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(71) Applicant *(for all designated States except US)*: **TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)** [SE/SE]; SE-164 83 Stockholm (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ZHAO, Shuang** [CN/CN]; No. 5 Lize East Street, Chaoyang District, Beijing 100102 (CN). **LI, Keding** [CN/CN]; No. 5 Lize East Street, Chaoyang District, Beijing 100102 (CN). **YANG, Wenliang** [CN/CN]; No. 5 Lize East Street, Chaoyang District, Beijing 100102 (CN). **WANG, Jian** [CN/CN]; No. 5 Lize East Street, Chaoyang District, Beijing 100102 (CN).

(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Cetre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

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(54) **Title**: METHOD AND DEVICE FOR UPLINK POWER CONTROL

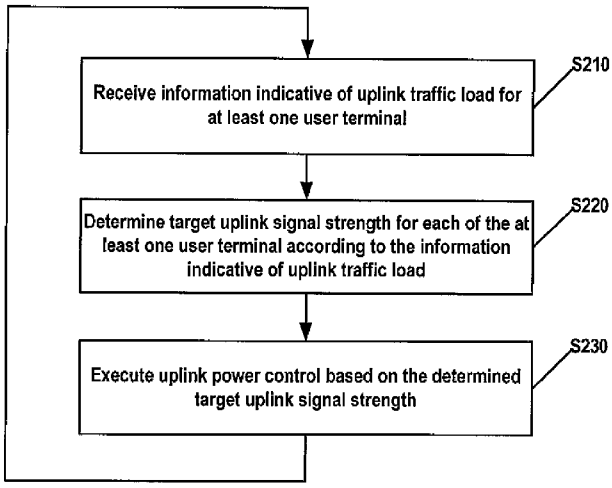


Fig. 2

(57) **Abstract**: One of the embodiments of present invention relates to a method for uplink power control. The method comprises: receiving information indicative of uplink traffic load for at least one user terminal; determining target uplink signal strength for said at least one user terminal according to said information indicative of uplink traffic load; executing uplink power control based on the determined target uplink signal strength. Embodiments of the present invention also relate to relevant base station and computer program product. According to the various embodiments of the present invention, the uplink power of user terminals served by a small base station such as a femto base station in a heterogeneous network can be adjusted according to uplink traffic demand of those user terminals.

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METHOD AND DEVICE FOR UPLINK POWER CONTROL

TECHNICAL FIELD

The embodiments of the present invention generally relate to wireless communication, particularly to a method and device for uplink power control.

DESCRIPTION OF THE RELATED ART

To meet the rapidly increasing demand for higher capacity and achieve substantial throughput enhancement, a small radio base station having a low power level and covering a small scale communication area is adopted to enable efficient reuse of spectrum with an existing macro cell base station in a heterogeneous network (HetNet).

As an example of such small base stations, a femto cell base station, such as a Home evolved Node B (HeNB) specified in the Third Generation Partnership Project (3GPP) Release 9, is a short-range low-cost low-power base station installed by consumers, which communicates with a cellular network over a broadband connection such as digital subscriber line (DSL), cable modem or a separate radio frequency (RF) backhaul channel.

Fig. 1 illustrates a general structure of a HetNet 100 comprising at least one macro cell and at least one femto cell according to related art.

Referring to Fig. 1, in the HetNet 100, a plurality of HeNBs may exist within the coverage of a macro base station, evolved Node B (eNB), 110. For the purpose of simplicity, only one HeNB 120 is shown in Fig. 1.

A plurality of Macro User Equipments (MUEs) can be served by the Macro eNB 110 and a plurality of Femto User Equipment (FUE) can be served by the HeNB 120. For the purpose of simplicity, only one MUE and one FUE are shown in Fig.1 respectively.

Since the HeNB 120 re-uses the frequency used by the Macro eNB 110, an uplink signal from the FUE is a source of interference for uplink of the MUE. Meanwhile, uplink of the FUE also suffers interference from uplink transmission of the MUE.

Considering the situation in which more than one MUE is located near the HeNB 120 but communicates with the Macro eNB 110, the interference for uplink both the macro cell and the femto cell would decrease the throughput of the HetNet 100 evidently.

If the power of uplink of the FUE is too low, uplink throughputs of the femto cell would be decreased badly due to interference from the MUE. Meanwhile, if the power of the FUE is too high, performance of uplink of the macro cell would be affected due to high interference from uplink of FUEs.

Current 3GPP standards specify buffer status reporting (BSR) mechanism to use for scheduling, which is irrelevant to uplink power control.

European patent publication No. EP2063587 A1 discloses a solution for controlling transmission rate based on buffer occupancy of radio mobile stations in a WCDMA/HSUPA system. It does not relate to a solution for uplink power control either.

SUMMARY OF THE INVENTION

To solve the problems in the prior art, one or more method and apparatus embodiments according to the present invention aim to provide an improved solution for uplink power control.

According to an aspect of the present invention, an embodiment of the present invention provides a method for uplink power control. The method comprises: receiving information indicative of uplink traffic load for at least one user terminal; determining target uplink signal strength for the at least one user terminal according to the information indicative of uplink traffic load; and executing uplink power control based on the determined target uplink signal strength.

