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Other: **WPI, EPODOC**

(54) Title of the Invention: **Indoor radio map verification**
Abstract Title: **Validating an indoor radio-map through comparison with a global radio-map**

(57) A system that obtains position related information associated with a radio node from a global radio map stored within a first database; checking the validity of said radio node in an indoor radio map stored within a second database. Validating the radio node may comprise determining if the radio node has moved or is moving. The position of the radio emitter within the indoor radio map may be determined without the use of a Global Navigation Satellite System (GNSS); the position may instead be determined from indoor manual data collection. The radio transmitter may be declared invalid if the movement distance is above a threshold. Determination that the radio transmitter is moving may be made based on a number of samples. If the radio node is determined as invalid it may be removed from the indoor radio map or marked as invalid within the indoor radio map. The position related information within the first database may be based on location information from a GNSS.

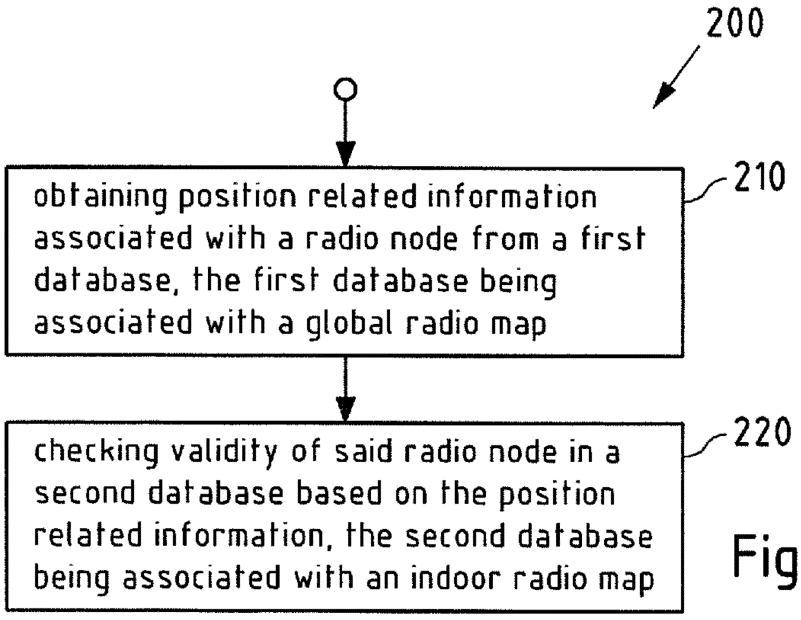

Fig.2

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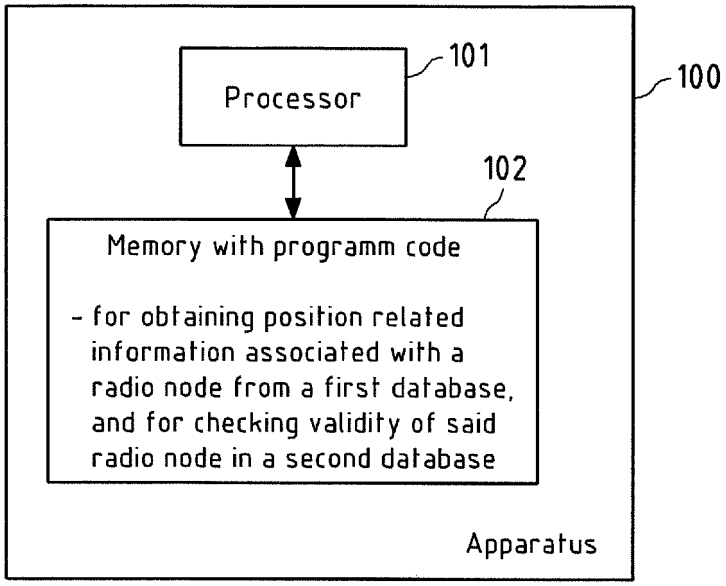
Processor
101
100
102
Memory with programm code
- for obtaining position related information associated with a radio node from a first database, and for checking validity of said radio node in a second database
Apparatus

Fig.1

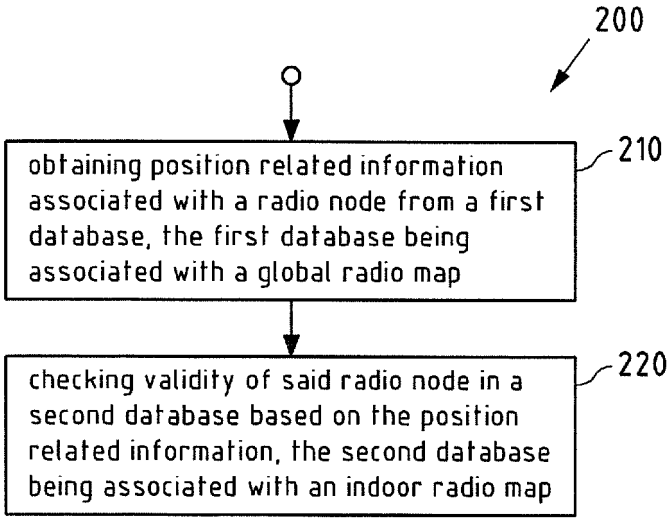
200
obtaining position related information associated with a radio node from a first database, the first database being associated with a global radio map
210
checking validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map
220

