cause the apparatus to provide said information used to change said user equipment to a different cell if said information about said power with which said signal is received is less than said first threshold and the information about the quality with which said signal is received is less than said second threshold.

The different cell may be a cell of a different radio access technology to a current cell of said user equipment or a same radio access technology to a said current cell.

The at least one memory and the computer code may be configured with the at least one processor to cause the apparatus to use information about a signal strength of a signal of said different cell of said different radio access technology to provide said information used to change said user equipment to a different cell.

The at least one memory and the computer code may be configured with the at least one processor to cause the apparatus to compare said information about said signal strength to a third threshold.

The at least one memory and the computer code may be configured with the at least one processor to cause the apparatus to provide said information used to change said user equipment to a different cell if the information about said signal strength is above said third threshold.

The at least one memory and the computer code may be configured with the at least one processor to cause the apparatus to receive threshold information defined at least one of said first, second and third thresholds.

The at least one memory and the computer code may be configured with the at least one processor to cause the apparatus to provide said information used to change said user equipment to a different cell.

According to an aspect, there is provided an apparatus comprising: means for using information about a power with which a signal is received by a user equipment and information about a quality with which the signal is received by a user equipment to provide information used to change said user equipment to a different cell.

The signal received by said user equipment may comprise a reference signal.

The using means may be for comparing said information about said power with which said signal is received to a first threshold.

The using means may be for comparing said information about said quality with which said signal is received to a second threshold.

5 The using means may be such that if said information about said power with which said signal is received is less than said first threshold and the information about the quality with which said signal is received is less than said second threshold then said information used to change said user equipment to a different cell is provided.

The different cell may be a cell of a different radio access technology to a current cell of said user equipment or a same radio access technology to a said current cell.

10 The using means may be for using information about a signal strength of a signal of said different cell of said different radio access technology to provide said information used to change said user equipment to a different cell.

The using means may be for comparing said information about said signal strength to a third threshold.

15 The using means may be such that if the information about said signal strength is above said third threshold then said information used to change said user equipment to said different cell of said different radio access technology is provided.

The apparatus may comprise receiving threshold information defined at least one of said first, second and third thresholds.

20 The apparatus may comprise means for providing said information used to change said user equipment to a different cell.

A user equipment may comprise any of the above apparatus.

25 According to another aspect, there may be provided apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: cause information to be sent to a user equipment, said information comprising first threshold information associated with a power with which a signal is received by a user equipment and second threshold information associated with a quality with which the signal is received by a user equipment, said thresholds being used to determine when said user equipment is to be provided to a different cell.

30

According to another aspect, there may be provided an apparatus comprising: means for causing information to be sent to a user equipment, said information comprising first threshold information associated with a power with which a signal is received by a user equipment and second threshold information associated with a quality with which the signal is received by a user equipment, said thresholds being used to determine when said user equipment is to be provided to a different cell.

A base station may comprise any of the above apparatus.

A computer program may comprise computer executable code which when run may cause any of the above methods to be performed.

Some embodiments will now be described, by way of example only, with reference to the following examples and accompanying drawings in which:

Figure 1 shows an example of a communication system in which some embodiments of the may be implemented;

Figure 2 shows an example of a communication device;

Figure 3 shows a schematic diagram of a control apparatus according to some embodiments;

Figure 4 schematically illustrates co-channel deployment;

Figure 5 shows a method of an embodiment; and

Figure 6 shows a graph of the impact of WCDMA (wideband code division multiple access) on LTE RSRQ (reference signal receive quality).

In the following certain exemplifying embodiments are explained with reference to a wireless or mobile communication system serving mobile communication devices. Before explaining in detail the exemplifying embodiments, certain general principles of a wireless communication system and mobile communication devices are briefly explained with reference to Figures 1 to 3 to assist in understanding the technology underlying the described examples.

In a wireless communication system mobile communication devices or user equipment (UE) 102, 103, 105 are provided wireless access via at least one base station or similar wireless transmitting and/or receiving node or point. In the Figure 1 example two overlapping access systems or radio service areas of a cellular system 100 and 110 and

three smaller radio service areas 115, 117 and 119 provided by base stations 106, 107, 116, 118 and 120 are shown. Each mobile communication device and station may have one or more radio channels open at the same time and may send signals to and/or receive signals from more than one source. It is noted that the radio service area borders or edges are schematically shown for illustration purposes only in Figure 1. It shall also be understood that the sizes and shapes of radio service areas may vary considerably from the shapes of Figure 1. A base station site can provide one or more cells. A base station can also provide a plurality of sectors, for example three radio sectors, each sector providing a cell or a subarea of a cell. All sectors within a cell can be served by the same base station.

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. In Figure 1 control apparatus 108 and 109 is 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.

In Figure 1 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 stations 116, 118 and 120 can also be connected to the network 113, for example by a separate gateway function and/or via the controllers of the macro level stations. 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.

It should be appreciated that at least one of the base stations is associated with a first radio access technology and at least one other base station may be associated with a second different radio access technology.

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 102. 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) 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, personal data  
5 assistant (PDA) 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  
10 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 102 may receive signals over an air interface 207 via appropriate  
15 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 wireless communication device can be provided with a Multiple Input / Multiple  
20 Output (MIMO) antenna system. MIMO arrangements as such are known. MIMO systems use multiple antennas at the transmitter and receiver along with advanced digital signal processing to improve link quality and capacity. Although not shown in Figures 1 and 2, multiple antennas can be provided, for example at base stations and mobile stations, and  
25 the transceiver apparatus 206 of Figure 2 can provide a plurality of antenna ports. More data can be received and/or sent where there are more antenna elements. A station may comprise an array of multiple antennas. Signalling and muting patterns can be associated with TX antenna numbers or port numbers of MIMO arrangements.

