(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification:**
H04B 7/00 (2006.01)

(21) **International Application Number:**
PCT/US2009/001411

(22) **International Filing Date:**
4 March 2009 (04.03.2009)

(25) **Filing Language:** English

(26) **Publication Language:** English

(71) **Applicant** *(for all designated States except US)*: **NOKIA CORPORATION** [FI/FI]; Keilalahdentie 4, 02150 Espoo (FI).

(71) **Applicant** *(for LC only)*: **NOKIA INC.** [US/US]; 6000 Connection Drive, Irving, TX 75039 (US).

(72) **Inventors; and**

(75) **Inventors/Applicants** *(for US only)*: **WIROLA, Lauri Aarne, Johannes** [FI/FI]; Vestonkatu 67 F 19, 33580 Tampere (FI). **LAINE, Tommi, Antero** [FI/FI]; Kirjavaisenkatu 19 B 4, 33560 Tampere (FI). **RAITOHAR-**

JU, Matti, Samuli [FI/FI]; Havumetsankatu 27 D 61, 33820 Tampere (FI). **SIROLA, Niilo, Torsten** [FI/FI]; Tammelan Puistokatu 14-16 A 40, 33100 Tampere (FI).

(74) **Agents**: **MAGUIRE, Francis, J.** et al.; Ware, Fressola, Van Der Sluys & Adolphson LLP, 755 Main Street, P.O. Box 224, Monroe, CT 06468 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **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,

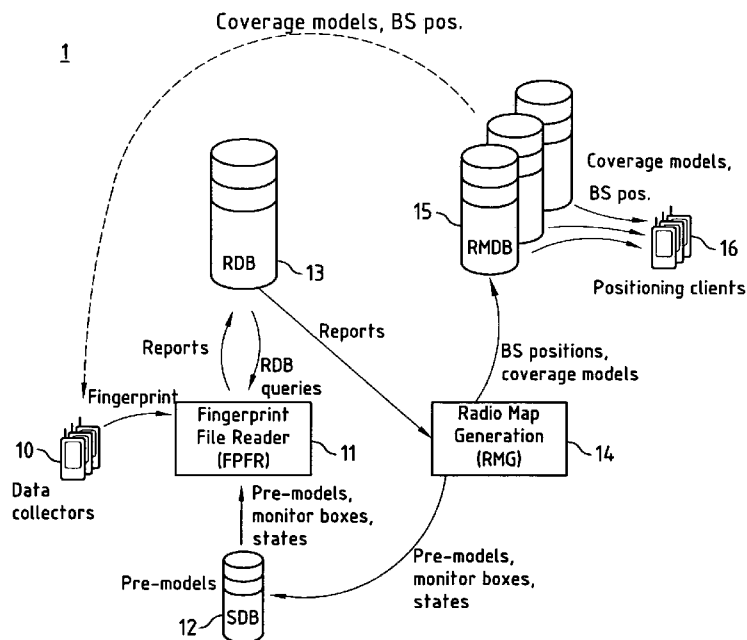(54) Title: SCREENING TERMINAL POSITIONS AT A TERMINAL

Fig. 1

(57) **Abstract**: It is disclosed an apparatus, a method and a computer program for determining, at a terminal, whether at least one terminal position associated with a coverage area of a communication node shall be discarded or reported to allow at least one of said coverage area and said communication node to be characterized at least partially based on said at least one reported terminal position.

Screening Terminal Positions at a Terminal

FIELD

This invention relates to communication nodes and coverage
areas of communication nodes and to the process of their
characterization.

BACKGROUND

As an alternative or add-on to satellite-based positioning
systems, positioning systems in which a present position of
a terminal is estimated based on a list of communication nodes
(such as for instance cellular base stations, access points
or beacons) that can presently be heard by the terminal and
a database that contains identifiers and positions of the
communication nodes and/or models for the coverage areas for
a number of communication nodes have gained recent interest.

Given that the communication node positions are known and
distances from the terminal to the communication nodes can
be estimated, the terminal's position can be estimated
through triangulation. Distance between a terminal and the
heard communication nodes can be estimated for instance based
on either the path loss using a channel model (i.e. how much
the signal attenuates between the terminal and the
communication node) or based on timing (or round-trip timing)
measurements (i.e. information expressing how long signals
propagate between terminal and communication node).

Alternatively, if models for the communication node coverage
areas are known, then a terminal may pick the coverage areas

for the heard communication nodes and find the intersection
of these coverage areas. The terminal can then be assigned
a position that is, for instance, the center-of-mass of the
intersection area. Similarly an error estimate for the
position estimate can be given, for example, based on the size
of the intersection.

A model for the coverage area of a communication node can for
instance be determined by having one or more terminals that
are capable of determining their position send reports with
their present position and a list of one or more communication
nodes that can presently be heard to a server, gathering, for
each communication node, the terminal positions reported into
a set of terminal positions and deriving, from this set of
terminal positions, a model for the coverage area of the
communication node.

Furthermore, if the reports further contain information on
a distance between terminal and communication node, it is also
possible to estimate a position of the communication node
based on the set of terminal positions and the associated
distances.

SUMMARY OF SOME EXEMPLARY EMBODIMENTS OF THE INVENTION
With increasing numbers of reporting terminals and increasing
frequency of reporting, a huge amount of reports may have to
be processed when determining one or more models for the
coverage area of a communication node and/or estimating a
position of a communication node.

According to a first aspect of the present invention, an
apparatus is disclosed, comprising a processor configured to

determine, at a terminal, whether at least one terminal position associated with a coverage area of a communication node shall be discarded or reported to allow the coverage area and/or the communication node to be characterized at least partially based on the at least one reported terminal position.

The processor may for instance be implemented in hardware alone, may have certain aspects in software alone, or may be a combination of hardware and software. An exemplary embodiment of the processor may comprise a memory, wherein instructions executed by the processor may be transferable to the memory and/or contained in the memory. The memory may for instance store a program according to the fourth aspect of the present invention described below, or at least parts thereof.

According to a second aspect of the present invention, further an apparatus is disclosed, comprising means for determining, at a terminal, whether at least one terminal position associated with a coverage area of a communication node shall be discarded or reported to allow the coverage area and/or the communication node to be characterized at least partially based on the at least one reported terminal position.

Therein, the means for determining may for instance be embodied as a processor, but the means are not limited thereto.

The apparatuses according to the first and second aspect of the present invention may for instance be embodied as a module. They may for instance comprise a user interface and/or

3

an antenna. They may for instance be embodied as a portable
electronic communication device.

According to a third aspect of the present invention,
furthermore a method is disclosed, comprising determining,
at a terminal, whether at least one terminal position
associated with a coverage area of a communication node shall
be discarded or reported to allow the coverage area and/or
the communication node to be characterized at least partially
based on the at least one reported terminal position.

According to a fourth aspect of the present invention, further
a program is disclosed, comprising program code for
performing the method according to the first aspect of the
present invention and all exemplary embodiments thereof, when
the program is executed on a processor.

The program may for instance be distributed via a network,
such as for instance the Internet. The program may for
instance be stored or encoded on a readable-medium, for
instance a computer-readable or processor-readable medium.
The readable medium may for instance be embodied as an
electric, magnetic, electro-magnetic, optic or other storage
medium, and may either be a removable medium or a medium that
is fixedly installed in an apparatus or device. The readable
medium may for instance be a tangible medium, for instance
a tangible storage medium.

The communication node may for instance be a communication
node of a communication system. It may then for instance
provide coverage for one or more terminals. The communication
system may be a wireless or a wire-bound communication system,

and may be of cellular or non-cellular type. The communication node may for instance be a one-directional or bi-directional communication node. Non-limiting examples of the communication node are thus a cellular base station, a Wireless Local Area Network (WLAN) access point, an FM radio station, a TV station. The communication node may be fixed or mobile, for instance with low mobility and/or velocity. In case of sectorization of cells, each sector may also be understood as a communication node, even if all sectors are controlled by the same (cellular) base station.

The terminal may for instance be fixed or mobile, and may be embodied in various types of devices allowing for communication with one or more communication nodes (of one or more different communication systems such as cellular communication systems and WLAN communication systems), such as for instance a mobile phone, a personal digital assistant, a (laptop) computer or netbook, to name but a few non-limiting examples.

The communication node has a coverage area, which may be understood as an area within which one or more terminals are able to receive signals sent from the communication node at least with a pre-determined minimum quality (for instance with a quality that allows a terminal to receive and decode signals sent by the communication node, such as for instance a broadcast channel, or with a quality that allows a terminal to be able to decode an identification of the communication node (e.g. a MAC address or any other type of communication node identification)), wherein the quality may for instance be expressed in terms of signal strength or signal-to-noise-ratio, to name but a few examples. In case

of a wireless communication node, the coverage area may for
instance depend on the transmission frequency and the
propagation environment, which may for instance cause
shadowing. The coverage area does not necessarily have to be
continuous, it may equally well have recesses and may equally
well consist of several sub-areas.

The at least one terminal position is a position of the
terminal. This position is for instance measured by the
terminal itself, for instance based on a satellite- and/or
beacon-based navigation system, or is measured or determined
by an entity (such as human being or an apparatus) that is
different from the terminal and then provided to the terminal.
The terminal positions may for instance be measured by the
terminal regularly, for instance according to a schedule
(e.g. in pre-defined equidistant intervals). The terminal
positions may also be determined by a human being (regularly
or irregularly) based on a map and/or on characteristic
landmarks and entered into the terminal. The terminal
position may be a present position of the terminal, but
equally well may be a position of the terminal at a previous
time instant (for instance with respect to the time instant
of reporting). For instance, the terminal may measure/obtain
several terminal positions at different time instants that
are to be reported in a joint report (a so-called batch
report).

The terminal position is associated with the coverage area.
Therein, a terminal position may be associated with coverage
areas of several communication nodes at the same time. The
feature that the terminal position is associated with the
coverage area may for instance be understood to require that

the terminal is (or is at least believed to be) within the coverage area of the communication node at a time instant when the terminal position is determined. The terminal may for instance be considered to be within the coverage area of the communication node if it is able to hear the communication node. Therein, a terminal may for instance be considered to "hear" a communication node if it is able to receive one or more signals, which are sent by the communication node, with a pre-defined minimum quality, wherein the quality may for instance be defined in terms of a signal-to-noise ratio or a signal-to-noise and interference ratio. An example of such a signal sent by a communication node may for instance be a broadcast channel. As an alternative, the terminal may for instance be considered to "hear" a communication node if the terminal is capable of at least partially receiving and correctly decoding one or more signals sent by the communication node, such as a broadcast channel. For instance, the terminal may considered to "hear" the communication node if it is at least able to decode an identification of the communication node (e.g. a MAC address or any other type of communication node identification). The information which communication nodes a terminal can hear may for instance result from a scanning/sniffing operation performed by the terminal.

Terminal positions can be reported, for instance by including the terminal position into a report (e.g. a so-called fingerprint) and transmitting the report to a unit that is different from the terminal, for instance to a server. Therein, the server may be a component of the communication system that comprises the communication node, but may equally well not be a part of the communication system that comprises

the communication node. For instance, the terminal positions
may be reported in messages exchanged between the terminal
and the communication node (or another communication node of
the same communication system), and may then be forwarded by
the receiving communication node to a server that collects
such reports. Equally well, the report may be sent from the
terminal to a receiving unit that is not part of the
communication system that comprises the communication node
(for instance to a communication node of another
communication system). The terminal position may be reported
together with an identification of the communication node,
for instance if this identification can not be derived
otherwise. For instance, if the terminal reports the terminal
position to (or via) the communication node (i.e. the
communication node it is associated with), it may not be
necessary to include the identification of the communication
node. Otherwise, if the terminal reports the terminal
position to a different communication node of either the same
communication system (e.g. in case of a batch report) or a
different communication system, it may be necessary to also
report an identification of the communication node together
with the terminal position. The terminal position may be
reported together with further parameters, such as for
instance range measurements indicating a distance to the
communication node and/or timestamps.

At least partially based on the at least one reported terminal
position (i.e. potentially also under consideration of
further reported terminal positions and/or further
parameters), the coverage area and/or the communication node
can be characterized. For instance, the at least one reported
terminal position may allow generating/updating one or more

models for the coverage area of the communication node (for
instance based on geometrical shapes that may for instance
enclose all terminal positions reported for the coverage
area). Equally well, the at least one reported terminal
position may allow estimating a position of the communication
node. This may for instance require further parameters to be
reported together with the terminal position, such as for
instance information on a distance between the terminal and
the communication node.

At the terminal, it is determined whether at least one
terminal position shall be discarded or reported to allow the
coverage area and/or the communication node to be
characterized at least partially based on the at least one
reported terminal position. This determining may be based on
information provided to the terminal, or on information
produced by the terminal itself. Therein, the at least one
terminal position may for instance be understood to be
discarded since it is considered to be insignificant for the
characterizing of the coverage area and/or the communication
node and/or because further information for the
characterizing of the coverage area and/or the communication
node is (currently) not required.

Thus instead of reporting every terminal position that is
determined or obtained at the terminal, i.e. is already
present and available at the terminal for reporting, the
terminal can determine if one or more terminal positions shall
be discarded instead. In exemplary embodiments of the present
invention, this may contribute to reduce an amount of
information that has to be processed when characterizing the
coverage area and/or the communication node, for instance by

a unit that is configured to characterize the coverage area
of the communication node (for instance by generating and/or
updating one or more models for the coverage area of the
communication node) and/or the communication node (for
instance by estimating a position of the communication node).
Furthermore, the amount of transmission resources (e.g.
bandwidth, power) required for reporting the terminal
positions to this unit may also be reduced, accordingly. The
determining whether the at least one position shall be
discarded or reported may be considered as a screening or
filtering of terminal positions in the terminal.

According to exemplary embodiments of all aspects of the
present invention, the determining whether the at least one
terminal position shall be discarded or reported is at least
partially based on at least one of a model for the coverage
area of the communication node and a modified model for the
coverage area of the communication node that is obtained by
modifying the at least one model for the coverage area of the
communication node. It may for instance be determined whether
the at least one terminal position shall be discarded or
reported depending on whether the at least one terminal
position is covered by the model for the coverage area of the
communication node and/or the modified model or not. The model
for the coverage area of the communication node may for
instance approximate the (assumed) coverage as a geometrical
object (such as for instance an ellipse (including a circle
as a special case) and a polygon (including a triangle and
a rectangle as special cases)). Therein, the geometrical
object may for instance be considered as a hard boundary, so
that a terminal position has to be within the geometrical
object to be considered to be covered by the model for the

coverage area. Equally well, the geometrical object may be a soft statistical boundary that is for instance based on a statistical model for the distribution of the terminal positions in the coverage area and is characterized by further parameters such as for instance a confidence value. A terminal position may then for instance be considered to be covered by the model for the coverage area even if it is not within the geometrical object (an example of such a geometrical object is for instance the 1σ-, 2σ- or 3σ-area of an assumed 2D Gaussian distribution of terminal positions in a coverage area). The modifying of the model for the coverage area may for instance comprise changing a format of the model and/or changing an area described by the model, to name but a few examples. The model and/or the modified model may for instance be provided to the terminal by a unit that is different from the terminal, such as a server.

The model for the coverage area of the communication node may for instance be derived, as a characterization of the coverage area, from one or more terminal positions associated with the coverage area of the communication node and reported by one or more terminals. The model for the coverage area of the communication node may for instance be a geometrical object that encloses all of the one or more terminal positions, or may be derived from such a geometrical object. The deriving may for instance be performed at a server that receives the one or more reported terminal positions.

The at least one terminal position may for instance be determined to be discarded if it is covered by at least one of the model for the coverage area of the communication node and the modified model. It may for instance be considered that

a terminal position that is already covered by the model
and/or the modified model does not contribute to the
characterization of the coverage area and/or the
communication node and thus should not be reported. In
contrast, terminal positions that are not already covered by
the model and/or the modified model may be considered to be
significant for the characterization of the coverage area
and/or the communication node and thus may be reported.

