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Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), [Continued on next page]

Published:
— with international search report

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A METHOD OF CONTROLLING NOISE RISE IN A CELL

This invention relates to a method of controlling noise rise in a cell, in particular for 3rd generation wireless communication systems, such as 3rd generation partnership project (3GPP) frequency division duplex (FDD) or time division duplex (TDD), but is also applicable to any wireless communication system operating enhanced uplink.

In order to control a number of mobile stations, known as user equipment (UE), in a cell operating enhanced dedicated channel (E-DCH) or enhanced uplink, it is necessary to take measurements at a base station, or Node B, serving those UEs to see how much noise the UEs contribute at the Node B when using E-DCH.

In accordance with the present invention, a method of controlling noise rise in a cell comprises setting a maximum noise rise for a cell; allocating maximum noise rise for each mobile station within the cell; measuring at a base station the actual noise rise from each mobile station within the cell; and signalling the measured noise rise at the base station to a network; wherein the cell is operating enhanced dedicated channel (E-DCH); and wherein the contribution to noise rise of EDCCH signalling is determined; the method further comprising measuring received signal code power (RSCP) at the base station; decoding the RSCP measurement to determine contributions from mobile stations within and outside the cell; calculating contributions from mobile stations within the cell; and notifying the network of the measured noise rise.

To determine how much of the noise rise is due to E-DCH, a digital domain measurement of RSCP is made. The present invention makes use of a measurement that is already defined in the standard for 3GPP FDD, but was designed for determining signal to interference ratio (SIR). Using this measurement allows each node B to inform the network of the measured noise rise due to mobile stations within the cell, or noise rise that other cells are producing, so that the network can ensure that there is no undue interference with the operation of other base stations and their associated UEs. The measured noise rise is a change in value and having measured this change, it is used in the signalling method.

Preferably, the network is notified of the amount of noise at the base station due to E-DCH, the amount due to legacy channels and the amount due to other cells.

Preferably, the method further comprises applying a compensation value to compensate for temperature induced noise.
The method of the present invention makes certain assumptions about the behaviour of the receiver of the Node B. However, receiver behaviour can change with time and temperature, for example if there is a significant difference between day and night time operating temperatures. As the receiver heats up, then noise measurements may change, so it is desirable to apply some compensation for temperature when any in-use measurement of noise is made.

Preferably, the compensation value is calculated in advance and stored.

Preferably, the store comprises a look up table (LUT).

For convenience, compensation values are calculated in advance and stored, e.g. in a look up table (LUT), allowing the variations to be tuned out. Using a look up table in this way improves overall accuracy of the data reported back to the network, so maximising the number of UEs which can operate at one time, or the data rate available.

Preferably, the compensation value comprises a factor by which to modify a measurement of received total wideband power (RTWP) taken when no uplink transmissions are taking place.

Without compensation, a $\frac{1}{2}$ dB error in measuring noise at the base station can mean up to 10% drop in cell throughput.

Preferably, the base station is a Node B; the mobile station is a user equipment (UE); and the network is a radio network controller (RNC).

Preferably, the cell is part of a third generation communication system.

An example of a method of controlling noise rise in a cell according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates a typical network arrangement in which the method of the present invention is applied;

Figure 2 illustrates in more detail the communications between the components of Figure 1; and,

Figure 3 shows how maximum noise rise can be broken down into its constituent components.

There have been discussions in connection with 3GPP frequency division duplex (FDD) enhanced dedicated channel, or enhanced uplink (E-DCH) relating to
how radio resource management (RRM) for uplink (UL) resources and the
 corresponding scheduling of E-DCH resources in the network can be improved. The
 proposals consider measurements by a radio network controller (RNC).

E-DCH is a packet oriented uplink channel especially suited for high data rates
and bursty transmission. The received power used by user equipments (UEs) in the
uplink is managed by a base station (BS) in order to improve utilization of uplink noise
rise. However since the network is responsible for overall RRM, including legacy
channels, noise rise in the BS receiver needs to be carefully controlled by the network.
Radio resource management is a method whereby the network controls how many UEs
come into a Node B. Noise contributed by each UE is measured, so that the network
can determine if the number of UEs in a cell is at its maximum, or whether it can be
increased, or whether the data rate of existing UEs in the cell can be increased.

