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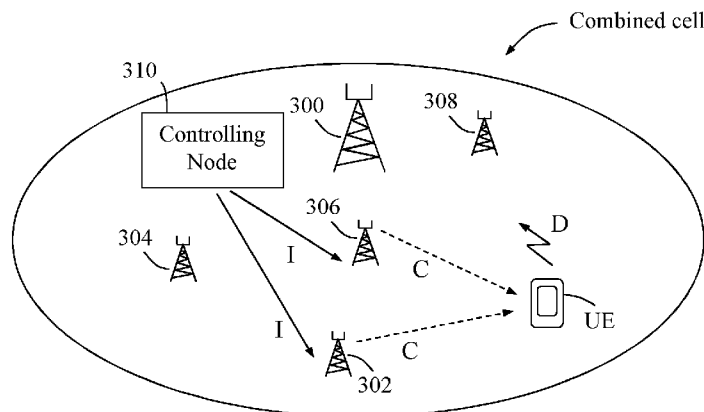


Fig. 3

(57) Abstract: A method and controlling node(310)of a cellular network for wireless communication, to control transmission of control information (C) to a User Equipment, UE. The UE communicates radio signals (D) with multiple radio nodes (300-308) serving a combined cell in the cellular network. In this method, the controlling node selects a subset (302, 306) of the multiple radio nodes and instructs(I) the selected subset of the multiple radio nodes to send said control information to the UE. Thereby, the amount of power used for transmitting downlink signals to the UE is reduced which may improve capacity and efficiency of resource usage in the combined cell.



METHOD AND CONTROLLING NODE FOR TRANSMISSION OF CONTROL INFORMATION TO A USER EQUIPMENT

Technical field

[0001] The present disclosure relates generally to a method and a controlling node of a cellular network for wireless communication, for controlling transmission of control information to a User Equipment, UE, wherein the UE communicates radio signals with multiple radio nodes serving a combined cell.

Background

[0002] In recent years, different types of cellular networks for wireless communication have been developed to provide radio access for various wireless terminals in different areas. The cellular networks are constantly improved to provide better coverage and capacity to meet the demands from subscribers using services and increasingly advanced terminals, e.g. smartphones and tablets, which may require considerable amounts of bandwidth and resources for data transport in the networks. As a result, it is common to configure a network with cells of varying types and sizes, e.g. in an overlapping fashion, to provide needed capacity and flexibility depending on expected traffic intensity in different areas, the cells forming a so-called heterogeneous cellular network.

[0003] In this disclosure, the term "User Equipment, UE" will be used to represent any user-controlled wireless terminal or device capable of radio communication including receiving downlink signals transmitted from a radio node of a wireless communication network. Further, the term "radio node", also commonly referred to as a base station, e-nodeB, eNB, etc., represents any node of a wireless communication network that can communicate uplink and downlink radio signals with UEs. The radio nodes described here may include so-called macro nodes and low power nodes.

[0004] A heterogeneous cellular network may comprise hierarchically arranged nodes, including macro nodes transmitting with relatively high power and covering relatively large areas of a size in the order of kilometers, and low power nodes transmitting with relatively low power and covering areas of a size in the order of a

few meters, e.g. micro, pico, femto and relay nodes, to mention some customary examples. The low power nodes may be employed together with the macro nodes in an overlapping fashion to locally provide added capacity in so-called "hot spot" areas such that multiple small areas served by such micro/pico/femto/relay nodes may be located within the area served by a macro node. The above-described heterogeneous network may be realized basically in two different ways, commonly referred to as:

- 1) "Co-channel deployment" where the macro node and the low power nodes cover individual cells with different cell identities, which means that a UE is served by one radio node at a time and must undergo handover between the cells when necessary to maintain adequate radio coverage, and
- 2) "Combined cell deployment", where the macro node and the low power nodes cover the same common cell with a single cell identity, which means that a UE in the cell is basically served by all radio nodes at the same time. The radio nodes of such a combined cell, sometimes also called a "soft cell", can be regarded as a distributed radio node with multiple antennas at different locations in the cell.

[0005] The latter alternative of using a combined cell with multiple radio nodes has the advantage of eliminating the need for performing handover which reduces the amount of signaling and reduces the risk of dropped connection due to failed handover, among other things. Uplink radio signals, e.g. containing data, sent from the UE is received by all the radio nodes which are able to process the data jointly. On the other hand, any downlink radio signals, e.g. containing control information are sent from all radio nodes of the combined cell, meaning that considerable transmit power is consumed for such radio signals which results in a deficient power room left for other communications in the cell and in that interference is generated disturbing other communications, e.g. in neighboring cells.

[0006] An example of such downlink control information is feedback sent from the radio nodes to indicate whether uplink data from the UE has been received

and decoded by the radio nodes or not, which is illustrated in Fig. 1. This feedback "F" is also referred to as ACK/NAK of a Hybrid Automatic Repeat Request, HARQ, process, where "ACK" acknowledges successful reception and decoding and "NAK" is effectively a request for retransmission of non-decoded data. Further examples of such downlink control information include scheduling grant information, power control commands, and so forth.

[0007] In Fig. 1, a combined cell is served by a macro node 100 covering the whole cell and a plurality of low power nodes 102, 104, 106 and 108 each covering a small part of the whole cell. A UE located somewhere in the combined cell may be connected to virtually all nodes 100-108 at the same time such that these nodes receive and process uplink radio signals comprising data "D" sent from the UE. When a HARQ process is active for the uplink data, all nodes send the same control information, i.e. the feedback F, to the UE thus consuming a substantial part of the available power room in the cell which in turn reduces the cell's capacity for other communications in the combined cell.

