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(71) Applicant (for all designated States except US): HUAWEI TECHNOLOGIES CO., LTD. [CN/CN]; Huawei Administration Building, Bantian, Longgang, Shenzhen, Guangdong 518129 (CN).

(72) Inventors; and
(75) Inventors/Applicants (for US only): LEGG, Peter [GB/DE]; Riesstr. 25, 80992 Munich (DE); OLOFSSON, Henrik [SE/DE]; Riesstr. 25, 80992 Munich (DE); ZHANG, Hongzhuo [CN/DE]; Riesstr. 25, 80992 Munich (DE).


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(54) Title: METHOD FOR ESTIMATING MOBILITY STATE

(57) Abstract: According to an aspect of the invention, the objects are achieved with a method for estimating mobility state of a mobile node in a cellular wireless communication system, said mobility state being estimated by means of at least one counter (CR, CH) representing a number of cell reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; wherein said at least one counter (CR, CH) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events. Furthermore, the invention also relates to a method in a network node, a computer program, a computer program product, and network node device.

![Diagram](image-url)
METHOD FOR ESTIMATING MOBILITY STATE

Technical Field
The present invention relates to a method for estimating mobility state of mobile nodes in a cellular wireless communication system. Furthermore, the invention also relates to a method in a network node, a computer program, a computer program product, and network node device.

Background of the Invention
A mobile node, such as a User Equipment (UE) in the LTE system, may exist in different mobility states according to how quickly it is moving. The mobility state of the mobile node is a representation of the speed of the mobile node.

The current LTE specifications include UE mobility state estimation based on: past number of cell reselections when the UE is in Idle mode, or past number of handovers when the UE is in Active mode. There are similar rules for cell reselection in UMTS systems.

The mobility state estimation in these types of system is based on the use of cell reselection counters or handover counters depending on the mode of the UE.

In Idle mode the rules in 3GPP TS36.304, "User Equipment (UE) procedures in idle mode" are followed. Besides Normal-mobility state a High-mobility state and a Medium-mobility state are applicable if the parameters [$TcRmax$, $NCR_H$, $NCR_M$ and $TcRmaxHyst$] are sent in the system information broadcast of a serving cell.

The following state detection criterions are applied:

- **Medium-mobility state criteria**, if a number of cell reselections during a time period $TcRmax$ exceeds $NCR_M$ and not exceeds $NCR_H$;

- **High-mobility state criteria**, if a number of cell reselections during a time period $TcRmax$ exceeds $NCR_H$. 
The UE shall not count consecutive reselections between same two cells into mobility state detection criteria if the same cell is reselected just after one other reselection.

Furthermore, the algorithm for state transitions is given so that the UE shall:

- if the criteria for High-mobility state is detected:
  - enter High-mobility state.
- else if the criteria for Medium-mobility state is detected:
  - enter Medium-mobility state.
- else if criteria for either Medium- or High-mobility state is not detected during a time period $T_{c,R_{maxHyst}}$
  - enter Normal-mobility state.

When the UE is in active mode, the same rules apply, except that handovers are counted instead of cell reselections, and the parameters are sent to the UE in a measurement configuration message.

In idle mode, the mobility state estimated/determined by the UE can be used to modify the cell re-selection rules: for medium and high mobility states, the UE may add an offset to the signalled $Q_{hyst}$ (hysteresis margin) and scale the $T_{reselection}$ (cell reselection timer value) by a factor. These scaling factors are parameters signalled by the network and are optional so the speed dependent scaling can also be turned off.

In active mode, the mobility state determined by the UE can be used to modify the Time To Trigger (TTT) parameter used in the triggered measurement procedure. Triggered measurements are used for handover from one cell to another. The UE typically sends a measurement report to the eNB when it detects a neighbour cell that is "offset" dB stronger than the current serving cell for a time interval equal to the TTT. The TTT parameter can be used to adjust the timing of the handover. An example of the use of speed scaling of TTT is to ensure a shorter TTT for faster travelling UEs so that they can begin the handover procedure at an earlier point. This improves the reliability of the handover by ensuring a better link quality to the serving cell.