According to an aspect of the present invention, an embodiment of the present invention provides a base station. The base station comprises: receiving unit configured to receive information indicative of uplink traffic load for at least one user terminal; determining unit configured to determine target uplink signal strength for the at least one user terminal according to the information indicative of uplink traffic load; power control unit configured to execute uplink power control based on the determined target uplink signal strength.

According to an aspect of the present invention, an embodiment of the present invention provides a computer program product. The computer program product comprises instructions which, when loaded into a processor, enable the processor to perform a method for uplink power control according to an embodiment of the present invention.

According to the embodiments of the present invention, the uplink power of user terminals served by one base station such as a femto base station in a heterogeneous network can be adjusted according to uplink traffic demand of those user

terminals, so that uplink interference between user terminals served by one base station and user terminals served by another base station can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Inventive features regarded as the characteristics of the present invention are set forth in the appended claims. However, the present invention, its implementation mode, other objectives, features and advantages will be better understood through reading the following detailed description on the exemplary embodiments with reference to the accompanying drawings, where in the drawings:

Fig. 1 schematically illustrates a general structure of a HetNet according to related art;

Fig. 2 schematically illustrates a flow chart of a method for uplink power control according to an embodiment of the present invention;

Figs. 3A and 3B schematically illustrate exemplary structures of a buffer status report information element according to an embodiment of the present invention; and

Fig. 4 schematically illustrates a block diagram of a base station according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings. In the following description, many specific details are

illustrated so as to understand the present invention more comprehensively. However, it is apparent to the skilled in the art that implementation of the present invention may not have these details. Additionally, it should be understood that the present invention is not limited to the particular embodiments as introduced here. For example, the present invention is not limited to heterogeneous network, not limited to scenarios with femto cells or HeNBs, not limited to LTE system. On the contrary, any arbitrary combination of the following features and elements may be considered to implement and practice the present invention, regardless of whether they involve different embodiments. Thus, the following aspects, features, embodiments and advantages are only for illustrative purposes, and should not be understood as elements or limitations of the appended claims, unless otherwise explicitly specified in the claims.

Those skilled in the art should appreciate that when a HetNet for serving a small scale region of coverage is configured using a pico cell, a femto cell, wireless relays of low power, etc., a capacity may be increased at low cost. From this perspective, any cell served by a low power base station, such as a pico cell, a femto cell and wireless relays can be collectively called a femto cell, in which the embodiments of the present invention can be implemented to improve the uplink throughput of the HetNet by reducing co-channel interference between different kinds of cells that re-use the same frequency resource in the HetNet. Therefore, for the purpose of non-limitation, embodiments of the present invention will be described in conjunction with a HetNet environment where macro cells and femto cells are mixed.

The embodiments of the present invention provide a mechanism for uplink power control so that uplink power of user terminals served by a femto base station in a HetNet can

be set adaptively. In the various embodiments of the present invention, target uplink signal strength for at least one user terminal served by a femto base station is adjusted according to information indicative of uplink traffic load of the at least one user terminal.

Usually, uplink of a femto cell is used to bear control signaling and thus the traffic load on uplink is moderate. Only in some period the uplink traffic bursts to a high level, such as a period when a user(s) in the femto cell wants to share video or transfer big files to his/her friend(s), uplink will have heavy load. In an embodiment, target uplink signal strength is determined and adjusted based on traffic demand so as to achieve the goal of enhancing uplink throughput of the HetNet including at least a femto cell and a macro cell.

Specifically speaking, referring to the HetNet of Fig. 1 again, when uplink demand of the HeNB 120 is lower, the target uplink signal strength of the FUE(s) can be set as a relative low level so as to meet the requirement of lower SINR. On the other hand, when uplink demand of the HeNB 120 bursts to heavy load, the target uplink signal strength of the FUE(s) can be set as a relative high level so as to resist the interference from the MUE(s) of the macro cell and ensure good enough SINR for high throughput requirement.

It can be appreciated that based on this mechanism, in most cases, uplink SINR and throughput in the macro cell served by the Macro eNB 110 in the HetNet 100 is improved due to less interference from the femto cell serving by the HeNB 120. Meanwhile, if traffic of uplink in the femto cell bursts to high level, uplink capacity of the femto cell is enhanced by increasing uplink power in this certain period. Furthermore, a higher SINR in the femto cell results in a shorter time window of transmission with high power. That means the macro cell

served by the Macro eNB 110 can enjoy a longer period with low interference from the femto cell served by the HeNB 120 as much as possible.

Various embodiments of the present invention will be described in details in conjunction with Figs. 2-4.

Fig. 2 schematically illustrates a flow chart of a method for uplink power control according to an embodiment of the present invention.

Referring to Fig.2, at step S210, information indicative of uplink traffic load for at least one user terminal is received at a femto base station, such as the HeNB 120.

The information indicative of uplink traffic load can be reported periodically by the user terminals. For example, existing BSR procedure specified in current Long Term Evolution (LTE) standards can be used to provide the information indicative of uplink traffic load. 3GPP TS 36.331 V9.5.0 and 3GPP TS 36.321 V10.4.0 as examples of relevant LTE standards are incorporated by reference herein in their entirety.