A mobile device is typically provided with at least one data processing entity 201,  
30 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 wire-  
less) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

Figure 3 shows an example of a control apparatus for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a base station. In some embodiments, base stations comprise a control apparatus such as shown in Figure 3. In other embodiments, the control apparatus can be another network element such as a radio network 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 109 can be arranged to provide control on communications in the service area of the system. The control apparatus 109 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 control apparatus 109 can be configured to execute an appropriate software code to provide the control functions.

The communication devices 102, 103, 105 can access the communication system based on various access techniques, such as code division multiple access (CDMA), or wideband CDMA (WCDMA). Other examples include 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 LTE 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 may provide E-UTRAN features such as user plane Radio Link Control/Medium Access Con-

5 trol/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).

.The radio spectrum assigned for the particular mobile operator is a resource which needs to be carefully used. There may be limited availability associated with the radio spectrum. There may be significant license costs associated with the use of the radio spectrum.

10 In more and more countries the given frequency band or radio spectrum is technology agnostic. In other words, it is no longer the regulators' decision as to which radio access technology is used in a particular frequency band.

15 Network operators are therefore looking for options which facilitate frequency sharing where two or more radio access technologies operate at the same time on the same frequency band. It is an aim of some embodiments to utilize the spectrum in an effective manner.

Some embodiments may provide a single RAN (radio access network), where two or more coexisting and cooperating radio technologies are used to access distributed network resources.

20 An improvement in the effectiveness of the spectrum sharing may be achieved if:

A guard band between the two systems in the frequency domain is as small as possible. In other words the carrier-to-carrier spacing between the adjacent channels used by two different technologies is minimized; and/or

25 The buffer zone (or geographical distance) between sites that use the same part of the spectrum but for different radio access technology is as low as possible.

It has been proposed to use spectrum sharing arrangements in a single RAN environment where the Radio Resource Management logic does not focus separately on each RAT but considers the radio network as a whole. This may improve the E2E (end to end) performance as perceived by the end user.

Some embodiments may allow separate and technologically different radio technologies to include input from other RATs as a part of their normal operation. This may be for example as part of the Radio Resource Control procedures.

Reference is made to figure 4. A first RAT 10 is provided and a second, different  
5 RAT 14. The first RAT 10 has an associated access point 6, for example a base station. Likewise, the second RAT 14 has an associated second access point 8. Again, the access point may be a base station. A first user equipment 2 is arranged to communicate with the first RAT 10 whilst a second user equipment 4 is arranged to communicate with the second RAT 14. The first user equipment may have interference from the second RAT  
10 while the second user equipment may have interference from the first RAT. A buffer zone 12 is provided between the two RATs.

In one example of frequency sharing, a co-channel deployment such as shown in Figure 4 may be deployed. There are two different radio technologies, e.g. WCDMA and LTE, sharing the same carrier, for example in the 2100 MHz band. For example the first  
15 RAT may be WCDMA and the second RAT may be LTE.

On the one hand, to assure full separation from inter-system interference the geographical buffer zone 12 between the base stations of the different RATs should be typically relatively high. The buffer zone 12 may be required to have the in-band signal of one system at so low a level that the other system is not affected.

20 On the other hand, it is desirable to keep the buffer zone at its minimum distance to increase spectrum reuse.

It has been recognised by the inventors that the mutual influence between two RATs depends on many factors. By way of example, the factors may include one or more of:

- 25
- parameterization of the interfering system: scheduler, RRM (radio resource management) and/or the like.
  - network optimization with respect to transmitted power,
  - dynamic system load,
  - geographical distribution of the users (and hence traffic and interference towards  
30 the other RAT).

Of course, one or more other factors may additionally or alternatively have an influence on the interference.

In some embodiments, dedicated mobility procedures may be provided.

By way of example consider a scenario where the packet connection is moved from LTE to WCDMA if:

- LTE coverage is ending and at the same time
- 5        - interference as perceived by the measured signal quality exceeds certain level.

Currently, two measurements are defined by the 3GPP to govern mobility procedures in LTE: RSRP (reference signal received power) and RSRQ (reference signal received quality). The RSRP reflects the signal strength of the Reference Symbols of the serving and/or surrounding LTE cells. Therefore RSRP is associated with network coverage.

The RSRQ reflects the quality of the Reference Signals of the serving or surrounding LTE cells in such a way that a highly interfered LTE signal directly leads to RSRQ deterioration.

Currently in the RRC connected mode, mobility procedures in the LTE network are network controlled. The mobility procedures are handled with the help of so called mobility events. If the given event takes place, this means that certain radio conditions described via provided parameters are met.

These radio conditions are evaluated on the mobile terminal (UE) side. The UE informs the network about occurrence of such radio event via a dedicated reporting message, according to the measurement and reporting configurations. This in turn triggers certain actions on the eNodeB side. The most common action is the handover to another cell if e.g. target cell satisfy certain predefined criteria.

A so-called A2 event has been standardized by 3GPP to trigger the mobility procedures (e.g. inter-RAT redirection) once the signal strength (or signal quality) of the serving cell is below the certain threshold.

A so-called B2 event was standardized by 3GPP to trigger coverage-based handovers from one RAT to another RAT. Currently the B2 event uses either RSRP or RSRQ data. Signal strength/quality of the inter-RAT cell is also checked.