The modified model for the coverage area of the communication
node may for instance be a scaled representation of the at
least one model for the coverage area of the communication
node. The scaling may for instance cause the modified model
to have a smaller area than the original model. This may allow
reducing the amount of (insignificant) terminal positions
reported to a process that characterizes the coverage area
and/or the communication node based on the reported terminal
positions, while still reporting (significant) terminal
positions near the assumed boundary of the coverage area. This
may for instance be advantageous if at least one portion of
the boundary (e.g. a boundary point) of the assumed coverage
area is monitored to determine if it is at least partially
outdated and/or if it represents on outlier with respect to
the coverage area by setting up a monitoring area around the
at least one portion of the boundary and by checking if
terminal positions within this monitoring area are reported
(which would indicate that the boundary portion is not
outdated and does not represent an outlier) or not (indicating
that the boundary portion is outdated or an outlier).

In an exemplary embodiment of the apparatus according to the
first aspect of the present invention, the processor is

further configured to determine a mismatch between the at
least one terminal position and at least one of the model for
the coverage area of the communication node and the modified
model and to report an indication of such a mismatch. The
apparatus according to the second aspect of the present
invention comprises according means for determining such a
mismatch and means for reporting an indication of such a
mismatch, and the method according to the third aspect of the
present invention comprises determining such a mismatch and
reporting an indication of such a mismatch. The mismatch may
for instance be determined if a distance between the terminal
position and the model and/or the modified model exceeds a
pre-defined threshold. The threshold may for instance depend
on an assumed maximum extension (e.g. an assumed maximum
radius) of a coverage area. The mismatch may for instance be
interpreted to indicate that the terminal position is a
potential outlier.
Therein, an outlier may for instance be defined as a terminal
position that is too far apart from the coverage area of the
communication node, for instance since it has a distance with
respect to the coverage area that is above a distance
threshold. A position may be classified as a potential outlier
if it is considered to be too far apart from the assumed
coverage area of the communication node, for instance since
it has a distance with respect to the assumed coverage area
that is above a distance threshold, wherein the assumed
coverage area of the communication node may for instance be
represented by a model for said coverage area. Such a
potential outlier may for instance indicate that the coverage
area of the communication node has changed, for instance
moved. The indication may for instance be a flag (e.g. a
one-bit word), and this indication may be reported together

with the terminal position to indicate to a process that characterizes the coverage area and/or the communication node (e.g. generates/updates one or more models for the coverage area of the communication node) that the reported terminal position is a potential outlier and/or that the coverage area might have changed.

According to an exemplary embodiment of all aspects of the present invention, the determining whether the at least one terminal position shall be discarded or reported is at least partially based on information on terminal positions that have been reported by the terminal before. The terminal may for instance keep a history of already reported terminal positions, and it may be decided based on this history whether a terminal position shall be discarded or reported. This history may also store, for instance based on an identifier, such as an identifier of the communication node, for which coverage area a terminal position has already been reported, for instance to account for cases where a terminal position has already been reported, but with respect to a coverage area with another identifier, or for cases where an identifier of the coverage area has changed. In both of these cases, reporting of the terminal position may be desired.

Filtering terminal positions based on information on terminal positions that have been reported (for instance for a coverage area with the same identifier) by the terminal before may contribute to reducing the amount of insignificant terminal positions reported to a process that characterizes the coverage area and/or the communication node, since, for instance in the case that a coverage area does not change,

already reported terminal positions may have already been
considered and thus add no new information to the process.

The at least one terminal position may for instance be
discarded if it is in a respective defined environment of any
terminal position of a defined set of terminal positions that
have been reported for a coverage area with the same
identifier (e.g. the same coverage area) before. The at least
one terminal position may for instance be discarded if it
equals an already reported terminal position, or if it is
within a defined environment of one or more already reported
positions (for instance with respect to a coverage area with
the same identifier). The defined environment may for
instance be a pre-defined environment, such as for instance
a pre-defined area such as a rectangle or a circle around an
already reported terminal position. The defined set of
terminal positions that have been reported before may for
instance comprise all terminal positions reported so far
(e.g. for a coverage area with the same identifier), or only
a part thereof, for instance only those terminal positions
that have been reported (e.g. for a coverage area with the
same identifier) within a pre-defined period of time (for
instance on the same day or in the last hour, to name but a
few examples).

According to an exemplary embodiment of all aspects of the
present invention, it is determined whether the at least one
terminal position and information on a distance between the
at least one terminal position and the communication node
shall be discarded or reported, and wherein the determining
is at least partially based on information on a quality of
an estimate of a position of the communication node. The

information on the distance may for instance be a Timing
Advance (TA) value that is used for each terminal to ensure
synchronism of transmission, or a Round-Trip-Delay (RTD) or
Received Signal Strength (RSS) value, to name but a few
non-limiting examples. The quality of the estimate of the
position of the communication node may for instance be
provided to the terminal (for instance from a unit that
produced the estimate), for instance together with the
estimate itself. The quality may for instance be indicated
by a flag (such as a one-bit word) that indicates a good or
bad quality, or by a covariance matrix (or a part or
characteristic value thereof) associated with the estimate,
to name but a few examples. A low quality may for instance
indicate that further information should be reported to
improve the characterization of the communication node (for
instance in terms of its position).

The position of the communication node may for instance be
estimated, as a characterization of the communication node,
based on one or more terminal positions and respective
information on the distance between the terminal positions
and the communication node reported by one or more terminals.
The position of the communication node may for instance be
estimated by a unit (e.g. a server) that is different from
the terminal and that receives reports containing terminal
positions and respective distances between the terminal
position and the communication node from one or more
terminals. The unit may then also determine a quality of the
estimate, and may also provide the estimate to the terminal.
The unit may furthermore determine one or more models for the
coverage area of the communication node based on the terminal
positions reported by the one or more terminals.

The at least one terminal position and the information on the
distance between the at least one terminal position and the
communication node may for instance be determined to be
reported if the quality of the estimate of the position of
the communication node is considered low according to a
defined criterion. The criterion may for instance be a
pre-defined criterion or a criterion that is controlled
dynamically. In exemplary embodiments of the present
invention, reporting the at least one terminal position and
the information on the distance may be advantageous in case
the quality of the communication node position estimate is
low, since then more information for the estimation of the
communication node position is available to a process that
implements this estimation. On the other hand, if the quality
is high, an amount of information provided to the process
and/or an amount of transmission resources (e.g. bandwidth,
power) required may be significantly reduced by discarding
terminal positions (and the respective information on the
distance).

According to an exemplary embodiment of all aspects of the
present invention, the determining whether the at least one
terminal position shall be discarded or reported is at least
partially based on a state of a process for characterizing
the coverage area of the communication node at least partially
based on one or more terminal positions reported by one or
more terminals. The process for characterizing the coverage
area of the communication node may for instance be a process
for generating and/or updating one or more models for the
coverage area of the communication node. The state of the
process may for instance represent a maturity or progress of

the characterizing, for instance a maturity of at least one
model produced by the process for generating and/or updating
the one or more models for the coverage area of the
communication node. For instance, there may exist a state
where the terminal shall report any terminal position, and/or
a state where the terminal shall only report terminal
positions that are not already covered by one of a model for
the coverage area of the communication node and a modified
model for the coverage area of the communication node. The
state may for instance be provided to the terminal by a unit
that is different from the terminal and that implements the
process of characterizing. As already indicated above, the
determining whether the at least one terminal position shall
be discarded or reported may thus be partially based on both
on such a state and on one of a model for the coverage area
of the communication node and a modified model for the
coverage area of the communication node, wherein this
modified model may for instance be obtained from the
(original) model by modifying, for instance by scaling (such
as area reduction). Similarly, the determining whether the
at least one terminal position shall be discarded or reported
may also be based on a state of a process for characterizing
the communication node (for instance its position) at least
partially based on one or more terminal positions reported
by one or more terminals.

According to an exemplary embodiment of the first aspect of
the present invention, the apparatus further comprises a
transmitter for reporting the at least one terminal position
in case it is determined that the at least one terminal
position shall be reported. Accordingly, the apparatus
according to the second aspect of the present invention

comprises means for reporting the at least one terminal
position in case it is determined that the at least one
terminal position shall be reported, and the method according
to the third aspect of the present invention comprises
reporting the at least one terminal position in case it is
determined that the at least one terminal position shall be
reported.

According to an exemplary embodiment of all aspects of the
present invention, in case it is determined that the at least
one terminal position shall be reported, the at least one
terminal position is reported as a fingerprint that further
comprises an identifier of the communication node. The
identifier of the communication node may however be not
included in the fingerprint if it can be otherwise determined,
for instance since the terminal is currently associated (e.g.
registered) with the communication node.

The fingerprint may further comprise an identifier of another
communication node for which it is determined that the
terminal position shall be reported to allow at least one of
a coverage area of the other communication node and the other
communication node to be characterized at least partially
based on the at least one reported terminal position. The
fingerprint may furthermore contain distances from the
terminal position to the one or more communication nodes (if
available), and/or a timestamp, and/or further parameters.

The fingerprint may be reported solely, or in combination with
further fingerprints (for instance as a batch of fingerprints
measured at different time instants).

It is to be noted that the above description of embodiments of the present invention is to be understood to be merely exemplary and non-limiting. Furthermore, the exemplary embodiments described above and in particular their single features shall be understood to be disclosed in all possible combinations with each other.

These and further concepts of the invention will be apparent from and elucidated with reference to the detailed description presented hereinafter.

BRIEF DESCRIPTION OF THE FIGURES
In the figures show:

Fig. 1:   A schematic block diagram of an exemplary system that implements exemplary concepts of the present invention;

Fig. 2:   a schematic illustration of an exemplary coverage area of a base station with exemplary models for this coverage area;

Fig. 3:   a schematic block diagram of an exemplary embodiment of a process for generating and/or updating models for the coverage area of a base station according to the present invention;

Fig. 4:   a schematic illustration of the states and state transitions of an exemplary state machine according to the present invention;

Fig. 5:   a flowchart of an exemplary embodiment of
               filtering of terminal positions;

Fig. 6:   a schematic block diagram of an exemplary
               embodiment of an apparatus according to the
               present invention;

Fig. 7:   a schematic illustration of an exemplary
               embodiment of a tangible storage medium
               according to the present invention;

Fig. 8:   a flowchart of an exemplary embodiment of a
               method according to the present invention;

Fig. 9:   a flowchart of a further exemplary embodiment of
               a method according to the present invention;

Fig. 10:   a flowchart of a further exemplary embodiment of
               a method according to the present invention;

Fig. 11:   a flowchart of a further exemplary embodiment of
               a method according to the present invention;

Fig. 12:   a flowchart of a further exemplary embodiment of
               a method according to the present invention;

Fig. 13:   a flowchart of a further exemplary embodiment of
               a method according to the present invention; and

Fig. 14:   a schematic illustration of a timing advance
               parameter.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS OF THE

INVENTION

Satellite positioning does not work well indoors or in other
shadowed environments. However, various communication nodes
are ubiquitous in the modern world. Non-limiting examples of
such communication nodesinclude cellular base stations, WLAN
access points, FM radio or TV stations. Instead of the term
"communication node", also the term "base station" will be
used in the following description, wherein the term "base
station" is not necessarily understood to be restricted to
a cellular base station. These base stations have good
penetration and coverage virtually everywhere of interest.
Since the range of these beacons may usually be relatively
short (for instance hundreds of meters to some kilometers),
these beacons may be exploited for positioning purposes.

For instance, WLAN-based positioning may complement Global
Navigation Satellite System (GNSS) based positioning in urban
environments. Typically GNSS-based positioning methods have
problems in urban canyons - however, these are also areas,
in which the WLAN AP density is high. WLAN-positioning also
enables indoor positioning allowing for more effective
Location Based Services (LBS).

WLAN Access Points (WLAN APs) can be used for positioning
given that the position(s) of the AP(s) are known. In general,
WLAN-based positioning assumes a database, either local (in
the terminal) or remote (in the server) or a combination of
those containing at least WLAN AP identification information
(e.g. a WLAN AP Medium Access Control (MAC) address) and the
geographical coordinates of the WLAN APs. The database may

also contain an estimate of the WLAN AP position accuracy.
Moreover, a coverage area of the WLAN AP may also be modeled.

The database of WLAN APs and their geographical coordinates
and/or coverage models allow for positioning the terminal
with WLAN. GNSS or some other conventional positioning
capability may then not be required.

In positioning, the terminal performs a WLAN AP scan and then
compares the scan results to the records in the database. If
applicable records are found, the information is combined in
some suitable manner (such as, weighted average based on
Relative Signal Strength (RSS) values) to produce a position
estimate for the terminal.

Therein, if the base station positions are known and distances
from the terminal to the base stations can be estimated, the
terminal's position can be estimated through triangulation.
The distance between a terminal and the heard base stations
can for instance be estimated based on either the path loss
(i.e. how much the signal attenuates between the terminal and
the base station) using a channel model or based on timing
(or round-trip timing) measurements (i.e. information
expressing how long signals propagate between terminal and
base station).

If models for the coverage areas of base stations are known,
then a terminal may pick the coverage areas for the heard base
stations and find the intersection of these coverage areas.
The terminal can then be assigned a position that is, for
instance, the center-of-mass of the intersection area.

Moreover, a position error estimate may be given based on the size of the intersection.

These mechanisms may also be combined: distance measurements can be combined with coverage area models to produce a position estimate. Even satellite (GNSS) pseudorange measurements may be taken into account in these hybrid methods to obtain additional measurements.

The database for WLAN-based positioning can be built in various ways. One solution may be that a company buys hotspot directories from WLAN network providers and assimilates these directories in their databases. Alternatively, a plurality of terminals may perform the WLAN AP mapping. In such a case the terminals may have a Global Navigation Satellite System (GNSS) or Assisted GNSS (AGNSS) receiver attached to or inside the terminal and provide data on the WLAN APs' coverage. It may also be the case that the database build-up is a community-based effort.

It is readily understood by a person skilled in the art that the techniques described above in the context of a WLAN system are equally applicable with any other radio network-technology as well. Potential candidates include Bluetooth, Wibree (Ultra Low Power Bluetooth), Global System for Mobile Communication (GSM), Wideband Code Division Multiple Access (WCDMA), Code Division Multiple Access (CDMA), Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WiMAX), to name but a few non-limiting examples.

The above-described WLAN-based positioning may also be combined/complemented with Cell ID-based positioning. When collecting the data for the WLAN AP database, then also information on 2G (second generation, e.g. GSM) and/or 3G (third generation, e.g. UMTS) cells (or on cells of any cellular communication system) that can be observed in the present position (serving cell and optionally also the neighboring stations) may be collected.

The data collected on WLAN APs and 2G/3G cells can for instance be collected on central servers and distributed to the terminals for position determination.

Fig. 1 schematically illustrates the functional blocks of an exemplary system 1 that implements concepts of the present invention.

The server side of the exemplary system 1 comprises two processing blocks, Finger Print (FP) File Reader (FPFR) block 11 and Radio Map Generation (RMG) block 14. Moreover, there are three data stores, Report Data Base (RDB) 13, Screening Data Base (SDB) 12 and Radio Map Data Base (RMDB) 15. Each can be either centralized or, for example, regionally distributed. Moreover, although the exemplary architecture shows several different databases, they can be implemented as one single same database or may be broken down in more databases in different implementations. It is clear to a person skilled in the art that the actual number and naming of databases is an implementation issue and does not affect the concept disclosed in this specification. The terminals 10 acting as data collectors or positioning clients 16 can also be seen as processing blocks of system 1.

The one or more terminals (e.g. mobile terminals of cellular or WLAN communications systems) 10 with positioning capacity (e.g. a GNSS such as GPS) send a fingerprint, which may for instance comprise a terminal position and usually also an identification of the base station(s) heard, if the identification of the base station(s) cannot be determined/reconstructed by a receiving end otherwise. Optionally, the fingerprint may comprise further parameters, as will be explained in further detail below.