According to an embodiment of the present invention, the period for adjusting target uplink signal strength of the femto cell can be configured as the basis of one or more BSR periods. When each user terminal establishes a radio resource control (RRC) connection with the HeNB 120, the HeNB 120 can configure a BSR parameter by an information element *MAC-MainConfig* in a message *RRCConnectionSetup*. In an implementation of the embodiment of the present invention, the parameter *periodicBSR-Timer* in the information element *MAC-MAINConfig* stands for the BSR period and can be configured as a basic unit of the period for adjusting target uplink signal strength **Period_PowerTargetAdjust**. In a configuring phase of the HeNB 120 (not shown in Fig.1), the HeNB needs to configure

the parameter **Period_PowerTargetAdjust** in advance so as to perform the processing flow of Fig.1.

According to an embodiment of the present invention, the information indicative of uplink traffic load reported from each user terminal can be its buffer status (es) in respective periods of adjusting target uplink signal strength of the femto cell. In an implementation of the embodiment of the present invention, the buffer status information can be carried in a BSR MAC control element, which has been specified in 3GPP TS 36.321 V10.4.0.

According to 3GPP TS 36.321 V10.4.0, BSR MAC control elements consist of either:

- Short BSR and Truncated BSR format: one logical channel group (LCG) ID field and one corresponding Buffer Size field, as shown in Fig. 3A; or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #0 through #3, as shown in Fig. 3B.

The fields LCG ID and Buffer Size in Figs.3A and 3B are defined as follows:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) whose buffer status is being reported. The length of the field is 2 bits;
- Buffer Size: The Buffer Size field identifies the total amount of data available across all logical channels of a logical channel group after all MAC Protocol Data Units (PDUs) for the Transmission Time Interval (TTI) have been built. The amount of data is indicated by the number of bytes. It shall include all data that is available for transmission in the RLC layer and in the PDCP(Packet Data Convergence Protocol) layer. The length of this field is 6 bits. If extended BSR size levels are not configured, the values taken by the Buffer Size field are shown in Table 1. If extended BSR size levels

are configured, the values taken by the Buffer Size field are shown in Table 2.

Table 1: Buffer size levels for BSR

Index	Buffer Size value [bytes]	Index	Buffer Size value [bytes]
0	BS = 0	32	1132 < BS <= 1326
1	0 < BS <= 10	33	1326 < BS <= 1552
2	10 < BS <= 12	34	1552 < BS <= 1817
3	12 < BS <= 14	35	1817 < BS <= 2127
4	14 < BS <= 17	36	2127 < BS <= 2490
5	17 < BS <= 19	37	2490 < BS <= 2915
6	19 < BS <= 22	38	2915 < BS <= 3413
7	22 < BS <= 26	39	3413 < BS <= 3995
8	26 < BS <= 31	40	3995 < BS <= 4677
9	31 < BS <= 36	41	4677 < BS <= 5476
10	36 < BS <= 42	42	5476 < BS <= 6411
11	42 < BS <= 49	43	6411 < BS <= 7505
12	49 < BS <= 57	44	7505 < BS <= 8787
13	57 < BS <= 67	45	8787 < BS <= 10287
14	67 < BS <= 78	46	10287 < BS <= 12043
15	78 < BS <= 91	47	12043 < BS <= 14099
16	91 < BS <= 107	48	14099 < BS <= 16507
17	107 < BS <= 125	49	16507 < BS <= 19325
18	125 < BS <= 146	50	19325 < BS <= 22624

19	146 < BS <= 171	51	22624 < BS <= 26487
20	171 < BS <= 200	52	26487 < BS <= 31009
21	200 < BS <= 234	53	31009 < BS <= 36304
22	234 < BS <= 274	54	36304 < BS <= 42502
23	274 < BS <= 321	55	42502 < BS <= 49759
24	321 < BS <= 376	56	49759 < BS <= 58255
25	376 < BS <= 440	57	58255 < BS <= 68201
26	440 < BS <= 515	58	68201 < BS <= 79846
27	515 < BS <= 603	59	79846 < BS <= 93479
28	603 < BS <= 706	60	93479 < BS <= 109439
29	706 < BS <= 826	61	109439 < BS <= 128125
30	826 < BS <= 967	62	128125 < BS <= 150000
31	967 < BS <=1132	63	BS > 150000

Table 2: Extended Buffer size levels for BSR

Index	Buffer Size value [bytes]	Index	Buffer Size value [bytes]
0	BS = 0	32	4940 < BS <= 6074
1	0 < BS <= 10	33	6074 < BS <= 7469
2	10 < BS <= 13	34	7469 < BS <= 9185
3	13 < BS <= 16	35	9185 < BS <= 11294
4	16 < BS <= 19	36	11294 < BS <= 13888
5	19 < BS <= 23	37	13888 < BS <= 17077
6	23 < BS <= 29	38	17077 < BS <= 20999