For B2 the measurements of the target system are considered, for A2 this information is not considered. A2 may be used for intra-system mobility or for inter-system mobility (blind redirection).

5 The current Event B2 mechanism defined in 3GPP standard 36.331 Release 11 is described below.

The B2 event is triggered when the performance of the currently serving cell becomes worse than a first threshold and the performance of an inter RAT neighbouring cell is better than a second threshold.

The UE may do one of the following:

10 for UTRA and CDMA2000 RATs, only trigger the event for cells which have been included in the corresponding measurement object;

decide that the requirements for entering this event are met when conditions B2-1 and B2-2, which are described below, are both satisfied;

15 decide that the requirements to leave this event are met when any of the conditions B2-3 or B2-4, as described below, is satisfied;

A first Inequality B2-1 is defined in the standard

$$M_p + H_{ys} < Thresh1$$

Inequality B2-2

$$M_n + O_{fn} - H_{ys} > Thresh2$$

20 Inequality B2-3

$$M_p - H_{ys} > Thresh1$$

Inequality B2-4

$$M_n + O_{fn} + H_{ys} < Thresh2$$

Where:

25  $M_p$  is the measurement result of the serving cell, ignoring any offsets.

$M_n$  is the result of measurement of the inter-RAT neighbouring cell, ignoring any offsets. For a CDMA2000 measurement result, the pilot signal strength is divided by -2.

Ofn is a frequency specific offset of the frequency of the inter-RAT neighbour cell and is expressed in dB Hys is a hysteresis parameter for this event expressed in dB Thresh1 is a threshold parameter for this event

Thresh2 is a threshold parameter for this event. For CDMA2000, this threshold is divided by 2.

Mp is expressed in dBm for RSRP, or in dB for RSRQ.

Mn is expressed in dBm or dB, depending on the measurement associated with inter-RAT neighbour cell.

Ofn, Hys are expressed in dB.

Thresh1 has the same unit as Mp.

Thresh2 has the same unit as Mn.

The inventors have identified that basing a decision about changing the network only on the RSRQ is disadvantageous. In some embodiments, the RSRQ and the RSRP are both taken into consideration. A low RSRQ value could be an outcome of bad performing LTE network as such. For example there may be high intra-system interferences which may be temporary. The low RSRQ value does not necessarily mean that LTE coverage is ending. This in turn means that inter-system network change (via handover or redirection) in such a case is not desired, especially that some operators have the strategy to keep the connection in LTE as long as possible. Moreover, if the handover/redirection to another system is triggered when the RSRP is still high, it is likely that this connection will be soon moved back to LTE.

Currently, if an inter-system network change is triggered solely using the RSRP, this means that the connection is kept in the LTE even if perceived RSRQ is already poor. Unless the UE enters the area with very low RSRP, the connection is forced to be kept on the LTE network. This may not be beneficial from the E2E perspective.

In some embodiments, events may be configured by the BS and sent to the user equipment. The user equipment may trigger a report with a given event according to the configured thresholds and/or timers. Base station then triggers the actual handover. Alternatively, the base station may receive information which allows the base station to decide if the conditions defined for a given event are met.

Some embodiments thus use the following conditions. Event A2 may be configured by the base station, sent to the UE and triggered by the UE if:

- RSRP of the serving LTE cell is below a first given threshold AND

- RSRQ of the serving LTE cell is below a second given threshold

In some embodiments both RSRP and RSRQ are analysed at the same time for the given mobility event in the multi-RAT environment. That is, the B2 event is triggered if:

- RSRP of the serving LTE cell is below the first threshold AND
- RSRQ of the serving LTE cell is below the second threshold AND
- Signal strength and/or quality of the inter-RAT, for example WCDMA network cell is above a third threshold.

Some embodiments may provide an improved handling of mobility procedures that address inter-system interference issue in the co-channel deployment. The handover/redirection is speeded up due to the low RSRQ, if the signal strength of the LTE network is low.

Reference is made to Figure 5 which shows a method of an embodiment.

In step 1, the network events are configured by the base station and sent to the UE. The network events may be configured by the control apparatus of Figure 3. At least one memory 301 and at least one processing unit 302, 303 may be arranged to configure the network events. Information about the network events may be passed via the input/output interface 304 for transmitting by the transmitter of the base station to the user equipment. Any suitable information about the configured events may be sent to the user equipment. In some embodiments, the information may comprise one or more of the first to third thresholds. The information which is received by the transceiver apparatus 206 of the user equipment may be stored in at least one memory 202.

In step S2, the user equipment measures the RSRQ. In other words, the received quality of a reference signal is determined at the user equipment. The user equipment will receive the reference signal via the transceiver apparatus 206 and the received signal is processed in order to determine the received quality of the received signal. This may be at least partly performed by the at least one data processing entity 201 in conjunction with the at least one memory 202.

In step S3, the user equipment measures the RSRP. In other words, the user equipment measures the received power of the reference signal. It should be appreciated that the steps S2 and S3 can take place at the same time all in either order. Again the received signal is processed in order to determine the received power of the received signal. This may be at least partly performed by the at least one data processing entity 201 in conjunction with the at least one memory 202.

In this step S4, the UE determines if RSRP is less than a threshold. If RSRP is not less than a threshold, then no action is taken by the UE. If, however, the RSRP is less than a threshold, then the next step is step S5. The at least one data processing entity 202 may compare the determined RSRP with the threshold value. The RSRP and/or the threshold value may be stored in at least one memory 202.