The fingerprint arrives to the FPFR block 11, which splits the information into base-station-specific reports, and stores the base-station-specific reports into the RDB 13. Therein, it is to be noted that the base station does not necessarily have to be the primary record for storing fingerprints/reports. Equally well, the fingerprints may be stored in a database in a terminal-position-specific way, so that the according entries in the database then may pertain to several base stations. The fingerprints may of course also be stored and/or processed according to other criteria.

FPFR block 11 may further implement a filter that drops (discards) reports, for instance when they are considered to add no new information to the already collected data. In particular, to be able to deal with the massive number of incoming reports, the FPFR block 11 may for instance make use of simplified pre-models of the coverage area (stored in SDB 12) to be able to quickly drop a large number of redundant reports. Use of these pre-models may depend on the states of a state machine set up for the coverage area.

The RMG block 14 reads (for instance continuously or periodically, or in response to a trigger event, such as an arrival of a new report or an accumulation of a certain amount of reports) reports from the RDB 13, and generates/updates different types of models for the coverage area of the base station. The RMG block 14 may also remove redundant reports from RDB 13, keeping only a small but representative set of reports on the coverage area of each base station. RDB 13 may for instance store a pre-defined number of reports with respect to each base station, and it may be targeted to use as little computation as possible to sieve the significant ones from the mass of incoming reports.

In the exemplary system of Fig. 1, RMG block 14 may exemplarily use a polygon (for instance a polygon such as a convex hull) to represent the terminal positions that are reported by the one or more terminals 10, pass the FPFR block 11 and are at least temporarily stored (in the form of reports) in RDB 13. That is, instead of storing all terminal positions received from FPFR block 11 in RDB 13, only the terminal positions that form the vertices of a polygon (e.g. a convex hull) that encloses all these terminal positions are stored.

An example of a polygon 22 (in this case a convex hull) enclosing the terminal positions 21 in a coverage area 20 of a base station 26 is given in Fig. 2.

In addition to the polygon 22, the RMG block 14 further generates/updates a coverage model and different pre-models based on this polygon 22.

All of these models (including the polygon) are models for
the coverage area of the base station. In the following,
models for the coverage area of the base station that are to
be provided to the positioning terminals 16 (and optionally
also the data collectors 10, see Fig. 1) will be denoted as
"coverage models", whereas the models for the coverage area
of the base station that are provided to FPFR 11 and stored
in SDB 12 will be denoted as "pre-models". All of these models
may represent both "hard" and "soft" (e.g. statistical)
boundaries for the coverage area, as further explained below.

In the exemplary system of Fig. 1, an elliptical coverage
model is generated by RMG block 14 by fitting the minimum
enclosing ellipse around the polygon 22 (see for instance
ellipse 23 enclosing convex hull 22 in Fig. 2). When updating
this ellipse, the old ellipse may be used as the initial guess.

The following two ellipse formats are exemplarily used in this
specification, wherein the term "ellipse" is understood to
also comprise a circle as a special case of an ellipse with
equal major and minor semi-axes:

An **"axis/angle-form" ellipse**, defined by coordinates of the
centre (in World Geodetic System WGS-84) longitude and
latitude, lengths of the semi-major and semi-minor axes (in
meters, referring to WGS-84 coordinates), and orientation of
the semi-major axis (degrees, clock-wise from North).
Moreover, a confidence value can be included as well. If the
ellipse is interpreted in a statistical sense, i.e. to
represent a soft statistical boundary for the positions in
the coverage area rather than a hard boundary that includes
all positions in the coverage area, the confidence value may

specify which area with respect to the coverage area the
ellipse describes. For instance, if the positions are assumed
to be statistically distributed in the coverage area
according to a 2D Gaussian distribution, the confidence value
may for instance express if the ellipse represents the σ, 2σ
or 3σ area of the 2D Gaussian distribution, wherein σ is the
standard deviation. Therein, the σ, 2σ and 3σ areas may for
instance be understood as the areas in which 39%, 86% and 99%
of the terminal positions are considered to be within,
respectively.

A "matrix-form" ellipse: coordinates (WGS-84) of the centre
$c=(lat_E, lon_E)$, and three coefficients $a > 0$, $d > 0$, and b so
that point $x=(lat, lon)$ is inside the ellipse if

$$(x-c)^T A(x-c) \le 1$$

with

$$A = \begin{bmatrix} a & b \\ b & d \end{bmatrix} .$$

The matrix-form ellipse may require more memory space for
storage, but may be faster to manipulate than the
axis/angle-form ellipse. Similar to the axis/angle-form
ellipse, also the matrix-form ellipse may represent a soft
statistical boundary for the positions in the coverage area
rather than a hard boundary that includes all positions in
the coverage area. For instance, the centre c may then be
interpreted as the mean value and the matrix A may then be
interpreted as the covariance matrix, for instance of a 2D

Gaussian distribution assumed for the distribution of the positions in the coverage area. The ellipse may then no longer coincide with the outer boundary of the coverage area, it may rather define a sub-area of the coverage area, for instance the σ area.

Details on conversion between the two axis/angle-form ellipse and the matrix-form ellipse are given in Appendix A.1.

In the following, for the sake of simplicity of presentation, it is exemplarily assumed that all models for the coverage area of a base station represent "hard" boundaries of the coverage area.

In the exemplary system of Fig. 1, an elliptical model in axis/angle form or a model derived from it (for instance by adding further parameters) serves as coverage model and is saved in RMDB 15, for instance in the format shown in Table 1. The coverage models (for one or more base stations) stored in RMDB 15 are then delivered to terminals 16 to be used for positioning on their own or combined to other positioning data in the terminals 16, and optionally to data collectors 10, as will be described in further detail below. RMDB 15 may also store further information that may be used by the positioning clients 16 and/or the data collectors 10, as will also be discussed in further detail below.

Parameter	Description
ID	Unique ID code of the base station
Type	2G, 3G, WLAN, etc.
State	State of the state machine

Position	Base station position estimate and/or quality of this estimate (if available)
Coverage model	Coverage model, e.g. a model comprising the parameters of the axis/angle-form ellipse and optionally further parameters

Table 1: Exemplary coverage model entry in the RMDB

Furthermore, an elliptical model in matrix-form may for instance serve as a pre-model for the filtering in FPFR block 11.

Fig. 3 is a schematic illustration of an example of the generation of a polygon serving as a representation of the coverage area of a base station and the coverage model and pre-models derived from this polygon.

Therein, block 302 performs detection of potential outliers. This detection is based on pre-models and/or information on the type of coverage area to be determined, for instance the maximum possible radius of the coverage area, which may for instance be stored in SDB 301 (corresponding to SDB 12 of Fig. 1). The concept of detecting potential outliers will be explained in further detail below.

For all reports contained in RDB 300 (corresponding to RDB 13 of Fig. 1), a polygonal representation is determined in block 303. This polygon is then input into block 304, where a coverage model is generated from the polygon, and this coverage model is then stored in RMDB 311 (corresponding to RMDB 15 of Fig. 1).

For all currently non-monitored reports (i.e. for those
reports that are neither suspected to be outliers nor
suspected to be outdated, which will also be explained in more
detail below), a non-monitored polygon is determined in block
305, and this non-monitored polygon (which usually covers a
smaller area as compared to the polygon generated in box 303)
serves as a basis for pre-model generation in block 306. This
way, in case of potential outliers and/or potentially
outdated positions, the optimal polygons both including and
excluding the potential outliers and/or the potentially
outdated positions can be maintained. This arrangement may
ensure that if some of the monitored vertices are removed (as
will be explained below), there are positions in reserve (i.e.
positions in the vicinity of the monitored vertices that are
not discarded in the filtering of FPFR block 11 since the
pre-models used in this filtering are based on the
non-monitored polygon) to produce a good coverage model.

The pre-models output by block 306 are then stored in SDB 308
(corresponding to SDB 12 in Fig. 1). SDB 308 further stores
monitoring boxes (as will be explained in more detail below)
set by block 302. Finally, SDB 308 further may store states
of a state machine determined by a state algorithm 307.

The reports of the polygon determined in block 303 and of the
non-monitored polygon determined in block 305 are stored back
to RDB 309 (corresponding to RDB 13 in Fig. 1).

Reports in RDB 300 that additionally comprise information on
a distance between the terminal position and the base station
(for instance Timing Advance (TA) values available for

instance in 2G systems) are processed by a base station
estimation process 310 that estimates the position of the base
station based on the terminal position and the distance to
the base station as exemplarily explained in Appendix A.2.
The base station position is then stored in RMDB 311 for
distribution to the positioning clients 16 and optionally to
the data collectors 10).

Each of blocks 303, 304, 305 and 306 in Fig. 3, or some or
all of these blocks taken together, may be considered to
represent a generating/updating process that generates
and/or updates at least one model for the coverage area of
a base station. The functionality of all blocks 303, 304, 305
and 306 taken together is referred to as RMG process in this
specification.

In order to ensure that the coverage model and the pre-models
are robustly adapted when the related coverage area changes
(including moving, shrinking and disappearing of the coverage
area), it may be advantageous to have a process that
identifies and monitors potentially outdated reports and/or
potential outliers and removes them if it is found that the
reports are indeed outdated and/or outliers.

In the exemplary system of Fig. 1, a monitoring process (MON)
keeps running (e.g. continuously, periodically or
event-based) through the reports stored in RDB 13 and puts
reports with too old timestamps (which timestamps are for
instance assigned to the report upon reception), which are
then considered as potentially outdated, into monitoring
mode. This is accomplished by creating monitoring boxes for
the reports, with an expiry time some time in the future. The

associated coverage area is then also put into the RMG queue.
Any new report with a position hitting a monitor box will cause
the monitor box to be removed and the corresponding report's
timestamp to be updated to the current time. The timestamp
of a report therefore indicates when was the last time that
there was a report from (the vicinity) of the report's
position.

Furthermore, if any monitor box is detected to be past its
expiry time, it is removed together with its associated
report, and the associated coverage area is put into the RMG
queue. The monitoring process further triggers state
transitions of the state diagram, as will be explained with
reference to Fig. 4 below.

In the exemplary system of Fig. 1, in addition to the MON
process, which puts reports that are suspected to be outdated
into monitoring mode, also an outlier detection process is
implemented (as part of the RMG process), which may put
reports that are suspected to be outliers into monitoring
mode. Outlier detection is performed by checking new reports
against the old coverage area estimates and by putting
potential outliers directly into monitoring with a specific
expiry time. Therein, once a report is in monitoring mode,
the treatment is the same irrespective of which process (MON
or RMG/outlier detection) actually put the report into
monitoring mode.

In the exemplary system of Fig. 1, single potential outliers
are put in monitoring so that they disappear quickly (if their
monitoring boxes get no hits, so that they are considered to
be indeed outliers) unless they are verified by new reports

(if their monitoring boxes get one or more hits, so that they are considered to be no outliers, for instance when the coverage area has moved). In case of multiple (for instance more than a pre-defined threshold) potential outliers from different terminals (or, if it cannot be distinguished between terminals, having different timestamps i.e. coming from different upload batches (for instance if the reports are assigned the timestamps only in the server)), all the vertices of the polygon are put in monitoring and the coverage area is set to MOVING state, so that either the old positions or the new positions are quickly verified and the obsolete ones expire away.

For the exemplary system of Fig. 1, Fig. 4 illustrates an exemplary state transition diagram for the states of a state machine associated with a coverage area and the events from the MON and RMG processes that partially trigger the state transitions. Exemplarily an elliptical coverage model is assumed. The states of the state machine may for instance influence the amount of filtering in FPFR block 11, but also may influence whether a coverage model shall be updated and written to RMDB 15 or not and if a coverage area shall be removed from the system, to name but a few examples.

Initialization leads to the INITIAL state 400, i.e. there is a new coverage area to be determined, and all incoming reports may be stored (for instance, no filtering may then be performed in FPFR block 11). If monitoring reveals that there are no reports for the coverage area anymore, the state is changed to GHOST 401, i.e. there are no reports or all reports expired. If monitoring turns out that no changes occur in a pre-defined duration of time, the coverage area is removed.

If the state is INITIAL 400, and RMG reports that an elliptical
coverage model has been successfully generated, the new state
is MATURING. If monitoring now turns out that there are no
changes within a pre-defined duration of time (and the
coverage area is not in the RMG queue), the state is changed
to STABLE 403, and is only changed back to MATURING 402 in
case that the RMG process informs on changes in the coverage
area. Furthermore, if in state STABLE 403, the RMG process
informs that there are multiple potential outliers, the state
is changed to DUBIOUS 404. The same information causes also
a transition from state MATURING 402 to state DUBIOUS 404.

In state DUBIOUS 404, the elliptical coverage model is not
updated (see step 303 in Fig. 3), but it is indicated that
it might be wrong (for instance via the state of the state
machine in RMDB 15, see Table 1). From the DUBIOUS state 404,
a transition to state MATURING 402 is possible if the RMG
process reports that the coverage model is no longer
considered to be completely wrong (for instance since it
passed one or more sanity checks, for instance that the size
of the assumed coverage area is again within predefined
limits).

As already mentioned above, these states may be used in FPFR
block 11 of the exemplary system of Fig. 1 to perform
pre-filtering of terminal positions, based on pre-models.

Fig. 5 is an exemplary flowchart of such a pre-filtering
operation, wherein exemplarily an elliptical pre-model in
matrix-form is used. After a reported terminal position is
received (e.g. in a fingerprint from one of the data

collectors 10, see Fig. 1), it is checked in step 501 if this
terminal position is within a monitoring box. If this is the
case, in a step 502, the monitoring box is removed and the
timestamp of the report that is associated with the reported
terminal position is updated. The terminal position is then
stored in RDB 13 (see Fig. 1) in a step 503. If the terminal
position is not in a monitoring box (see step 501), the state
of the state machine is checked in step 504. If the state is
INITIAL or GHOST, the terminal position is stored to RDB 13
in step 503 without any checking. Otherwise (states are
MATURING, DUBIOUS or STABLE), it is checked if the terminal
position is already covered by the matrix-form elliptical
pre-model. If this is not the case, the terminal position is
stored in RDB 13 (step 503), and otherwise, the terminal
position is discarded in step 506. Both steps 503 and 506 lead
to step 507, where it is checked if the process shall be
aborted, and if this is not the case, the flowchart jumps back
to step 500.

Fig. 6 shows an exemplary embodiment of an apparatus 6
according to the present invention, which apparatus may for
instance be a terminal 10 (see Fig. 1) or a part thereof.
Apparatus 6 comprises a processor 60 that interfaces with a
program memory 61, a main memory 62, a communication unit 63
and a positioning unit 64.

Positioning unit 64 is configured to allow apparatus 6 to
perform positioning (i.e. determining its position), for
instance based on a satellite-based positioning system, such
as GNSS, and/or other positioning techniques (including for
instance fingerprint-based positioning techniques, but this
may not be preferred or only applied with due care since it

may induce circular reasoning into the exemplary system of
Fig. 1). Positioning unit 64 may also receive the position
information via a user interface of apparatus 6, for instance
if a user of a device that includes apparatus 6 enters the
position information, e.g. based on a map and/or on
characteristic landmarks. The positioning may for instance
be controlled by processor 60 and may for instance be
performed periodically or upon specific events (such as for
instance a request from a user of a device that comprises
apparatus 6 and/or from a request received from an external
unit, such as for instance a unit of a fingerprint collection
system).

Communication unit 63 is configured to allow processor 60 to
communicate with one or more devices. Communication unit 63
is for instance configured to enable apparatus 6 to exchange
data with base stations of one or more communications systems
or to at least receive data from base stations of one or more
communications systems. For instance, apparatus 6 may use
communication unit 63 to perform a sniffing operation to
determine which base stations (of the same or different
communication systems, including serving and neighboring
base stations) can presently be heard and to provide the
identifiers of these base stations (e.g. MAC IDs) and
optionally further parameters related to these base stations
to processor 60.

Communication unit 63 may also allow apparatus 6 to exchange
information with a fingerprint collection system such as the
exemplary fingerprint collection system of Fig. 1.