7	29 < BS <= 35	39	20999 < BS <= 25822
8	35 < BS <= 43	40	25822 < BS <= 31752
9	43 < BS <= 53	41	31752 < BS <= 39045
10	53 < BS <= 65	42	39045 < BS <= 48012
11	65 < BS <= 80	43	48012 < BS <= 59039
12	80 < BS <= 98	44	59039 < BS <= 72598
13	98 < BS <= 120	45	72598 < BS <= 89272
14	120 < BS <= 147	46	89272 < BS <= 109774
15	147 < BS <= 181	47	109774 < BS <= 134986
16	181 < BS <= 223	48	134986 < BS <= 165989
17	223 < BS <= 274	49	165989 < BS <= 204111
18	274 < BS <= 337	50	204111 < BS <= 250990
19	337 < BS <= 414	51	250990 < BS <= 308634
20	414 < BS <= 509	52	308634 < BS <= 379519
21	509 < BS <= 625	53	379519 < BS <= 466683
22	625 < BS <= 769	54	466683 < BS <= 573866
23	769 < BS <= 945	55	573866 < BS <= 705666
24	945 < BS <= 1162	56	705666 < BS <= 867737
25	1162 < BS <= 1429	57	867737 < BS <= 1067031
26	1429 < BS <= 1757	58	1067031 < BS <= 1312097
27	1757 < BS <= 2161	59	1312097 < BS <= 1613447
28	2161 < BS <= 2657	60	1613447 < BS <= 1984009
29	2657 < BS <= 3267	61	1984009 < BS <= 2439678
30	3267 < BS <= 4017	62	2439678 < BS <= 3000000

31	4017 < BS <=4940	63	BS > 3000000

Although two kinds of exemplary information elements are provided with reference to 3GPP TS 36.321 V10.4.0, those skilled in the art can understand that the information indicative of uplink traffic load may employ any other suitable formats or be carried in any other suitable information elements reported from femto user terminals to the femto base station, without being limited to the above examples.

At step S220, target uplink signal strength for said at least one user terminal is determined according to the information indicative of uplink traffic load from the user terminal(s). In one example, same target uplink signal strength is determined for two or more user terminals, particularly for a cell with small amount of users. In another example, target uplink signal strength is determined specifically for each user terminal.

In the conventional uplink power control solution, uplink of all user terminals is ensured to have a same target uplink signal strength, for example denoted as a parameter **P_UplinkNominal** at an antenna of the femto base station, such as the HeNB 120. Furthermore, **P_UplinkNominal** is always fixed in the conventional solution.

However, the embodiments of the present invention provide a mechanism to adjust target uplink signal strength based on the information indicative of uplink traffic load from the user terminal(s).

According to an embodiment of the present invention, target uplink signal strength can be determined for respective logical channel groups of the user terminals served by the

femto base station, such as the HeNB 120.

Alternatively or additionally, the target uplink signal strength for the user terminals can be determined according to a function of the information indicative of uplink traffic load reported from respective user terminals. For example, it would be advantageous that the target uplink signal strength for the user terminals can be determined according to a maximum of the information indicative of uplink traffic load. That means the target uplink signal strength can be adjusted according to the maximum uplink load of respective user terminals or even of respective logical channel groups of respective user terminals. Alternatively, the target uplink signal strength for the user terminals can be determined according to an average of the information indicative of uplink traffic load.

With reference to the BSR procedure introduced above, exemplary embodiments of the present invention will be described in details as below.

Each period for adjusting target uplink signal strength **Period_PowerTarget**, the HeNB 120 can get a BSR MAC control element in a short or long BSR format from all user terminals. From this information element, the HeNB 120 could know the buffer sizes of the respective logical channel group(s) that are available for transmission. A BSR MAC control element uses 6 bits to express index of buffer sizes for each logical channel group of a user terminal (referring to Figs. 3A and 3B as well as Tables 1 and 2). Taking a long BSR format as an example, it can be assumed that all BSR information from the number N of user terminals can be denoted by a parameter **Index_UplinkBuffer_n_m_k**, where n=0,1,…,3 denotes index with respect to logical channel groups; m=1,2,…,N denotes index with respect to user terminals, k denotes index with respect

to current uplink adjustment period.

In the embodiment where the target uplink signal strength for the user terminals can be determined according to a maximum of the information indicative of uplink traffic load, for a certain period k, let **Index_UplinkBuffer_Function_k** = **Index_UplinkBuffer_max_k** = **MAX**{**Index_UplinkBuffer_n_m_k**}, where n=0,1,…,3; m=1,2,…,N. It is apparent that **Index_UplinkBuffer_max_k** stands for the maximal traffic demand over all of the four logical channels from all user terminals at this period k.

In the embodiment where the target uplink signal strength for the user terminals can be determined according to an average of the information indicative of uplink traffic load, for a certain period k, let **Index_UplinkBuffer_Function_k = Index_UplinkBuffer_average_k=** **AVERAGE**{**Index_UplinkBuffer_n_m_k**}, where n=0,1,…,3; m=1,2,…,N.

Then, the adjustment of the target uplink signal strength at this period k **P_UplinkAdjust_k** can be determined based on specific **Index_UplinkBuffer_Function_k**.

According to an embodiment of the present invention, the adjustment value of the target uplink signal strength can be determined based on a predefined mapping between the buffer statuses and adjustment values of the target uplink signal strength.

Here, Table 3 shows an example of mapping between the parameters **Index_UplinkBuffer_max_k** and **P_UplinkAdjust_k** with respect to the embodiment where the maximum of the information indicative of uplink traffic load is adopted to determine the target uplink signal strength.