[0008] It is thus a problem that considerable power is used and consumed for downlink transmissions in a combined cell with multiple radio nodes, which may more or less reduce capacity and efficiency in resource usage in the cell.

Summary

[0009] It is an object of embodiments described herein to address at least some of the problems and issues outlined above. It is possible to achieve this object and others by using a method and a controlling node as defined in the attached independent claims.

[00010] According to one aspect, a method is provided which is performed by a controlling node of a cellular network for wireless communication, to control transmission of control information to a User Equipment, UE, wherein the UE communicates radio signals with multiple radio nodes serving a combined cell in the cellular network. In this method, the controlling node selects a subset of the multiple radio nodes and instructs the selected subset of the multiple radio nodes to send said control information to the UE.

[00011] According to another aspect, a controlling node of a cellular network for wireless communication is provided. The controlling node is configured to control transmission of control information to a UE that is configured to communicate radio signals with multiple radio nodes serving a combined cell in the cellular network. The controlling node comprises a logic unit configured to select a subset of the multiple radio nodes, and an instructing unit configured to instruct the selected subset of the multiple radio nodes to send said control information to the UE.

[00012] By using the above method and/or controlling node, it is possible to reduce and limit the amount of power used and consumed for downlink transmissions in a combined cell with multiple radio nodes, which in turn may improve the combined cell's capacity and efficiency in resource usage in the combined cell.

[00013] The above method and controlling node may be configured and implemented according to different optional embodiments to accomplish further features and benefits, to be described below.

Brief description of drawings

[00014] The solution will now be described in more detail by means of exemplary embodiments and with reference to the accompanying drawings, in which:

[00015] Fig. 1 is a communication scenario illustrating how feedback is sent as control information to a UE from multiple radio nodes of a combined cell, according to the prior art.

[00016] Fig. 2 is a flow chart illustrating a procedure in a controlling node for controlling transmission of control information to a UE, according to some possible embodiments.

[00017] Fig. 3 is a communication scenario illustrating how transmission of control information to a UE is limited, according to further possible embodiments.

[00018] Fig. 4 is a block diagram illustrating a controlling node, according to further possible embodiments.

[00019] Fig. 5 is an exemplifying flow chart with actions by a controlling node for selecting a subset of radio nodes, according to further possible embodiments.

[00020] Fig. 6 is another exemplifying flow chart with actions by a controlling node for selecting a subset of radio nodes, according to further possible embodiments.

Detailed description

[00021] In this solution, it has been recognized that considerable power is used and consumed when downlink control information is transmitted to a UE in a combined cell with multiple radio nodes, which may in turn reduce capacity by leaving deficient room for any power needed for other radio communications and/or may cause interference problems for other radio communications, e.g. within the same cell or in a neighboring cell. Briefly described, a solution is provided to enable improved capacity in a combined cell and/or in one or more neighboring cells nearby or adjacent to the combined cell by reducing the number of radio nodes that transmit control information to a UE being served by virtually all radio nodes in the combined cell at the same time. Thereby, the power being consumed for transmitting the downlink control information is reduced and there will be more power room left for other radio transmissions in the cell. Further, the amount of potentially harmful interference caused by transmitting the downlink control information may be reduced which could also improve the capacity in the combined cell and/or in one or more neighboring cells located nearby the combined cell.

[00022] In this description, the term “combined cell” is used to represent a cell being served by multiple radio nodes at the same time such that they all may receive uplink radio signals transmitted from a UE in the cell, or at least those radio nodes that are close enough to the UE to detect the UE’s transmitted radio signals. The radio nodes of the combined cell may be arranged in an overlapping fashion of a heterogeneous cellular network for wireless communication as described above. The radio nodes of the combined cell may comprise a macro node transmitting with relatively high power to basically cover the whole cell, and a

set of low power nodes transmitting with relatively low power to cover a part of the combined cell that is smaller than the area covered by the macro node.

[00023] An example of a procedure to control transmission of control information to a UE that communicates radio signals with multiple radio nodes serving a combined cell in a cellular network for wireless communication, will now be described with reference to the flow chart in Fig. 2 comprising actions that are to be performed by a controlling node of the cellular network. For example, the cellular network may be based on Wideband Code Division Multiple Access, WCDMA, and/or High Speed Packet Access, HSPA. It should further be noted that the embodiments described in this disclosure are also applicable in a Long Term Evolution, LTE, based network employing soft cells.

[00024] The control information that is to be transmitted to the UE according to this procedure may, without limitation, comprise at least one of: feedback to indicate whether uplink data has been received and decoded by the multiple radio nodes or not, a power control command, and scheduling grant information for uplink data transmission. It should be noted that the embodiments described in this disclosure are in general applicable for any type of downlink control information transmitted to a UE.

[00025] The above-mentioned feedback may include an ACK/NAK of a HARQ process which may be sent over a downlink channel called "Enhanced Hybrid Indicator Channel E-HICH" which is sent to the UE to indicate successful or unsuccessful reception and decoding of uplink data sent from the UE over an uplink channel called "Enhanced Dedicated Physical Data Channel E-DPDCH".

[00026] Further, the above-mentioned power control command is typically sent to instruct the UE to adjust its transmit power level, which command may be sent over a downlink channel called "Fractional Dedicated Physical Channel F-DPCH". Further, the above-mentioned scheduling grant information for uplink data transmission is sent to instruct the UE which radio resource to use for its data transmissions, which information may be sent over a downlink channel called "Enhanced Relative Grant Channel E-RGCH". Similar scheduling information may

also be sent over a downlink channel called "Enhanced Absolute Grant Channel E-AGCH".