The current mobility estimation method as used in the existing 3GPP standard performs
poorly in a macro cell deployment (consisting of high power cells (>20W) with diameters of several hundred metres), and very poorly in Heterogeneous Network (HetNet) deployments (consisting of a mixture of macro cells and low power cells (<10 W) of diameters less than 100 metres). Low power cells are often called micro cells or pico cells. In a macro cell (only) deployment the mobility state is sensitive to the path followed by the UE as well as its speed. In a HetNet deployment, there is the additional shortcoming that the cell sizes vary markedly between macro cell and low power nodes. Consequently, the handover frequency for a UE of fixed speed depends strongly on whether it passes through macro cells or low power cells. This makes the mobility state estimation inaccurate.

According to a prior art solution it has been proposed that: the velocity estimation at a UE is possible based on the LI time offset measurement or power measurement. There are also many network-based speed/velocity estimation methods such as Doppler estimation at the eNB. In this solution timing advance (LI time offset) is used for velocity estimation. The problem with using timing advance to estimate speed is that it is sensitive to the path of the UE - if the UE moves at a constant distance from the base station (in the arc of circle) the TA will not change. A similar reservation applies to the power measurement approach. This is also sensitive to radio shadowing.

According to another prior art it is proposed that the UE mobility state estimation can be enhanced by selectively counting cell reselection into UE mobility state estimation. Re-selections that occur between frequency layers would be excluded from the count. This method is only applicable to idle mode mobility.

**Summary of the Invention**

The object of the present invention is to provide a method which mitigates and/or solves the disadvantages of prior art solutions, and more specifically to a method which provides more accurate estimation of mobility state of a mobile.

According to an aspect of the invention, the objects are achieved with a method for estimating mobility state of a mobile node in a cellular wireless communication system, said mobility state being estimated by means of at least one counter \((c_R, c_H)\) representing a number of cell
reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; wherein said at least one counter \((c_R, c_H)\) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events.

According to another aspect of the invention, the objects are achieved with a method in a network node for estimating mobility state of a mobile node in a cellular wireless communication system, said network node being adapted for communication in said cellular wireless communication system and said mobility state being estimated by means of at least one counter \((c_R, c_H)\) representing a number of cell reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; wherein said at least one counter \((c_R, c_H)\) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events.

The invention also relates to a computer program and a computer program product adapted to execute any of the methods according to the invention.

According to yet another aspect of the invention, the objects are achieved with a network node device for estimating mobility state of a mobile node in a cellular wireless communication system; said network node device being adapted for communication in said cellular wireless communication system, and said mobility state being estimated by means of at least one counter \((c_R, c_H)\) representing a number of cell reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; wherein said network node is adapted so that said at least one counter \((c_R, c_H)\) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events.

The present invention provides a more accurate method for mobility state estimation of mobile nodes in idle and/or active mode. It addresses the shortcomings of the prior art, e.g.:
• inaccuracies arising from the path followed by the UE:
  o e.g. in macro cell only network when a mobile node crosses a cell near a base station,
  o e.g. in a dense urban network when rapid handovers occur into small pockets of coverage caused by high shadowing;
• inaccuracies arising from performing handover to small coverage cells.

The invention is also easy to implement in existing wireless communication systems, such as LTE, and has low complexity.

Further applications and advantageous of the invention will be apparent from the following detailed description.

**Brief Description of the Drawings**

The appended drawings are intended to clarify and explain different embodiments of the present invention in which:

- Figure 1 shows two UEs crossing a HetNet network at equal speeds. The upper UE experiences 7 handovers, while the lower UE experiences only two, resulting in different mobility states (fast and normal, respectively) for the two UEs;
- Figure 2 illustrates different cases when handovers are excluded from the mobility state estimation counter;
- Figure 3 illustrates a case when handovers are excluded from the mobility state estimation counter;
- Figure 4 illustrates when timing advance is used for excluding handovers; and
- Figure 5 illustrates RSRP roll-off for macro and micro cells, respectively.