In step S5, the UE determines if the RSRQ is less than a threshold. Again, if RSRQ is not less than a threshold, then no action is taken by the UE. If, on the other hand, RSRQ is less than the threshold, then the next step is step S6. Again this may involve the data processing entity and the at least one memory.

In step S6, it is determined if the signal strength of the inter-RAT cell is above a threshold. This inter-RAT cell is a candidate cell for the user equipment to be handed over to. Again this may involve the data processing entity and the at least one memory.

In step S7, the user equipment sends information to the base station. The information may take any suitable form. For example the information will comprise information indicating that handover to another cell is to occur. The information may comprise information indicating the cell to which the user equipment should be handed off to. This information is sent via the transceiver apparatus 206 to the base station. This information is thus received by the base station.

In step 8 the base station will cause the user equipment to change to a different RAT. In other words, the user equipment may be handed over to a different RAT. The base station may store the received information in the at least one memory 301 of the control apparatus. The at least one processing unit 302, 303 may be configured to cause the user equipment to be handed over to another cell, in response to the received information.

In the embodiments described, reference has been made to RSRP and RSRQ. This terminology is used in relation for example to the LTE standard. However, it should be appreciated that embodiments may be used in relation to the received quality of any suitable reference signal and/or the received power of any reference signal. The reference signal may take any suitable form, and may for example in some standards be a pilot signal or other suitable signal.

In some alternative embodiments, instead of or additionally, the received quality and received power of a non-reference signal may be measured and used to trigger changes to different cells, whether they be of the same RAT or a RAT.

5 In the described embodiments, step S4, S5 and S6 have been shown in a particular order. It should be appreciated that alternatively, these steps may be performed in any order. Alternatively or additionally, two or more of the steps may be performed at the same time.

10 In the example described, the two RATs have been described as being LTE and WCDMA. It should be appreciated that this is by way of example only and any two different RATs may alternatively be involved in embodiments.

In some embodiments, more than two different RATs may be involved.

15 In some embodiments, a comparison has been made to see whether the value of the RSRP and RSRQ is below a respective threshold. In some embodiments, alternatively one or other of these values may be checked to see if the respective value is above the respective threshold.

It should be appreciated that there are one or more alternative or additional parameters which could alternatively or additionally be used. For example RSSI (received signal strength information) or  $E_c/N_0$  (Ratio of energy per modulating bit to the noise spectral density) or the like may be used.

20 In some embodiments an average of the RSRP and/or RSRQ may be compared to a respective threshold. The average may be determined in the base station and/or the user equipment. In some embodiments the inter-RAT signal strength used may be an average.

25 Reference is made to Figure 6 which shows the results of a test. These tests assessed the mutual influence between WCDMA and LTE in the co-channel environment in the 2100 MHz band. As can be seen from Figure 6, the impact of a WCDMA interferer (both signalling and full WCDMA load) on the LTE RSRQ (shown on the y axis) was measured. For a medium DL LTE signal (RSRP approximately -95 dBm), the perceived RSRQ value depends not only on DL WCDMA RSCP (received signal code power) which  
30 is shown along the x-axis, but also on the load on the WCDMA side. (The line referenced A is full WCDMA load, and the line referenced B is signalling WCDMA only).

If LTE RSRP is already low, then it may be beneficial then to perform the inter-system handover (e.g. to WCDMA) if also the RSRQ value suggests that WCDMA network is heavily loaded. This means that there is no point in keeping the connection inside LTE network. Of course, in such a case, it is beneficial to move the connection not to the congested WCDMA carrier but preferably to another WCDMA carrier – that is not deployed in the co-channel manner. Note that more than one WCDMA carrier is often deployed.

In the above reference has been made to signal power and signal strength. It should be appreciated that in some embodiments signal power may be a measure of signal strength and/or in some embodiments signal strength may be a measure of signal power. In some embodiments, the same type of measure is used for the adjacent cell as for the reference signal measurements. In other embodiments, different types of measure may be used for the adjacent cell as for the reference signal measurements.

A base station may configure the user equipment to, periodically or when a certain event happens, report measurements optionally along with the location coordinates. The measurement reports may be RSRP/RSRQ (reference signal received power/reference signal received quality) measurements. The location coordinates may be obtained by for example GNSS or in any suitable manner.

The user equipment may perform in real-time operation mode. In other words, the user equipment reports measurements immediately to the base station as soon as the measurements have been performed. Alternatively the UE may use logged reporting. In this case, the user equipment will perform some measurements. However, the user equipment will store these measurements to report them to the network at a later point in time. These measurement results may be sent to the network when, for example, requested by the network. This activity may take place when the user equipment is in an idle state. When user equipment is in the idle state, the user equipment will have no active connection to the network. Thus, the network will have no control over the user equipment while it is performing the logging, if the user equipment is in the idle mode. When the user equipment changes from the idle mode to the active or connected mode, the user equipment may indicate to the network the availability of the stored measurements. When the network gets this information, the network will cause the user equipment to report the measurement to the network.

The control apparatus of the base station may be configured to receive the messages or measurements sent by the UE. One or more of the steps performed by the appa-

ratus of the base station may be performed when one or more associated instructions are run on one or more of the processors. It should be appreciated that the one or more associated instructions may be stored in one or more memories of the base station.

5 It is noted that whilst embodiments may have been described in relation to user equipment or mobile devices such as mobile terminals, embodiments may be applicable to any other suitable type of apparatus suitable for communication via access systems.

