[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR GROUP PAGING IN WIRELESS COMMUNICATION
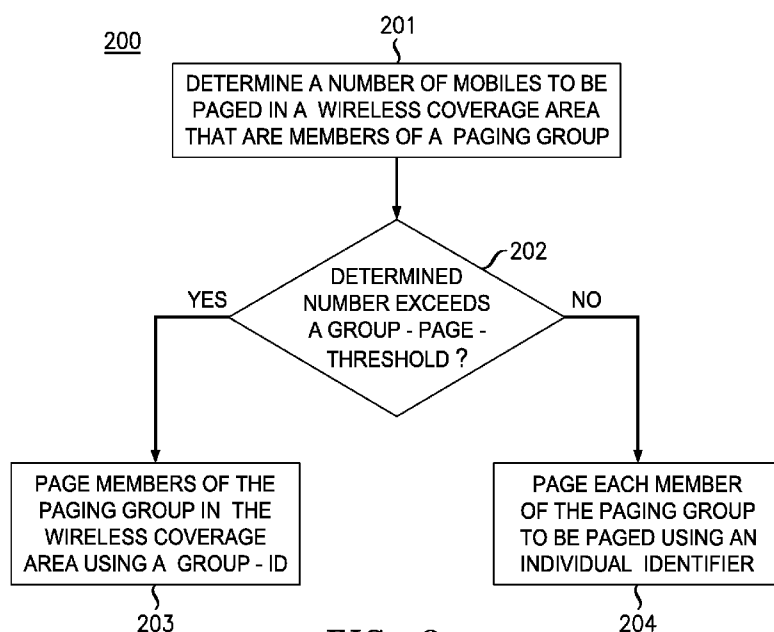


FIG. 2

(57) Abstract: Various methods and de-
vices are provided to address the need to
reduce paging latency. In one method, a
wireless network determines (201) a
number of mobiles to be paged in a
wireless coverage area that are members
of a paging group. If (202) the deter-
mined number of mobiles to be paged
exceeds a group-page- threshold, then
the wireless network pages (203) mem-
bers of the paging group in the wireless
coverage area using a group-id.

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# METHOD AND APPARATUS FOR GROUP PAGING IN WIRELESS COMMUNICATION

## Reference(s) to Related Application(s)

The present application claims priority from a provisional application, Serial No. 61/388319, entitled "METHOD FOR IMPROVED MOBILE PAGING IN WIRELESS COMMUNICATION," filed September 30, 2010, which is commonly owned and incorporated herein by reference in its entirety.

## Field of the Invention

The present invention relates generally to communications and, in particular, to paging in wireless communication systems.

## Background of the Invention

This section introduces aspects that may help facilitate a better understanding of the inventions. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is prior art or what is not prior art.

In cellular networks (such as 3G networks, UMTS networks, LTE networks, or network variants thereof), a mobile is in one of three states: active, inactive/detached, or sleep/idle. In active mode, the mobile has a bearer channel that it uses to send/receive data to/from the base station (BS). In inactive mode, the mobile does not have a bearer channel, but it is listening to the downlink control channel and is able to participate in the uplink control channel when needed. In sleep mode, the mobile is only listening the paging channel. When there is data to be sent to the mobile, the Mobility Management Element (MME) tries to contact the mobile over the paging channel, by broadcasting the mobile's identifier (EMSI/IMEI). In response, the mobile wakes up, acknowledges the wakeup call to the MME, and then attempts to receive the data from the BS.

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In high-load situations, where the MME is suddenly faced with an onslaught of data for multiple mobiles, it has to wakeup all of these mobiles as soon as possible. In a typical network with $N$ mobiles, the system is designed to handle $M$ simultaneous users, where $M$ is approximately $N/10$. In overload situations, sometimes the BS is faced with a high number of users, for example, $M > N/4$. In such situations, most of the mobiles are in sleep mode, and the MME has to activate all of these mobiles in order to deliver their messages. The time taken to do this in sequential fashion (as is done presently) can be on the order of seconds, and this performance degrades heavily under load. Thus, new solutions and techniques that are able to reduce paging latency, at least in certain situations, would meet a need and advance wireless communications generally.


Brief Description of the Drawings


FIG. 1 is a messaging flow diagram depicting the paging of a mobile.