Fig.2

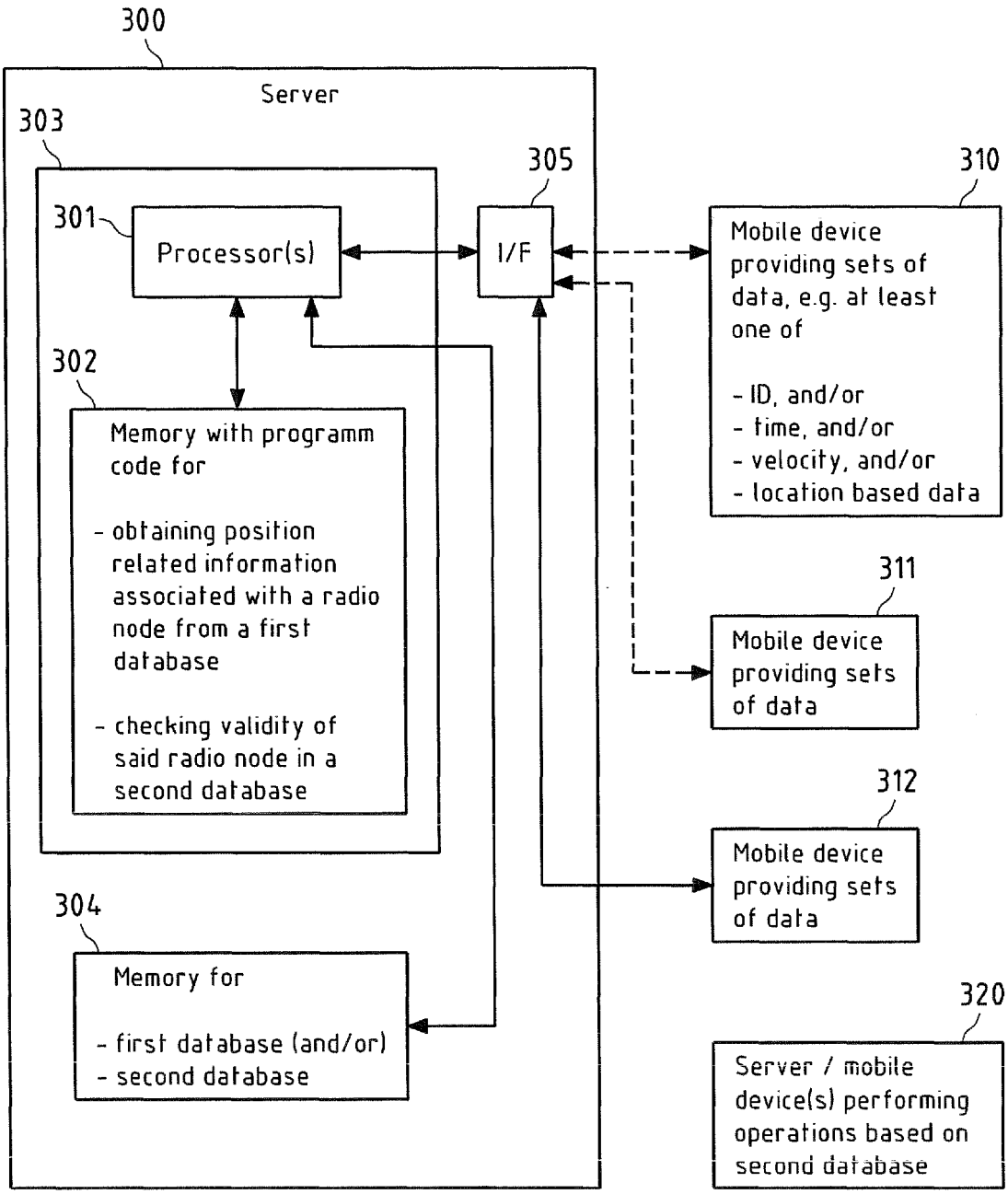
300
Server
303
305
310
301
Processor(s)
I/F
Mobile device providing sets of data, e.g. at least one of
- ID, and/or
- time, and/or
- velocity, and/or
- location based data
302
Memory with programm code for
- obtaining position related information associated with a radio node from a first database
- checking validity of said radio node in a second database
311
Mobile device providing sets of data
312
Mobile device providing sets of data
304
Memory for
- first database (and/or)
- second database
320
Server / mobile device(s) performing operations based on second database

Fig.3

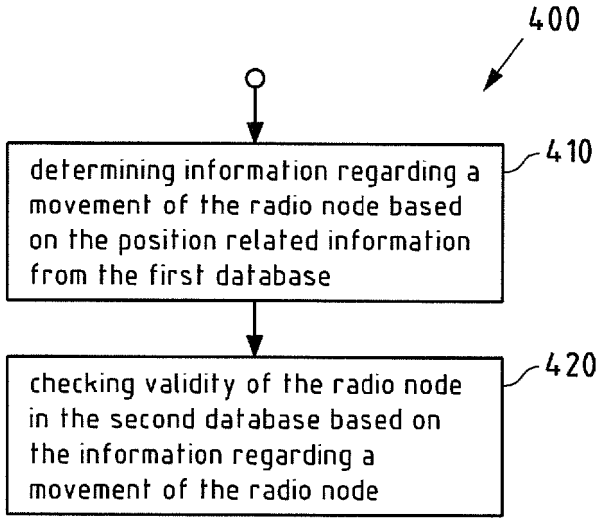
400
410
determining information regarding a movement of the radio node based on the position related information from the first database
420
checking validity of the radio node in the second database based on the information regarding a movement of the radio node

Fig.4

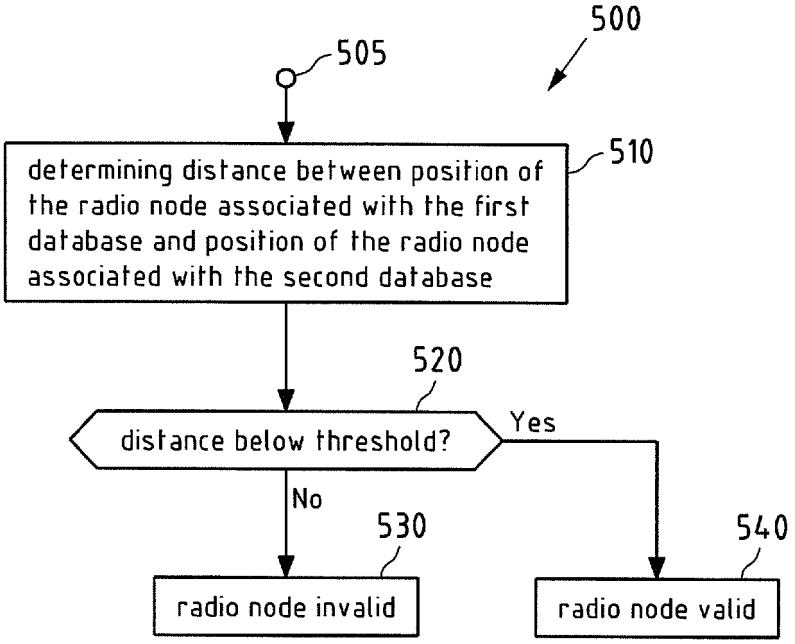
500
505
510
determining distance between position of the radio node associated with the first database and position of the radio node associated with the second database
520
distance below threshold?
Yes
No
530
radio node invalid
540
radio node valid