For instance, one or more coverage models, one or more
pre-models, a state of a state machine, and/or quality
measures for base station position estimates may be received
from such a fingerprint collection system via communication
unit 63, for instance from RMDB 15 (see Fig. 1 and Table 1).

Furthermore, fingerprints comprising a terminal position,
(usually) identifiers of one or more (serving or neighboring)
base stations, and optionally further parameters information
on distance(s) to the one or more base stations (e.g. TA and/or
Round Trip Delay (RTD) values and/or Received Signal Strength
(RSS) values) and/or one or more timestamps (which may for
instance reflect a time instance at which the position is
measured and/or the respective base station is heard) may be
sent to a fingerprint collection system via communication
unit 63. In a fingerprint, thus information pertaining to
coverage areas of several base stations (of the same or
different communications systems) can be reported.

Processor 60 controls communication unit 63 and positioning
unit 64 and is at least configured to determine (for instance
based on information received via communication unit 63 or
stored in main memory 62) whether at least one terminal
position (for instance obtained from positioning unit 64)
associated with a coverage area of a base station shall be
discarded or reported (for instance in a fingerprint via
communication unit 63) to allow at least one of said coverage
area and said base station to be characterized at least
partially based on said at least one reported terminal
position. Therein, the characterization of the coverage area
of the base station may for instance be performed by the RMG
process (see RMG block 14 of Fig. 1 and blocks 303-306 of Fig.

3) of the exemplary fingerprint collection system of Fig. 1,
and the characterization of the base station may for instance
be performed by the base station position estimation that is
part of the RMG process (see block 310 in Fig. 3), at least
partially based on the fingerprints sent 6 to FPFR block 11
(see Fig. 1).

Processor 60 may for instance run a computer program with
program code for determining, at a terminal, whether at least
one terminal position associated with a coverage area of a
base station shall be discarded or reported to allow at least
one of said coverage area and said base station to be
characterized at least partially based on said at least one
reported terminal position. This program code may for
instance be stored in program memory 61, which may be fixedly
attached in apparatus 6 or may be a removable memory. Main
memory 62 is used by processor 60 as a working memory, for
instance to store intermediate results and variables.

Apparatus 6 may for instance be entirely implemented as a
module that may for instance be integrated into a data
collector 10 (see Fig. 1). Apparatus 6 may for instance be
entirely implemented as a circuit on a semiconductor chip.
Apparatus 6 may for instance be entirely implemented on a
Digital Signal Processor (DSP), Application Specific
Integrated Circuit (ASIC) or Field Programmable Gate Array
(FPGA), to name but a few examples.

Fig. 7 is schematic illustration of an exemplary embodiment
of a tangible storage medium 70 according to the present
invention. Tangible storage medium 70 may for instance store
a computer program 71 with program code 72 for determining

whether at least one terminal position associated with a
coverage area of a base station shall be discarded or reported
to allow at least one of said coverage area and said base
station to be characterized at least partially based on said
at least one reported terminal position. Tangible storage
medium 70 is a readable medium, for instance a
computer-readable or processor-readable medium.
Accordingly, the computer program 71 stored on tangible
storage medium 70 may be executable by a computer or a
processor. Tangible storage medium 70 may for instance be
embodied as an electric, magnetic, electro-magnetic, optic
or other tangible storage medium, and may either be a
removable medium or a medium that is fixedly installed in an
apparatus or device, such as for instance apparatus 6 of Fig.
6.

Figs. 8-13 are flowcharts of exemplary embodiments of methods
according to the present invention. These flowcharts may for
instance be implemented as computer programs that are stored
in program memory 63 of apparatus 6 (see Fig. 6).
Consequently, these flowcharts may be executed by processor
60 of apparatus 6. Equally well, these flowcharts may be
implemented as program code 72 of computer program 71 stored
on tangible storage medium 70 (see Fig. 7).

In the flowchart of Fig. 8, in a first step 800, a terminal
position is obtained, for instance via positioning unit 64
of apparatus 6 (see Fig. 6). This terminal position is
associated with a coverage area of a base station, it is for
instance within or at least assumed to be within this coverage
area. In step 801, it is then determined if the terminal
position shall be reported or discarded. This determining may

be based on various types of information, such as a coverage
model, a history of terminal positions, a state of a state
machine and/or a quality of a base station position estimate,
to name but a few non-limiting examples. If the determining
is positive, the terminal position is considered to be
potentially significant for the characterization of the
coverage area, and is reported in a step 802 via communication
unit 63 of apparatus 6 (see Fig. 6), for instance in a
fingerprint.

Into this fingerprint, usually also an identifier of the base
station is included, for instance if this information can not
be determined/reconstructed by a unit that receives the
fingerprint. Alternatively, for instance, if the fingerprint
is sent by the terminal to its serving base station and the
fingerprint is either analyzed by this communication system
itself or forwarded to a fingerprint collection system, and
if the terminal is configured to report its position only to
its serving base station, the identification of this serving
base station may be added to or associated with the
fingerprint by the serving base station (or another network
node of the communication system) so that this information
is available for processing of the fingerprint.

If the determining in step 801 is negative, the terminal
position (and also the further optional parameters) is
considered insignificant for the characterization of the
coverage area and is discarded in a step 803 (for instance
by deleting the terminal position). The flowchart then
proceeds to step 804, where it is checked if the process shall
be aborted. If this is not the case, the flowchart jumps back
to step 800. Otherwise, the process terminates.

In this way, the amount of terminal positions that have to
be considered in the process of characterizing the coverage
area (such as for instance the RMG process that
generates/updates models for the coverage area of the base
station in the exemplary fingerprint collection system of
Fig. 1) as well as the transmission resources (such as
bandwidth and power) can be reduced.

It should be noted that a terminal position can be associated
with coverage areas of several base stations at the same time.
In the flowchart of Fig. 8, for the sake of simplicity of
presentation, it is exemplarily assumed that the terminal
position is only associated with one coverage area/base
station, so that the determining in step 801 and the reporting
in step 802 or the discarding in step 803 is performed with
respect to a single coverage area/base station.

If a terminal position is associated with several coverage
areas/base stations, then step 801 may be understood to be
executed for each of these coverage areas/base stations, and
the reporting in step 802 may be understood to represent that
for each coverage area/base station, for which the
determining in step 801 is positive, the corresponding base
station identifier is included into a fingerprint that
further includes the terminal position (and optionally
further parameters) and that is reported when step 801 has
been performed for all coverage areas/base stations the
terminal position is associated with.

An analogous extension from a single coverage area/base
station per terminal position to several coverage areas/base

stations per terminal position also applies to the flowcharts
of Figs. 9-13 described below.

Fig. 9 illustrates a flowchart of a further exemplary
embodiment of a method according to the present invention.

In a first step 902, a terminal position is obtained, as
already explained with respect to step 800 in Fig. 8. In step
903, it is then determined if the terminal position is already
covered by a modified coverage model. Therein, if the modified
coverage model describes a hard boundary, the terminal
position may for instance be considered to be covered by the
modified coverage model if it is within the area defined by
the modified coverage model.

If the checking in step 903 is positive, the terminal position
is considered insignificant for the characterization of the
coverage area (e.g. the generating/updating of models for the
coverage area of the base station as for instance performed
by the RMG process of the exemplary fingerprint collection
system of Fig. 1), and is discarded in step 904. Otherwise,
the terminal position may be reported in a fingerprint (for
instance via communication unit 63 of the apparatus 6 of Fig.
6), for instance to FPFR block 11 of Fig. 1. In the exemplary
flowchart of Fig. 9, before reporting the terminal position,
it is furthermore (and optionally) checked in step 905 if the
terminal position is a potential outlier. The terminal
position may for instance be considered a potential outlier
if its distance towards the coverage model (i.e. the assumed
coverage area of the base station) exceeds a pre-defined
threshold. If this is the case, the terminal position is

reported with a potential-outlier-flag (e.g. a one-bit word)
set, see step 907. Otherwise, the terminal position may be
reported without such a flag being set in step 906.

Classifying the terminal position as a potential outlier may
allow simplifying or even saving the outlier detection
process implemented in the exemplary fingerprint collection
system of Fig. 1 (see for instance block 302 in Fig. 3).
Terminal positions classified as potential outliers by a
terminal may then for instance directly be put into monitoring
upon reception by FPFR block 11 of Fig. 1, which may contribute
to speed up the detection of potential outliers. Depending
on the frequency of updating of the (modified) coverage model
in the terminal, it may however be the case that the outlier
detection process implemented in the exemplary fingerprint
collection system of Fig. 1 uses newer models and thus makes
different decisions compared to the terminal.

After any of steps 904, 906 or 907, it is checked if the process
shall be aborted, and only if this is not the case, the
flowchart jumps back to step 902.

The modified coverage model used in step 903 of the flowchart
of Fig. 9 may for instance be derived based on a coverage model
that may for instance have been received from RMDB 15 of Fig.
1 (for instance via communication interface 63 of apparatus
6 of Fig. 6). This coverage model may for instance be an
elliptical coverage model, for instance an axis/angle-form
ellipse, or a model derived from such an axis/angle-form
ellipse that may contain further parameters. This coverage
model may then be modified to obtain the modified coverage
model. The modified coverage model may for instance be

obtained by scaling the coverage model. If the coverage model
is an elliptical model, the scaling may for instance be
performed by reducing (or increasing) the length of the major
and/or minor semi-axis of the ellipse described by the
elliptical model. For instance, both axes may be modified by
multiplying it with the same factor (that is different from
1.0). In more general terms, the scaling may be performed by
reducing (factor smaller than 1.0) (or increasing, factor
greater than 1.0) the area of a geometrical object that is
described by a coverage model. Therein, the modified coverage
model may be stored in apparatus 6 of Fig. 6 or not.

Modifying the original coverage model by reducing the area
of the geometrical object that is described by the coverage
model, although slightly increasing the number of reported
terminal positions that may actually be considered to be
insignificant for the characterization of the coverage area,
may nevertheless be necessary so that filtering of terminal
positions does not interfere with monitoring of potentially
outdated positions and/or potential outliers, as described
with reference to the exemplary fingerprint collection system
of Fig. 1 above (see the description of the MON process). For
instance, if instead of the modified coverage model, the
original (unmodified) coverage model was used, the filtering
in step 903 might have the effect that only those parts of
monitor boxes that are outside the coverage model would get
hits. Such hits may however not occur at all if the coverage
model already forms an accurate boundary of the coverage area
(as for instance in the STABLE state). The factor by which
the area described by the modified coverage area is smaller
than the area of the original coverage area may for instance
depend on the size of the monitor boxes used in monitoring.

If this size is variable, the factor may for instance be chosen based on the maximum possible size of a monitoring box.

It should be noted that, instead of modifying the coverage model, in apparatus 6 (e.g. a data collector 10 of Fig. 1), the modified coverage model may also be determined by a unit that is different from apparatus 6, for instance by RMG block 14 in the exemplary system of Fig. 1, and then be sent to apparatus 6. Furthermore, if the coverage model is an elliptical model, and if the determining step 903 has to be performed rather frequently with respect to the update rate of the coverage model, it may be advantageous to use a matrix-form ellipse in step 903, since the matrix-form allows to determine if a terminal position is covered by the model with less operations than an axis/angle-form model. If the coverage model provided is in axis/angle-form, this transformation to matrix-form may for instance be performed together with the modification. If already the modified elliptical model is provided to apparatus 6, it may be advantageous to perform the transformation to matrix-form only in apparatus 6, since the parameters of the axis/angle-form model may require less bandwidth for transmission than the parameters of the matrix-form model.

Furthermore, it should be noted that a modification of the coverage model used for filtering is not necessary in the flowchart of Fig. 5, which describes filtering in the FPFR block 11 of the exemplary system of Fig. 1, since there, monitoring boxes are checked in step 501 before any potential filtering is performed (see step 506).

Consequently, when integrating the checking if a terminal
position is inside a monitoring box (see step 501 of Fig. 5)
into the flowchart of Fig. 9, modification of the coverage
model may no longer be necessary, and the unmodified coverage
model that reflects the assumed coverage area could be used
for checking in step 903 of the flowchart of Fig. 9. This may
of course require that the monitoring boxes are transferred
to apparatus 5 (that implements the flowchart of Fig. 9), and
that apparatus 5 is further capable of signaling that a
monitoring box shall be removed and the timestamp of the
associated report shall be updated if a monitoring box got
a hit.

Fig. 10 illustrates a flowchart of a further exemplary
embodiment of a method according to the present invention.

Therein, step 1002 corresponds to step 902 of the flowchart
of Fig. 9, respectively. In the flowchart of Fig. 10, the
determining whether a terminal position should be discarded
or reported does not only dependent on a (modified) coverage
model, but furthermore on a state of a state machine
associated with the process of characterizing the coverage
area (e.g. the state machine associated with the RMG process
for a coverage area in the exemplary fingerprint collection
system of Fig. 1, see Fig. 4). This state may for instance
be received via communication unit 63 of the apparatus 6 of
Fig. 6, for instance from RMDB 15 of Fig. 1.

In a state 1003, if the state is found to be INITIAL or GHOST,
the terminal position is reported in a step 1004 (for instance
with further parameters such as an identifier of the base
station). This may reflect that any terminal position is

considered to be significant for the current state of the RMG process.

If the state is STABLE, DUBIOUS or MATURING, it is checked in step 1004 if the terminal position is already covered by a modified coverage model (which may for instance be derived from a coverage model as already described in the context of Fig. 9 above). If this is not the case, the terminal position is again reported in step 1004; otherwise, the terminal position is discarded in step 1006.

After steps 1004 or 1006, it is checked in step 1007 if the process shall be aborted, and only if this is not the case, the flowchart jumps back to step 1002.

The terminal-side filtering according to the flowcharts of Figs. 9 and 10 may for instance allow reducing the amount of information that has to be transferred to and considered in the RMG process of the system of Fig. 1. It may furthermore allow simplifying or even saving filtering of incoming fingerprints in the FPFR block 11 of the exemplary fingerprint collection system of Fig. 1, depending on how much of this filtering is outsourced to apparatus 6 (e.g. data collector 10 of Fig. 1).

Fig. 11 illustrates a flowchart of a further exemplary embodiment of a method according to the present invention.

In a first step 1100, a terminal position associated with a coverage area is obtained, as already explained with reference to step 800 of Fig. 8 above. In a step 1101, it is then checked if the terminal position is in the environment

of any terminal position contained in a terminal position
history for this coverage area, which may for instance be
maintained in main memory 62 of the apparatus 6 (see Fig. 6)
and may store all terminal positions reported for this
coverage area so far, or all terminal positions reported for
this coverage area in a specific (e.g. pre-defined or
dynamically adapted) time interval. The coverage area may for
instance be identified by a specific identifier, such as for
instance a base station identifier. The environment may for
instance be a pre-defined environment, which may for instance
be represented by an area of pre-defined shape and size around
each terminal position in the terminal position history. The
size of the area may equally well be adapted dynamically, for
instance according to an information need of the process for
characterizing the coverage area (e.g. the process of
generating/updating models for the coverage area of the base
station such as the RMG process of the exemplary fingerprint
collection system of Fig. 1). The minimum size of the
environment may for instance be determined by the resolution
of the positioning of the terminal and/or the resolution of
the process for characterizing the coverage area.

If the determining in step 1101 is positive, the terminal
position is discarded in step 1102, and otherwise, in a step
1103, the terminal position is reported, for instance in a
fingerprint (with further parameters such as for instance an
identifier of the base station), and for instance to FPFR
block 11 of the exemplary system of Fig. 1. In this step,
furthermore the terminal position (and its associated further
parameters, if present) is stored in the terminal position
history for this coverage area so that it can be considered
in the next determining in step 1101.

After steps 1102 or 1103, it is checked if the process shall
be aborted, and only if this is not the case, the flowchart
jumps back to step 1100.