A communication device may be configured to enable use of different access technologies, for example, based on an appropriate multi-radio implementation.

10 It is also noted that although certain embodiments may have been described above by way of example with reference to the exemplifying architectures of certain mobile networks and a wireless local area network, embodiments may be applied to any other suitable forms of communication systems than those illustrated and described herein. It is also noted that the term access system may be understood to refer to any access system configured for enabling wireless communication for user accessing applications.

15 The above described operations may require data processing in the various entities. The data processing may be provided by means of one or more data processors. Similarly various entities described in the above embodiments may be implemented within a single or a plurality of data processing entities and/or data processors. The data processing entities may be controlled by one or more computer programs which may be  
20 stored in one or more memories of the apparatus.

Alternatively or additionally appropriately adapted computer program code product may be used for implementing the embodiments, when loaded to a computer or a processor. The program code product for providing the operation may be stored on and provided by means of a carrier medium such as a carrier disc, card or tape. In some embodiments,  
25 there may be the possibility to download the program code product via a data network.

Some embodiments may be implemented as a chipset, in other words a series of integrated circuits communicating among each other. The chipset may comprise micro-processors arranged to run code, application specific integrated circuits (ASICs), and/or programmable digital signal processors for performing the operations described above.

30 Embodiments may be practiced in various components such as integrated circuit modules.

The design of integrated circuits may be by a highly automated process. Complex and powerful software tools may be available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

5           Programs, such as those provided by Synopsys, Inc. of Mountain View, California and Cadence Design, of San Jose, California may automatically route conductors and locate components on a semiconductor chip using well established rules of design as well as libraries of pre-stored design modules. Once the design for a semiconductor circuit may have been completed, the resultant design, in a standardized electronic format (e.g.,  
10   Opus, GDSII, or the like) may be transmitted to a semiconductor fabrication facility or "fab" for fabrication.

          The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the exemplary embodiments. However, various modifications and adaptations may become apparent to those skilled in the relevant  
15   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.

## CLAIMS

1. A method comprising:

Using information about a power with which a signal is received by a user  
5 equipment and information about a quality with which the signal is received by a user  
equipment to provide information used to change said user equipment to a different cell.

2. A method as claimed in claim 1, wherein said signal received by said user equip-  
ment comprises a reference signal.

10

3. A method as claimed in claim 1 or 2, wherein using comprises comparing said in-  
formation about said power with which said signal is received to a first threshold.

4. A method as claimed in any preceding claim, wherein said using comprises com-  
15 paring said information about said quality with which said signal is received to a second  
threshold.

5. A method as claimed in claim 3 or 4, wherein if said information about said power  
with which said signal is received is less than said first threshold and the information about  
20 the quality with which said signal is received is less than said second threshold then said  
information used to change said user equipment to a different cell is provided.

6. A method as claimed in any preceding claim, wherein said different cell is a cell of  
a different radio access technology to a current cell of said user equipment or a same ra-  
25 dio access technology to a said current cell.

7. A method as claimed in claim 6, wherein said using comprises further using infor-  
mation about a signal strength of a signal of said different cell of said different radio ac-

cess technology to provide said information used to change said user equipment to a different cell.

8. A method as claimed in claim 7, wherein said using comprises comparing said information about said signal strength to a third threshold.

9. A method as claimed in claim 8, wherein if said information about said signal strength is above said third threshold then said information used to change said user equipment to said different cell of said different radio access technology is provided.

10

10. A method as claimed in any of claims 3, 4 or 8, or any claim appended thereto comprising receiving threshold information defined at least one of said first, second and third thresholds.

11. A method as claimed in any preceding claim, comprising providing said information used to change said user equipment to a different cell.

12. A method comprising:

Causing information to be sent to a user equipment, said information comprising providing first threshold information associated with a power with which a signal is received by a user equipment and second threshold information associated with a quality with which the signal is received by a user equipment, said thresholds being used to determine when said user equipment is to be provided to a different cell.

13. A computer program comprising computer executable code which when run causes the method of any of claims 1 to 12 to be performed.

14. Apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: use information about a power with which a signal is received by a user equipment and information about a quality with which the signal is received by a user equipment to provide information used to change said user equipment to a different cell.

15. Apparatus as claimed in claim 14, wherein the signal received by said user equipment comprises a reference signal.

16. Apparatus as claimed in claim 14 or 15, wherein the at least one memory and the computer code are configured with the at least one processor to cause the apparatus to compare said information about said power with which said signal is received to a first threshold.

17. Apparatus as claimed in any of claims 14 to 16, wherein the at least one memory and the computer code are configured with the at least one processor to cause the apparatus to compare said information about said quality with which said signal is received to a second threshold.

18. Apparatus as claimed in claim 16 and 17, wherein the at least one memory and the computer code are configured with the at least one processor to cause the apparatus to provide said information used to change said user equipment to a different cell if said information about said power with which said signal is received is less than said first threshold and the information about the quality with which said signal is received is less than said second threshold.

19. Apparatus as claimed in claim 18, wherein the different cell is a cell of a different radio access technology to a current cell of said user equipment or a same radio access technology to a said current cell.

20. Apparatus as claimed in any of claims 14 to 20, wherein the at least one memory and the computer code are configured with the at least one processor to cause the apparatus to use information about a signal strength of a signal of said different cell of said  
5 different radio access technology to provide said information used to change said user equipment to a different cell.