Fig.5

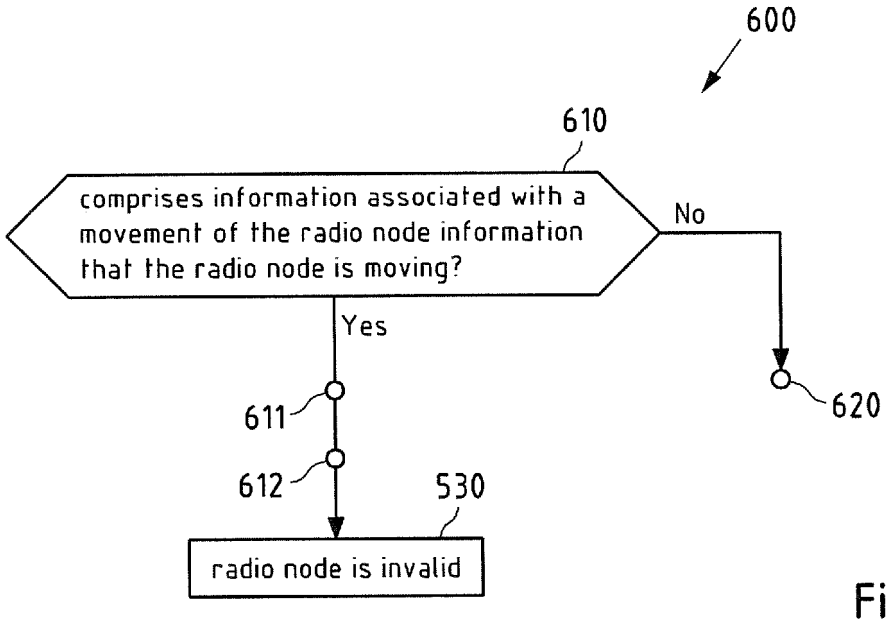
600
610
comprises information associated with a movement of the radio node information that the radio node is moving?
No
Yes
620
611
612
530
radio node is invalid

Fig.6

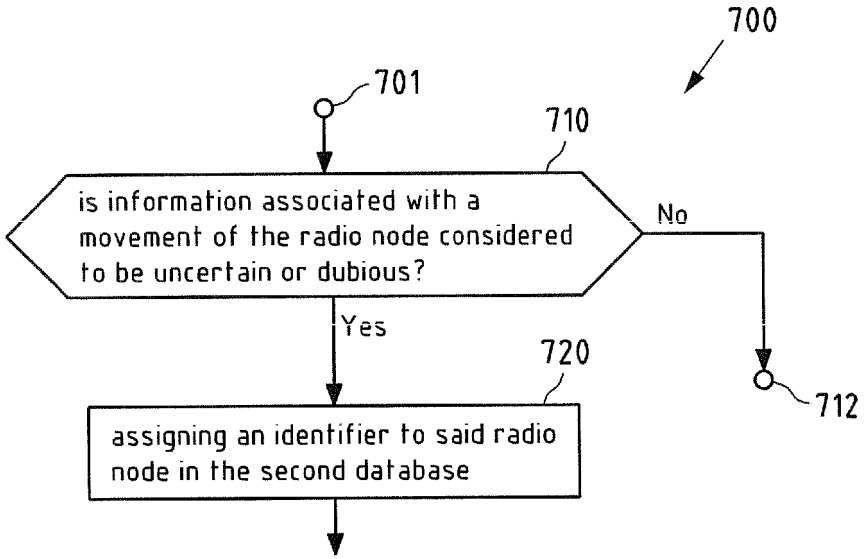
700
701
710
is information associated with a movement of the radio node considered to be uncertain or dubious?
No
Yes
720
712
assigning an identifier to said radio node in the second database

Fig.7

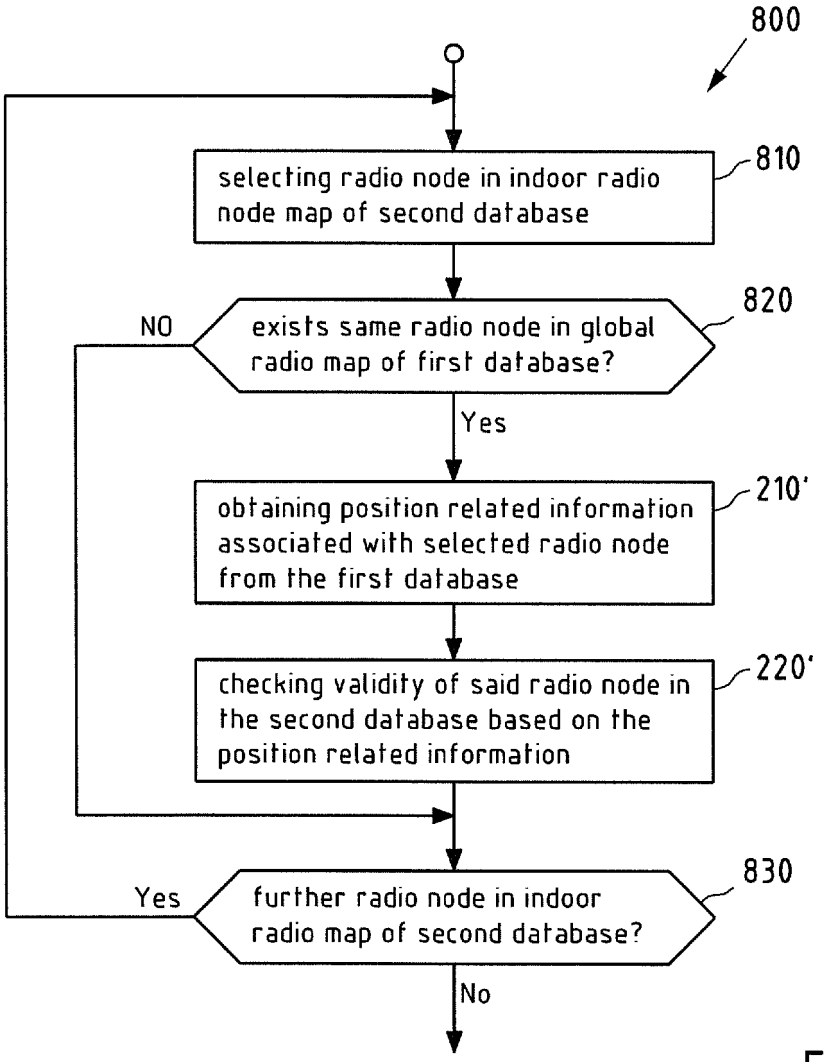
800
selecting radio node in indoor radio node map of second database
810
NO
exists same radio node in global radio map of first database?
820
Yes
obtaining position related information associated with selected radio node from the first database
210'
checking validity of said radio node in the second database based on the position related information
220'
Yes
further radio node in indoor radio map of second database?
830
No