[00027] The controlling node in the example of Fig. 2 is associated with the combined cell and may be arranged to operate exclusively for this cell or for a plurality of cells in the network. The controlling node may be implemented in a macro node of the combined cell or in a more centralized network node, for example a Radio Network Controller "RNC" or similar, which is connected to the radio nodes of the combined cell and possibly also to radio nodes of other cells as well in the case when the controlling node is shared by several cells. In either case, the controlling node is able to communicate with the radio nodes of the combined cell over a suitable interface, for example the so-called "X2 interface" which is commonly used for signaling between radio nodes in an LTE-based cellular network.

[00028] A first **action 200** illustrates that a radio communication has been established with the UE such that the UE communicates radio signals with the multiple radio nodes of the combined cell. For example, any uplink data transmitted from the UE is received by the multiple radio nodes and may be processed jointly or individually by the multiple radio nodes. It should be noted that this action mainly comprises activities in the radio nodes and the UE, including various signaling, for setting up a connection for the radio communication in a regular manner, while the controlling node as such does not take part in the actual establishment of the radio communication. In practice, however, the controlling node may be implemented in an RNC which in turn may be involved in the establishment of the radio communication which is outside the scope of this solution. Nevertheless, the controlling node somehow becomes aware of the established radio communication with the UE, for example by receiving a suitable notification from one of the multiple radio nodes of the combined cell.

[00029] In a next **action 202**, the controlling node selects a subset of the multiple radio nodes comprising one or more radio nodes that are assigned to send the downlink control information to the UE, meaning that the number of radio nodes in the selected subset is less than the total number "N" of the multiple radio nodes

communicating radio signals with the UE. The selected subset of radio nodes may comprise any number “n” of radio nodes less than the total number N, i.e. $1 \leq n < N$. In this action, the controlling node may select the subset of radio nodes in different ways which will be described in more detail later below. It should be noted that the total number N above may include all radio nodes serving the combined cell or more likely only some of the radio nodes serving the combined cell, i.e. those able to communicate radio signals with the UE. For example, the UE may be located too far away from some low power radio nodes in the combined cell such that uplink signals from the UE cannot reach those radio nodes.

[00030] A final shown **action 204** illustrates that the controlling node instructs the selected subset of the multiple radio nodes to send the control information to the UE, instead of letting all of the multiple radio nodes in radio communication with the UE send the same control information to the UE at the same time. Thereby, the power consumed for conveying the control information to the UE can be limited to be not more than necessary to get the control information across to the UE, thus minimizing the consumed power and the interference that it may potentially cause for other radio communications either within the same cell or in other nearby cells.

[00031] The consumed power will thus be reduced by having fewer radio nodes transmitting the control information instead of all of the multiple radio nodes. In order to reduce the power used for transmitting the control information as much as possible, the selected subset of radio nodes should also be located as close as possible to the UE such that this subset of multiple radio nodes can transmit with as low power as possible which further contributes to reducing the transmission power. In order to accomplish this, a possible embodiment is suggested where the subset of the multiple radio nodes is selected based on an indication of vicinity, i.e. closeness, of the UE to the respective radio nodes. The term “vicinity” thus relates to the mutual distance between the UE and each respective radio node. In this way, one or more of the radio nodes that are closest to the UE can be selected for transmission of the control information so as to minimize the need for transmit power.

[00032] The controlling node may obtain the indication of vicinity for each of the multiple radio nodes of the combined cell in different ways. For example, the indication of vicinity may comprise signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes. In that case, the signal quality may be indicated by at least one of the following quality-related parameters: Signal to Noise Ratio, SNR, Signal to Interference and Noise Ratio, SINR, Reference Signal Received Quality, RSRQ, and Channel Quality Indicator, CQI. One or more of these parameters may be obtained from measurements made by the UE on a reference signal transmitted from the multiple radio nodes, for example in a specific measurement process, or "probing period", when the multiple radio nodes of the combined cell may take turns to transmit the reference signal one at a time thus enabling the UE to measure the received reference signal, as received from each respective radio node, for determination of any of the above quality-related parameters. The above reference signal may also be called a "pilot signal" which is a common term in the field of radio communication for signals specifically intended for measurements.

[00033] Alternatively or additionally, the indication of vicinity may comprise path loss between the UE and each respective radio node of the multiple radio nodes, which path loss may be calculated from the transmit power used by the UE, which is known to the radio nodes, and a received signal strength of uplink signal transmissions from the UE which can be measured at the respective radio nodes.

[00034] In another possible embodiment, selecting the subset of the multiple radio nodes may comprise selecting a single radio node from the multiple radio nodes. The selected single radio node is thus instructed alone to send the control information to the UE, whereby unnecessary transmissions from further radio nodes in the cell may be avoided provided that the UE is able to receive and decode the control information from the single radio node. In this case, the controlling node may further instruct the selected single radio node to transmit a node-specific pilot, which is a known signal that can be used by the UE as an aid for decoding the control information, thus enabling the UE to detect and read the control information transmitted from the single radio node. By measuring the

specific pilot signal, the UE may estimate the channel for transmissions from the selected single radio node, and the estimated channel can be used to correctly decode control information transmitted from the single radio node.

[00035] Fig. 3 illustrates an example of communication scenario where the above-described solution is used to control transmission of control information “C” to a UE in a combined cell wherein the UE communicates radio signals with multiple radio nodes. Similar to Fig. 1, the multiple radio nodes include a macro node 300 covering the whole cell and a plurality of low power nodes 302, 304, 306 and 308 each covering a small part of the whole cell. The UE is located somewhere in the combined cell and may be connected to virtually all nodes 300-308 at the same time such that these nodes may receive and process any radio signals e.g. containing uplink data “D” sent from the UE. In this example, the combined cell may comprise further radio nodes, not shown, which are not in communication with the UE and therefore not included in the term “multiple radio nodes” as used in this context. A controlling node 310 is also involved which may be implemented in the macro node 300 or in another network node, for example a more centralized node such as an RNC or similar.