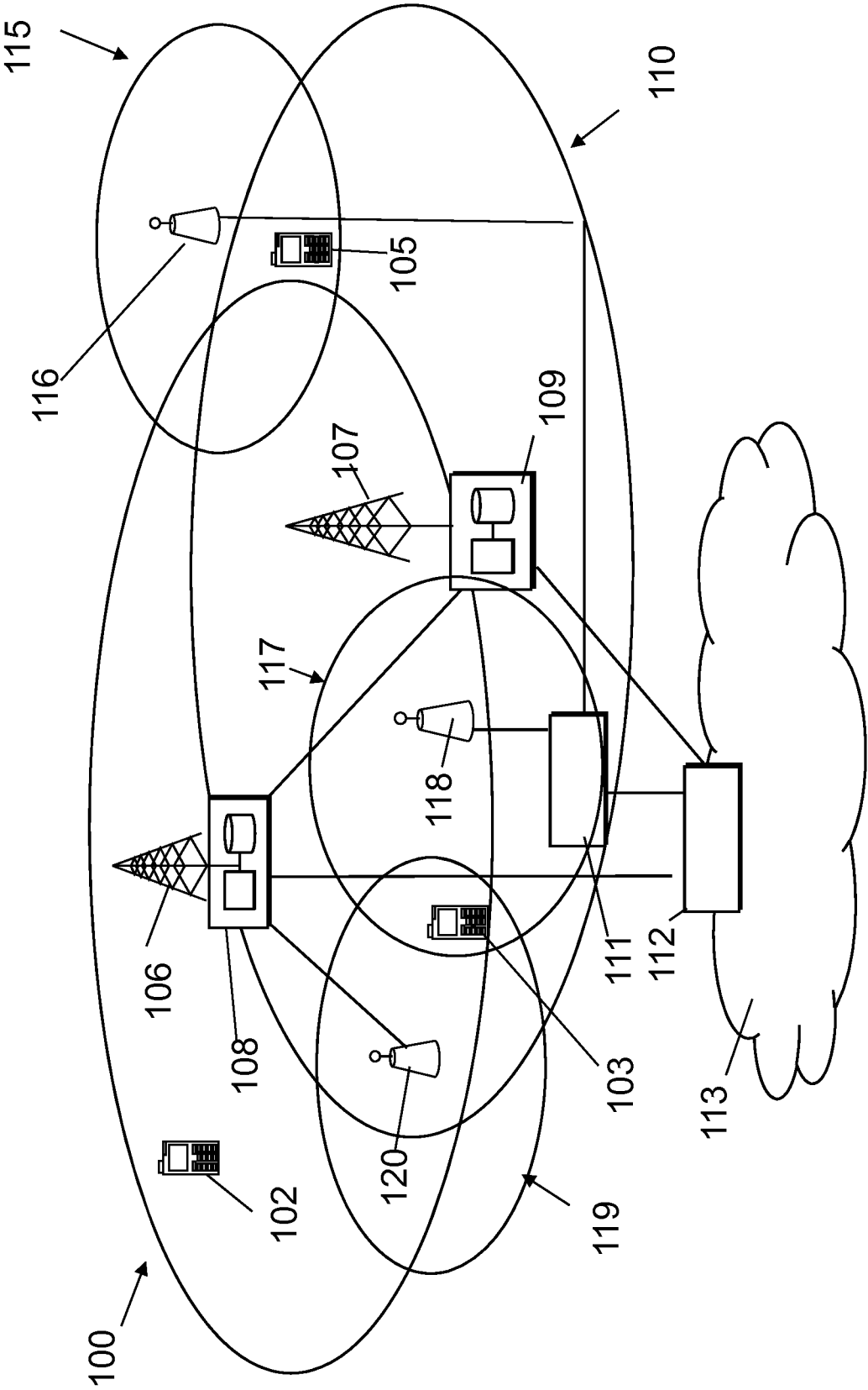
21. Apparatus as claimed in claim 20, wherein the at least one memory and the computer code are configured with the at least one processor to cause the apparatus to compare  
10 said information about said signal strength to a third threshold.

22. Apparatus as claimed in claim 21, wherein the at least one memory and the computer code are configured with the at least one processor to cause the apparatus to provide  
15 said information used to change said user equipment to a different cell if the information about said signal strength is above said third threshold.

23. Apparatus as claimed in claim 16, 17 or 21 or any claim appended thereto, wherein the at least one memory and the computer code may be configured with the at least one  
20 processor to cause the apparatus to receive threshold information defined at least one of said first, second and third thresholds.

24. Apparatus as claimed in any of claims 14 to 23, wherein the at least one memory and the computer code may be configured with the at least one processor to cause the  
25 apparatus to provide said information used to change said user equipment to a different cell.