Fig.8

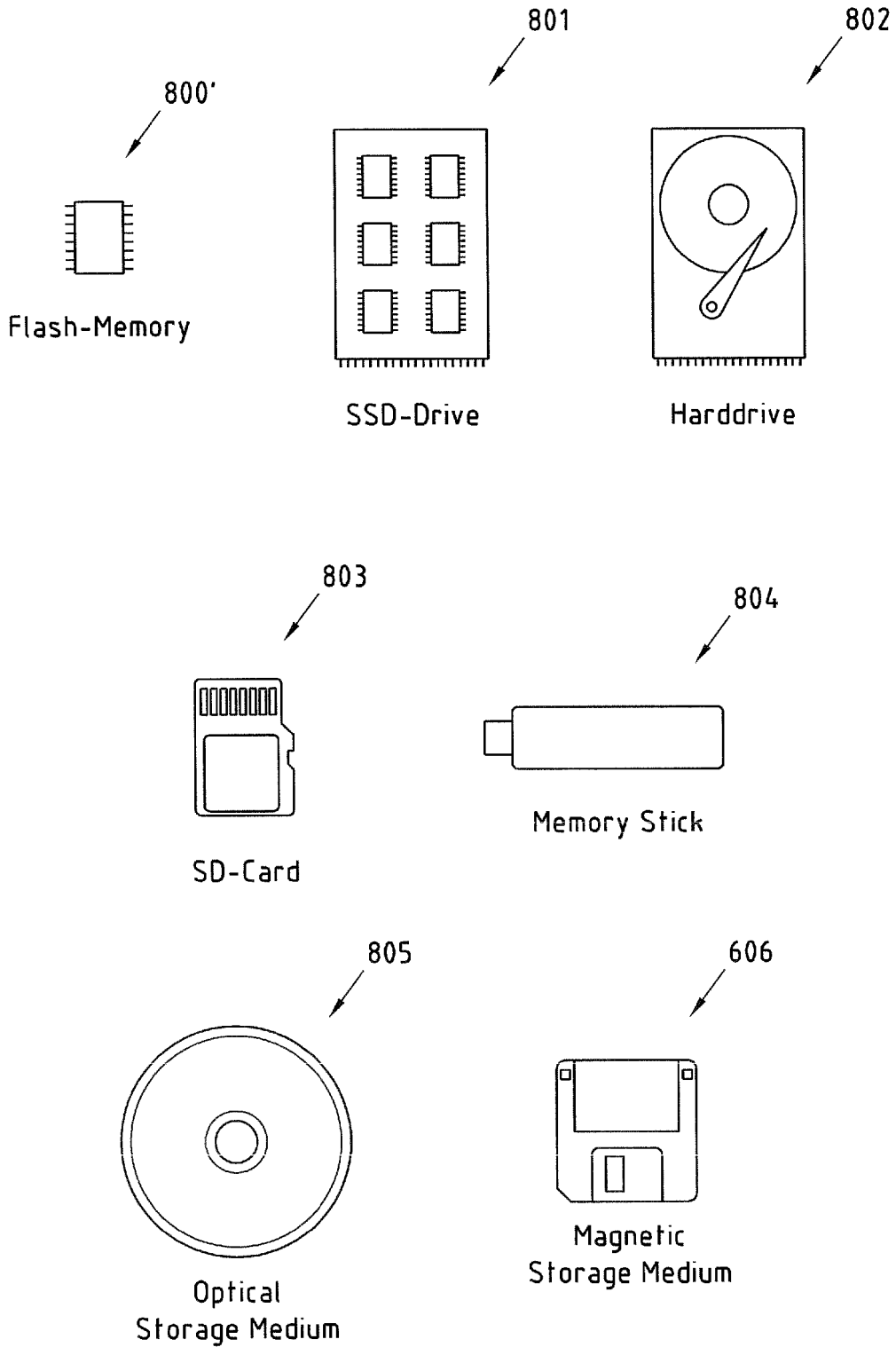
800'
801
802
Flash-Memory
SSD-Drive
Harddrive
803
804
SD-Card
Memory Stick
805
606
Optical
Storage Medium
Magnetic
Storage Medium

Fig.9

Indoor Radio Map Verification

FIELD OF THE DISCLOSURE

The invention relates to the field of indoor radio map verification.

BACKGROUND

Indoor Positioning technology may be based on radio beacons, such as WiFi access points and Bluetooth (BLE) beacons. Even though such a radio environment can be considered almost stable, it still changes: e.g. WiFi access points can be moved from one place to another, and so can BLE beacons. In addition to this, there are mobile (moving) radio nodes.

Such changes in radio environment, or moving radio nodes affect the positioning system adversely, and may even ruin it completely, e.g. if suddenly all the access points from one building are relocated to another building.

It turns out that these situation are often difficult detect without some additional information. For instance, in case the company takes its APs with when moving, the movement of all the access points at the same time makes it practically impossible to detect the change.

SUMMARY OF SOME EMBODIMENTS OF THE INVENTION

According to an exemplary aspect of the invention, a method is disclosed, which may be performed by a first apparatus, wherein the method comprises obtaining position related information associated with a radio node from a first database, the first database being associated with a global radio map, and checking validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map.

The method according to the exemplary aspect of the invention may for example at least partially be performed by the first apparatus.

According to the exemplary aspect of the invention, furthermore a first apparatus is disclosed, which comprises means for at least partially realizing the method according to the first exemplary aspect of the invention. The means of the first apparatus may be implemented in hardware and/or software. They may comprise for instance at least one processor for executing computer program code for realizing the required functions, at least one memory storing the program code, or both. Alternatively, they could comprise for instance circuitry that is designed to realize the required functions, for instance implemented in a chipset or a chip, like an integrated circuit. In general, the means may comprise for instance one or more processing means such as a processor and a memory. Optionally, the first apparatus may comprise various other components, like a radio interface, a data interface, a user interface etc.