Filtering the terminal positions in the terminal based on a
(coverage-area-specific) terminal position history may
account for the fact that users of data collectors 10 (see
Fig. 1) may follow the same patterns from day to day - for
instance, the same route every day to work, the same route
every day to the supermarket. Therefore, it may be expected
that a given user of a data collector collects the same data
a high fraction of the time. Thus, storing the history of
terminal positions already reported for a coverage area in
a data collector 10 may allow for filtering out redundant
terminal positions that then do not get reported to the
server. Since the terminal position history is specific for
a coverage area (which may for instance be identified by the
base station identifier), also cases like assignment of new
identifiers to base stations can be handled (a new base
station identifier has no history so far, so that terminal
positions will be reported for its associated coverage area).

Fig. 12 is a flowchart of a further exemplary method according
to the present invention.

In a first step 1200, a terminal position and a distance to
the base station are obtained, for instance from positioning
unit 64 of apparatus 6 (see Fig. 6). These values may for
instance be periodically determined, or may be determined in
response to a specific event, such as a request. Therein, the

distance to the base station may for instance be represented by a TA, RTD or RSS value.

In step 1201, it is then determined if a base station position estimate is of good quality. Such a position of a base station may for instance be estimated as a characterization of the base station by the RMG process of the exemplary fingerprint collection system of Fig. 1 (see step 310 of Fig. 3 and appendix A.2), based on a plurality of terminal positions and respective distances to the base station. This estimation of the base station position may for instance also produce a quality value for the base station position estimate, such as for instance the covariance matrix. The determining in step 1201 may for instance be based on this covariance matrix, or on a bad-quality-flag (e.g. a 1-bit word) derived from it (for instance by setting the bad-quality flag if the variance is above a pre-defined absolute or relative threshold or, for instance, large residuals were detected in the base station position estimation or, for instance, the estimate did not pass some other statistical test including the χ^2-test for the sum of the squared residuals). Consequently, the measure on which the determining in step 1201 is based has to be made available to apparatus 6, for instance via its communication unit 63. This measure may for instance be stored in RMDB 15 (see Fig. 1).

If the determining in step 1201 is positive, it is considered that there is no need to report further terminal positions to improve the base station estimate, and the terminal position and the distance to the base station are discarded in step 1202. Otherwise, it is considered that there is a need to report further terminal positions to allow the base station

estimate to be improved, and the terminal position and the distance to the base station are reported in step 1203 (e.g. in a fingerprint, optionally with further parameters such as an identifier of the base station).

After steps 1202 or 1203, it is checked if the process shall be aborted in step 1204, and only if this is not the case, the flowchart jumps back to step 1200.

It is readily clear that the exemplary method described with reference to Fig. 12 can be used for a system that only estimates the positions of base stations, but does not necessarily have to determine models for the coverage area of the base station. Nevertheless, this method can seamlessly be integrated with a system that also determines models for the coverage area of a base station, as will now be explained with reference to Fig. 13.

Fig. 13 is a flowchart of an exemplary method according to the present invention, and combines aspects of the flowcharts of Figs. 9 and 12.

In a first step 1302, a new terminal position and, if available, a distance to the base station is obtained.

It is then determined in step 1303 if the terminal position is covered by a modified coverage model (which may for instance be derived from a coverage model as already described with reference to Fig. 9 above), as in step 903 of the flowchart of Fig. 9. If this is not the case, the terminal position and the distance to the base station are reported in a fingerprint. Otherwise, the information could actually

be discarded. However, according to the flowchart of Fig. 13, it is checked if the information should nevertheless be reported to improve the base station position estimate.

To this end, in step 1305, it is checked if the distance to the base station is available. If this is the case, it is further checked in a step 1307 if the base station position estimate is of low quality, as discussed with reference to step 1201 of Fig. 12 above. If this is not the case (i.e. the base station position estimate is of good quality), the terminal position and the distance are discarded. Otherwise, it is considered that the terminal position and the distance should contribute to improve the base station position estimate, and both parameters are reported in a fingerprint.

After steps 1304, 1306 or 1308, it is checked if the process shall be aborted, and only if this is not the case, the flowchart jumps back to step 1302.

The concept of state-dependent filtering in the terminal, as exemplarily shown in the flowchart of Fig. 10, may equally well be introduced into the flowchart of Fig. 13, for instance by adding a checking of the state (as in step 1003 of Fig. 10) between steps 1302 and 1303 of Fig. 13, proceeding to step 1303 only in case of the state being, for example, MATURING, DUBIOUS or STABLE, and proceeding to step 1304 otherwise. The following appendix describes exemplary algorithmic details of the present invention and is to be understood as part of the disclosure.

Appendix A.1: Coordinate and ellipse conversions

Straight lines on Earth are defined as those following the great circles (i.e. the circles on the surface of the earth dividing the Earth into two equal hemisphere so that the centre of the Earth lies on the plane defined by the great circles), and there is a difference between them and the straight lines in geodetic coordinates. These are luckily negligible for small coverage areas. At latitudes less than 80°, this error is less than 3 m for coverage areas with 5 km diameter, and less than 150 m for coverage area with 35 km diameter.

At latitude ϕ, the length of one meter in East/North directions in degrees is:

$$s_E(\phi) = \frac{180}{\pi} \frac{\sqrt{1 - e^2 \sin(\phi)^2}}{a \cos(\phi)} \text{ degrees/meter}$$

$$s_N(\phi) = \frac{180}{\pi} \frac{\left(1 - e^2 \sin(\phi)^2\right)^{\frac{3}{2}}}{a\left(1 - e^2\right)} \text{ degrees/meter},$$

where a and e are the WGS-84 semi-major axis and eccentricity of Earth.

Then a local conversion from 2D geodetic coordinates (ϕ, λ) to Cartesian East-North coordinates (x, y) with origin at (ϕ_0, λ_0) is

$$\begin{bmatrix} x \\ y \end{bmatrix} = M \begin{bmatrix} \phi - \phi_0 \\ \lambda - \lambda_0 \end{bmatrix}$$

where

$$M = \begin{bmatrix} 0 & s_E^{-1}(\phi_0) \\ s_N^{-1}(\phi_0) & 0 \end{bmatrix},$$ (1)

Conversion between axis/angle-form and matrix-form ellipses

The centers of the axis/angle-form and the matrix-form ellipses are the same. Given an axis/angle-form ellipse with semi-axes with radii r_1 and r_2 (in meters), and clock-wise angle θ between first semiaxis and North, the corresponding matrix form is

$$A = M^T \begin{bmatrix} sin(\theta) & cos(\theta) \\ cos(\theta) & -sin(\theta) \end{bmatrix} \begin{bmatrix} r_1^{-2} & 0 \\ 0 & r_2^{-2} \end{bmatrix} \begin{bmatrix} sin(\theta) & cos(\theta) \\ cos(\theta) & -sin(\theta) \end{bmatrix} M.$$ (2)

Conversely, given the matrix A, the corresponding semiaxis lengths and rotation angle of the axis/angle-form ellipse are

$$r_1 = \sqrt{first\ eigenvalue\ of\ M\ A^{-1} M^T}$$

$$r_2 = \sqrt{second\ eigenvalue\ of\ M\ A^{-1}\ M^T}$$

$$\theta = atan2(v_1, v_2)$$

where v is the eigenvector of $M A^{-1} M^T$ corresponding to its first eigenvalue, and the atan2-function denotes the arc tangent taking the quadrants into account.

Appendix A.2: Base station position estimation

The base station position may for instance be estimated in the RMG block 14 (see Fig. 1) from the terminal positions and

associated distances to the base station, such as for instance
TA measurements. The resolution of 550 m in TA range
measurement may place severe penalty on the accuracy, which
may be of the order of 50-100 m even in ideal cases. The
relationship between distance and TA measurement is
illustrated in Fig. 14.

Let the initial base station position estimate be x_0 and its
covariance matrix C_0. These can be obtained form a previous
calculation. Alternatively, the initial position x_0 may for
example be an average of the terminal positions. The elements
of C_0 can then be set to some suitable large value.

The base station position as well as the terminal positions
are exemplarily assumed to be in geodetic WGS-84 coordinates,
and they then have to be converted to Cartesian coordinates
for distance computations. This is done by multiplying with
matrix M (see equation (1) in appendix A.1 above) at proper
places.

The resulting Gauss-Newton iteration for computing the base
station position x and its covariance C from n measurements
(with n, in this context, denoting the vertices of the polygon
stored in RDB 13 of Fig. 1) is:

1. $x \leftarrow x_0$

2. $R = \begin{bmatrix} \sigma_1^2 & & & \\ & \ddots & & \\ & & \sigma_n^2 & \\ & & & C_0 \end{bmatrix}$,

where σ_i^2 is the variance of the ith TA measurement y_i.

3. $d_i = M(p_i - x)$,

   where d_i is the unit vector from the base station position estimate x to the i-th terminal position p_i.

4. $f = \begin{bmatrix} y_1 - \|d_1\| \\ \vdots \\ y_n - \|d_n\| \\ x - x_0 \end{bmatrix}$

   (the innovation vector, with y_i denoting the i-th TA measurement)

   $J = \begin{bmatrix} \dfrac{d_1^T}{\|d_1^T\|} M^T \\ \vdots \\ \dfrac{d_n^T}{\|d_n^T\|} M^T \\ I \end{bmatrix}$

   (the Jacobian matrix of partial derivatives)

5. $\Delta x \leftarrow -(J^T R^{-1} J)^{-1} J^T R^{-1} f$. Note that the matrix $(J^T R^{-1} J)$ might be numerically singular because of e.g. collinear geometry of the reports. In this case, return with a failure.

6. $x \leftarrow x + \Delta x$

7. Repeat from 3. until convergence (e.g. $\|\Delta x\|$ below a pre-determined threshold) or until a (pre-defined) maximum number of iterations has been reached.

8. Finally, check the magnitude of the residual $f^T R^{-1} f$ against some critical value α of the inverse of the cumulative χ^2-distribution with n degrees of freedom. If the residual is small enough, set the covariance of the base station position to

   $C \leftarrow (J^T R^{-1} J)^{-1}$ and return x and C.

It is readily clear for a person skilled in the art that the logical blocks in the schematic block diagrams as well as the flowchart and algorithm steps presented in the above description and its appendices may at least partially be implemented in electronic hardware and/or computer software, wherein it may depend on the functionality of the logical block, flowchart step and algorithm step and on design constraints imposed on the respective devices to which degree a logical block, a flowchart step or algorithm step is implemented in hardware or software. The presented logical blocks, flowchart steps and algorithm steps may for instance be implemented in one or more digital signal processors (DSPs), application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs) or other programmable devices. The computer software may be stored in a variety of computer-readable storage media of electric, magnetic, electro-magnetic or optic type and may be read and executed by a processor, such as for instance a microprocessor. To this end, the processor and the storage medium may be coupled to interchange information, or the storage medium may be included in the processor.

The invention has been described above by means of embodiments, which shall be understood to be exemplary and non-limiting. In particular, it should be noted that there are alternative ways and variations which are obvious to a skilled person in the art and can be implemented without deviating from the scope and spirit of the appended claims. It should also be understood that the sequence of all method steps presented above is not mandatory, also alternative

sequences may be possible.

CLAIMS

1.   An apparatus comprising:

     - a processor configured to determine, at a terminal,
       whether at least one terminal position associated with
       a coverage area of a communication node shall be
       discarded or reported to allow at least one of said
       coverage area and said communication node to be
       characterized at least partially based on said at least
       one reported terminal position.

2.   The apparatus according to claim 1, wherein said
      determining whether said at least one terminal position
      shall be discarded or reported is at least partially
      based on at least one of a model for said coverage area
      of said communication node and a modified model for said
      coverage area of said communication node that is
      obtained by modifying said at least one model for said
      coverage area of said communication node.

3.   The apparatus according to claim 2, wherein said model
      for said coverage area of said communication node is
      derived, as a characterization of said coverage area,
      from one or more terminal positions associated with said
      coverage area of said communication node and reported
      by one or more terminals.

4.   The apparatus according to any of the claims 2-3, wherein
      said at least one terminal position is determined to be
      discarded if it is covered by at least one of said model

for said coverage area of said communication node and said modified model.

5.   The apparatus according to any of the claims 2-4, wherein said modified model for said coverage area of said communication node is a scaled representation of said at least one model for said coverage area of said communication node.

6.   The apparatus according to any of the claims 2-5, wherein said processor is further configured to determine a mismatch between said at least one terminal position and one of said model for said coverage area of said communication node and said modified model and to report an indication of such a mismatch.

7.   The apparatus according to any of the claims 1-6, wherein said determining whether said at least one terminal position shall be discarded or reported is at least partially based on information on terminal positions that have been reported by said terminal before.

8.   The apparatus according to claim 7, wherein said at least one terminal position is discarded if it is in a respective defined environment of any terminal position of a defined set of terminal positions that have been reported before.

9.   The apparatus according to any of the claims 1-8, wherein it is determined whether said at least one terminal position and information on a distance between said at least one terminal position and said communication node

shall be discarded or reported, and wherein said
determining is at least partially based on information
on a quality of an estimate of a position of said
communication node.

10. The apparatus according to claim 9, wherein said
position of said communication node is estimated, as a
characterization of said communication node, based on
one or more terminal positions and respective
information on the distance between the terminal
positions and the communication node reported by one or
more terminals.

11. The apparatus according to any of the claims 9-10,
wherein said at least one terminal position and said
information on said distance between said at least one
terminal position and said communication node is
determined to be reported if said quality of said
estimate of said position of said communication node is
considered low according to a defined criterion.

12. The apparatus according to any of the claims 1-11,
wherein said determining whether said at least one
terminal position shall be discarded or reported is at
least partially based on a state of a process for
characterizing said coverage area of said communication
node at least partially based on one or more terminal
positions reported by one or more terminals.

13. The apparatus according to any of the claims 1-12,
further comprising a transmitter for reporting said at

least one terminal position in case it is determined that said at least one terminal position shall be reported.

14. The apparatus according to any of the claims 1-13, wherein, in case it is determined that said at least one terminal position shall be reported, said at least one terminal position is reported as a fingerprint that further comprises an identifier of said communication node.

15. The apparatus according to claims 14, wherein said fingerprint further comprises an identifier of another communication node for which it is determined that said terminal position shall be reported to allow at least one of a coverage area of said other communication node and said other communication node to be characterized at least partially based on said at least one reported terminal position.

16. The apparatus according to any of the claims 1-15, wherein said apparatus is a module.

17. The apparatus according to any of the claims 1-15, wherein said apparatus further comprises a user interface.

18. The apparatus according to any of the claims 1-15 and 17, wherein said apparatus is a portable electronic communication device.

19. A method comprising:

- determining, at a terminal, whether at least one terminal position associated with a coverage area of a communication node shall be discarded or reported to allow at least one of said coverage area and said communication node to be characterized at least partially based on said at least one reported terminal position.

20. The method according to claim 19, wherein said determining whether said at least one terminal position shall be discarded or reported is at least partially based on at least one of a model for said coverage area of said communication node and a modified model for said coverage area of said communication node that is obtained by modifying said at least one model for said coverage area of said communication node.

21. The method according to claim 20, wherein said model for said coverage area of said communication node is derived, as a characterization of said coverage area, from one or more terminal positions associated with said coverage area of said communication node and reported by one or more terminals.

22. The method according to any of the claims 20-21, wherein said at least one terminal position is determined to be discarded if it is covered by at least one of said model for said coverage area of said communication node and said modified model.

23. The method according to any of the claims 20-22, wherein said modified model for said coverage area of said

communication node is a scaled representation of said
at least one model for said coverage area of said
communication node.

24.   The method according to any of the claims 20-23, further
        comprises:
-       determining a mismatch between said at least one
        terminal position and one of said model for said coverage
        area of said communication node and said modified model
        and
-       reporting an indication of such a mismatch.

25.   The method according to any of the claims 19-24, wherein
        said determining whether said at least one terminal
        position shall be discarded or reported is at least
        partially based on information on terminal positions
        that have been reported by said terminal before.

26.   The method according to claim 25, wherein said at least
        one terminal position is discarded if it is in a
        respective defined environment of any terminal position
        of a defined set of terminal positions that have been
        reported before.

