**Title:** LOAD ESTIMATION IN A USER EQUIPMENT

![Diagram of UE](https://example.com/diagram.png)

- Measure RSRP for all base stations the UE detects \(\sim 201\)
- Measure CINR \(\sim 202\)
- Determine a geometry measure \(G\) \(\sim 203\)
- Estimate the CINR at full load by using the geometry measure, \(G\) \(\sim 204\)
- Estimate the relative load by dividing CINR with \(G\) \(\sim 205\)
- Report the estimated relative load to the network \(\sim 206\)
- Map the relative load to a certain number of users in the cell \(\sim 207\)

**Abstract:** The embodiments of the present invention relates to a method and UE for estimating a relative interference load in an LTE network. This is accomplished by comparing a load measure based on a RSRP-based geometry measure and UE-measured CINR. Constructing a measure by calculating the corresponding quotient provides an estimation of the relative load in the network, more specifically the load in neighboring cells.
Published:
— with international search report (Art. 21(3))
Load estimation in a User Equipment

Technical Field

The embodiments of the present invention relate to a method and user equipment (UE) in a cellular communication network for estimating a relative load.

Background

In cellular communication networks such as Long Term Evolution (LTE) networks, it is desired to be able to estimate a relative load in the radio network from the user equipment (UE) without having access to network information. The relative load implies how much of the available radio resources which is occupied by traffic, regarding interference. Such load estimations may be used for input to algorithms, feedback to the network, creating possibilities for load based radio resource management algorithms and for throughput prediction.

There is currently no known method to estimate load in neighboring cells applicable for LTE. Further, there is no standardized method or measure available in the system that reflects what relative load the interference load situation corresponds to.

Summary

The embodiments of the present invention utilize the measurements available in an LTE UE to establish an estimation of the relative system load (interference load).

This is accomplished by comparing a load measure based on a RSRP-based geometry measure and UE-measured CINR. Constructing a measure by calculating the corresponding quotient provides an estimation of the relative load in the network, more specifically the load in neighboring cells.
According to a first aspect of embodiments of the present invention a method in a UE for estimating a relative load in a network is provided. The network comprises a plurality of base stations and one of the base station is a serving base station to the UE. In the method, RSRP is measured for all base stations the UE detects and a CINR is measured. A geometry measure (G) is determined wherein G is equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects. The CINR at full load is estimated by using the G and the relative load is estimated by dividing CINR with G.

According to a second aspect of embodiments of the present invention, a UE for estimating a relative load in a network is provided. The network comprises a plurality of base stations and one of the base station is a serving base station to the UE. The UE comprises a detector configured to measure RSRP for all base stations the UE detects, and to measure a CINR. Further a processor is provided which is configured to determine a geometry measure, G, wherein G is equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects. The processor is further configured to estimate the CINR at full load by using the geometry measure, G, and to estimate the relative load by dividing CINR with G.

An advantage with embodiments of the present invention is that the embodiments utilize the fact that an existing LTE UE measures and monitors RSRP for all detected neighbors and CINR for the serving cell. By using the RSRP, the UE has the possibility to create a good estimate of the geometry G, which estimates the CINR at full load.

Brief description of the drawings

Figure 1 illustrates a cellular network wherein the embodiments of the present invention may be implemented.
Figure 2 is a flowchart of a method according to an embodiment of the present invention.

Figure 3 illustrates schematically a user equipment according to an embodiment of the present invention.

Detailed description

Figure 1 illustrates a cellular network wherein the embodiments of the present invention may be implemented. Figure 1 shows two base stations 110,112, also referred to as eNB in LTE networks, wherein a UE 108 is connected to one of the base stations 110 which is the serving base station. Surrounding base stations 112 cause interference to the UE 108 as communication between the serving base station 110 and other UEs in the same cell 116 occurs. Accordingly, the UE 108 transmits/receives traffic to/from the serving base station 110 on traffic channels and at the same time is exposed to interference. As mentioned above, it is desired to be able to measure the load, wherein the load implies how much of the radio resources which is occupied by traffic.

In LTE, Reference Symbol Carrier to Interference and Noise Ratio (RS CINR) is measured by the UE, and provides an estimation of the carrier to interference and noise ratio (CINR) on the traffic channels provided that reference symbols are not synchronized thus not colliding synchronously at all times.

Further, the UE measures Reference Symbol Received Power (RSRP) for all neighboring cells it detects. This is for example used for handover purpose so that the UE can report which cell that it hears best.