For example, the first apparatus comprises at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause an apparatus at least to perform at least partially the method and/or the steps of the method according to the exemplary aspect of the invention.

Furthermore, for instance, the first apparatus may represent a server. Or, as another example, the first apparatus may represent a client device, e.g. a mobile device or a stationary device.

According to the aspect of the invention, furthermore a system is disclosed, which comprises the first apparatus.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, said validating comprises determining information associated with a movement of the radio node based on the position related information from the first database.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, said information associated with a movement comprises a distance between a position of the radio node associated with first database and a position of the radio node associated with the second database.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the position of the radio node associated with the second database has been determined without usage of a Global Satellite navigation system satellite (GNSS) system.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the position of the radio node associated with the second database has been determined by a manual collection of a fingerprint triggered by a user interaction.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises, if said distance is higher than a threshold, determining said radio node in the second database to be invalid.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the information associated with a movement of the radio node comprises information that the radio node is moving.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the information that the radio node is moving is determined based on the position related information associated with the radio node from the first database.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises, if it is detected that radio node is moving, determining said radio node in the second database to be invalid.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises determining whether the information associated with a movement of the radio node is considered to be uncertain.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises determining a level of uncertainty associated with the information associated with a movement of the radio node, wherein the information is considered to be uncertain if said level of uncertainty is higher than a threshold.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises assigning an identifier to said radio node in the second database if the informati1on is considered to be uncertain.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises, if said radio node in the second database is determined to be invalid, one of: (i) removing the radio node indicated to be invalid from the second database; and (ii) assigning an invalid indicator to the radio node in the second database.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises, if said radio node in the second database is determined to be valid, comprising providing an indicator to the radio node in the indoor radio map being indicative that this radio node has been successfully verified.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the position related information in the first database is obtained based on location information from a Global Satellite navigation system satellite (GNSS) system.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the indoor radio map of the second database has been generated and/or is generated based on indoor manual data collection.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises generating or updating the indoor radio model of the second database based on said checking validity of raid radio node in a second database.

According to a corresponding exemplary embodiment of the method according to the exemplary aspect of the invention, the method comprises, if the radio node is determined not to be valid, not considering the radio node when generating the indoor radio map of the second database.

The features and example embodiments of the invention described above may equally pertain to the different aspects according to the present invention.

It is to be understood that the presentation of embodiments of the invention in this section is merely exemplary and non-limiting.

Other features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. It should be further understood that the drawings are not drawn to scale and that they are merely intended to conceptually illustrate the structures and procedures described herein.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1	is a schematic block diagram of an example embodiment of at least one apparatus according to the invention;
Fig. 2	is a flow chart illustrating an example operation in the at least one apparatus of Figure 1;
Fig. 3	is a schematic block diagram of an example embodiment of system comprising an example apparatus according to the invention;
Fig. 4	is a flow charts illustrating an example embodiment of a method according to the invention;
Fig. 5	is a flow chart illustrating an example embodiment of a method according to the invention;
Fig. 6	is a flow chart illustrating an example embodiment of a method according to the invention;
Fig. 7	is a flow chart illustrating an example embodiment of a method according to the invention;
Fig. 8	is a flow chart illustrating an example embodiment of a method according to the invention;
Fig. 9	is a schematic illustration of examples of tangible storage media according to the present invention.

Figure 1 is a schematic block diagram of an example embodiment of any at least one apparatus according to the invention. Apparatus 100 comprises a processor 101 and, linked to processor 101, a memory 102. Memory 102 stores computer program code for obtaining position related information associated with a radio node from a first database, the first database being associated with a global radio map, and for checking validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map.

Apparatus 100 could be a server or any other kind of client like a mobile or stationary device. If a plurality of apparatus are used, each apparatus may comprise a processor 101, and linked to processor 101, a memory 102, wherein memory 102 at least partially stores computer program code for obtaining position related information associated with a radio node from a first database, the first database being associated with a global radio map, and for checking validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map. For instance, said plurality of apparatus may represent servers in a cloud interaction together. Apparatus 100 could equally be a component, like a chip, circuitry on a chip or a plug-in board, for any mobile or stationary device. Optionally, apparatus 100 could comprise various other components, like a data interface configured to enable an exchange of data with separate devices, a user interface like a touchscreen, a further memory, a further processor, etc.

An operation of at least one apparatus will now be described with reference to the flow chart of Figure 2. The operation is an example embodiment of a method according to the invention. At least one processor 101 (may be one processor 101 or a plurality of processors 101) and the program code stored in at least one memory 102 (may be one memory 102 or a plurality of memories 102) cause at least one apparatus (may be one apparatus ore a plurality of apparatuses) to perform the operation when the program code is retrieved from memory 102 and executed by processor 101. The at least one apparatus that is caused to perform the operation can be apparatus 100 or some other apparatus, for example but not necessarily a device comprising apparatus 100.

The at least one apparatus obtains position related information associated with a radio node from a first database, the first database being associated with a global radio map (action 210).

For instance, the global radio map may represent a radio map which is and/or has been generated based on signals received from at least one Global Satellite navigation system satellite (GNSS) system, for example based on signals received from GPS satellites, from BeiDou satellites, from GLONASS satellites or from Galileo satellites or other satellites. As an example, at least one mobile device may comprise a GNSS receiver in order to receive signals from the GNSS system such that each mobile device of the at least one mobile device can estimate its location based on the GNSS signals. For instance, such a mobile device may take a fingerprint at one ore more different position, wherein the fingerprint comprises a location estimation obtained based on the received GNSS signals and, if the mobile device is able to listen and/or connect to at least one radio node, the fingerprint may comprise information on this at least one radio node, e.g. one or more identifier for identifying the at least one radio node. For instance, the mobile device may listen to at least one radio node such that the mobile device is able to listen to a broadcast of a respective radio node of the at least one radio node and to device the identifier of the respective radio node. E.g., the radio node may be a radio node which can be used for indoor radio maps, e.g. a Wifi radio node, a Bluetooth radio node, and any other radio node suitable for indoor radio maps used for indoor positioning. As an example, a radio node may represent a wireless access point or a wireless beacon (e.g. a Bluetooth beacon).

Thus, as an example, the global radio map may comprise a plurality of radio nodes and may comprise a position related information for each radio node of the plurality of radio nodes. For instance, one radio node may be selected from the plurality of radio nodes of the global radio map and the position related information associated with the selected radio node may be obtained in action 210.