Fig. 1 shows a typical arrangement of cells 1, 2, 3 in a network 4 controlled by
an RNC 5. The RNC sends instructions via radio network links 6 to each node B NB1,
NB2, NB3 setting limits of maximum noise rise. Each Node B then subdivides the
available noise rise in a conventional manner and signals to each UE 7, 8, 9 (and 10,
11, 12) the maximum which is available to it.

Fig. 2 illustrates how one UE 12 can have an impact on the noise at more than
one node B NB2, NB3. E-DCH transmissions 13 from the UE are received at both
NB2, its serving node B and a non-serving node NB3. The serving node B can send
absolute grants 14 and relative grants and the non-serving node B sends relative grants
15. The RNC communicates the maximum noise rise to each Node B. Although, UE
12 is not served by NB3, its position is such that it can interfere with UEs served by
NB2, so the RNC needs to be able to control this effect.

Fig. 3 illustrates how different types of noise make up the noise rise at a node B.
For all node Bs there is a certain amount of noise whose source is unknown and which
cannot be compensated for. This unknown noise 16 is the minimum. Added to this is
an amount of noise caused by the receiver itself, e.g. due to the components 17. Noise
produced due to communication can be broken down into noise from other cells 18,
noise 19 from other channels communicating via the node B which are not operating
enhanced uplink; and noise 20 at the node B caused by its served UEs operating E-
DCH. As described in more detail below, the method of the present invention allows a
received total wideband power value to be determined for each of the operating noise
types, 18, 19, 20. An additional variable is that at different ambient temperatures the component noise 17 will vary. It will be least at the daily minimum and usually greatest at the daily maximum. The increase in this noise 17 is indicated by the dotted line 21. The maximum permitted noise rise in the cell is indicted by the level 22. To optimise efficiency, it is desirable to get as close to this level without exceeding it.

In order to effectively manage overall RRM, it is necessary for the RNC to be able to set targets for the BS for the uplink resources that it manages and monitor the usage of these resources (noise rise) by the BS. Currently the only suitable measurement in this area is received total wideband power (RTWP) at the BS receiver. RTWP measures uplink interference and so can be used to determine the overall noise rise if the noise level at the BS is known. RTWP measured at an antenna is analogue and takes into account the receiver behaviour. RTWP is measured in a quiet period with no 3G transmissions, so only hardware or random other noise outside the control of the node B is measured. The measured quiet RTWP is either stored at the Node B or returned to the RNC to give a basic level of noise from which to calculate the E-DCH generated noise.

Examples of determination of the optimum quiet period t0 based on statistical cell traffic analysis are described below. The phase of low traffic activity within one day can be determined by analyzing the cell traffic of an example cell, cell X and other cells close to cell X for a number of days. This can be analysed in the RNC. This analysis provides a time dependent probability for low traffic activity on a cell basis in terms of a time window where the probability for low traffic activity is the lowest for cell X and the surrounding cells. The optimal time t0 within this time window is either when there is no traffic in cell X, by setting a threshold, or at a time when the traffic is predicted to be lowest based on the statistics. The time t0 can be signalled from the RNC to the Node B, alternatively the RNC signals only the time window and the Node B decides t0 within this time window autonomously.

To determine the noise rise share of E-DCH users, a sum of received signal code power (RSCP) of all UEs using E-DCH is determined. RSCP in the Node B is not defined as a measurement in the standard, but such a determination of the code power can be easily done in the digital domain node B, since the signal to interference ratio (SIR) measurement also requires this functionality. Knowledge of corresponding scrambling and spreading codes that are used is required. RSCP is a digital
measurement, from which after decoding channels, the node B knows all transmission
power levels and where they are from. The UE from which these come may or may not
be served by that node B.