The measured RSRP can be used to assemble a geometry measure. The geometry measure is according to one embodiment built by calculating the quotient of RSRP from own serving cell divided by the sum of RSRP for all other neighboring cells as shown below:
\[
G = \frac{\text{RSRP}_{\text{own cell}}}{\sum \text{RSRP}_{\text{other cells}}}
\]

According to a further embodiment, the geometry measure built by calculating the quotient of RSRP from own serving cell divided by the sum of RSRP for all other neighboring cells plus additional noise as shown below:

\[
G = \frac{\text{RSRP}_{\text{own cell}}}{\sum \text{RSRP}_{\text{other cells}} + \text{noise}}
\]

The solution of embodiments of the present invention utilizes the fact that the geometry factor is a good estimation of CINR in a full-load situation. Full-load situation implies that all radio resources in all cells are occupied by traffic.

As \( G \) is a good estimate of the CINR at full load, \( G \) can therefore be combined with current CINR to estimate the current relative load. I.e., the relative load is \( G / \text{CINR} \) since this \( G \) indicates the carrier to interference ratio at full load and the current CINR indicates the load until the network is full. Accordingly, relative load implies that the load is determined relative the full load, and full load is the load when there is no more room for additional traffic in the radio network. The relative load is typically measured in percentage. According to embodiments, the load is determined as a straight linear quotient of \( G \) and the CINR, as shown below:

\[
\text{Load} = \frac{G}{\text{CINR}}
\]

For example, \( G = \text{"-70 dBm"} / \text{"-73 dB"} = -70 \text{ dBm} - (-73 \text{ dBm}) = 3 \text{ dB} \) which is equal to \( G=100\text{mW}/50\text{mW}=2. \) CINR is measured to 9 dB which is equal to 8. \( L=G/\text{CINR}=2/8=0,25=25\% \). If the surrounding interference increases, CINR decreases. Given same geometry factor, a 4 dB CINR corresponds to 80 % interference load, which is the sum of all interference that the UE is subject to.
Turning now to **figure 2** showing that a method in a UE is provided, wherein the UE measures 201,202 the RSRP and the CINR. The UE determines 203 a geometry measure (G) wherein G is equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects and divides the determined G with the CINR. According to a further embodiment the UE determines 203 a geometry measure (G) wherein G is equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects plus additional noise as in the formula below:

\[
G = \frac{\text{RSRP}_{\text{own cell}}}{\sum \text{RSRP}_{\text{other cells}} + \text{noise}}
\]

The CINR at full load is estimated 204 by using the geometry measure, i.e. CINR at full load is estimated to be G. The relative load is then estimated 205 by dividing CINR with G. The estimated relative load may then be reported 206 to the network.

Thus, in this way an estimate of the relative network load is obtained.

As illustrated in **figure 3** a UE 300 according to an embodiment is schematically illustrated. The UE comprises a transceiver 330 for wireless communication with base stations and a detector 310 configured to measure RSRP and CINR. The UE further comprises a processor 320 configured to determine a geometry measure (G). G is according to one embodiment equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects or according to a further embodiment equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects plus additional noise. The processor 320 is further configured to estimate the CINR at full load by using the geometry measure (G) and to estimate the relative load by dividing CINR with G.

The transceiver 330 is also configured to report the estimated relative load to the network according to an embodiment.
The UE may also comprise a lookup table 340 which maps the relative load to a certain number of users in the cell of the serving cell. The lookup table may also be located in the network. To be able to make the estimation for the lookup table, knowledge of the services used and mix between services are necessary.

The functionalities of the UE can be implemented by the processor 320 associated with a memory 340 storing software code portions as illustrated in Figure 3. The processor runs the software code portions to achieve the functionalities of the UE according to embodiments of the present invention.

The relative network load may be translated into absolute load figures throughout model training. Further development of the translation through reference system simulations and empirical testing may be performed.

In a further embodiment, the estimated load may be reported to the network.

For example by using a field standardized for this purpose or possibly using already existing reporting fields.

The network may use the load estimate when taking handover decisions; e.g. applying larger margins when the load is high and smaller margins when the load is low. The UE can also use these load estimations for field testing purposes, to be able to continuously get a figure for the interference load in the network.

The estimated load may also be useful as input to algorithms, to create possibilities for load based algorithms and be used for throughput prediction.

Moreover, the estimated load may be used as input to a throughput (performance) prediction algorithm that could operate without accessing the network. For example, to make a representative signal quality to bitrate lookup, the used signal quality measure must contain information reflecting the interference from neighboring cells.

According to one embodiment, the relative load is mapped to a certain number of users in the cell of the serving cell. Hence, a lookup table may be provided
which maps the estimated load to a certain number of users in the serving cell. However knowledge of traffic pattern and the mixture of services are necessary to be able to do this lookup.