As an example, the first database may comprise the global radio map, wherein the first database may be stored in one or more servers. For instance, the first database is frequently (e.g. continuously) updated with new fingerprints received from at least one mobile device and thus may be considered to represent crowd-sourced database. Thus, it may be assumed that the first database and therefore the global radio map is very much up-to-date. As an example, said first database may be updated by means of a crowd-sourcing system, i.e. by means of an automated background process, wherein indoor and/or outdoor changes may be detected automatically and which starts to locate the device using inertial sensors and other means. For instance, no user intervention may be needed for generating a fingerprint at the device, e.g. no user interaction with

the device may be needed for generating the fingerprint and transmitting the fingerprint to the at least one server.

From this global radio map position related information associated with a radio node is obtained (action 210). For instance, said position related information may comprise information on the actual position of the radio node in the global radio map and/or information on at least one historic position of the radio node in the global radio map. Alternatively, or additionally, as an example, said position related information may comprise information on a movement and/or on mobility of the radio node in the global radio map.

Furthermore, as an example, the position related information associated with a radio node in said first database may not be based on a Received Signal Strength (RSS)-measurement of a signal received from and/or transmitted to this radio node.

The at least one apparatus moreover checks validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map (action 220).

As an example, the second database may comprise the indoor radio map. For instance, the second database may be stored in the same one or more servers as used for storing the first database. Alternatively, the second database may be stored in another server or the second database may be stored in a client, e.g. in a mobile or stationary device.

The indoor radio map may be configured to be used for radiobased indoor positioning that may model the indoor radio environment from observed Received Signal Strength (RSS)-measurements as 2-dimensional and/or 3-dimensional radiomaps. Thus, the indoor radio map is based on radio nodes, e.g. Wifi access points and/or Bluetooth beacons and/or other radio nodes suited for indoor wireless transmission, wherein RSS-measurements at a position can be used to estimate the position based on the model of the indoor radio environment of the indoor radio map. For instance, the indoor radio map may comprise a plurality of radio nodes, the indoor radio map may comprise the position of at least one of the radio nodes or for each of the radio nodes and may comprise a model of the indoor radio environment observed from RSS-measurements as 2-dimensional and/or 3-dimensional radiomaps. As an example, the position of a respective radio node from the plurality of radio nodes in the indoor radio map may be based on a manual input of

the position, e.g. by a user or an administrator, e.g. by manually pointing location of the radio node.

For instance, said indoor radio map may be generated based on indoor manual data collection: As an example, a surveyor needs to manually point indoor location e.g. after each straight walk. For instance, fingerprints get interpolated between the two points assuming e.g. straight walk and constant speed. Furthermore, as an example, a semi-automatic data collection may be used for generating and/or updating the indoor radio map: A surveyor may need to pinpoint location only occasionally, can also take turns and walk more or less freely, wherein, as an example, inertial sensors may be used to detect turns.

As an example, the accuracy of a position estimated based on the indoor radio map may be more than 2 times, 5 times or 10 times higher than the accuracy of a position estimated based on the global radio map, wherein the accuracy may represent a mean accuracy. For instance, the accuracy of a position estimated based on the indoor radio map may be better than 4m, or better than 3m, or better than 2m, and the accuracy of position estimated based on the global radio map may be less than 10m, or less than 20m, or less than 30m, or less than 50m.

Based on the position related information associated with a radio node from the first database, the validity of this radio node in a second database is checked (action 220).

For instance, this validity may be related to the position of the radio node in the second database. As an example, this position of the radio node in the second database, i.e., the position of the radio map indicated by the indoor radio map, may be checked based on the position related information associated with this radio node from the first database.

For instance, if the position related information associated with this radio node from the first database indicates that the radio node has been relocated from position indicated by the indoor radio map, the result of the validity check in action 220 may be that the radio node in the second database is considered to be invalid. Or, as another example, if position related information associated with this radio node from the first database indicates that the radio node has not been relocated from position indicated by the indoor radio map, the result the validity check in action 220 may be that the radio node in the second database is considered to valid.

Such a relocation of a radio node may occur if the radio node may be moved from building to another building, e.g. in case an owner of this radio node moves from location A to another location B, wherein this move may be from one city to another or only from one building to another building in the same city. In this case the indoor radio map, which is based on the original location A of the radio node, would affect the indoor positioning system adversely, and may even ruin it completely, e.g. if suddenly all the radio nodes from one building may be relocated to another building. Furthermore, there may be a certain risk that such a movement is not reflected by the indoor radio map since the indoor radio map is based on a manual data collection, as explained above, and thus it may be assumed that the indoor radio map is not updated so often and might get out-of-date without noticing it.

Contrary to this, for instance, it may be assumed that the first database comprising the global radio map is more up-to-date than the second database since it frequently and/or constantly receives new fingerprints from the at least one device and thus can be updated with the fresh data. Accordingly, the validity of a radio node in the second database can be checked based on the position information associated with the same radio node, wherein this position information is obtained from the first database, which may be assumed to better updated than the second database.

As an example, in case the validity check in action 220 results in a negative result, i.e., the validity of the radio node in the second database is not confirmed, this may result in an update of the indoor radio map in the second database regarding this radio node. For instance, this update may comprise removing the radio node indicated to be invalid from the second database or it may comprise assigning an indication to this radio node in the second database, wherein this indication may indicate that this radio node in the second database is considered to be invalid or to be suspicious.

As an example, in case the validity check in action 220 results in a positive result, i.e., the validity of the radio node in the second database is confirmed, this may result in an update of the indoor radio map in the second database regarding this radio node. For instance, this update may comprise providing an indication to this radio node in the second database being indicative that the radio node has been verified successfully, wherein, as further example, this indication may comprise a time information on this verification. Thus, when using this radio node from the second database for navigation, it can be seen from this indication that this radio node has been

successfully verified and thus may be preferred compared to other radio nodes (which have not been verified or which have been verified at a later stage compared to this radio node) when performing position.

Furthermore, as an example, in case the global radio map of the first database is based on a Global Satellite navigation system satellite (GNSS), which might provide a less accuracy compared to the indoor radio map of the second database regarding position estimation, wherein in particular, a location information of the radio node (i.e., the position of the radio node) of a position related information associated with a radio node from the first database might be assumed to have a less accuracy compared to a position estimated by the indoor radio map, is nevertheless useful in order to check whether the radio node has completely moved compared to position indicated by the indoor radio map and thus to check whether this radio node in the second database is still valid or not since the position related information of the radio node in the first database can be assumed to be more up-to-date than the position of this radio node indicated by the second database.