FIG. 2 is a logic flow diagram of functionality performed by a wireless network in accordance with various embodiments of the present invention.


Specific embodiments of the present invention are disclosed below with reference to FIGs. 1 and 2. Both the description and the illustrations have been drafted with the intent to enhance understanding. For example, the dimensions of some of the figure elements may be exaggerated relative to other elements, and well-known elements that are beneficial or even necessary to a commercially successful implementation may not be depicted so that a less obstructed and a more clear presentation of embodiments may be achieved. In addition, although the logic flow diagrams above are described and shown with reference to specific steps performed in a specific order, some of these steps may be omitted or some of these steps may be combined, sub-divided, or reordered without departing from the scope of the claims. Thus, unless specifically indicated, the order and grouping of steps is not a limitation of other embodiments that may lie within the scope of the claims.

Simplicity and clarity in both illustration and description are sought to effectively enable a person of skill in the art to make, use, and best practice the

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present invention in view of what is already known in the art. One of skill in the art will appreciate that various modifications and changes may be made to the specific embodiments described below without departing from the spirit and scope of the present invention. Thus, the specification and drawings are to be regarded as illustrative and exemplary rather than restrictive or all-encompassing, and all such modifications to the specific embodiments described below are intended to be included within the scope of the present invention.


## Summary of the Invention

Various methods and devices are provided to address the need to reduce paging latency. In one method, a wireless network determines a number of mobiles to be paged in a wireless coverage area that are members of a paging group. If the determined number of mobiles to be paged exceeds a group-page-threshold, then the wireless network pages members of the paging group in the wireless coverage area using a group-id. An article of manufacture is also provided, the article comprising a processor-readable storage medium storing one or more software programs which when executed by one or more processors performs the steps of this method.

Many embodiments are provided in which the method above is modified. For example, in many embodiments if the determined number of mobiles to be paged does not exceed the group-page-threshold, then the wireless network pages each member of the paging group to be paged using an individual identifier. Depending on the embodiment, the group-page-threshold may serve as a threshold for many paging groups or simply as a threshold for a particular paging group. Thus, each paging group may have its own associated group-page-threshold.

In many embodiments, the wireless network selects mobiles to be members of the paging group. To do this, the wireless network may identify mobiles that have similar location characteristics over time. For example, it may identify mobiles that stay in the same wireless coverage area (e.g., a cell, a sector, or a plurality of either or both), that move between the same wireless coverage areas, or that move in to or out of the same wireless coverage area on a similar schedule. In many embodiments, the wireless network may indicate to members of the paging group the group-id associated with the paging group. For example, the wireless network may indicate the

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group-id after selecting mobiles to be members of a paging group or after adding new members to the group.

A wireless network equipment apparatus is also provided. The wireless network equipment being configured to communicate with other devices in the system and being operative to determine a number of mobiles to be paged in a wireless coverage area that are members of a paging group and to page members of the paging group in the wireless coverage area using a group-id, if the determined number of mobiles to be paged exceeds a group-page-threshold. Many embodiments are provided in which this wireless network equipment is modified. Examples of such embodiments can be found described above with respect to the method.

Various wireless network equipment architectures may be used to implement this paging technique. For example, it may be performed by a single device, or multiple devices, such as a mobility management element and one or more base stations, the devices acting either individually or in a distributed manner.

Detailed Description of Embodiments

To provide a greater degree of detail in making and using various aspects of the present invention, a description of our approach to reducing paging latency and a description of certain, quite specific, embodiments follows for the sake of example. FIG. 1 is referenced in an attempt to illustrate some examples of specific problems that specific embodiments of the present invention may address.

In cellular networks, there are typically multiple BSs under the control of a single MME. When packets (e.g., data and/or voice) arrive for multiple sleeping users simultaneously, the MME issues a page request for each mobile in sleep mode. Each page is associated with a geographical "area of interest" where the mobile is likely to be found. The MME informs all BSs in the area of interest to page the mobile. If the mobile is not found in a given round of pages, the area of interest is modified to another region not covered in the original page for that mobile. In each paging round, each BS broadcasts a list of mobiles in sleep mode that it is looking for.