Thus the proposed solution provides a method to estimate the network load taking interference from neighboring cells into account. In accordance with a further alternative, by using information of interference from other cells derived from the L expression, the signal quality to throughput lookup can be estimated.
CLAIMS

1. A method in a user equipment, UE, for estimating a relative load in a network, wherein the network comprises a plurality of base stations and one of the base station is a serving base station to the UE, the method comprises:
   - measuring (201) Reference Symbol Received Power, RSRP, for all base stations the UE detects,
   - measuring (202) a carrier to interference and noise ratio, CINR,
   - determining (203) a geometry measure, G, wherein G is equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects,
   - estimating (204) the CINR at full load by using the geometry measure, G, and
   - estimating (205) the relative load by dividing CINR with G.

2. The method according to claim 1, wherein the geometry measure, G, is determined as equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects plus additional noise.

3. The method according to any of claims 1-2, comprising the further step of:
   - reporting (206) the estimated relative load to the network.

4. The method according to any of claims 1-3, comprising the further steps of:
   - mapping the relative load to a certain number of users in the cell of the serving cell.

5. A user equipment, UE, (300) for estimating a relative load in a network, wherein the network comprises a plurality of base stations and one of the base station is a serving base station to the UE, the UE comprises a detector (310) configured to measure Reference Symbol Received Power, RSRP, for all base stations the UE detects, and to measure a carrier to interference and noise ratio, CINR, and processor (320) configured to determine a geometry
measure, $G$, wherein $G$ is equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects, to estimate the CINR at full load by using the geometry measure, $G$, and to estimate the relative load by dividing CINR with $G$.

6. The UE according to claim 5, wherein the processor (320) is configured to determine $G$ as equal to RSRP for the serving cell divided by a sum of RSRP for remaining base stations that the UE detects plus additional noise.

7. The UE according to any of claims 5-6, further comprising a transceiver (330) configured to report the estimated relative load to the network.

8. The UE according to any of claims 5-7, further comprising a lookup table (340) mapping the relative load to a certain number of users in the cell of the serving cell.
Measure RSRP for all base stations the UE detects

Measure CNR

Determine a geometry measure, G

Estimate the CNR at full load by using the geometry measure, G

Estimate the relative load by dividing CNR with G

Report the estimated relative load to the network

Map the relative load to a certain number of users in the cell of the serving cell
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see 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

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>WO 2008088257 A1 (ERICSSON TELEFON AB L M ET AL), 24 July 2008 (2008-07-24); abstract; page 10, line 28 - page 11, line 16; claim 1</td>
<td>1-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>WO 2007021159 A2 (SAMSUNG ELECTRONICS CO LTD ET AL), 22 February 2007 (2007-02-22); abstract; page 8, line 2 - page 8, line 15; claims 1-4</td>
<td>1-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>US 20080240217 A1 (LEE YU-RO ET AL), 2 October 2008 (2008-10-02); abstract; paragraphs [0036]-[0037]; claim 1</td>
<td>1-8</td>
</tr>
</tbody>
</table>

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
  "Q" document member of the same patent family

Date of the actual completion of the international search
23-11-2011

Date of mailing of the international search report
24-11-2011

Name and mailing address of the ISA/SE
Patent- och registreringssverket
Box 5055
S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 88

Authorized officer
Sebastian Diskay
Telephone No. + 46 8 762 25 00

Form PCT/ISA/210 (second sheet) (July 2009)
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3GPP TSG-RAN WG1 #57bis, R1-092833, &quot;Discussions on CoMP Cooperating Set&quot;, Los Angeles, USA, 29 June - 3 July, 2009; Section 2.2</td>
<td>1-8</td>
</tr>
</tbody>
</table>
doi: 10.1109/ICC.2002.997407  
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=997407&isnumber=21518; abstract; Section I | 1-8                  |

Form PCT/ISA/210 (continuation of second sheet) (July 2009)
Continuation of: second sheet

International Patent Classification (IPC)

H04W 72/04 (2009.01)
H04W 52/40 (2009.01)
H04W 72/08 (2009.01)

Download your patent documents at www.prv.se

The cited patent documents can be downloaded:

- From “Cited documents” found under our online services at www.prv.se (English version)
- From “Anförda dokument” found under “e-tjänster” at www.prv.se (Swedish version)

Use the application number as username. The password is KDHXTVDVIB.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.
<table>
<thead>
<tr>
<th>Country</th>
<th>Application Number</th>
<th>Priority Date</th>
<th>Filing Date</th>
<th>Application Number</th>
<th>Priority Date</th>
<th>Filing Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>WO</td>
<td>2008088257 A1</td>
<td>24/07/2008</td>
<td></td>
<td>CN 101617244 A</td>
<td>30/12/2009</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>US 8045527 B2</td>
<td>25/10/2011</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>US 20100135170 A1</td>
<td>03/06/2010</td>
<td></td>
</tr>
<tr>
<td>WO</td>
<td>2007021159 A2</td>
<td>22/02/2007</td>
<td></td>
<td>NONE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Form PCT/ISA/210 (patent family annex) (July 2009)