Figure 1



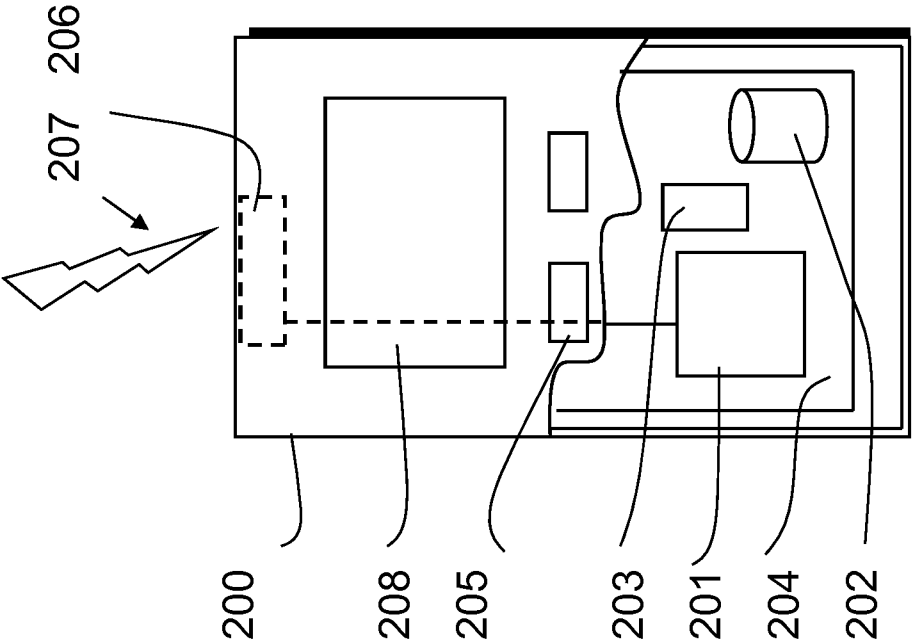


Figure 2

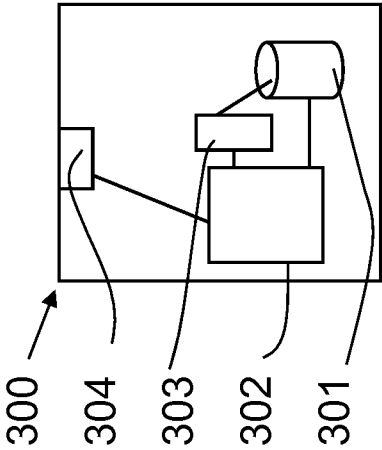
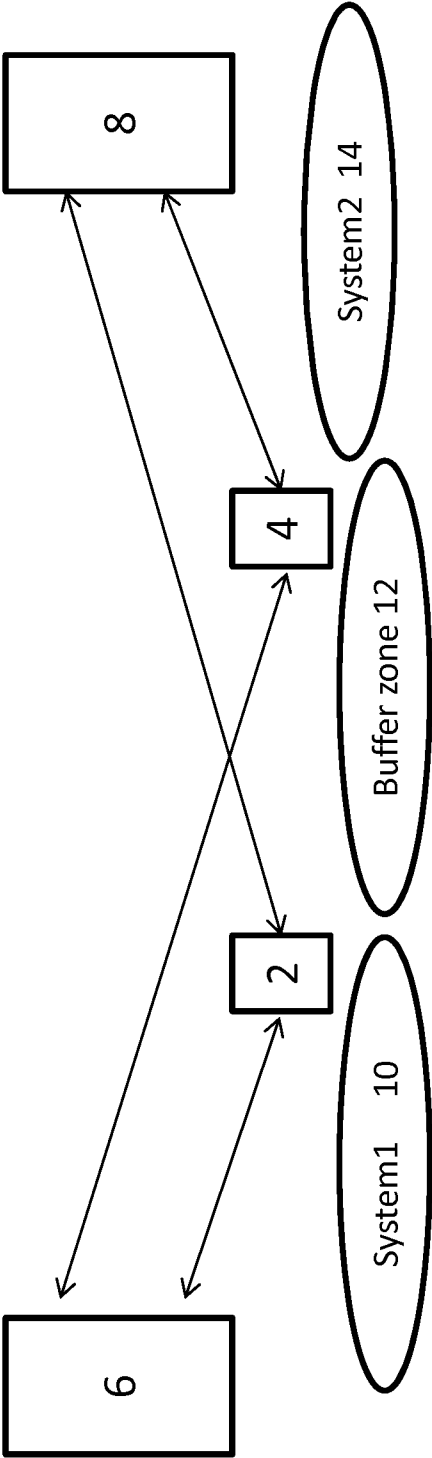