**Detailed Description of the Invention**

As aforementioned, the current 3GPP standards for mobility state estimation has its drawbacks, such as low mobility estimation accuracy. The inventors have realised that the current method does not take into account the path followed by the UE which can result in differing handover counts per second, and thus different mobility states, even when the network is regular with equally sized cells. This is illustrated in figures 2 and 3. The effect in
this example is partly from the path traversed (figure 2, cases (2a), (2b) and (3)) and partly from shadow fading which can give small pockets of coverage leading to short stay "rapid handovers" (figure 3). A rapid handover is a handover from Cell A to B to C in which the stay time in B is very short. A special case of a rapid handover is when \( A = C \), this is called a "ping-pong".

Additionally, the inventors have also realised that the current method does not take the cell size into account and were intended for macro-cell-only scenarios for optimizing mobility for high velocity UEs only. In future HetNet networks there will be cells of differing sizes, macro cells having cell diameters of several 100 m and micro or pico cells with cell diameters of less than 100 m. Consequently, the handover count measure will give a very poor measure of the UE mobility state so that if the UE of fixed speed passes through macro cells it may be determine the state to be "normal" but then when the UE passes through a few pico cells the state may be revised to "medium" or "high". Figure 1 illustrates a case where two UEs with equal speed follow different paths through a HetNet network and experience widely different numbers of handovers. The upper UE passes through a number of pico cells and hands over 7 times, the lower UE only hands over twice.

Figures 2 and 3 illustrate handover scenarios in which the distance travelled by a mobile node between handovers is significantly shorter than for a typical handover in which the mobile node passes across a macro cell. Figure 2 illustrate:

- (1) Handover to/from a small cell (e.g. a pico cell)
- Handovers to/from a macro cell when the path in the macro cell is very short
  - (2a) Cut across the edge of the cell
  - (2b) Cut across the edge of the cell (return to the same cell)
  - (3) Cut around the centre of the cell

Figure 3 illustrate:

- (4) Handover into an isolated pocket of coverage of the cell (isolated pockets of coverage are common in highly shadowed environments such as centres of cities).
For the above reasons, the present invention provides a method for mobility state estimation using counters \( c_R, c_H \), wherein cell reselection events or handover events are excluded based on a distance travelled by a mobile node between two consecutive cell reselection events or two consecutive handover events. Distance travelled in this context means the length of the path traversed by the UE between cell reselections or handovers.

Thereby, existing 3GPP solution may be used, but improved by excluding cell re-elections or handovers from current counting method in certain circumstances. In this way a lower complexity and more accurate method is provided by the invention.

According to an embodiment of the invention, the distance travelled is not measured precisely, but is inferred from signalling information comprising cell size information. For example, the distance travelled could be inferred to be less than or equal to the cell diameter. The cell size information may preferably be broadcasted by each cell in the communication system, and the information may comprise cell size information about its own size and/or the sizes of its neighbouring cells.

The cell size information may indicate whether a cell is a small cell or a large cell. A pico cell is obviously a small cell while a macro cell is a large cell. A small cell may e.g. have a cell diameter less than half of a cell diameter for a large cell according to a further embodiment.

The information may be broadcasted by a base station (eNB) using a bit indicator if the information relates to its own cell size. The information may be sent on the Broadcast Control Channel (BCCH) in existing systems. For example, each cell of each eNB broadcasts in the system information on the BCCH whether it is a small cell or not. The UE reads the BCCH e.g. after a handover to determine if the cell is small or not. Handovers or cell re-selections to small cells are not counted, i.e. excluded in this case because this represents case (1) in Figure 2.