In order to compensate errors when referencing such an RSCP value to the
antenna connector, e.g. due to RF gain variations, this is a relative measurement.

\[
\text{E-DCH noise} = \frac{\text{sum of all E-DCH RSCP in cell X}}{\text{total uplink noise}} \quad \text{RTWP in cell X}
\]

(note: this is a linear description, in dB it would be a difference)

Such a measurement reported from a node B to an RNC allows determination of the
share of the sum of all Enhanced UL (EDCH) channels from other cells (for which cell
X is called non-serving cell); and other intra cell interference in cell X (e.g. RACH or
HS-DPCCH in cell X) to the total UL noise. As the sum of all Enhanced UL (EDCH)
channels for which cell X is the serving cell and the sum of all Enhanced UL (EDCH)
channels from other cells (for which cell X is called non-serving cell) are controlled by
cell X in a different way, the former, serving cell is controlled by Absolute Grant (AG)
or Relative Grant (RG) up/hold/down commands, and the latter, non-serving cell is
controlled only by RG down/hold command, then these noise types can also be further
distinguished into:

\[
\text{served E-DCH} = \frac{\text{sum of all EDCH RSCP where cell X is the serving cell}}{\text{total UL noise}} \quad \text{RTWP in cell X}
\]

\[
\text{non-served EDCH} = \frac{\text{sum of all EDCH RSCP where cell X is NOT the serving cell}}{\text{total UL noise}} \quad \text{RTWP in cell X}
\]

This allows an even more detailed control of the UL interference caused by E-DCH and
such information can be used in the node B scheduler as well as in the admission
control by the RNC.

It is also possible to calculate and report to the RNC for a finer admission
control the ratio of:
sum of RSCPs of dedicated channels

   total RTWP in the cell

5 Measurement of RSCP applies more overall accuracy to control the noise rise by taking into account the type of use of each UE.

   In an active cell, an increase in noise occurs when physical receiver characteristics change due to variation in ambient temperature, e.g. at a different time of day. In some places temperatures may vary significantly between night and day, such as from 2°C to 40°C. A further feature of the present invention provides a method of dealing with these temperature induced changes, by measuring the temperature at the node B when the later measurement is made and using a LUT to determine how characteristics change due to temperature, a correction is applied to improve the accuracy of the total noise measurement. This method can be used in conjunction with the RSCP measurements, or separately.

   It is necessary to know how much E-DCH alone contributes to the measured differential, rather than from other cells in the vicinity. Conventionally, it has not been possible to determine an indication of the share of interference or noise rise resulting from E-DCH transmissions compared to that used for other transmissions such as legacy dedicated channel (DCH), forward access channel (FACH) etc., although, for the present invention this can be done using RSCP as described above. A scheduler in the Node B determines the available noise rise for all UEs and allocates a local maximum for each. Transmission at a higher data rate means more noise, so fewer UEs can transmit. The Node B allocates to the UE a maximum data rate that it can use and from this it is possible to determine the noise that this data rate will create at the Node B), so the node B must measure the actual noise correctly to keep within the allocated maximum.

   In a conventional system, the RNC can command that a certain portion of the noise rise (target noise rise) be used by the scheduler for E-DCH noise rise at the BS, or Node B receiver, but the Node B has no means of informing the RNC about the actual status, i.e. the noise rise in the BS receiver caused by E-DCH users which it serves, or E-DCH users in other cells. In this case, the expression “users in other cells” includes users sending their data to a different Node B, but receiving relative grants from the
same Node B. Therefore the RRM control mechanism available to the RNC is at best open loop, which is unlikely to be sufficient in a real network. The node B needs to measure all noise contributions and the RNC signals an upper limit which is the maximum uplink noise permitted. If the node B exceeds this maximum, the performance and throughput will deteriorate and at worst the whole cell will cease to operate. The RNC must tell each Node B the maximum noise rise it can use and send a limit and then the Node B must measure the actual noise rise against this limit and tell the RNC. In all cells there is background noise and the node B needs to know what the background noise is, so it can determine the amount by which it changes in busy times.

An absolute value for this purpose (e.g. absolute interference at the BS receiver) is not suitable, as ECH caused RTWP does not exist as such and such an absolute value would be of no use. An absolute value would not indicate noise rise to the RNC and the value would be determined in the base band and needs to be referenced to the antenna connector, thus containing inaccuracy due to the receiver gain in the receive chain.