27.   The method according to any of the claims 19-26, wherein
        it is determined whether said at least one terminal
        position and information on a distance between said at
        least one terminal position and said communication node
        shall be discarded or reported, and wherein said
        determining is at least partially based on information
        on a quality of an estimate of a position of said
        communication node.

28. The method according to claim 27, wherein said position of said communication node is estimated, as a characterization of said communication node, based on one or more terminal positions and respective information on the distance between the terminal positions and the communication node reported by one or more terminals.

29. The method according to any of the claims 27-28, wherein said at least one terminal position and said information on said distance between said at least one terminal position and said communication node is determined to be reported if said quality of said estimate of said position of said communication node is considered low according to a defined criterion.

30. The method according to any of the claims 19-29, wherein said determining whether said at least one terminal position shall be discarded or reported is at least partially based on a state of a process for characterizing said coverage area of said communication node at least partially based on one or more terminal positions reported by one or more terminals.

31. The method according to any of the claims 19-30, further comprising:
    - reporting said at least one terminal position in case it is determined that said at least one terminal position shall be reported.

32.   The method according to any of the claims 19-21, wherein,
      in case it is determined that said at least one terminal
      position shall be reported, said at least one terminal
      position is reported as a fingerprint that further
      comprises an identifier of said communication node.

33.   The method according to claims 32, wherein said
      fingerprint further comprises an identifier of another
      communication node for which it is determined that said
      terminal position shall be reported to allow at least
      one of a coverage area of said other communication node
      and said other communication node to be characterized
      at least partially based on said at least one reported
      terminal position.

34.   A program comprising:
-     program code for performing the method according to any
      of the claims 19-33, when said program is executed on
      a processor.