Further, each cell may broadcast, e.g. in the system information, a list of neighbour cells that are small cells. This could be a list of Physical Cell ID (PCI) values. Alternatively, it may be more economical to signal a list of PCI values for neighbour cells that are NOT small.
Handovers or cell re-selections to small cells are not counted when estimating mobility state.

According to another embodiment of the invention, the distance travelled is inferred from radio propagation measurements performed by a mobile node or one or more base stations in the communication system. There are a number of ways of using radio propagation measurements for inferring distance travelled and the following description discloses a few examples within the scope of the invention.

**Using timing advance (active mode only)**

Timing Advance (TA) is a mechanism in LTE to adjust the timing of UE transmissions on the uplink such that the transmissions arrive in the correct time window (sub-frame) at the eNB. As the UE moves further from the eNB, the timing is advanced further to compensate for the increased time of flight of the radio transmission. The TA is calculated at the eNB and signalled regularly to the UE. The TA updating of a UE may be paused when the UE is inactive, to save battery life, in which case the UE loses uplink synchronisation. When there is data to be transferred again the UE regains synchronisation and the correct TA is re-established. When UEs are held in active mode frequent packet transfer may be expected, otherwise the UEs would be moved to idle mode, so it is reasonable to expect many TA updates for a UE as it traverses a macro cell. The TA granularity is 0.52 μs, corresponding to a distance of 78 m (TA is equal to the round trip time from eNB to UE).

It should be noted that TA gives a true measure of the distance (measured in metres) from the UE to the eNB. TA is also used in UMTS, for TDD (TD-CDMA) but not FDD (WCDMA).

According to the invention the UE exploits the TA such that handovers are excluded if:

i. The maximum TA during the time the UE stay in the cell is below a threshold value $T_{TA1}$; and/or

ii. The TA does not vary more than a certain threshold value $T_{TA2}$ during the stay in the cell.

The thresholds may be passed to the UE in the same message that carries the parameters used in the 3GPP prior art for mobility state detection. Namely, in the


RRCConnectionReconfiguration message.

Condition (i) addresses exclusion cases (1) and (3) illustrated in Figure 2. If a cell is small the TA will be very low, and likewise if the UE passes near the centre of the cell.

Condition (ii) addresses all exclusion cases (1) to (4). The variation can be determined by maintaining the minimum TA value and the maximum TA value (as used in condition (i) if this is followed). The additional complexity for the UE is low in this embodiment.

Examples of possible threshold values for this embodiment are:

- $T_{TA}$ is 1.1 $\mu$s - this implies UE must move at least 156 m from the centre of the cell.
- $T_{TA2}$ is 0.52 $\mu$s - this implies that UE distance from the centre of the cell must vary by at least 78 m.

Figure 4 illustrates how TA can be used, with $T_{TA} = \forall A \ \mu$s and $T_{TA2} = 0.52 \ \mu$s. Three cells A, B and C that the UE passes through are shown. An additional cell D is not involved in the handovers. TA values in cell B are shown with concentric circles, in steps of the TA granularity of 0.52 $\mu$s. thus 1x0.52 $\mu$s, 2x0.52 $\mu$s, 3x0.52 $\mu$s. The figure also shows the handover count after each handover, as an underlined number. This is calculated according to the rules detailed below. The count is incremented to 1 after the first handover, A to B. The next handover, back to A, is recognised to fall into type (2a) because although the maximum value of TA > $T_{TA}$ the variation in TA in cell B is below the threshold $T_{TA2}$ (= 1 unit of TA), and the count is restored to the original value of zero. The UE then returns soon to B, again without incurring a TA variation as large as the threshold $T_{TA2}$. This is also a (2a) event and the count is restored to value 1. When the UE passes to cell C the TA variation threshold has been exceeded and the maximum value of TA > $T_{TA}$, this is a regular handover and the count is incremented to 2. It should be noted that the use of TA is only applicable when the UE is in active mode.