Current total RTWP power measurement has an error of +/-4dB absolute accuracy which cannot be significantly improved. An error of 0.5dB in the UL noise rise estimation will cause an E-DCH throughput loss of about 10% and a 3dB error leads to a loss in the order of 50%. Similar figures could be expected for any RRM based on absolute interference measurements, so a better solution is required.

There is also a relative accuracy defined for RTWP: +/-0.5dB. “Relative accuracy” refers to the allowed difference between two measurements of RTWP made at different points in time arising from measurement inaccuracy; however the time between these two RTWP measurements is not explicitly specified in 3GPP release 6.

One way to obtain a noise rise measurement, including a component which takes into account the interference from other cells, with a relative accuracy of 0.5dB, rather than the absolute accuracy of 4dB would be to measure the Node B noise power by means of taking an RTWP measurement at a point in time when the entire network is quiet, i.e. when there are no uplink transmissions in any cell, and then during active E-DCH operation to report measured RTWP relative to the quiet period value.

However, taking an RTWP in 'low cell traffic density hours', to get an estimation of the receiver noise and the other parts of interference which can not directly be influenced, as a reference could be a problem in that temperature drift can
produce fluctuations in receiver noise of 0.5dB, for the example of a temperature
difference between day and night of 20-30°C with remote radio heads. Another
problem is to determine the time of lowest cell traffic activity as this depends of the
deployment, time and other influences.

The node B can only measure the total noise, which includes unknown
background noise, temperature induced noise and noise from legacy channels which are
not operating E-DCH. Conventionally, the RNC controlled how much power each UE
could use, which is quite slow and inefficient because of the need to transmit
information over a long run. Enhanced uplink passes some of the management
function to the node B, thereby reducing signalling delays. However, the node B is not
able to control UEs in adjacent cells which might cause interference although it can
adjust the maximum power that they use by means of the relative grant, so the RNC
still has a role and a need to determine the noise actually generated at each node B to
ensure that one cell does not interfere with another. If the Node B scheduler is not
doing too well, the RNC will tell the node B to reduce its noise. The Node B does not
know what other node Bs are doing so RNC controls to make sure other Node Bs are
not interfered with.

The present invention enables a practical BS measurement that is useful for
RRM, has reasonable accuracy and reflects the proportion of uplink resources used for
E-DCH

RTWP received from cell X can be considered as a sum of:
(a) receiver noise caused by a receiver in Node B for cell X;
(b) inter-cell interference from other cells close to cell X (as long as not covered
below);
(c) the sum of all UL dedicated channels (UL DPCH) of cell X;
(d) the sum of all Enhanced UL (EDCH) channels for which cell X is the
serving cell;
(e) the sum of all Enhanced UL (EDCH) channels from other cells (for which
cell X is called non-serving cell); and
(f) other intra cell interference in cell X (e.g. RACH or HS-DPCCH in cell X)

A measurement RTWP_1 at time instant t1 relative to RTWP_0 at t0 where t1
is the time instant at which the UL noise should be controlled in an active network and
t0 is a phase of low traffic activity in the network, means that it is possible to get an
impression of how the parts c, d, e and f contribute to the UL noise rise (RTWP_1/RTWP_0).

In such a case RTWP_0 could either be stored in the Node B or provided by the RNC via lub signalling, indicating that this is to be used as a basis for the control of the total noise rise. The relative RTWP measurement has the advantage of higher accuracy as systematic errors (e.g. for RF gain variations when referring to the antenna connector) for both RTWP parts cancel each other for the quotient.

Drawbacks of the “quiet period” measurement must be overcome. Considering a reference RTWP_0 which is taken in the low activity hours, during which only (a) and (b) are relevant, the temperature drift of the receiver noise (a) can be improved by having a stored reference for receiver noise, i.e. a table dependent on temperature which may be provided for example in the Node B, in the RNC, or provided by OMC. Such a look up table can be e.g. noise figure as a function of temperature at the receiver and this can be either stored in the Node B or stored in the RNC or provided to Node B or RNC via operation & maintenance (O&M).