P_UplinkAdjust_k	Index_UplinkBuffer_max_k	P_UplinkAdjust_k	Index_UplinkBuffer_max_k
-6	0	+1	32
-6	1	+1	33
-6	2	+1	34
-5	3	+1	35
-5	4	+1	36
-5	5	+2	37
-5	6	+2	38
-4	7	+2	39
-4	8	+2	40
-4	9	+2	41
-4	10	+3	42
-3	11	+3	43
-3	12	+3	44
-3	13	+3	45
-3	14	+3	46
-2	15	+4	47
-2	16	+4	48
-2	17	+4	49
-2	18	+4	50
-1	19	+4	51
-1	20	+5	52
-1	21	+5	53
-1	22	+5	54
-1	23	+5	55
-1	24	+5	56
0	25	+6	57
0	26	+6	58
0	27	+6	59
0	28	+6	60
0	29	+6	61

0	30	+6	62
+1	31	+6	63

Those skilled in the art may appreciate that a similar mapping table can be predefined in the embodiments where any other function of the information indicative of uplink traffic load, such as average, weighted average, etc., is adopted to determine the target uplink signal strength.

Those skilled in the art may also appreciate that the specific algorithm used to determine the target uplink signal strength **P_UplinkAdjust_k** is feasible and practical. Generally speaking, any algorithm used to determine the target uplink signal strength **P_UplinkAdjust_k** based on the set of information indicative uplink traffic load {**Index_UplinkBuffer_n_m_k**} should be considered as a modification or variant of the embodiments of the present invention. For the purpose of simplicity, an abstract function F() can be defined to show the mapping relationship between {**Index_UplinkBuffer_n_m_k**} and **P_UplinkAdjust_k**:

P_UplinkAdjust_k= FUNCTION({**Index_UplinkBuffer_n_m_k**}).

Then, the target uplink signal strength at the HeNB 120 for k+1 period can be set as:

P_UplinkTarger_k+1= P_UplinkNominal + **P_UplinkAdjust_k**.

At step S230, uplink power control is executed based on the determined target uplink signal strength.

Based on the determined target uplink signal strength, the HeNB 120 can execute existing procedure for uplink power control. And when executing uplink power control in k+1 uplink power adjustment period, the HeNB 120 updates the parameter of target uplink signal strength at the antenna as **P_UplinkTarger_k+1**, which is determined in k uplink power

adjustment period.

In an embodiment of the present invention, the HeNB 120 can use an existing RRC protocol to command user terminals to adjust uplink power, as specified in 3GPP TS 36.331 V9.5.0. According to 3GPP TS 36.331 V9.5.0, by means of the information elements *UplinkPowerControlDedicated* and *UplinkPowerControlCommon* in message *RRCConnectionReconfiguration*, the HeNB 120 can adjust nominal uplink power of user terminals for PUSCH and PUCCH. Furthermore, by means of the information elements *TPC-PDCCH-Config* and *TPC-PDSCH-Config* in message *RRCConnectionReconfiguration*, the HeNB 120 performs inner loop uplink power control.

Fig. 4 schematically illustrates a block diagram of a base station according to an embodiment of the present invention.

Referring to Fig. 4, a base station 400 according to an embodiment of the present invention comprises a receiving unit 410, a determining unit 420, and a power control unit 430.

The base station 400 can operate as a femto base station, such as the HeNB 120 serving at least one user terminal in a femto cell.

The receiving unit 410 is configured to receive information indicative of uplink traffic load for the at least one user terminal. According to an embodiment of the present invention, the receiving unit 410 receives buffer status information of the BSR procedure in every period for adjusting target uplink signal strength of the femto cell. In an implementation of the embodiment of the present invention, the buffer status information can be carried in a BSR MAC control element, which is received by the receiving unit 410 and has been specified in 3GPP TS 36.321 V10.4.0.

The determining unit 420 is configured to determine target uplink signal strength for the at least one user terminal according to the information indicative of uplink traffic load received by the receiving unit 410.

According to an embodiment of the present invention, the determining unit 420 determines the target uplink signal strength for respective logical channel groups of the user terminals served by the base station 400.

Alternatively or additionally, the determining unit 420 can be configured to determine the target uplink signal strength for the user terminals according to a function of the information indicative of uplink traffic load reported from respective user terminals. For example, it would be advantageous that the determining unit 420 can be configured to determine the target uplink signal strength for the user terminals according to a maximum of the information indicative of uplink traffic load. In another example, the determining unit 420 can be configured to determine the target uplink signal strength according to an average of the information indicative of uplink traffic load.

According to an embodiment of the present invention, the determining unit 420 can be configured to determine an adjustment value of the target uplink signal strength based on a predefined mapping between the buffer statuses and adjustment values of the target uplink signal strength. As such, the determining unit 420 can determine the target uplink signal strength in k+1 uplink power adjustment period as the sum of the target uplink signal strength in k uplink power adjustment period and the determined adjustment value.

The power control unit 430 can be configured to execute uplink power control based on the target uplink signal strength determined by the determining unit 420.

According to an embodiment of the present invention, based on the target uplink signal strength determined by the determining unit 430, the power control unit 430 can execute an existing procedure for uplink control. And when executing uplink power control in k+1 uplink power adjustment period, the power control unit 430 updates the parameter of target uplink signal strength at an antenna (not shown in Fig. 4) of the base station 400 as the target uplink signal strength that is determined by the determining unit 420 in k uplink power adjustment period.