Messaging flow diagram 100 of Fig. 1 depicts such an approach to paging. In this approach, the page for a single mobile is sent over a large area, near where the mobile was last seen. If the mobile does not answer, the page is sent over the entire

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area of the RNC/MME, in order to reach the mobile. When the BS sends the page to the mobile, the mobile answers back by participating in a random access channel (RACH), and sends an acknowledgement back to the MME. In addition, the mobile starts listening to the CDCCH / CUCCH channels, which are control channels that provide channel information for downlink and uplink data traffic respectively. The MME, upon receipt of this acknowledgement, will assign appropriate data channels to the mobile and send this information to the mobile via the CDCCH channel. Data transfer now proceeds using the channels assigned to the mobile by the MME.

Although there are variations to this paging approach, the variations differ primarily in how well a mobile can be localized (i.e., maximizing the probability of identifying a mobile in a given cell), how often the mobile needs to update its location (update cost), and over how wide an area (number of BSs) a page should be sent (i.e., paging cost).

The common thread among all of these approaches is that each mobile is paged in sequential order. In other words, if the MME has a list of mobiles to page, then it sends this list of mobiles to different base stations, such that each mobile is paged at least once over at least one BS. This is very inefficient, since it takes $O(M)$ time to wake up $M$ mobiles.

One way to make this more efficient is to use a group identity page to awaken simultaneously a group of mobiles with a single paging message. Depending on the embodiment of this approach, multiple mobiles in the same neighborhood can form groups/clusters in various ways. For example, this can be performed either by the BS/MME using GPS coordinates associated with the mobiles or by using a secondary radio (e.g., Wi-Fi) present on the mobiles. The MME has knowledge of this group and its membership and may give the group a *group-id*, which is known or made known to all the mobiles in the group.

Again, as noted above, group formation can be realized in various ways. More generally, mobiles that tend to stay together and/or move together in a cluster can be a group. A subset of this cluster may also have its own group-id. Mobiles that stay for extended periods in the same cell / sector, regardless of their relative location within the cell / sector can also be part of the same group.

In many of the embodiments, when the MME initiates a large set of paging requests, it looks at the paging queue and considers the set of BS sectors where a

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paged mobile may be present. For each BS sector, the MME compiles the list of mobiles that might be present in the cell corresponding to the BS. The MME/BS identifies all the mobiles that belongs to a single group, and can re-arrange them by queuing the mobiles of the same group together. The main restriction is that the region of interest for all mobiles in this group should be the same. (Each page has a defined broadcast area, i.e., region of interest (ROI)).

If the number of mobiles in a given group exceeds a group-page-threshold *G,* then the BS uses the group-id of the group instead of the individual mobiles' EMSIs/IMEIs for paging the entire group. Otherwise, if the number of mobiles in the same group does not exceed the threshold **G**, then the BS can page them one-by-one in the normal fashion. This allows multiple paging messages to be reduced into a single paging message when desirable. All of the mobiles in the group wakeup upon listening to the group page. These mobiles then attempt to contact the MME via the RACH, as usual. The mobiles for which no data is presently available will eventually go back to sleep.

By appropriately setting the group-page-threshold *G,* we can realize the benefit of this method -- i.e., at the cost of a single page, all the mobiles in the group can be reached at the same time. In this way, the overall paging latency can be reduced.

The detailed and, at times, very specific description above is provided to effectively enable a person of skill in the art to make, use, and best practice the present invention in view of what is already known in the art. In the examples, specifics are provided for the purpose of illustrating possible embodiments of the present invention and should not be interpreted as restricting or limiting the scope of the broader inventive concepts.

Aspects of embodiments of the present invention can be understood with reference to FIG. 2. Diagram 200 of FIG. 2 is a logic flow diagram of functionality performed by a wireless network in accordance with various embodiments of the present invention. In the method depicted in diagram 200, a wireless network determines (201) a number of mobiles to be paged in a wireless coverage area that are members of a paging group. If (202) the determined number of mobiles to be paged exceeds a group-page-threshold, then the wireless network pages (203) members of the paging group in the wireless coverage area using a group-id.

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Otherwise, if the determined number of mobiles to be paged does not exceed the group-page-threshold, then the wireless network pages (204) each member of the paging group to be paged using an individual identifier. Depending on the embodiment, the group-page-threshold may serve as a threshold for many paging groups or simply as a threshold for a particular paging group. Thus, each paging group may have its own associated group-page-threshold.