Thus, for instance, information from the global radio map about radio node mobility and movement can be used to check validity of this radio node in the indoor radio map, and, in particular, to validation of manually collected radio data used to generate the indoor radio map.

Furthermore, as an alternative example, the first database and the second database may be stored in a client, e.g. in a mobile or stationary device, and actions 210 and 220 may be performed by this client. Or, as another example, the first database may be stored in a server and the second database may be stored in a client, e.g. in a mobile or stationary device, wherein the client is configured to be communicate to the client, e.g. via an internet connection, in order to obtain the position related information associated with a radio node from the first database from the server, such that the client can perform actions 210 and 220 after having received this position related information from the server.

Fig. 3 depicts a schematic block diagram of an example embodiment of system comprising an example apparatus according to the invention.

The system comprises a server 300, which may comprise the at least one apparatus 100 depicted in Fig. 1. Furthermore, the system comprises a plurality of mobile devices 310, 311, 312.

Server 300 comprises a processor 301 that is linked to a first memory 302, to a second memory 304 and to a communication interface 305. Processor 301 is configured to execute computer program code, including computer program code stored in memory 302, in order to cause server 300 to perform desired actions.

Memory 302 stores computer program code for obtaining position related information associated with a radio node from a first database, the first database being associated with a global radio map, wherein this may correspond to action 220 depicted in Fig. 2. Furthermore, memory 302 stores computer program code for checking validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map, wherein this may correspond to action 220 depicted in Fig. 2. The computer program code may comprise for example similar program code as memory 102. In addition, memory 302 could store computer program code configured to realize other functions. In addition, memory 302 could also store other kind of data.

Processor 301 and memory 302 may optionally belong to a chip or an integrated circuit 303, which may comprise in addition various other components, for instance a further processor or memory. It may comprise for instance a working memory for processor 301.

Memory 304 is configured to store data, for example, the data associated with at least one road segment, which is held available in action 201, may be stored in memory 304. Furthermore, memory 304 may be configured to store sets of data received from mobile devices 310, 311, 312.

For instance, a mobile device 310, 311, 312, 320 may be for instance a mobile communication device, like a smartphone or any other mobile device. For instance, each of the at least one mobile device 310, 311, 312 may comprise a Global Satellite navigation system satellite (GNSS) receiver, for example based on signals received from GPS satellites, from BeiDou satellites, from GLONASS satellites or from Galileo satellites or other satellites, in order to estimate the location of the mobile device, or the mobile device may comprise another unit for estimating the location. Furthermore, as an example, each of the at least one mobile device 310, 311, 312 may comprise a radio interface which is configured to connect to a radio node, wherein this radio node may represent any of the radio nodes mentioned above with respect to Figs. 1 and 2, i.e., such a radio node may be Wifi access node or a Bluetooth beacon or another other suited wireless radio node. Thus, as an example, each of the mobile devices 310, 311, 312 may be configured to collect a

fingerprint comprising a location based data, e.g. the estimated location, and, optionally, an identifier (ID) which identifies a radio node the respective mobile device 310, 311, 312 listens and/or connects to the radio node . Furthermore, such a fingerprint may comprise further data, e.g. a timestamp being indicative of the time when the fingerprint was collect, and/or an identifier configured to identify the mobile device which collected the fingerprint, and/or velocity data being indicative of the velocity of the mobile device when collecting the fingerprint, and/or other data. Such a fingerprint may be represented as a set of data and each of the mobile devices 310, 311, 312 may be configured to transmit the fingerprint to the at least one server 300, e.g. based an push service, i.e., the communication for transmitting the fingerprint is initiated by the respective mobile device 310, 311, 312 or based on a pull service, i.e., the communication for transmitting the fingerprint is initiated by the at least one server 300.

Thus, as an example, the global radio map may comprise a plurality of radio nodes and may comprise a position related information for each radio node of the plurality of radio nodes. For instance, one radio node may be selected from the plurality of radio nodes of the global radio map and the position related information associated with the selected radio node may be obtained in action 210.

For instance, the first database may be frequently (e.g. continuously) updated with new fingerprints received from the at least one mobile device 310, 311, 312 and thus may be considered to represent crowd-sourced database. Accordingly, the location based data of such a fingerprint may represent the position related information, and if the fingerprint comprises an ID which identifies a radio node, then this position related information is considered to be associated with this radio node and the position related information and the ID may be stored and/or updated in global radio map of the first database stored in the at least one server 300.

Thus, it may be assumed that the first database and therefore the global radio map is very much up-to-date. As an example, said first database may be updated by means of a crowd-sourcing system, i.e. by means of an automated background process, wherein indoor and/or outdoor changes may be detected automatically and which starts to locate the mobile device 310, 311, 312 using inertial sensors and other means. For instance, no user intervention may be needed for generating a fingerprint at the mobile device 310, 311, 312, e.g. no user interaction with the device 310, 311, 312 may be needed for generating the fingerprint and transmitting the fingerprint to the at least one server 300.

For instance, said indoor radio map in the second database may be generated based on indoor manual data collection: As an example, a surveyor needs to manually point indoor location e.g. after each straight walk with a mobile device, which may be one of the mobile device 310, 311 and 312 but may also represent a mobile device having no GNNS receiver. For instance, fingerprints get interpolated between the two points assuming e.g. straight walk and constant speed. Furthermore, as an example, a semi-automatic data collection may be used for generating and/or updating the indoor radio map: A surveyor may need to pinpoint location only occasionally, can also take turns and walk more or less freely, wherein, as an example, inertial sensors may be used to detect turns. Thus, as an example, a position related to a radio node stored in the second database might be obtained by such a manual collection of a fingerprint triggered by a user interaction with a respective mobile device 310, 311, 312 in order to collect the fingerprint, e.g. during surveying a specific indoor route in order to manual collect fingerprints on this specific indoor route, wherein the location based information in this fingerprint may be obtained by a user interaction, e.g. by indicating the position on a map of the mobile device or by any other well-suited user interaction, is used by the receiving at least one server 300 in order to store the position related to this radio node in the second database.