[00036] Following the procedure described above in connection with Fig. 2, the controlling node 310 selects a subset of the multiple radio nodes 300-308, in this case radio nodes 302 and 306, which are instructed, as indicated by “I” in the figure, to transmit the control information C to the UE. For example, radio nodes 302 and 306 may be selected after having determined that these two radio nodes 302, 306 are the ones that are closest to the UE of the multiple radio nodes 300-308. Determining which radio node(s) to include in the subset of radio nodes may comprise evaluating a threshold condition for an indication of vicinity of the UE to the respective radio nodes, which will be described in more detail below when discussing the flow charts of Figs 5 and 6. In the example of Fig. 3, the radio nodes 302 and 306 have been selected because they are the radio nodes closest to the UE while the other radio nodes 300, 304 and 308 are farther away from the UE and would therefore require higher transmit power for the transmission of the control information C than the radio nodes 302 and 306.

[00037] A detailed but non-limiting example of how a controlling node may be structured with some possible functional units to bring about the above-described operation of the controlling node, is illustrated by the block diagram in Fig. 4. In this figure, the controlling node 400 is comprised in a cellular network for wireless communication and is configured to control transmission of control information to a UE that is configured to communicate radio signals with multiple radio nodes 402 serving a combined cell. The controlling node 400 may be similar to the controlling node 310 in Fig. 3.

[00038] The controlling node 400 comprises a **logic unit 400a** configured to select a subset of the multiple radio nodes, e.g. in the manner described for action 202 above. For example, the subset of the multiple radio nodes may be selected based on an indication of vicinity to the UE which may comprise a signal quality and/or path loss determined for each radio node of the multiple radio nodes, as described above. The controlling node 400 also comprises an **instructing unit 400b** configured to instruct the selected subset of the multiple radio nodes to send the control information to the UE, e.g. in the manner described for action 204 above.

[00039] It should be noted that Fig. 4 illustrates various functional units in the controlling node 400 and the skilled person is able to implement these functional units in practice using suitable software and hardware. Thus, the solution is generally not limited to the shown structures of the controlling node 400, and the functional units 400a-b may be configured to operate according to any of the features described in this disclosure, where appropriate.

[00040] The functional units 400a-b described above may be implemented in the controlling node 400 by means of program modules of a respective computer program comprising code means which, when run by a processor "P" causes the controlling node 400 to perform the above-described actions and procedures. The processor P may comprise a single Central Processing Unit (CPU), or could comprise two or more processing units. For example, the processor P may include a general purpose microprocessor, an instruction set processor and/or related chips sets and/or a special purpose microprocessor such as an Application

Specific Integrated Circuit (ASIC). The processor P may also comprise a storage for caching purposes.

[00041] Each computer program may be carried by a computer program product in the controlling node 400 in the form of a memory "M" having a computer readable medium and being connected to the processor P. The computer program product or memory M thus comprises a computer readable medium on which the computer program is stored e.g. in the form of computer program modules "m". For example, the memory M may be a flash memory, a Random-Access Memory (RAM), a Read-Only Memory (ROM) or an Electrically Erasable Programmable ROM (EEPROM), and the program modules m could in alternative embodiments be distributed on different computer program products in the form of memories within the controlling node 400.

[00042] The above controlling node 400 and its functional units 400a-b may be configured or adapted to operate according to various optional embodiments. In a possible embodiment, the logic unit 400a could be configured to select the subset of the multiple radio nodes based on an indication of vicinity of the UE to each respective radio node of the multiple radio nodes. An advantage of this embodiment is that one or more radio nodes may be selected which are relatively close to the UE such that the selected radio node(s) can transmit the control information with relatively low power and still reach the UE properly.

[00043] In another possible embodiment, the indication of vicinity may comprise signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes. As described above, the signal quality may be indicated by at least one of the quality-related parameters SNR, SINR, RSRQ, and CQI. In another possible embodiment, the logic unit 400a may be configured to select the subset of the multiple radio nodes by selecting one or more radio nodes for which the signal quality of downlink signals received by the UE is above a first threshold. Further, the logic unit 400a may be configured to obtain the signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes, from measurements made by the UE on a reference signal transmitted in turn by each respective one

of the multiple radio nodes. Advantages of these embodiments include that the signal quality is a fairly reliable indication of vicinity and can easily be determined from measurements on downlink signals which the UE is able to perform.

[00044] In another possible embodiment, the indication of vicinity may comprise path loss between the UE and each respective radio node of the multiple radio nodes. In that case, the logic unit 400a may be configured to select the subset of the multiple radio nodes by selecting one or more radio nodes for which the path loss relative to the UE is below a second threshold. Advantages of the latter embodiments include that the path loss is likewise a fairly reliable indication of vicinity and can easily be determined from measurements on uplink signals from the UE which the respective radio nodes are able to perform. It is also possible to select the subset of the multiple radio nodes based on both signal quality and path loss, as follows. It is e.g. possible that both of the above-mentioned first and second thresholds are evaluated in terms of the signal quality and path loss, respectively, for each radio node of the multiple radio nodes. For example, a particular radio node may be selected only if both thresholds are satisfied for that radio node, or if at least one of the first and second thresholds are satisfied for that radio node.