In many embodiments, the wireless network selects mobiles to be members of the paging group. To do this, the wireless network may identify mobiles that have similar location characteristics over time. For example, it may identify mobiles that stay in the same wireless coverage area (e.g., a cell, a sector, or a plurality of either or both), that move between the same wireless coverage areas, or that move in to or out of the same wireless coverage area on a similar schedule. In many embodiments, the wireless network may indicate to members of the paging group the group-id associated with the paging group. For example, the wireless network may indicate the group-id after selecting mobiles to be members of a paging group or after adding new members to the group.

A person of skill in the art would readily recognize that steps of various above-described methods can be performed by programmed computers. Herein, some embodiments are intended to cover program storage devices, e.g., digital data storage media, which are machine or computer readable and encode machine-executable or computer-executable programs of instructions where said instructions perform some or all of the steps of methods described herein. The program storage devices may be, e.g., digital memories, magnetic storage media such as a magnetic disks or tapes, hard drives, or optically readable digital data storage media. The embodiments are also intended to cover computers programmed to perform said steps of methods described herein.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments of the present invention. However, the benefits, advantages, solutions to problems, and any element(s) that may cause or result in such benefits, advantages, or solutions, or cause such benefits, advantages, or solutions to become more pronounced are not to be construed as a critical, required, or essential feature or element of any or all the claims.

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As used herein and in the appended claims, the term "comprises," "comprising," or any other variation thereof is intended to refer to a non-exclusive inclusion, such that a process, method, article of manufacture, or apparatus that comprises a list of elements does not include only those elements in the list, but may

5      include other elements not expressly listed or inherent to such process, method, article of manufacture, or apparatus. The terms a or an, as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. Unless otherwise indicated herein, the use of relational terms, if any, such as first and second,

10     top and bottom, and the like are used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions.

The terms including and/or having, as used herein, are defined as comprising (i.e., open language). The term coupled, as used herein, is defined as connected,

15     although not necessarily directly, and not necessarily mechanically. Terminology derived from the word "indicating" (e.g., "indicates" and "indication") is intended to encompass all the various techniques available for communicating or referencing the object/information being indicated. Some, but not all, examples of techniques available for communicating or referencing the object/information being indicated

20     include the conveyance of the object/information being indicated, the conveyance of an identifier of the object/information being indicated, the conveyance of information used to generate the object/information being indicated, the conveyance of some part or portion of the object/information being indicated, the conveyance of some derivation of the object/information being indicated, and the conveyance of some

25     symbol representing the object/information being indicated.

What is claimed is:

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# CLAIMS

1.      A method for paging a group, the method comprising:

determining, by a wireless network, a number of mobiles to be paged in a wireless coverage area that are members of a paging group;

paging, by the wireless network, members of the paging group in the wireless coverage area using a group-id, if the determined number of mobiles to be paged exceeds a group-page-threshold.

2.      The method as recited in claim 1, further comprising

selecting, by the wireless network, mobiles to be members of the paging group.

3.      The method as recited in claim 2, wherein selecting mobiles to be members of the paging group comprises

identifying mobiles that have similar location characteristics over time.

4.      The method as recited in claim 3, wherein identifying mobiles that have similar location characteristics over time comprises at least one of

identifying mobiles that stay in the same wireless coverage area,

identifying mobiles that move between the same wireless coverage areas, or

identifying mobiles that move in to or out of the same wireless coverage area on a similar schedule.

5.      The method as recited in claim 1, further comprising

indicating, to members of the paging group by the wireless network, the group-id associated with the paging group.

6.      The method as recited in claim 1, further comprising

paging, by the wireless network, each member of the paging group to be paged using an individual identifier, if the determined number of mobiles to be paged does not exceed the group-page-threshold.

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7.      The method as recited in claim 1, wherein the wireless coverage area comprises at least one of a cell or a sector.

8.      The method as recited in claim 1, wherein the group-page-threshold comprises

5      a group-page-threshold for the paging group.

9.      Wireless network equipment in a communication system, the wireless network equipment being configured to communicate with other devices in the system, wherein the wireless network equipment is operative

10              to determine a number of mobiles to be paged in a wireless coverage area that are members of a paging group, and

to page members of the paging group in the wireless coverage area using a group-id, if the determined number of mobiles to be paged exceeds a group-page-threshold.