Figure 3

Figure 4



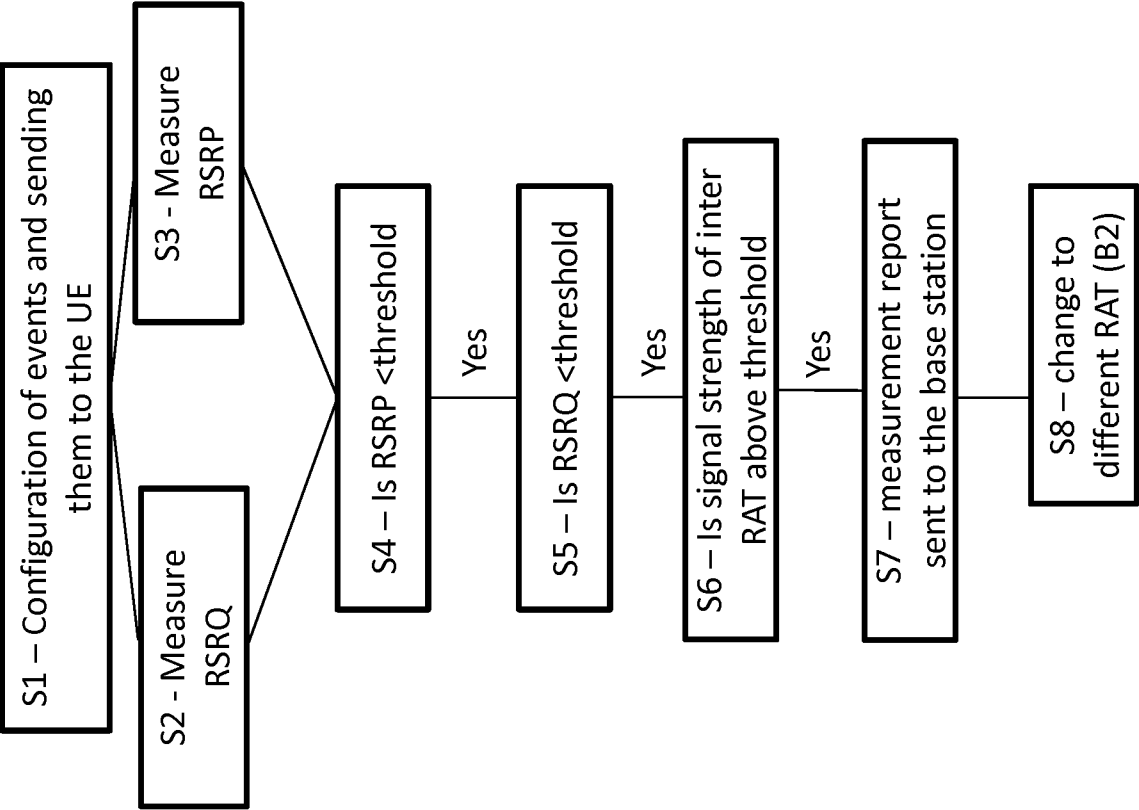
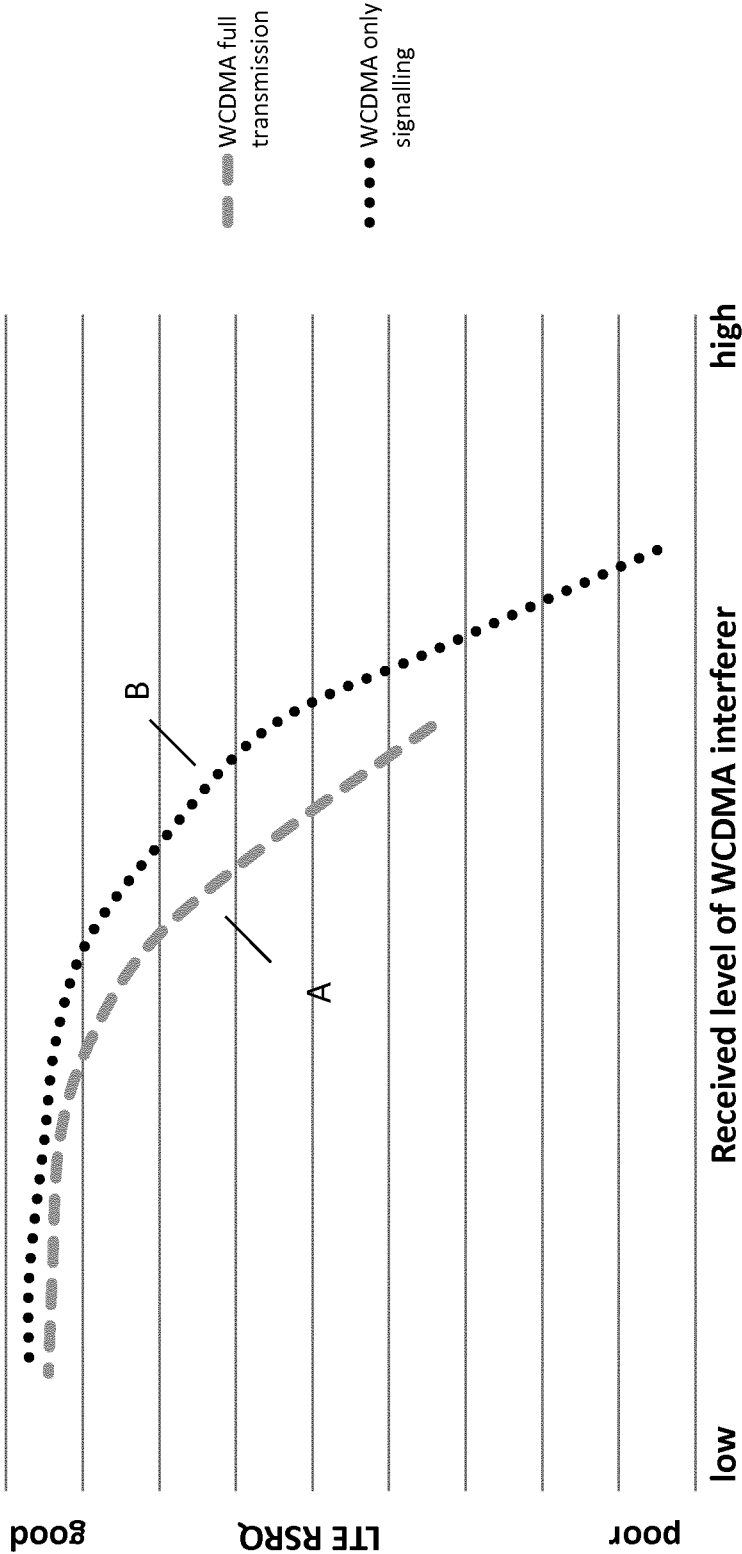


Figure 5

Figure 6

Impact of WCDMA interferer on LTE RSRQ



## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2012/072464

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04W36/00  
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

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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

26 March 2013

Date of mailing of the international search report

25/04/2013

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Authorized officer

Delucchi, Cecilia

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2012/072464

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       |
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Information on patent family members

International application No

PCT/EP2012/072464

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