Here, the base station 400 as illustrated in Fig. 4 is described with the modules or components which are most relevant to the embodiments of the present invention. However, those skilled in the art can appreciate that the base station 400 also comprises other modules and components for performing the functionality of cellular communication, including antennas; transceiver (having a transmitter (TX) and a receiver (RX)); processors such as one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multi-core processor architecture; memory module of any type suitable to the local technical environment and implemented using any suitable data storage technology; etc. Those modules or components are well known in the art and the description thereof is omitted for the purpose of conciseness.

The processing of uplink power control according to an embodiment of the present invention has been depicted in detail with reference to Fig. 2.

It should be noted that the above depiction is only exemplary, not intended for limiting the present invention. In other embodiments of the present invention, this method

may have more, or less, or different steps, and numbering the steps is only for making the depiction more concise and much clearer, but not for stringently limiting the sequence between each steps; while the sequence of steps may be different from the depiction. For example, in some embodiments, the above one or more optional steps may be omitted. Specific embodiment of each step may be different from the depiction. All these variations fall within the spirit and scope of the present invention.

According to one or more embodiments of this invention, the interference between user terminals served by different base stations, such as user terminals served by one femto cell orHeNB and user terminals served one Macro bases station, can be reduced by adjusting uplink power through adjusting target uplink signal strength based on the uplink traffic load. Take heterogeneous network for example, for user terminals served by femto cell or HeNB,the uplink power can be increased to enhance uplink capacity when the traffic load is relatively low, and be decreased uplink power when the traffic load is relatively high, thus the uplink throughput of macro cells in proximity of the femto base station or HeNB in the heterogeneous network can be increased to a great extent by reducing co-channel interference.

Embodiments of the present invention as described in details above could be implemented into a LTE cellular network with little impact to the whole system. According to the embodiment where the BSR procedure is involved, a femto base station such as the HeNB 120 can know the current uplink demand from the BSR information reported from user terminals. Based on this information, the HeNB 120 only needs to adjust target uplink signal strength at its antenna, and then execute an existing power control procedure. That is, based on the updated target signal strength at the antenna, the HeNB 120

is able to calculate the required uplink power for a next uplink power adjustment period and notify the respective user terminals of the calculated uplink power. As discussed above, one or more embodiments of the present invention are capable of increasing the overall uplink throughput of a heterogeneous network by adaptively adjusting uplink power of user terminals served by a femto base station, and are capable of decreasing the interference to macro user terminal as much as possible, with no or little impact to the existing requirement of uplink throughput and meanwhile.

In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logical or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the exemplary embodiments of this invention may be illustrated and described as block and signaling diagrams, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logical, general purpose hardware or controller or other computing devices, or some combination thereof.

As such, it should be appreciated that at least some aspects of the exemplary embodiments of the inventions may be practiced in various components such as integrated circuit chips and modules. As well known in the art, the design of integrated circuits is by and large a highly automated process.

The present invention may also be embodied in the computer program product which comprises all features capable of

implementing the method as depicted herein and may implement the method when loaded to the computer system.

The present invention has been specifically illustrated and explained with reference to the preferred embodiments. The skilled in the art should understand various changes thereto in form and details may be made without departing from the spirit and scope of the present invention.

WHAT IS CLAIMED IS:

1. A method for uplink power control, comprising:

receiving information indicative of uplink traffic load for at least one user terminal;

determining target uplink signal strength for said at least one user terminal according to said information indicative of uplink traffic load;

executing uplink power control based on the determined target uplink signal strength.

2. The method according to Claim 1, wherein determining target uplink signal strength for said at least one user terminal comprises:

determining target uplink signal strength for at least one channel of said at least one user terminal.

3. The method according to Claim 1, wherein determining target uplink signal strength for said at least one user terminal comprises:

determining target uplink signal strength for said at least one user terminal according to a maximum of said information indicative of uplink traffic load.

4. The method according to Claim 1, wherein determining target uplink signal strength for said at least one user terminal comprises:

determining target uplink signal strength for said at

least one user terminal according to an average of said information indicative of uplink traffic load.

5. The method according to any of Claims 1, wherein said information indicative of uplink traffic load includes one or more buffer statuses for said at least one user terminal.

6. The method according to Claim 5, wherein determining target uplink signal strength for said at least one user terminal comprises:

determining an adjustment value of said target uplink signal strength based on a predefined mapping between said buffer statuses and adjustment values of said target uplink signal strength.

7. A base station, comprising:

receiving unit configured to receive information indicative of uplink traffic load for at least one user terminal;

determining unit configured to determine target uplink signal strength for said at least one user terminal according to said information indicative of uplink traffic load;

power control unit configured to execute uplink power control based on the determined target uplink signal strength.

8. The base station according to Claim 7, wherein

said determining unit is configured to determine target uplink signal strength for at least one channel of said at

least one user terminal.

9. The base station according to Claim 7 or 8, wherein

said determining unit is configured to determine target uplink signal strength for said at least one user terminal according to a maximum of said information indicative of uplink traffic load.

10. The base station according to Claim 7 or 8, wherein

said determining unit is configured to determine target uplink signal strength for said at least one user terminal according to an average of said information indicative of uplink traffic load.

11. The base station according to any of Claims 7, wherein

said information indicative of uplink traffic load includes one or more buffer statuses for said at least one user terminal.

12. The base station according to Claim 11, wherein

said determining unit is configured to determine an adjustment value of said target uplink signal strength based on a predefined mapping between said buffer statuses and adjustment values of said target uplink signal strength.