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10.      The wireless network equipment as recited in claim 9 being further operative

to page each member of the paging group to be paged using an individual identifier, if the determined number of mobiles to be paged does not exceed the group-page-threshold.

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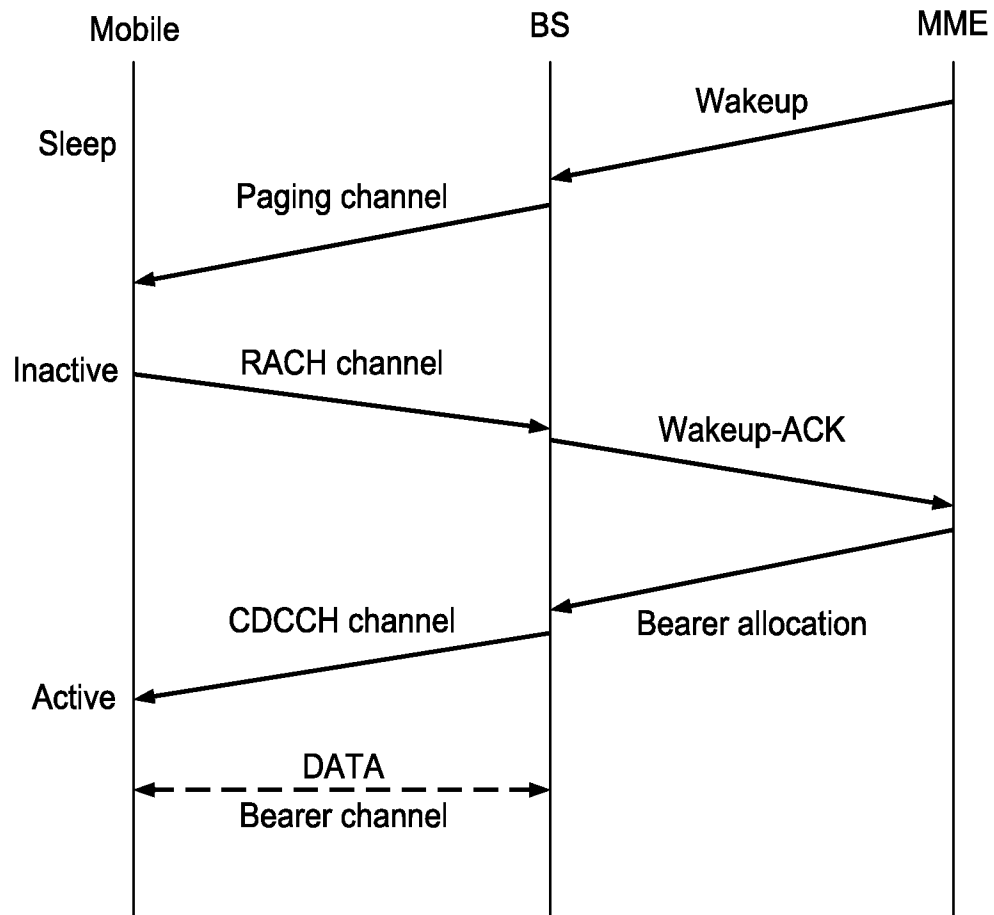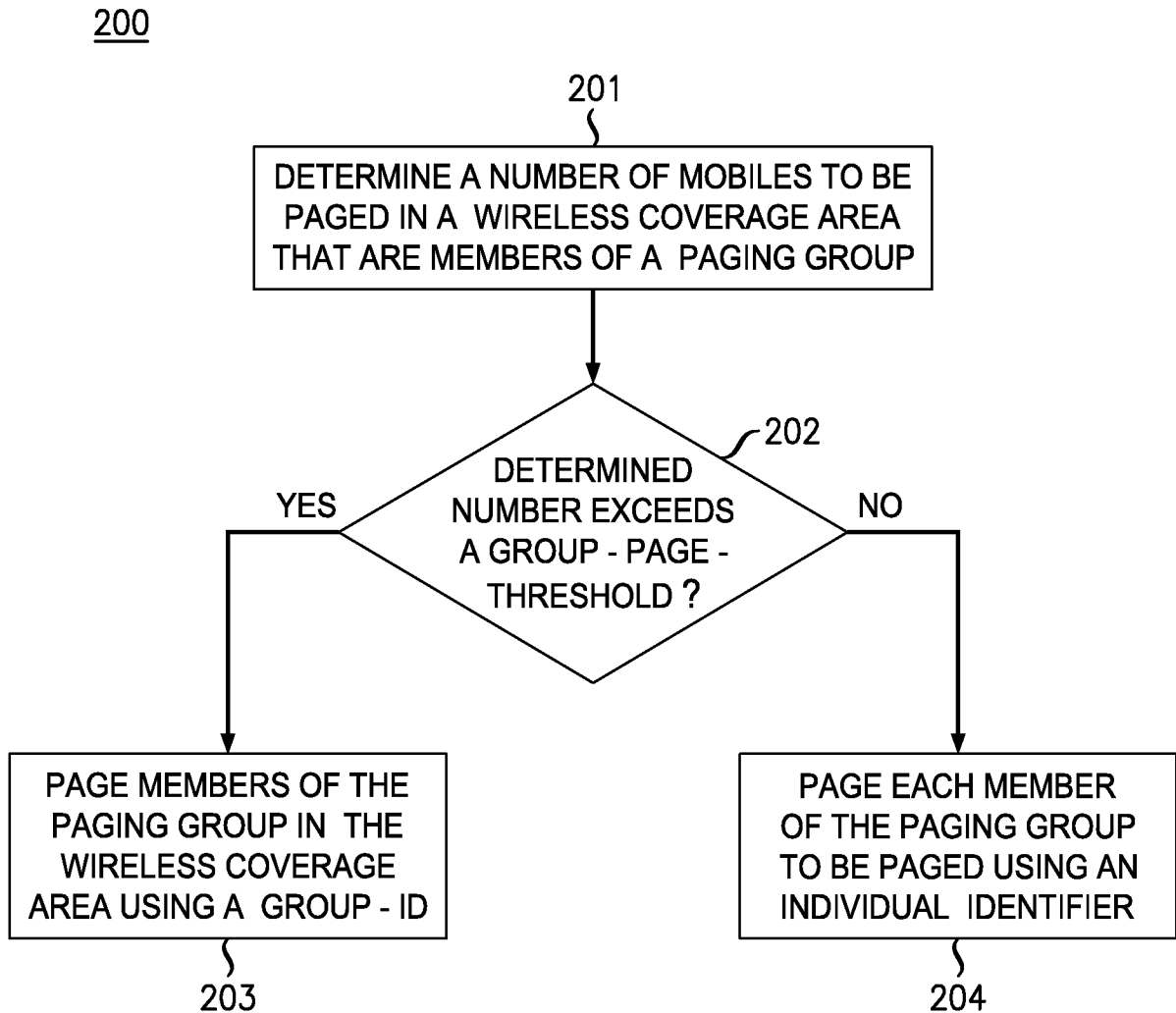
FIG. 1