**Path loss (measured given Reference Symbol transmit power sent on BCCH)**

The path loss to the UE varies markedly with distance from the eNB. It can be calculated by the UE by taking the reference symbol transmit power broadcasted by the eNB and
subtracting the measured Reference Symbol Received Power (RSRP). Example: reference symbol transmit power is 20 dBm (in a 15kHz bandwidth) and RSRP is -80 dBm, which gives a path loss of 100 dB. This enables the UE to apply similar criteria to those when using TA for mobility state estimation.

Handovers are excluded from counting if:

i. The maximum measured path loss during the time the UE stay in a cell is below a threshold value $T_{\text{path}}$; and/or

ii. The measured path loss does not vary more than a certain threshold value $T_{\text{pa,h}}$ during the stay in the cell.

Path loss measurements are very sensitive to factors influencing the radio propagation, such as shadowing, line of sight paths, etc. Thus, this approach is less reliable than the TA method, but may be useful when the TA method is short of information, e.g. for very fast travelling UEs with short stay times giving insufficient TA updates to the UE.

In active mode, the thresholds may be passed in a \textit{RRConnectionReconfiguration} message to the UE, and in idle mode they can be included in system information, \textit{SystemInformationBlockType3}.

**Transmit power of mobile node (active mode only)**

In LTE, the uplink transmit power (per resource block) has two components. Power per resource block = basic open-loop operating point + dynamic offset. The former has two components:

- A semi-static base level, $P_0$; and
- An open-loop path loss compensation component.

The latter (open-loop part) uses the estimate of the downlink path loss of a UE, as described above, such that the UE transmit power is increased as the path loss increases. Thus, the UE transmit power may also be used in a similar way, but this is likely to be less reliable since the power also depends on other factors and the path loss compensation may not be switched on.
Handovers are excluded from counting if:

i. The maximum UE transmit power during the time the UE stay in the cell is below a threshold value $T_{TxPower1}$, and/or

ii. The UE transmit power does not vary more than a certain threshold value $T_{TxPower2}$ during the stay in the cell.

The thresholds may be passed to UEs in the same message that carries the parameters used in the 3GPP prior art for mobility state detection. Namely, in the \textit{RRCConnectionReconfiguration} message.

\textbf{Rate of change of reference symbol received power}

This embodiment exploits the expectation that the signal strength (RSRP) difference between target and serving cells for a macro-to-pico or pico-to-macro handover changes more rapidly with distance than for a macro-to-macro cell handover. The UE can easily measure the rate of change of ARSRP with respect to time. Thus, handovers or cell re-selections to or from pico cells may be excluded from the mobility estimation counter.

Handovers or cell re-selections are excluded from counting if:

- The rate of change of reference symbol received power (RSRP) of a serving cell or a target cell is greater than a threshold value $T_{RSRP}$.

In the figure 5, the RSRP measured by a UE at different locations between two macro cells is illustrated. Additionally, the RSRP from a single pico cell is shown. Notice the rapid drop off in RSRP of the pico cell at the point where a handover would take place from the macro cell - this is approximately the point at which the RSRP is equal for the two cells. In contrast a macro to macro handover is typified by RSRP values that vary slowly with distance. Alternatively, just the rate of change of the target RSRP when handing in or source RSRP when handing out could be used to identify a small cell.

In active mode, the rate of change of ARSRP thresholds may be passed to the UE in the same message that carries the parameters used in the 3GPP prior art for mobility state detection. Namely, in the \textit{RRCConnectionReconfiguration} message. In idle mode, the thresholds can be
included in system information, SystemInformationBlockType3.

This embodiment is sensitive to UE speed - a very high rate of change would be observed for a macro-to-macro handover if the UE speed is very high. It is also sensitive to shadowing.

Hence, the invention can be implemented by taking e.g. the existing 3GPP method, that uses a counter of the number of cell reselections or number of handovers divided by the time interval, and specifies conditions under which a handover (or cell reselection) shall be excluded from the count. This gives a tighter distribution in the path length within the cell, giving a better accuracy in the mobility state estimation.