[00045] In further possible embodiments, the logic unit 400a may be configured to select the subset of the multiple radio nodes by selecting a single radio node from the multiple radio nodes, e.g. by evaluating one or both of the above-mentioned first and/or second thresholds in terms of the signal quality and/or path loss, respectively, for each radio node of the multiple radio nodes. Alternatively, a predetermined "default" radio node, or a randomly picked radio node, of the multiple radio nodes may be included in the subset of the multiple radio nodes. Further, the instructing unit 400b may be configured to instruct the selected single radio node to transmit a node-specific pilot enabling the UE to detect the control information transmitted from the single radio node, as described above.

[00046] In further possible embodiments, the control information may comprise at least one of: feedback, e.g. according to a HARQ process, to indicate whether data transmitted by the UE has been received and decoded by the multiple radio

nodes or not, a power control command, and scheduling grant information for uplink data transmission. Furthermore, if the multiple radio nodes of the combined cell comprise a macro node transmitting with a relatively high power, such as node 300 in Fig. 3, and a set of low power nodes transmitting with a relatively low power, such as nodes 302-308 in Fig. 3, the controlling node 400 may be configured to be implemented in the macro node.

[00047] An example of how the above-described controlling node may select the subset of radio nodes from the multiple radio nodes, will now be described with reference to the flow chart of Fig. 5. It was mentioned above that the subset of radio nodes may be selected by evaluating a threshold condition for each one of the multiple radio nodes. In this example, a threshold condition is used that is related to signal quality which may be determined from measurements made by the UE of received downlink signals as follows. The signal quality may be used as an indication of the above-described vicinity, or distance, of the UE to each respective radio node.

[00048] In a first **action 500**, the controlling node obtains a received signal quality of a pilot signal, or reference signal, that is received by the UE from one of the multiple radio nodes. For example, the received signal quality of the received pilot or reference signal may be indicated by at least one of the quality-related parameters SNR, SINR, RSRQ, and CQI. It is then determined whether the obtained signal quality of the considered radio node is above a first threshold, in an **action 502**. The first threshold may have been set to ensure that downlink signals from the considered radio node will be good enough to enable correct reception and decoding of the control information sent from the considered radio node when the signal quality is above the first threshold. If so, the considered radio node is selected to be included in the subset of radio nodes, in an **action 504**, thus qualifying for the transmission of the control information.

[00049] On the other hand, if the received signal quality from the considered radio node is not above the first threshold in action 502, the controlling node returns to action 500 for evaluating a next radio node among the multiple radio nodes in communication with the UE. In this way, the procedure of Fig. 5 may be

repeated for all of the multiple radio nodes in communication with the UE, or until a sufficient amount of radio nodes have been selected for inclusion in the subset of radio nodes.

[00050] Another example of how the above-described controlling node may select the subset of radio nodes from the multiple radio nodes, will now be described with reference to the flow chart of Fig. 6. In this example, a threshold condition is used that is related to path loss which may be determined from measurements made by each respective radio node of received uplink signals as follows. The path loss may be used as an indication of the above-described vicinity, or distance, of the UE to each respective radio node where a low path loss implies a relatively short distance and a high path loss implies a relatively long distance.

[00051] In a first **action 600**, the controlling node obtains the path loss between the UE and one of the multiple radio nodes. For example, the path loss of the considered radio node may be calculated from the transmit power used by the UE, which is known to the radio node, and a received signal strength of uplink signal transmissions from the UE which can be measured at the considered radio node. It is then determined whether the obtained path loss of the considered radio node is below a second threshold, in an **action 602**. The second threshold may have been set to ensure that downlink signals from the considered radio node will be good enough to enable correct reception and decoding of the control information sent from the considered radio node when the path loss is below the second threshold. If so, the considered radio node is selected to be included in the subset of radio nodes, in an **action 604**, thus qualifying for the transmission of the control information.

[00052] On the other hand, if the path loss of the considered radio node is not below the second threshold in action 602, the controlling node returns to action 600 for evaluating a next radio node among the multiple radio nodes in communication with the UE. In this way, the procedure of Fig. 6 may be repeated for all of the multiple radio nodes in communication with the UE, or until a sufficient

amount of radio nodes have been selected for inclusion in the subset of radio nodes.

[00053] While the solution has been described with reference to specific exemplary embodiments, the description is generally only intended to illustrate the inventive concept and should not be taken as limiting the scope of the solution. For example, the terms “controlling node”, “User Equipment, UE”, “radio node”, “control information”, “threshold” and “feedback” have been used throughout this description, although any other corresponding entities, functions, and/or parameters could also be used having the features and characteristics described here. The solution is defined by the appended claims.

CLAIMS

1. A method, performed by a controlling node (310, 400) of a cellular network for wireless communication, to control transmission of control information to a User Equipment, UE, wherein the UE communicates radio signals with multiple radio nodes (300-308, 402) serving a combined cell in the cellular network, the method comprising:

- selecting (202) a subset of the multiple radio nodes, and
- instructing (204) the selected subset of the multiple radio nodes to send said control information to the UE.

2. A method according to claim 1, wherein the subset of the multiple radio nodes is selected based on an indication of vicinity of the UE to each respective radio node of the multiple radio nodes.

3. A method according to claim 2, wherein the indication of vicinity comprises signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes, the signal quality being indicated by at least one of: Signal to Noise Ratio, SNR, Signal to Interference and Noise Ratio, SINR, Reference Signal Received Quality, RSRQ, and Channel Quality Indicator, CQI.

4. A method according to claim 3, wherein selecting the subset of the multiple radio nodes comprises selecting one or more radio nodes for which the signal quality of downlink signals received by the UE is above a first threshold.