13. The base station according to any of Claims 7-12, wherein

said base station is a home evolved node B.

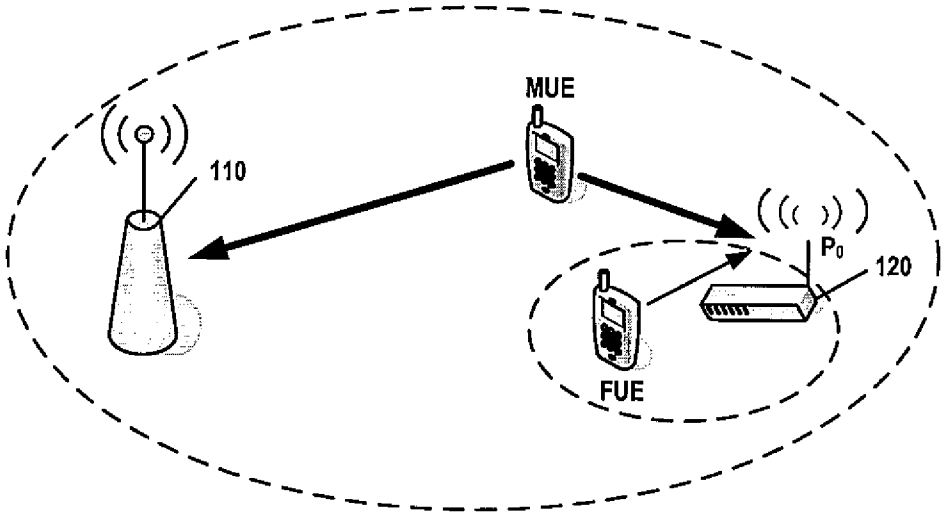


Fig. 1

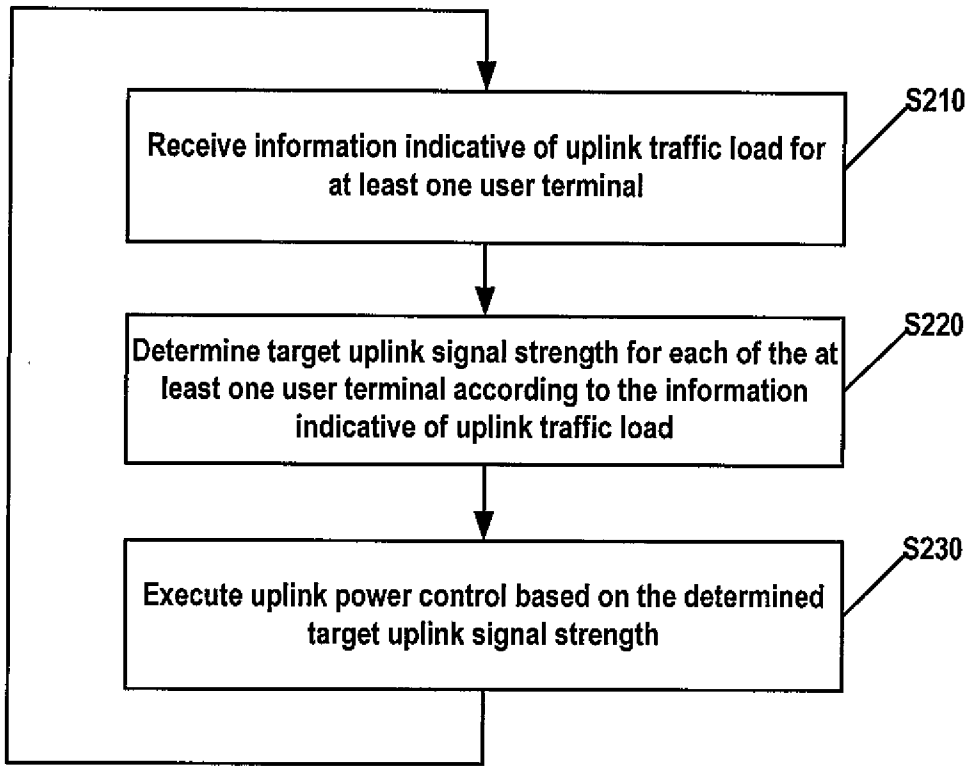

Receive information indicative of uplink traffic load for at least one user terminal
S210
Determine target uplink signal strength for each of the at least one user terminal according to the information indicative of uplink traffic load
S220
Execute uplink power control based on the determined target uplink signal strength
S230

Fig. 2

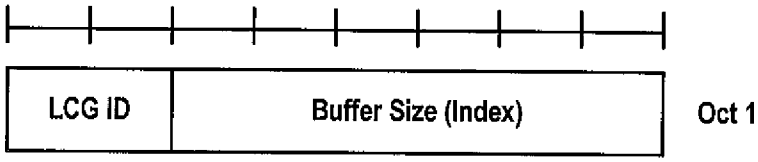

LCG ID
Buffer Size (Index)
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Fig. 3A