How many handovers (or cell re-selections) to exclude from the count? There are many different possible rules, and the following describes one such rule. In cases (1), (2b) and (4) the UE returns to the original cell after passing a short distance in another cell (small cell or isolated pocket of a second cell). In these cases the handover count is restored to the value it was originally (i.e. two previous handovers previously). In cases (2a) and (3) the UE passes a short distance in a cell (say B) in transit between two other cells (A and C) - here we do not count the exit handover.

Combination of multiple indications of whether a handover (or cell re-selection) should be included or not: different approaches may be combined using logical AND or logical OR. Alternatively, fuzzy truth values could be estimated for each criterion. Truth values represent a probability that a state is true. For example, the truth to exclude a handover according to TA could be 0.7, and the truth according to UE path loss could be 0.4. A fuzzy AND operation can be used which takes the minimum of the two to give 0.4, and this is compared to a threshold of say 0.55 (so it is decided not to exclude the handover). If a UE is configured with radio propagation measurement based threshold, and at the same time it is signalled explicitly which cells are small using signalling information, then when the UE hands into and out of a small cell (according to the explicit signalling) then this handover is not counted, irrespective of the recommendation from the other radio propagation measurement based method.

There could be additional ways of identifying that a cell is small beyond those discussed above:
• UE could compare cell reference symbol transmit power to a threshold - smaller cells have lower transmit powers,

• If the time of stay is short and the UE knows that its velocity is low (e.g. through Doppler measurement), then the cell is probably small.

Moreover, the present invention also relates to a method in a network node and to a network node device. The method in a network node and device thereof relates to the above described method and its embodiments in a cellular communication system, which means that mentioned method and device may be modified within the scope of the invention.

Furthermore, as understood by the person skilled in the art, any method according to the present invention may also be implemented in a computer program, having code means, which when run in a computer causes the computer to execute the steps of the method. The computer program is included in a computer readable medium of a computer program product. The computer readable medium may consist of essentially any memory, such as a ROM (Read-Only Memory), a PROM (Programmable Read-Only Memory), an EPROM (Erasable PROM), a Flash memory, an EEPROM (Electrically Erasable PROM), or a hard disk drive.

Finally, it should be understood that the present invention is not limited to the embodiments described above, but also relates to and incorporates all embodiments within the scope of the appended independent claims.
CLAIMS

1. Method for estimating mobility state of a mobile node in a cellular wireless communication system, said mobility state being estimated by means of at least one counter \((c_R, c_H)\) representing a number of cell reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; said method being \textit{characterised in that} said at least one counter \((c_R, c_H)\) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events.

2. Method according to claim 1, wherein said distance travelled is inferred from signalling information comprising cell size information.

3. Method according to claim 2, wherein each cell in said cellular wireless communication system broadcasts cell size information about its own size and/or the sizes of its neighbouring cells.

4. Method according to claim 3, wherein said cell size information specifies whether a cell is a small cell or a large cell, and cell reselection events or handover events to small cells are excluded.

5. Method according to claim 4, wherein a small cell has a cell diameter less than half of a cell diameter for a large cell.

6. Method according to any of the proceeding claims, wherein said distance travelled is inferred from radio propagation measurements performed by said mobile node or one or more base stations in said cellular wireless communication system.

7. Method according to claim 6, wherein timing advance (TA) is used for inferring/deriving said distance travelled so that handover events are excluded if:
- a maximum timing advance (TA) value for said mobile node in a cell is less than a threshold value $T_{TA1}$, and/or
- a variation of a timing advance (TA) value for said mobile node in said cell is less than a threshold value $T_{TA2}$.

8. Method according to claim 7, wherein said variation of timing advance (TA) is determined by using said maximum timing advance (TA) value and a minimum timing advance (TA) value.

9. Method according to claim 6, wherein path loss between said mobile node and a base station is used for inferring said distance travelled so that cell reselection events or handover events are excluded if:
- a maximum measured path loss value for said mobile node in a cell is less than a threshold value $T_{Path1}$, and/or
- a variation of a measured path loss value for said mobile node in a cell is less than a threshold value $T_{Path2}$.