35.   A readable medium having a program according to claim
      34 stored thereon.

Fig. 1

Fig. 2

3/13

Fig. 3

Fig. 4

5/13

Receive reported terminal position ⌐500

Inside a monitoring box? ⌐501

Yes

No

State? ⌐504

502

Remove the monitoring box and update timestamp of the associated report

INITIAL, GHOST

MATURING, DUBIOUS, STABLE

Terminal position already covered by matrix-form ellipse? ⌐505

No

Yes

Store terminal position in RDB

503

506

Discard terminal position

No

Abort? ⌐507

Yes

Fig. 5

6/13
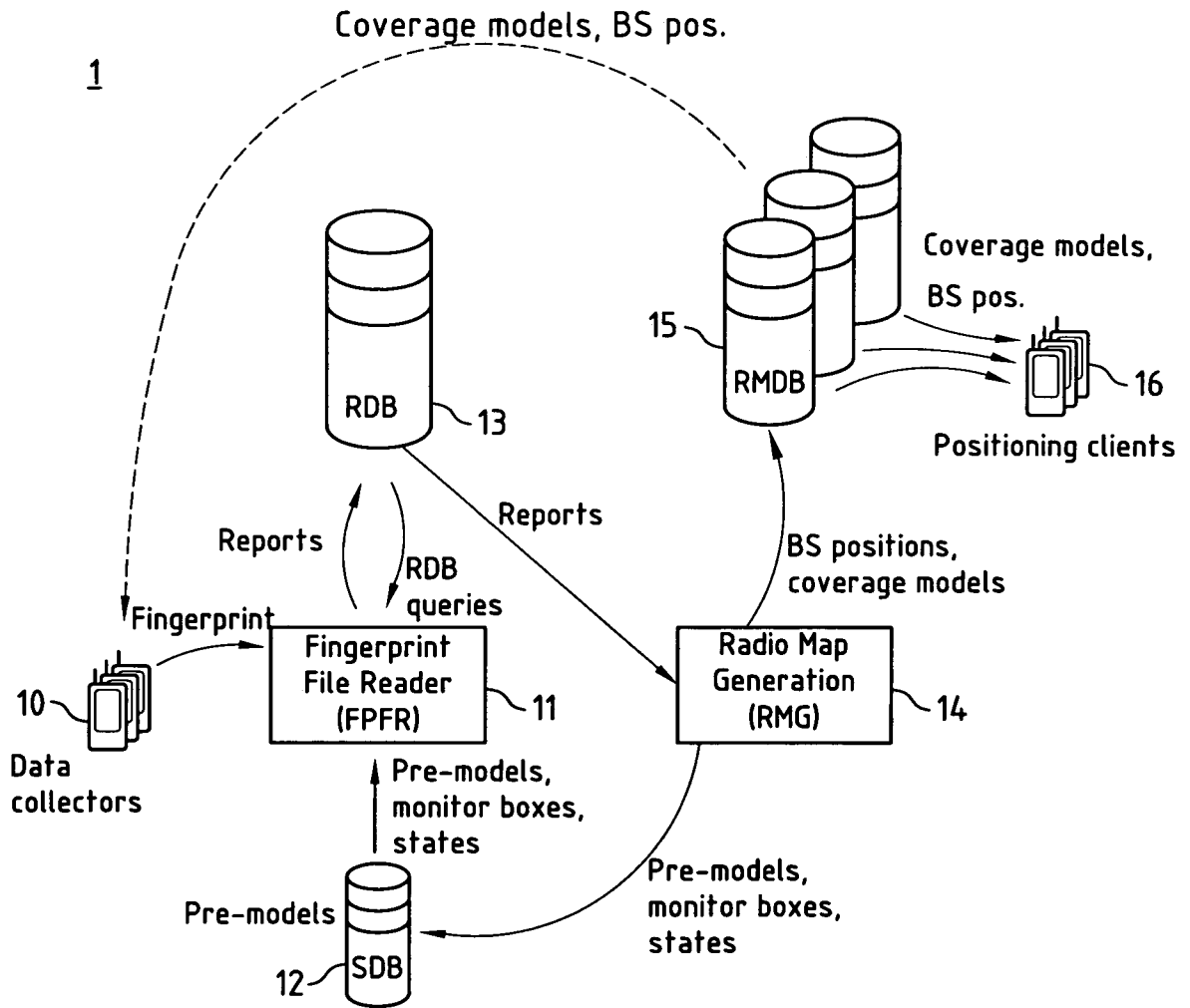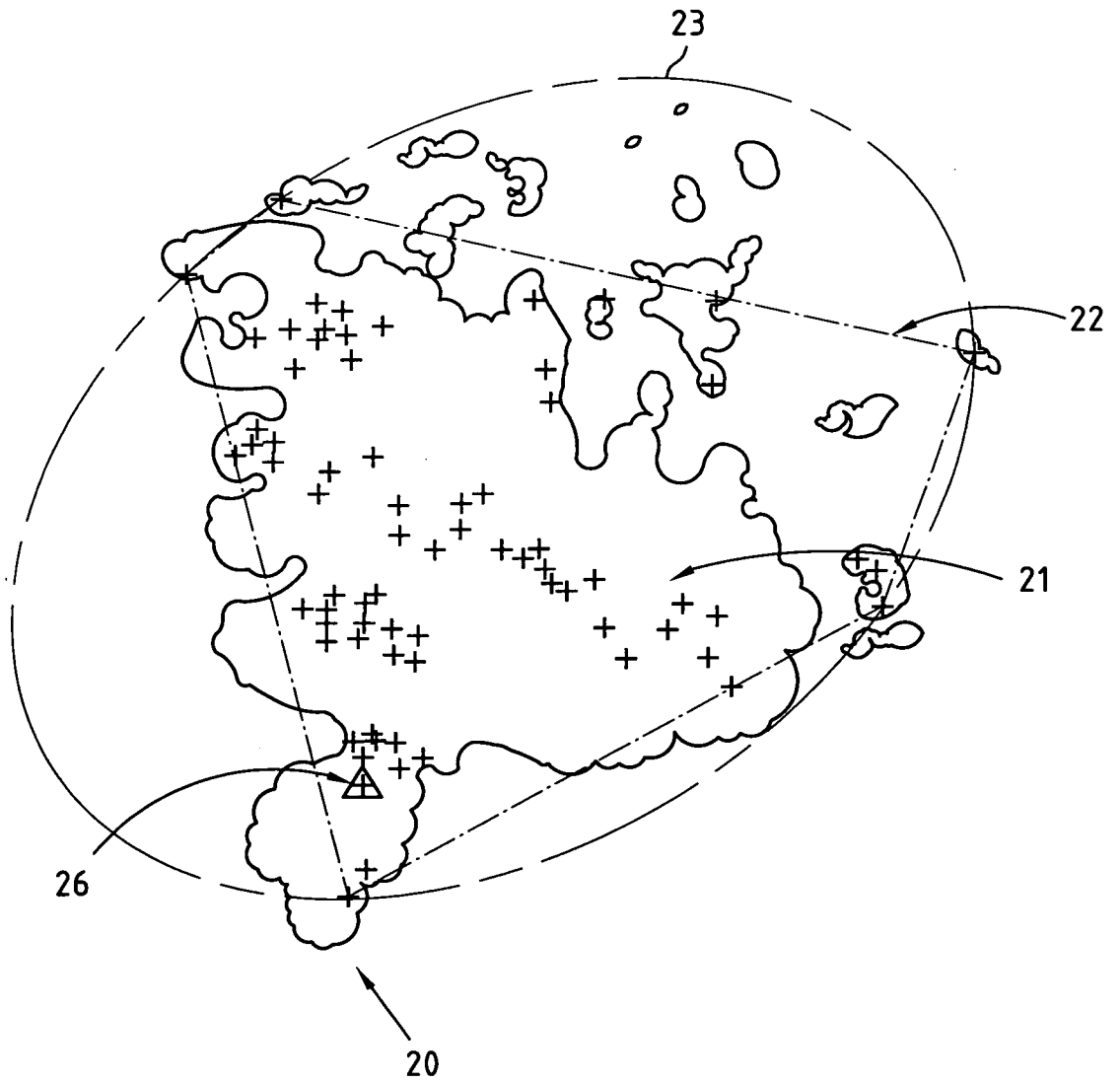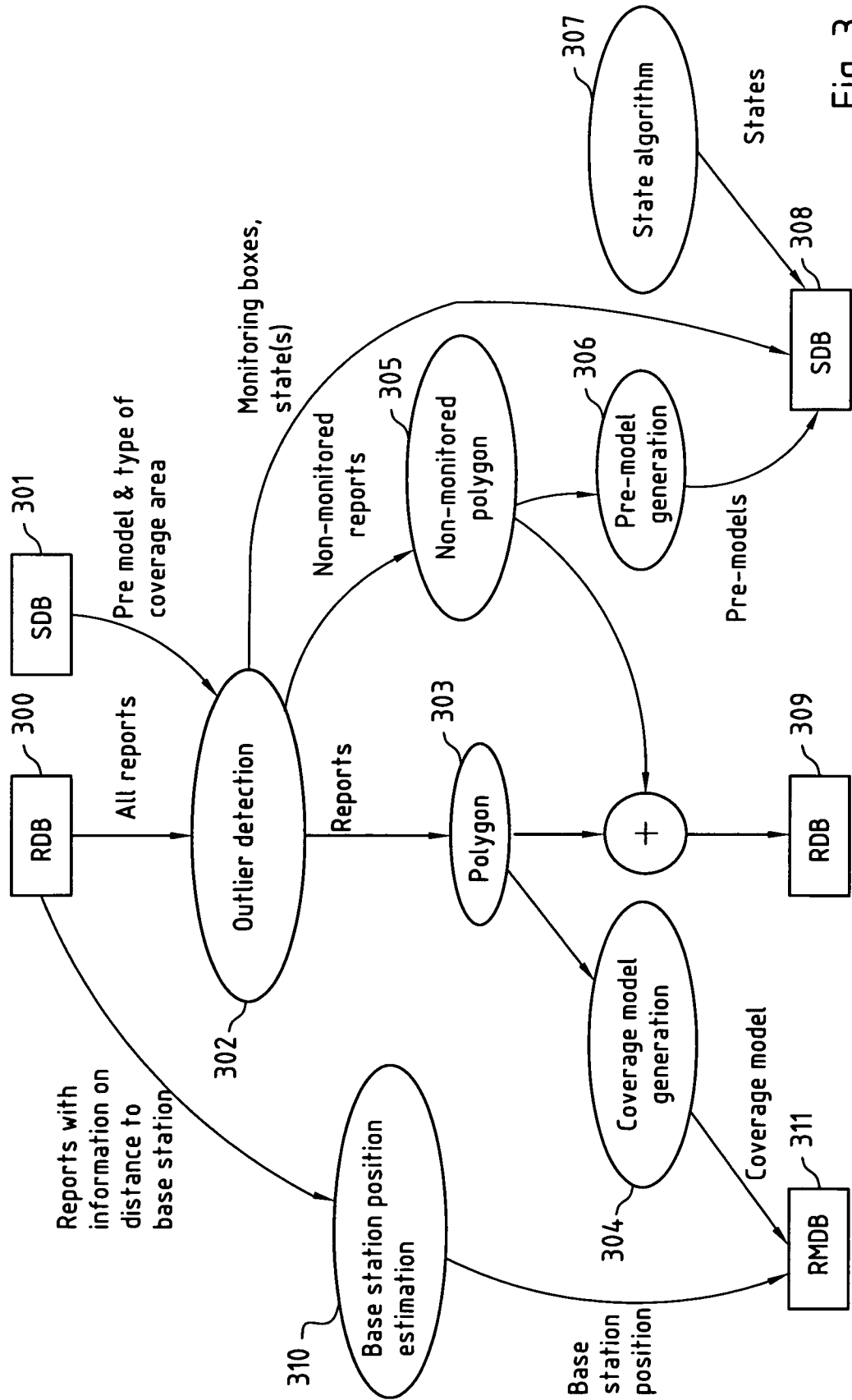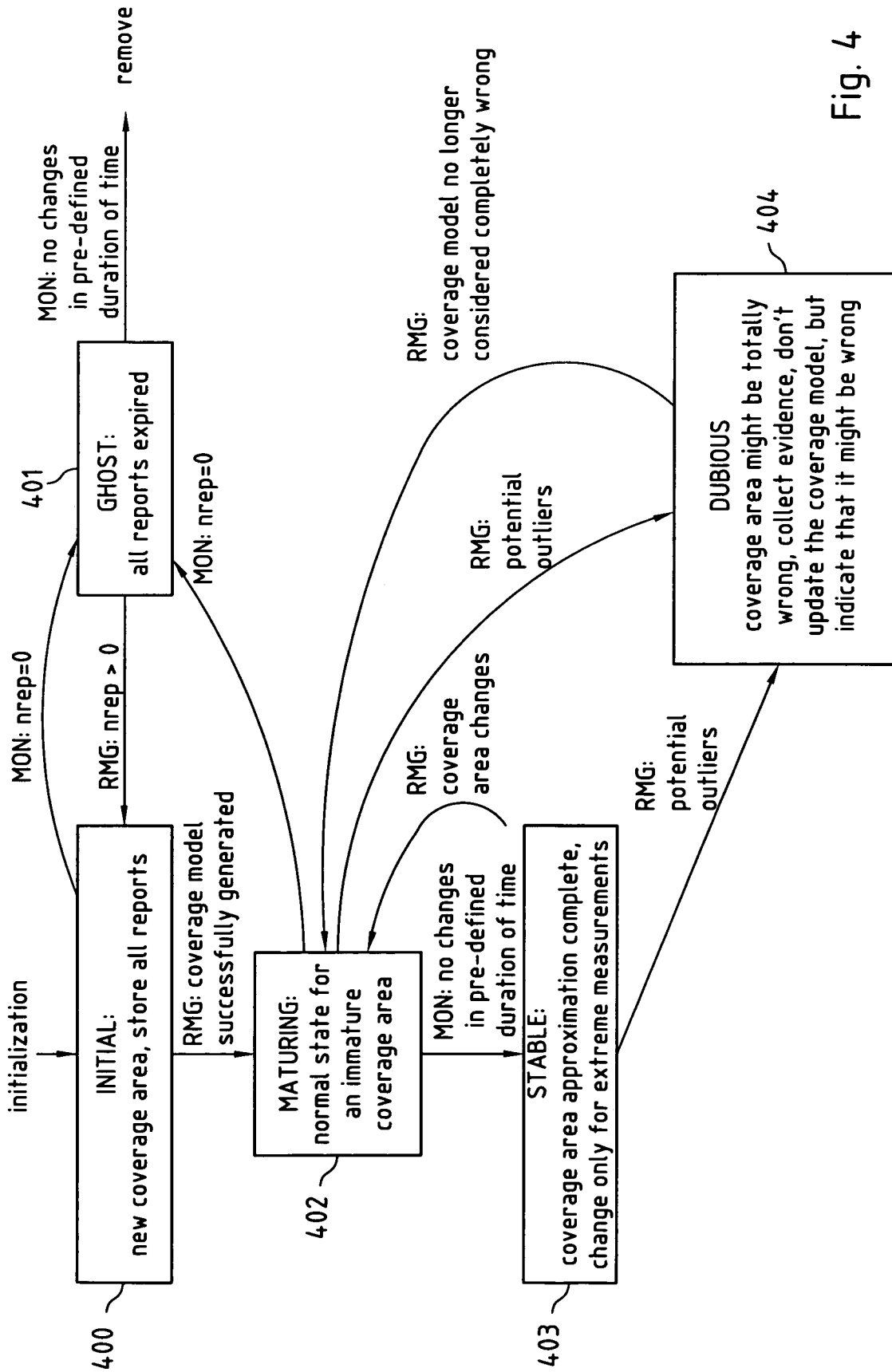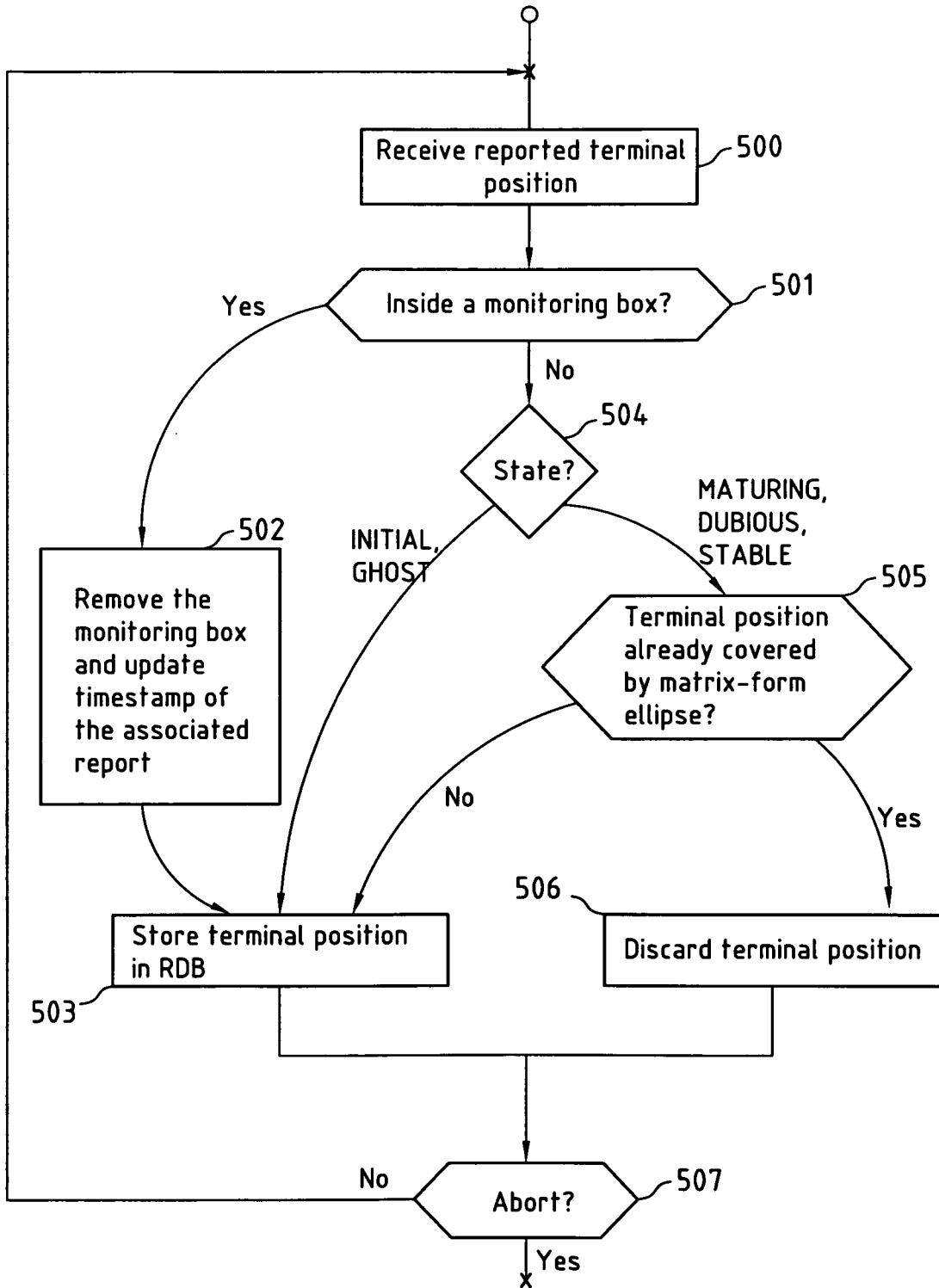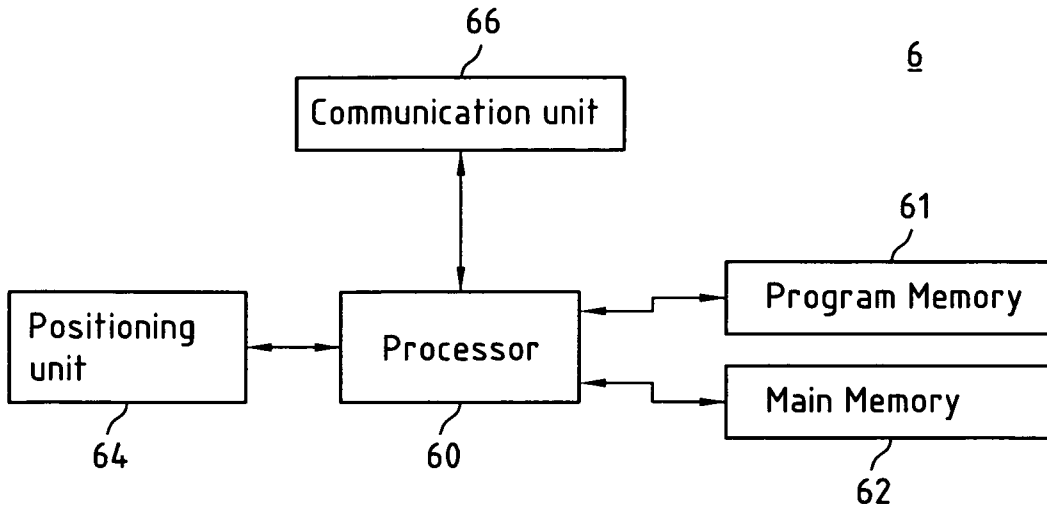
Fig. 6
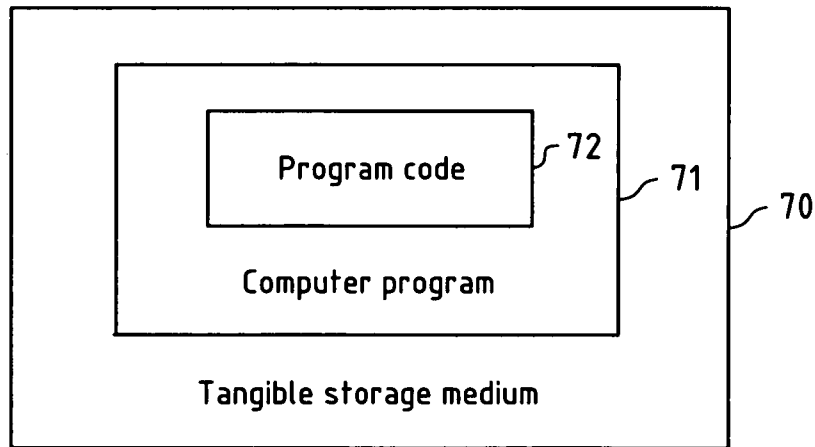
Fig. 7
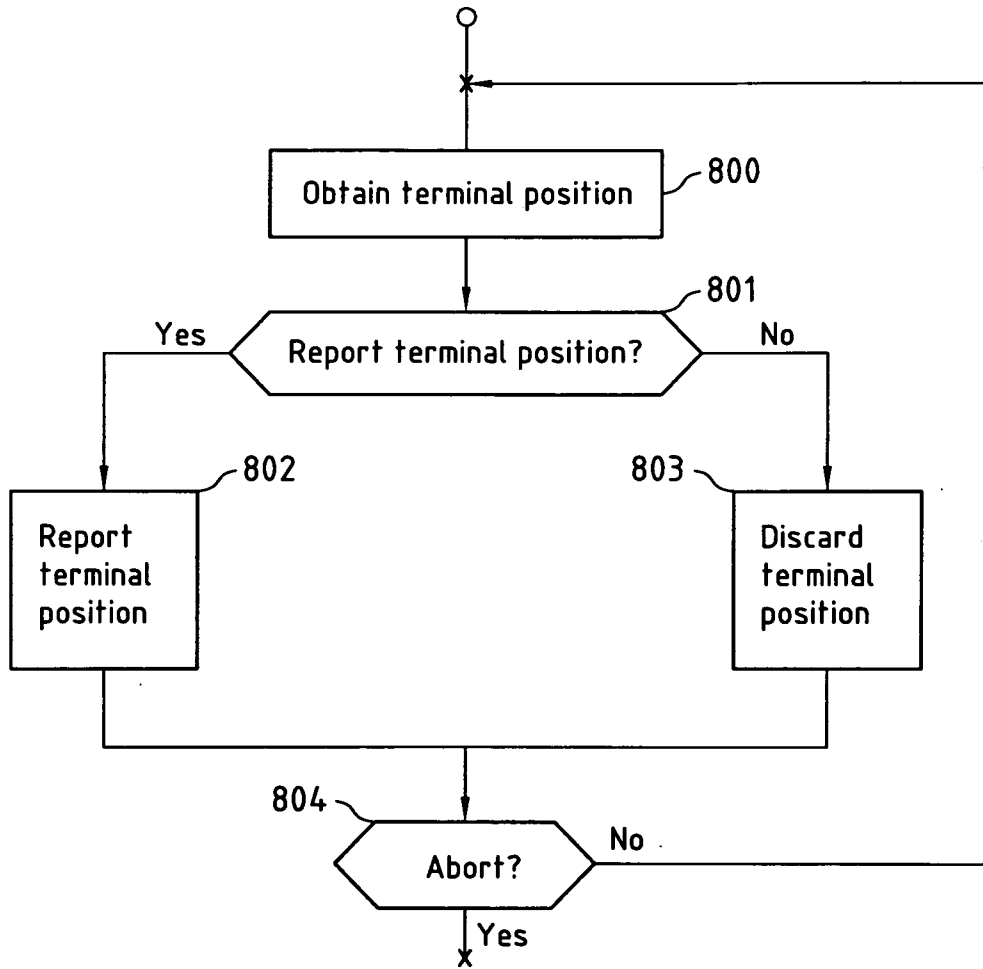
Fig. 8
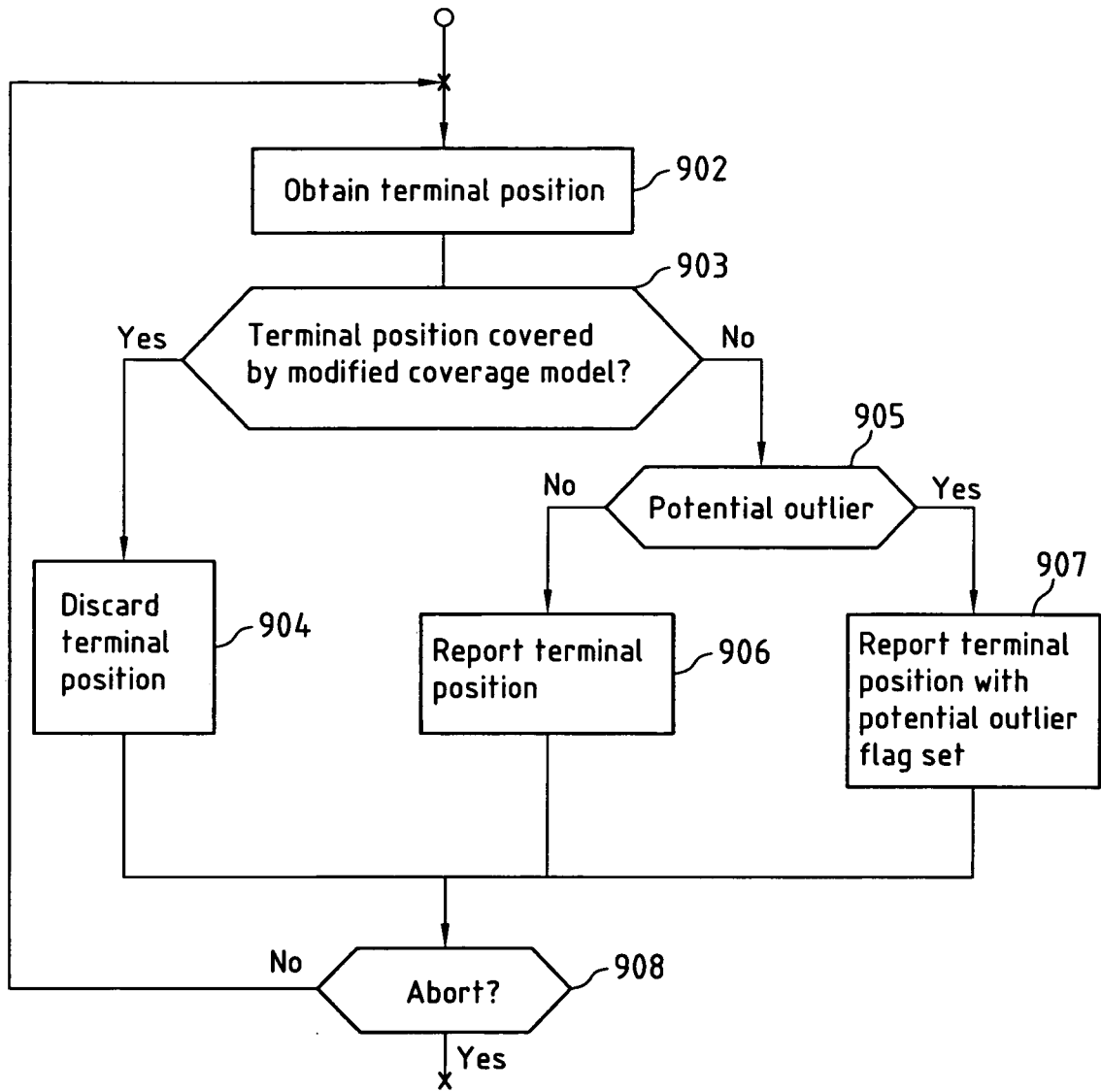
Fig. 9
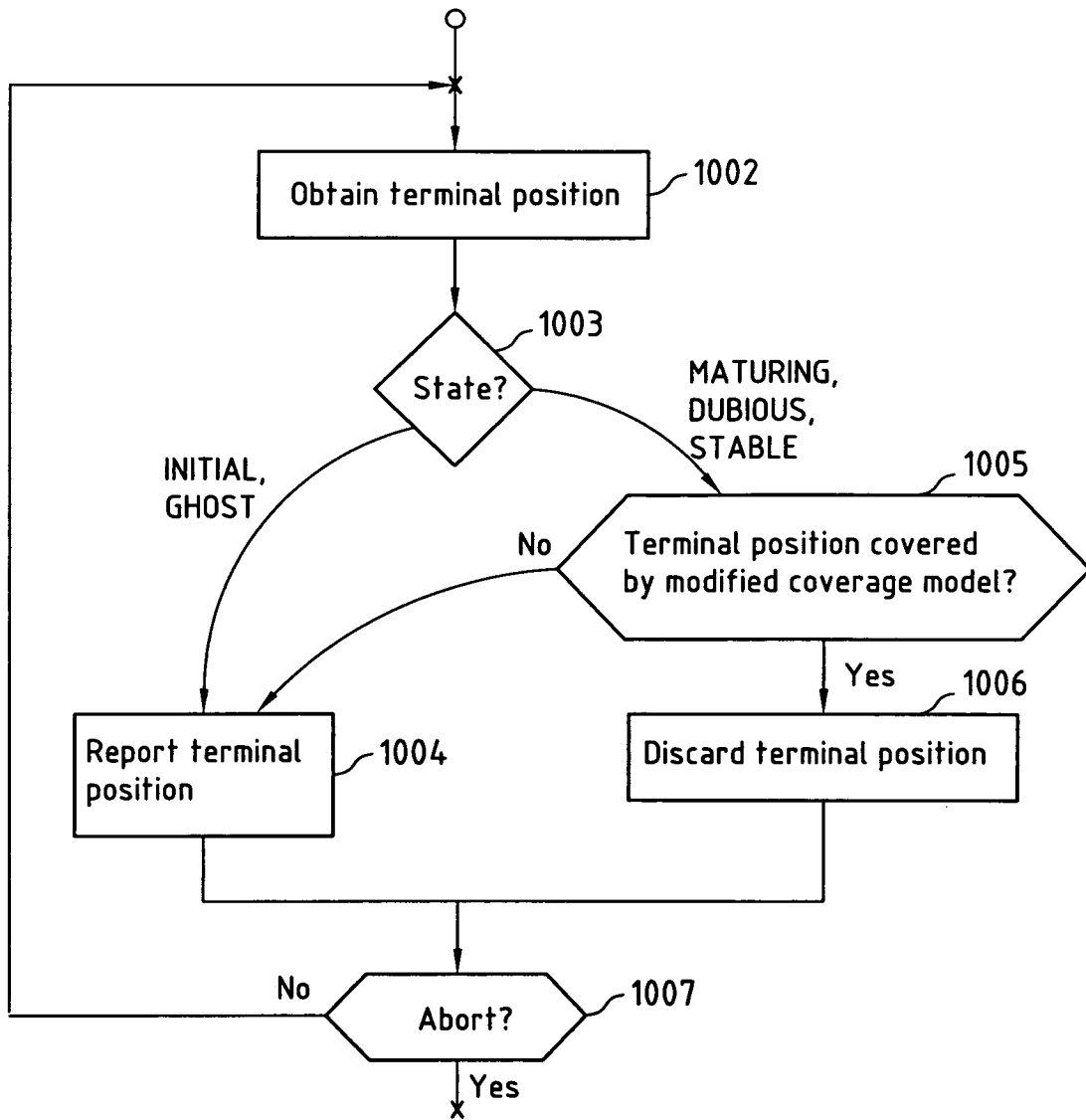
Fig. 10
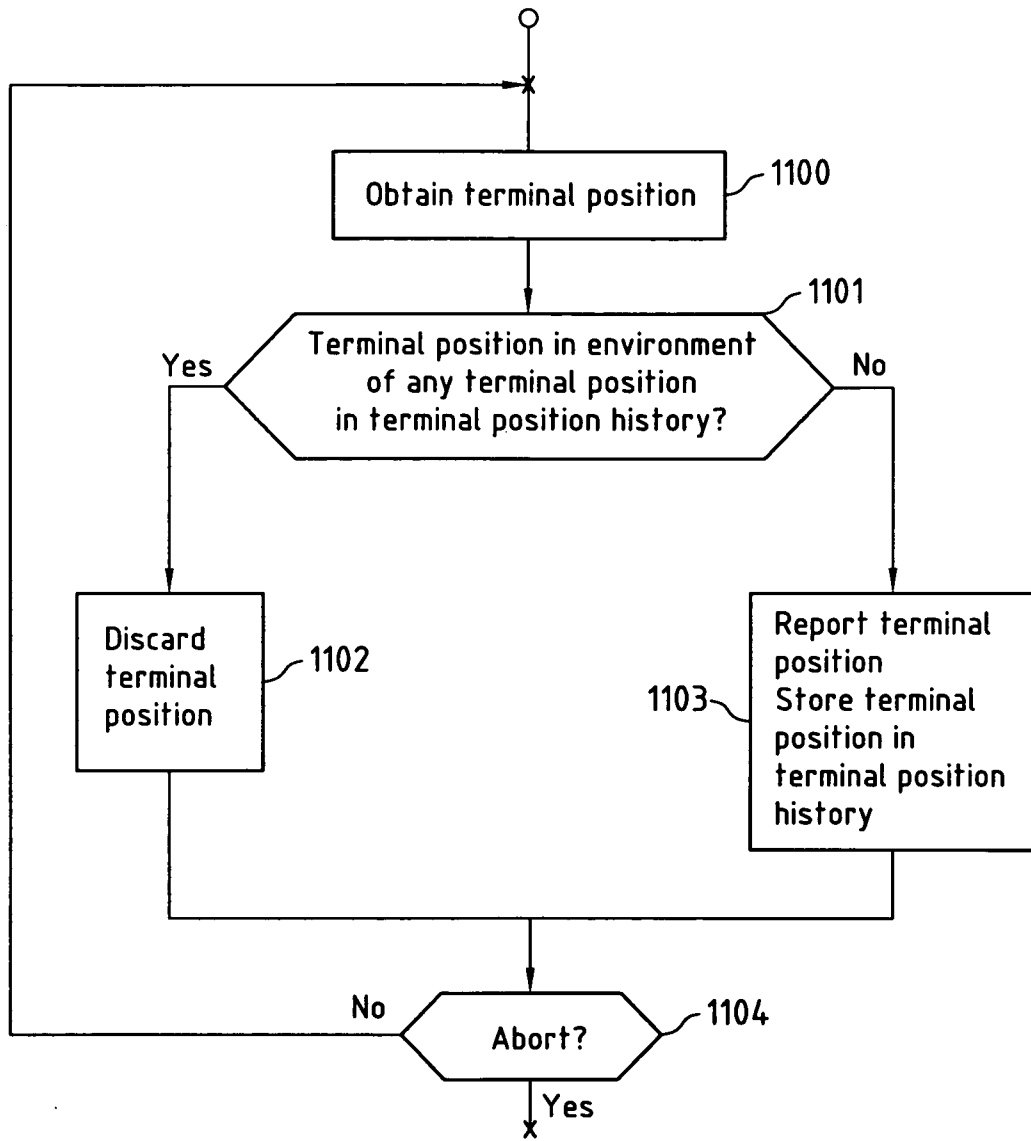
Fig. 11
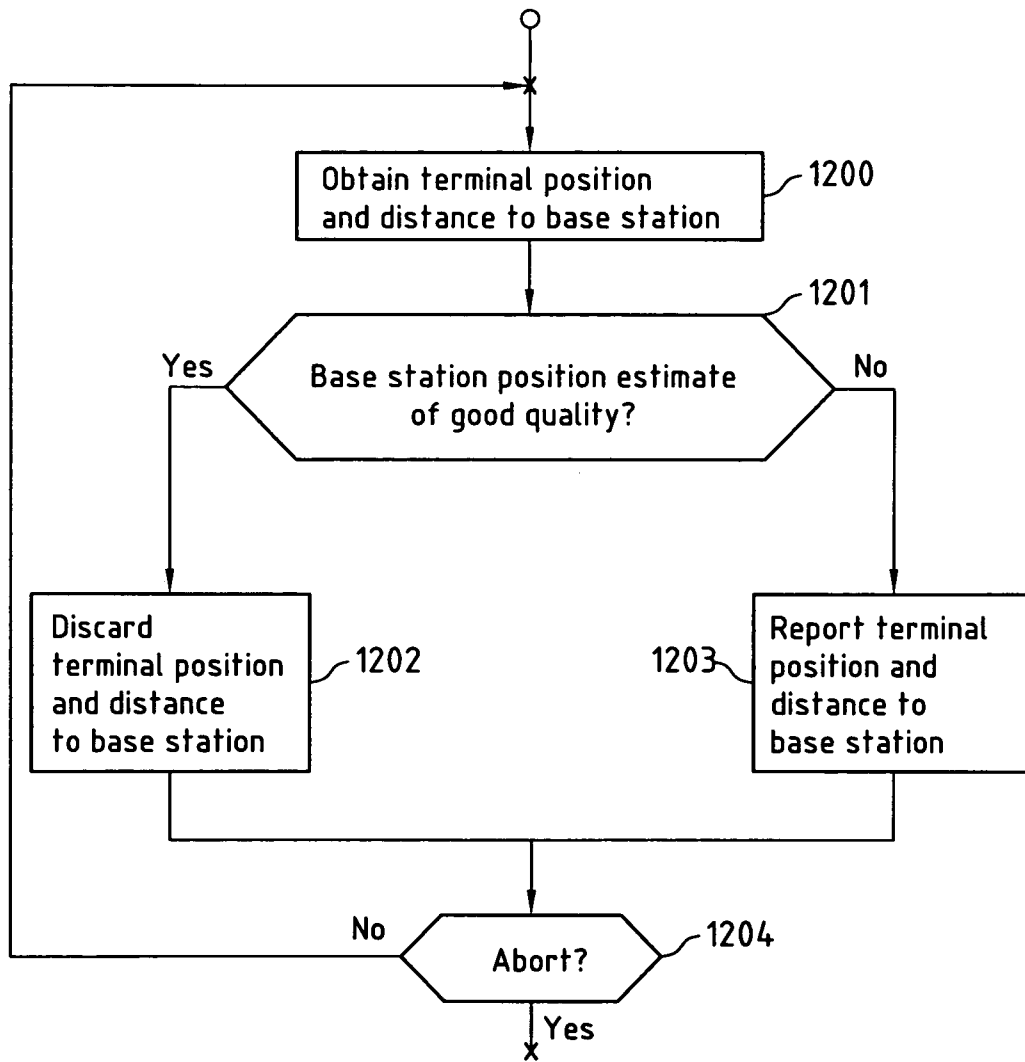
Fig. 12
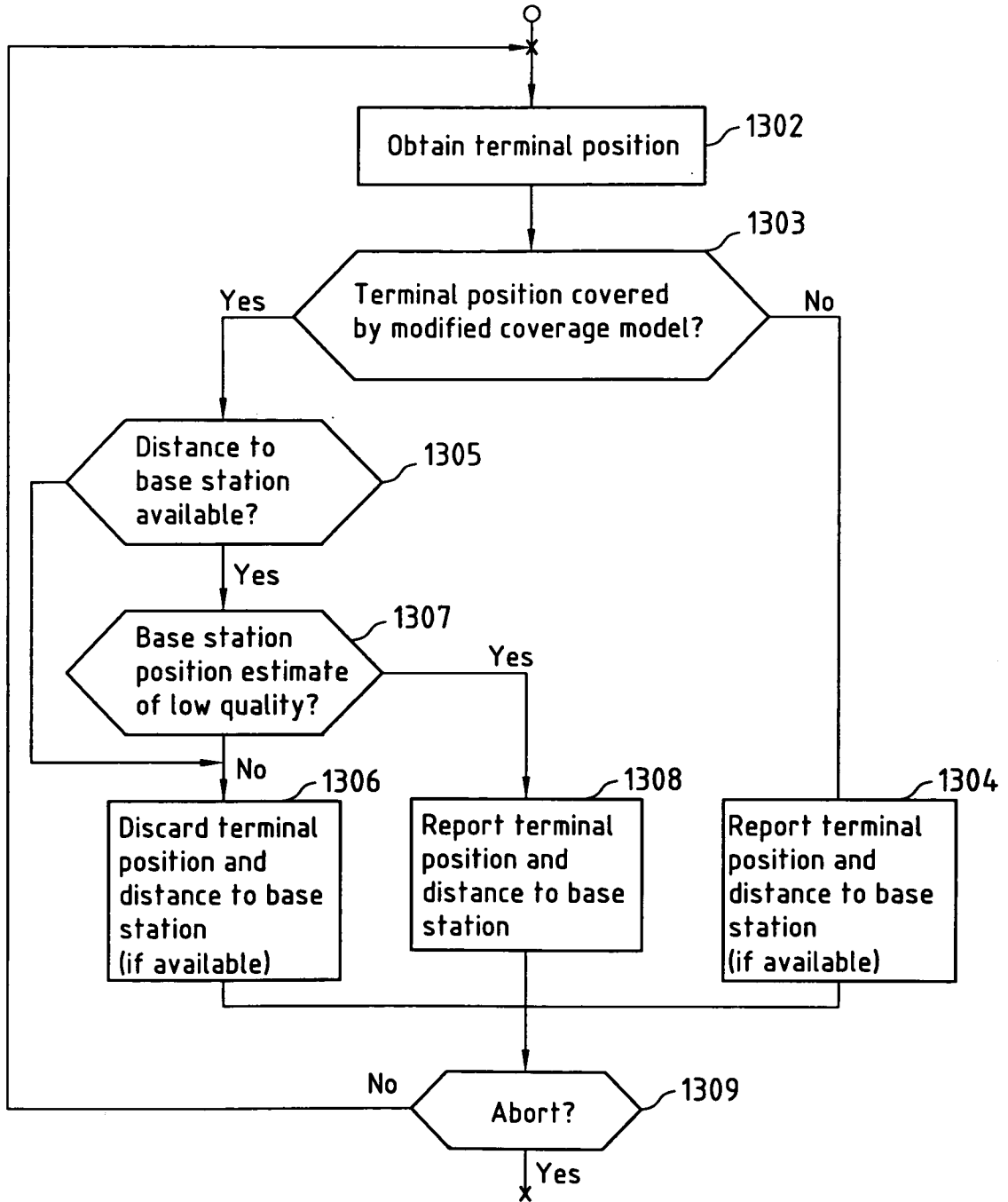
Fig. 13
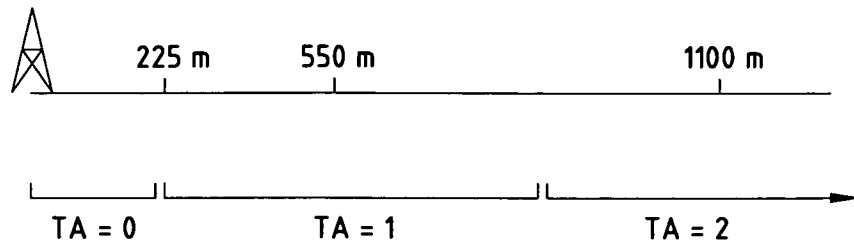
Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 09/01411