5. A method according to claim 3 or 4, wherein said signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes is obtained from measurements made by the UE on a reference signal transmitted in turn by each respective one of the multiple radio nodes.

6. A method according to any of claims 2-5, wherein the indication of vicinity comprises path loss between the UE and each respective radio node of the multiple radio nodes.
7. A method according to claim 6, wherein selecting the subset of the multiple radio nodes comprises selecting one or more radio nodes for which the path loss relative to the UE is below a second threshold.
8. A method according to any of claims 1-7, wherein selecting the subset of the multiple radio nodes comprises selecting a single radio node from the multiple radio nodes.
9. A method according to claim 8, wherein the selected single radio node is instructed to transmit a node-specific pilot enabling the UE to detect the control information transmitted from the single radio node.
10. A method according to any of claims 1-9, wherein the control information comprises at least one of: feedback to indicate whether data transmitted by the UE has been received and decoded by the multiple radio nodes or not, a power control command, and scheduling grant information for uplink data transmission.
11. A method according to any of claims 1-10, wherein the multiple radio nodes comprise a macro node (300) transmitting with a relatively high power and a set of low power nodes (302-308) transmitting with a relatively low power, and wherein the controlling node (310, 400) is implemented in the macro node.
12. A controlling node (400) of a cellular network for wireless communication, the controlling node being configured to control transmission of control information to a User Equipment, UE, that is configured to communicate radio signals with multiple radio nodes (402) serving a combined cell in the cellular network, the controlling node comprising:
 - a logic unit (400a) configured to select a subset of the multiple radio nodes, and
 - an instructing unit (400b) configured to instruct the selected subset of the multiple radio nodes to send said control information to the UE.

13. A controlling node (400) according to claim 12, wherein the logic unit (400a) is configured to select the subset of the multiple radio nodes based on an indication of vicinity of the UE to each respective radio node of the multiple radio nodes.

14. A controlling node (400) according to claim 13, wherein the indication of vicinity comprises signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes, the signal quality being indicated by at least one of: Signal to Noise Ratio, SNR, Signal to Interference and Noise Ratio, SINR, Reference Signal Received Quality, RSRQ, and Channel Quality Indicator, CQI.

15. A controlling node (400) according to claim 14, wherein the logic unit (400a) is configured to select the subset of the multiple radio nodes by selecting one or more radio nodes for which the signal quality of downlink signals received by the UE is above a first threshold.

16. A controlling node (400) according to claim 14 or 15, wherein the logic unit (400a) is configured to obtain said signal quality of downlink signals received by the UE when transmitted by each respective radio node of the multiple radio nodes, from measurements made by the UE on a reference signal transmitted in turn by each respective one of the multiple radio nodes.

17. A controlling node (400) according to any of claims 13-16, wherein the indication of vicinity comprises path loss between the UE and each respective radio node of the multiple radio nodes.

18. A controlling node (400) according to claim 17, wherein the logic unit (400a) is configured to select the subset of the multiple radio nodes by selecting one or more radio nodes for which the path loss relative to the UE is below a second threshold.

19. A controlling node (400) according to any of claims 12-18, wherein the logic unit (400a) is configured to select the subset of the multiple radio nodes by selecting a single radio node from the multiple radio nodes.

20. A controlling node (400) according to claim 19, wherein the instructing unit (400b) is configured to instruct the selected single radio node to transmit a node-specific pilot enabling the UE to detect the control information transmitted from the single radio node.

21. A controlling node (400) according to any of claims 12-20, wherein the control information comprises at least one of: feedback to indicate whether data transmitted by the UE has been received and decoded by the multiple radio nodes or not, a power control command, and scheduling grant information for uplink data transmission.

22. A controlling node (400) according to any of claims 12-21, wherein the multiple radio nodes comprise a macro node (300) transmitting with a relatively high power and a set of low power nodes (302-308) transmitting with a relatively low power, and wherein the controlling node (310, 400) is configured to be implemented in the macro node.

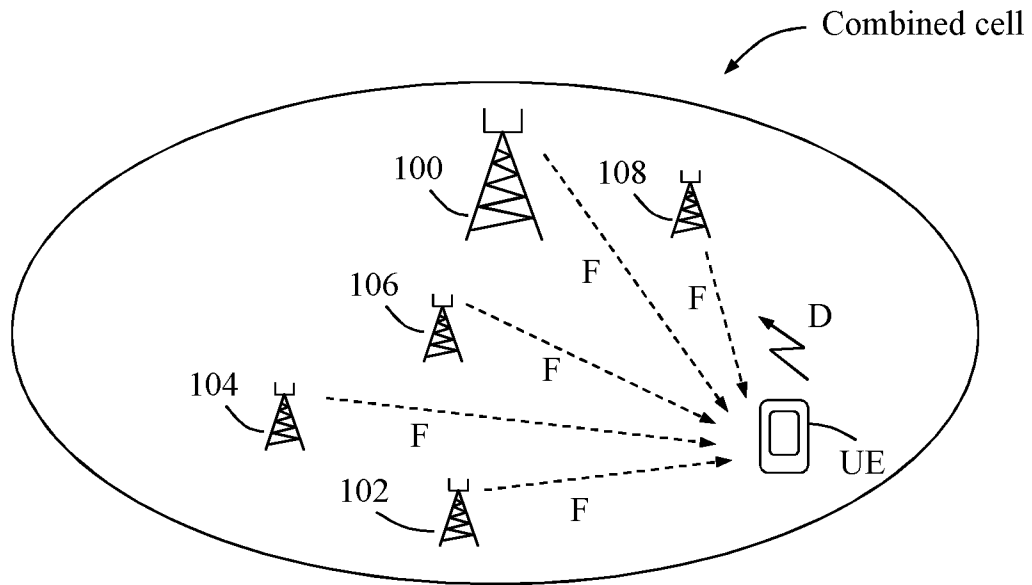


Fig. 1 (Prior art)