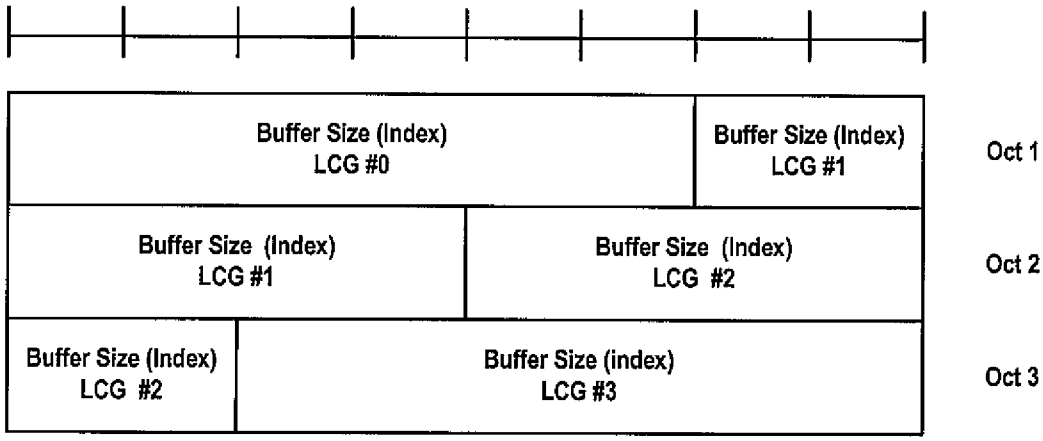

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LCG #0
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LCG #1
Oct 1
Buffer Size (Index)
LCG #1
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LCG #3
Oct 3

Fig. 3B

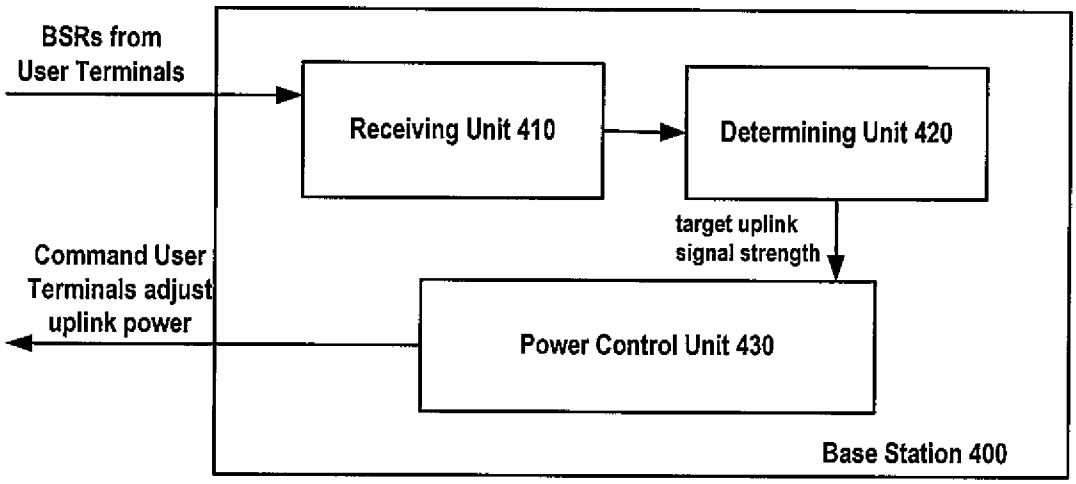

BSRs from
User Terminals
Receiving Unit 410
Determining Unit 420
target uplink
signal strength
Command User
Terminals adjust
uplink power
Power Control Unit 430
Base Station 400

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/076199

A. CLASSIFICATION OF SUBJECT MATTER

H04W 52/24(2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W52/-

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)

VEN, CPRSABS, CNTXT, CNKI, 3GPP FTP, IEEE: power, control+, adjust+, uplink, traffic, load, demand, buffer w status w report+, bsr, target, signal, strength, macro, base w station, eNB, femto, bs, nodeb, HeNB, interference

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO2011035807A1 (NOKIA SIEMENS NETWORKS OY) 31 Mar. 2011(31.03.2011) the abstract; description, page 8, lines 27-37, page 11, line 32 to page 12, line 30, page 19, line 28 to page 20, line 3, page 22, lines 29-35 and page 23, line 30 to page 24, line 25; figures 1, 9	1-13
A	CN102119560A (QUALCOMM INC) 06 Jul. 2011(06.07.2011) the whole document	1-13
A	CN102202343A (INST TELECOM SCI&TECHNOLOGY MIN O) 28 Sept. 2011(28.09.2011) the whole document	1-13
A	CN102405675A (QUALCOMM INC) 04 Apr. 2012(04.04.2012) the whole document	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 Jan. 2013(30.01.2013)	**07 Mar. 2013 (07.03.2013)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. (86-10)62019451	Authorized officer LI, Rongjuan Telephone No. (86-10)62411350

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/076199

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO2011035807A1	31.03.2011	US20120176998A1	12.07.2012
		EP2481245A1	01.08.2012
CN102119560A	06.07.2011	WO2010019483A1	18.02.2010
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		KR1173793B1	16.08.2012
		EP2314107A1	27.04.2011
		JP2011530963A	22.12.2011
CN102202343A	28.09.2011	None	
CN102405675A	04.04.2012	US2010273481A1	28.10.2010
		KR20120005531A	16.01.2012
		EP2422555A1	29.02.2012
		JP2012525086W	18.10.2012
		WO2010124243A1	18.10.2012