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04B 7/00 (2009.01)
USPC - 455/512
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(8) - H04B 7/00
USPC - 455/512

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 455/3.01, 39, 404.2, 512; 701/214

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(PGPB, USPT, USOC, EPAB, JPAB); Google Scholar
Search Terms Used: terminal position, report, discarded, fingerprint, coverage area, communication node, database, radio map, satellite, processor.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,243,648 B1 (KILFEATHER et al.) 05 June 2001 (05.06.2001), entire document, especially Figures 1-2; Figures 4(A)-4(B); Col 3, Lns 1-67; Col 4, Lns 58-62; Col 5,Lns 18-24; Col 6, Lns 4-17; Col 8, Lns 4-42; Col 9, Lns 14-18	1-4,19-22
A	US 5,038,398 A (WILLS) 06 August 1991 (06.08.1991), entire document	1-4,19-22
A	US 2006/0189272 A1 (WILLENEGGER et al.) 24 August 2006 (24.08.2006), entire document	1-4,19-22
A	US 2008/0186882 A1 (SCHERZER et al.) 07 August 2008 (07.08.2008), entire document	1-4,19-22

☐ Further documents are listed in the continuation of Box C.   ☐

* Special categories of cited documents:	"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
"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	"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
"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)	"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
"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	"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2009 (15.04.2009)	0 4 MAY 2009

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 09/01411

Box No. II   Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 5-18, 23-35
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III   Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest   ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)