Assuming RTWP_0(T0, t0) is measured where T0 is the temperature at the receiver at the time instant t0 and at a later time t1 where the temperature at the receiver is T1 but it is not possible to measure RTWP_0 at t1 as there is already a higher activity in the cell: In this case the receiver noise for T0 could be subtracted from the RTWP_0 value at t0 (based on the table) and a corresponding correction for T1 could be added (also dependent on the table) as soon as T0 and T1 are known.

Although this does not deal with the problem that the inter cell interference (b) at t0 and t1 might not be identical, it improves the temperature drift of the receiver noise (a).

The look up table can be made dependent on further parameters which influence the receiver noise. The more parameters that are included, the more desirable it is to keep the table in the Node B, as otherwise these parameters need to be signalled to the RNC too, removing some of the benefits of operating E-DCH. The optimal time t0 can be determined by statistical analysis of the cell traffic in cell X and the other cells close to cell X, as described above.

Taken alone, such an improved measurement gives a more accurate idea of the noise rise level and in combination with measuring the share of the noise rise occupied by E-DCH users, significantly improves efficiency. The control of UL noise rise is
based on the assumption that the RNC provides a target value and the Node B measures corresponding quantities and the Node B reports them back to the RNC (in a filtered way) and/or uses them for its own scheduler. With the measurement improvements described above, a finer control of the UL noise rise is possible which improves the cell capacity, the interference control and the performance at the cell edge. The overall noise rise report using RTWP is improved by means of a temperature dependent lookup table and an indication of noise rise share is provided using relative RSCP measurements.
CLAIMS

1. A method of controlling noise rise in a cell, the method comprising setting a maximum noise rise for a cell; allocating maximum noise rise for each mobile station within the cell; measuring at a base station the actual noise rise from each mobile station within the cell; and signalling the measured noise rise at the base station to a network; wherein the cell is operating enhanced dedicated channel (E-DCH); and wherein the contribution to noise rise of E-DCH signalling is determined; the method further comprising measuring received signal code power (RSCP) at the base station; decoding the RSCP measurement to determine contributions from mobile stations within and outside the cell; calculating contributions from mobile stations within the cell; and notifying the network of the measured noise rise.

2. A method according to claim 1, wherein the network is notified of the amount of noise at the base station due to E-DCH, due to legacy channels and due to other cells.

3. A method according to claim 1 or claim 2, wherein the method further comprises applying a compensation value to compensate for temperature induced noise.

4. A method according to claim 3, wherein the compensation value is calculated in advance and stored.

5. A method according to claim 4, wherein the store comprises a look up table (LUT).

6. A method according to at least claim 3, wherein the compensation value comprises a factor by which to modify a measurement of received total wideband power (RTWP) taken when no uplink transmissions are taking place.

7. A method according to any preceding claim, wherein the base station is a Node B; the mobile station is user equipment (UE); and the network is a radio network controller (RNC).
8. A method according to any preceding claim, wherein the cell is part of a third generation communication system.

9. A method of controlling noise rise in a cell, the method comprising setting a maximum noise rise for a cell; allocating maximum noise rise for each mobile station within the cell; measuring at a base station the actual noise rise from each mobile station within the cell; and signalling the measured noise rise at the base station to a network; wherein the cell is operating enhanced dedicated channel (E-DCH); and wherein the contribution to noise rise of E-DCH signalling is determined; wherein the method further comprises applying a compensation value to compensate for temperature induced noise.

10. A method according to claim 9, wherein the compensation value is calculated in advance and stored.

11. A method according to claim 10, wherein the store comprises a look up table (LUT).

12. A method according to at least claim 9, wherein the compensation value comprises a factor by which to modify a measurement of received total wideband power (RTWP) taken when no uplink transmissions are taking place.
FIG 3

RTWP

EUL IN MY CELL

NON EUL IN MY CELL

NOISE FROM OTHER CELLS

COMPONENTS ETC

UNKNOWN NOISE
**INTERNATIONAL SEARCH REPORT**

**PCT/GB2006/001478**

### A. CLASSIFICATION OF SUBJECT MATTER

INV. H04B17/00

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

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 practical, search terms used)

EPO-Internal, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search

4 July 2006

Date of mailing of the international search report

17/07/2006

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Authorized officer

Helms, J

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