10. Method according to claim 9, wherein path loss is measured by subtracting reference symbol received power (RSRP) from reference symbol transmit power.

11. Method according to claim 6, wherein transmit power of said mobile node is used for inferring said distance travelled so that handover events are excluded if:
- a maximum transmit power value for said mobile node in a cell is less than a threshold value $T_{TxPower1}$, and/or
- a variation of a transmit power value for said mobile node in a cell is less than a threshold value $T_{TxPower2}$.

12. Method according to claim 6, wherein rate of change of reference symbol received power (RSRP) is used for inferring said distance travelled so that cell reselection events and handover events are excluded if:
- a rate of change of reference symbol received power (RSRP) of a serving cell or a target cell is greater than a threshold value $T_{\text{RSRP}}$.

13. Method according to claim 12, wherein said rate of change of reference symbol received power (RSRP) is a rate of change of a difference in reference symbol received power (RSRP) between a serving cell and a target cell.

14. Method according to any of claims 7-13, wherein mobility state estimation is performed at said mobile node, and said threshold values are transmitted to said mobile node in a downlink message.

15. Method according to claim 14, wherein said threshold values are transmitted in a RRCConnectionReconfiguration message.

16. Method according to claim 1, wherein said at least one counter ($c_R$, $c_H$) is used as an input parameter in a mobility algorithm and/or for modifying mobility parameters, such as time to trigger (TTT).

17. Method according to claim 1, wherein said cellular wireless communication system is a UMTS, LTE or a LTE Advanced communication system.

18. Method in a network node for estimating mobility state of a mobile node in a cellular wireless communication system, said network node being adapted for communication in said cellular wireless communication system and said mobility state being estimated by means of at least one counter ($c_R$, $c_H$) representing a number of cell reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; said method being characterised in that said at least one counter ($c_R$, $c_H$) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events.
19. Method according to claim 18, wherein said network node is a mobile node, such as a user equipment (UE), or a base station, such as an eNB.

20. Computer program, **characterised in** code means, which when run in a computer causes said computer to execute said method according to any of claims 1-19.

21. Computer program product comprising a computer readable medium and a computer program according to claim 20, wherein said computer program is included in the computer readable medium.

22. Network node device for estimating mobility state of a mobile node in a cellular wireless communication system; said network node device being adapted for communication in said cellular wireless communication system, and said mobility state being estimated by means of at least one counter \((c_R, c_H)\) representing a number of cell reselection events for a mobile node when said mobile node is in idle mode, and/or a number of handover events for said mobile node when said mobile node is in active mode; **characterised in that** being adapted so that said at least one counter \((c_R, c_H)\) excludes cell reselection events or handover events based on a distance travelled by said mobile node between two consecutive cell reselection events or two consecutive handover events.

23. Network node device according to claim 22, wherein said network node is a mobile node, such as a user equipment (UE), or a base station, such as an eNB.
(4) HO in (and then out) of small pocket of coverage of cell 2

Fig. 3

Fig. 4
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet

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: H04W, H04Q, H04B, H04L

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,CNTXT,CNABS, WOTXT, CNKLG00GLE: UE, mobility, state, estimation, estimat+, detect+, evaluat+, estimate, estimating, evaluation

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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Further documents are listed in the continuation of Box C. See patent family annex.

* "A" document defining the general state of the art which is not considered to be of particular relevance
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* "&" document member of the same patent family

Date of the actual completion of the international search 19 Apr. 2012 (19.04.2012)

Date of mailing of the international search report 24 May 2012 (24.05.2012)

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 WU, Xinghua
Telephone No. (86-10)62411371

Form PCT/ISA/210 (second sheet) (July 2009)
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CLASSIFICATION OF SUBJECT MATTER

H04W 64/00 (2009.01) i

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