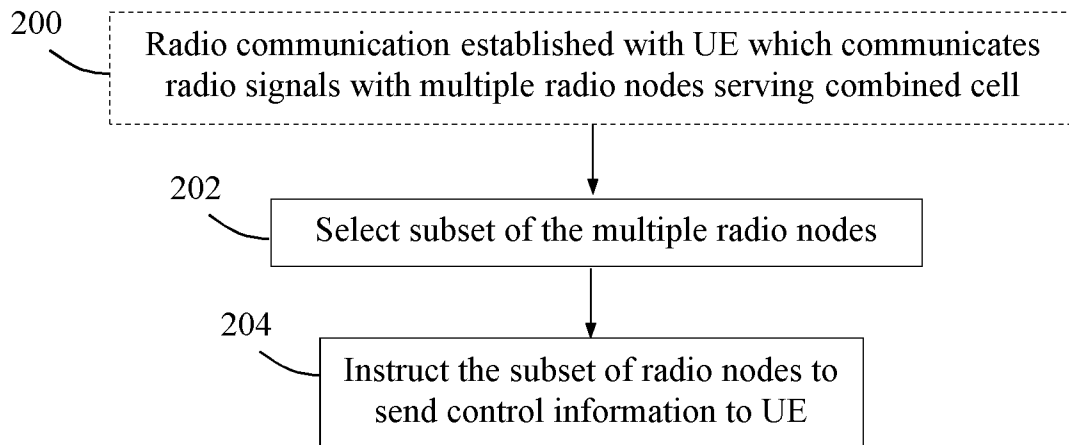


Fig. 2

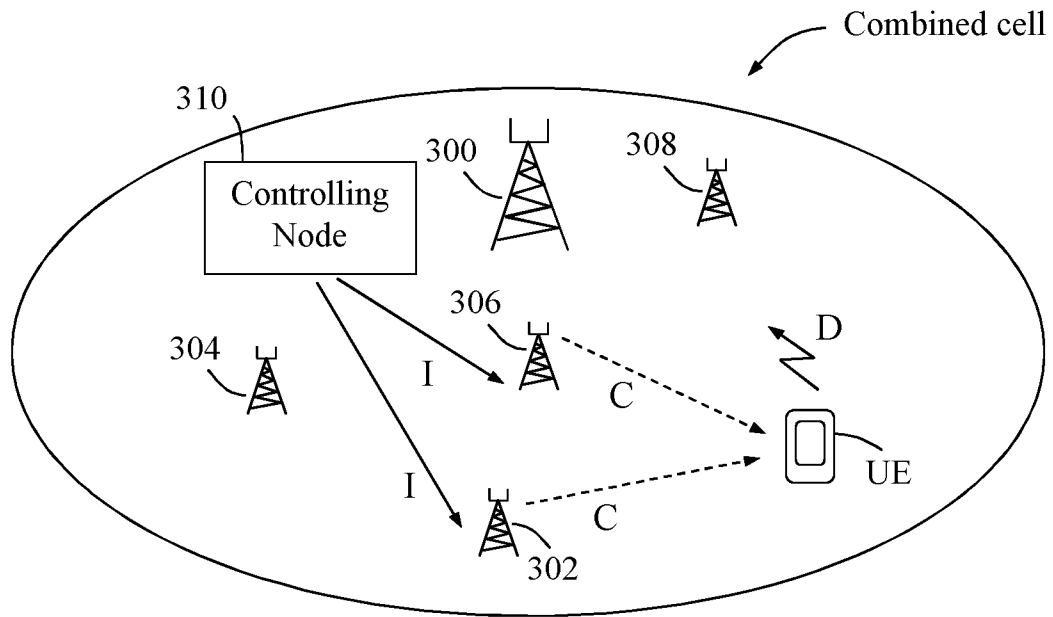


Fig. 3

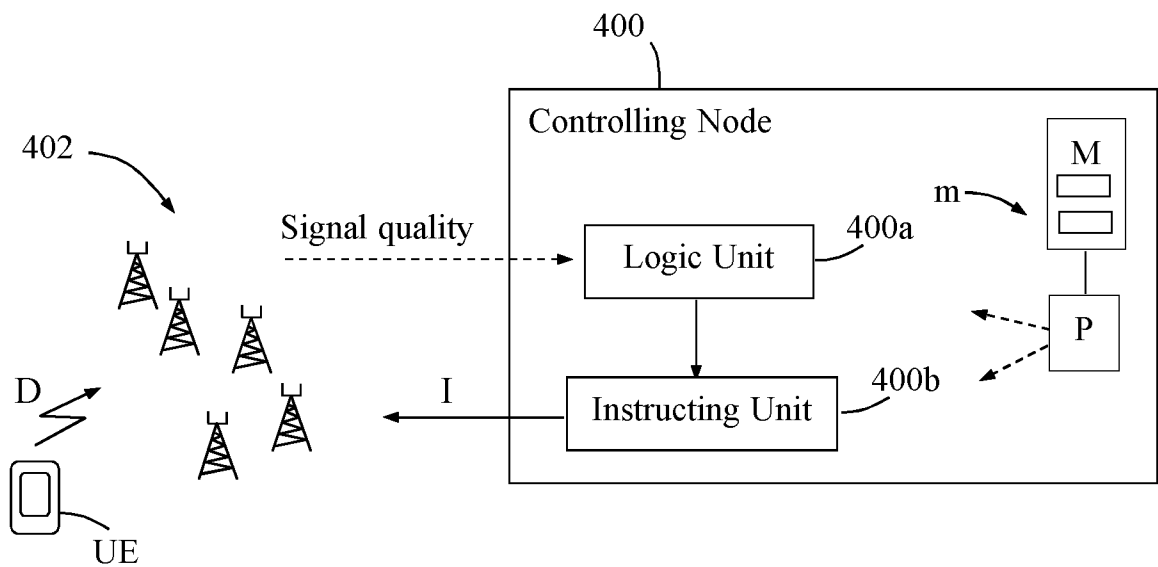


Fig. 4

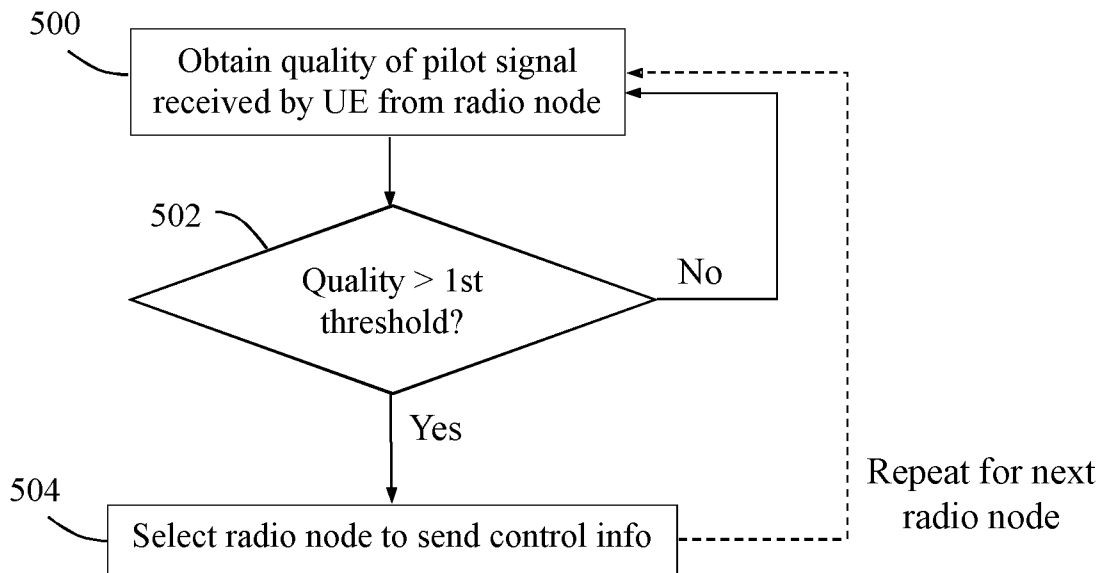


Fig. 5

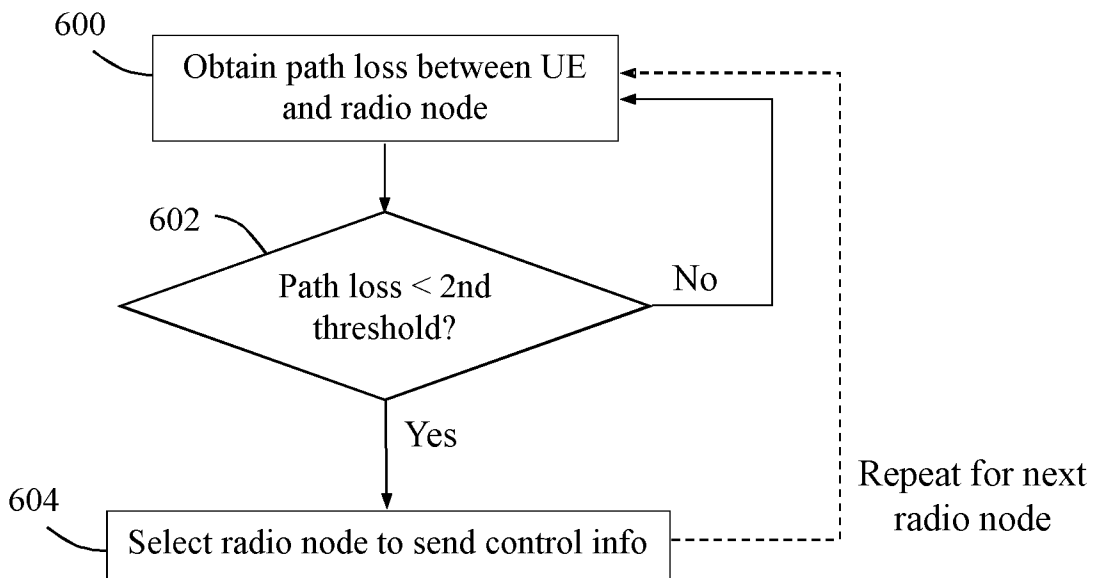


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2013/050363

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/02 H04W36/18 H04W52/02 H04W52/40 H04W52/32
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)
H04B 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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 010 322 B2 (KIM YOUN-SUN [KR] ET AL) 7 March 2006 (2006-03-07) abstract column 4, line 18 - column 5, line 67 claims 1, 4 figures 2, 3	1-22
X	US 7 006 828 B1 (CZAJA STANISLAW [US] ET AL) 28 February 2006 (2006-02-28) abstract column 9, line 23 - column 10, line 53 claim 1 figures 2, 3	1-22
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 26 November 2013	Date of mailing of the international search report 04/12/2013
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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 Helms, Jochen
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INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2013/050363

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

International application No

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