200

201

DETERMINE A NUMBER OF MOBILES TO BE
PAGED IN A WIRELESS COVERAGE AREA
THAT ARE MEMBERS OF A PAGING GROUP

202

DETERMINED
NUMBER EXCEEDS
A GROUP - PAGE -
THRESHOLD ?

YES                                                          NO

PAGE MEMBERS OF THE
PAGING GROUP IN THE
WIRELESS COVERAGE
AREA USING A GROUP - ID

PAGE EACH MEMBER
OF THE PAGING GROUP
TO BE PAGED USING AN
INDIVIDUAL IDENTIFIER

203                                                          204

*FIG. 2*

# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W68/02
ADD. H04W4/02     H04W4/08     H04W4/06

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)

H04W

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

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

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| X | WO 98/25422 A1 (NOKIA TELECOMMUNICATIONS OY [FI]; HAUMONT SERGE [FI]) 11 June 1998 (1998-06-11) page 4, lines 13-29 page 8, line 18 - page 9, line 25 ----- | 1-10 |
| X | US 2003/087653 A1 (LEUNG NIKOLAI K N [US] ET AL) 8 May 2003 (2003-05-08) paragraphs [0113] - [0114] ----- | 1-10 |

☐ 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 document 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 |
|---|---|
| 12 December 2011 | 20/12/2011 |

| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | Authorized officer Weinmiller, Jost |
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