As an example, in case the validity check in action 220 results in a negative result, i.e., the validity of the radio node in the second database is not confirmed, this may result in an update of the indoor radio map in the second database in memory 304 of the at least one server 300 regarding this radio node or in not considering this radio node when generating the indoor radio map in the second database by the at least one server 300. For instance, this update may comprise removing the radio node indicated to be invalid from the second database or it may comprise assigning a specific indicator to this radio node in the second database, wherein this specific indicator may indicate that this radio node in the second database is considered to be invalid or to be suspicious. As an example, in case the validity check in action 220 results in a positive result, i.e., the validity of the radio node in the second database is confirmed, this may result in an update of the indoor radio map in the second database regarding this radio node. For instance, this update may comprise providing an indication to this radio node in the second database being indicative that the radio node has been verified successfully, wherein, as further example, this indication may comprise a time information on this verification. Thus, when using this radio node from the second database for navigation, it can be seen from this indication that this radio node has been successfully verified and thus may be preferred compared to other radio nodes (which have not

been verified or which have been verified at a later stage compared to this radio node) when performing position.

Furthermore, after such an update of the second database has been performed, for instance, the at least one server 300 may transmit the second database or a part of the second database, e.g. that part which has been updated, to at least one server and/or mobile device 320 that uses this second database for performing operations based on the second database, e.g. for performing indoor positioning based on the indoor radio map of the second database. Thus, if this indoor radio map is locally stored in at least one mobile device 320 and/or in another server 320, this indoor radio map may be updated based on the result of the validity check in action 220.

Thus, as an example, method 200 may be performed by the at least one server 300 when generating and/or updating the indoor radio map of the second database.

Or, as another example, method 200 may be performed by at least one mobile device 320 during positioning, e.g. if the mobile device 320 has at least the second database and, optionally, the first database.

Fig. 4 depicts a flow chart illustrating an example embodiment of a method 400 according to the invention. This method 400 may be used to check validity of the radio node in a second database based on the position related information, e.g. as performed in action 220 in method 200 depicted in Fig. 2 or by server 300 depicted in Fig. 3 or by a client, e.g. by mobile device 320.

An information regarding a movement of the radio node is determined based on the position related information from the first database (action 410). For instance, this position related information may be obtained by action 210 of method 200 depicted in Fig. 2.

As an example, this information regarding a movement of the radio node may comprise an information that the radio node has been moved from a first position to a second position, wherein the first position may represent a position indicated by the indoor radio map of the second database and the second position is a position indicated by the position related information from the first database.

Or, as another example, this information regarding a movement may comprise an information that the radio node is moving, wherein this moving may represent an actual and/or continuous moving, e.g. since it is now located in or on a moving object like a train or car or a plane or another movable object. For instance, this information that the radio node is moving may be determined from the position related information from the first database.

Furthermore, as another example, this information regarding a movement may comprise an information that the radio node has not been moved with respect to a position of the radio map indicated by the indoor radio map and with respect to the position of the radio map indicated by the position related information from the first database.

Validity of the radio node in the second database is checked based on the information regarding a movement of the radio node (action 420).

For instance, if the information regarding a movement of the radio node comprises an information that the radio node has been moved from a first position to a second position, it may be checked whether the distance between the first position and the second position is higher than a threshold, and if this checking yields a positive result, the radio node might be assumed to be invalid. Otherwise, as an example, if this checking yields a negative result, the radio node might be assumed to be valid in action 420.

As another example, if the information regarding a movement comprises an information that the radio map actually and/or continuously moves, the radio node might be assumed to be invalid in action 420.

Or, as a further example, if the information regarding a movement comprises an information that the radio node has not been moved with respect to a position of the radio map indicated by the indoor radio map and with respect to the position of the radio node indicated by the global radio map, the radio node might be assumed to be valid in action 420.

Fig. 5 depicts a flow chart illustrating an example embodiment of a method 500 according to the invention. This method 500 may be used for implementing method 400 depicted in Fig. 4.

In action 510, a distance between the position of the radio node associated with the first database and the position of the radio node associated with the second database is determined.

For instance, this distance may be considered to represent the above mentioned that the radio node has been moved from a first position to a second position or the information that the radio node has not been moved from a first position to a second position, wherein the first position may represent the position of the radio node associated with the first database (i.e., determined based on the position related information of the global radio map), and wherein the second position may represent the position of the radio node associated with the second database (i.e., determined based on the position of the radio node indicated by the indoor radio map).

It then may be checked whether the distance is below a threshold (action 520). For instance, if the distance is below the threshold, the radio node may be considered to be valid (action 540). Or, as an example, if the distance is not below the threshold (e.g., if the distance is higher than the threshold), the radio mode may be considered to be invalid (action 530) since it can be deduced from global radio map, which can be considered to be more up-to-date than the indoor radio map, that the radio node has moved away from his original position which is used for the radio model of the indoor radio map.

As an example, this threshold may be one of 20m, 30m, 40m, 50m, 100m, 200m, 500m.

Fig. 6 depicts a flow chart illustrating an example embodiment of a method 600 according to the invention. This method 600 may be used for implementing at least a part of method 400 depicted in Fig. 4, in particular action 420.

According to the example method 600 it is checked whether the information associated with a movement of the radio node (which is determined in action 410) comprises an information that the radio node is moving, wherein as an example, this moving may represent an actual and/or continuous or discontinuous moving, e.g. since it is now located in or on a moving object like a train or car are plane or another movable object. For instance, this information that the radio node is moving may be determined from the position related information from the first database. For instance, the position related information may determined be based on several fingerprints all associated with the same radio node but indicating different positions at different times (e.g., the time when the fingerprint was collected). Thus, it may be deduced from those fingerprints that the

radio node is moving (e.g. the position according to position related information changes over time) and thus the position related information is set to an information being indicative of such a movement of the radio node, i.e., it then comprises an information that the radio node is moving.

If the information associated with a movement of the radio node (which is determined in action 410) comprises information that the radio node is moving the radio node may be considered to be invalid, as indicated by action 530. Then, for instance, the radio node may be removed from indoor radio map.

On the other hand, if the information associated with a movement of the radio node does not comprise an information that the radio node is moving, as an example, the radio node may considered to be in a mode "stable", i.e. not moving. For instance, if the information associated with a movement of the radio node does not comprise an information that the radio node is moving, method 600 may then jump from reference sign 620 to reference sign 505 of method 500 and may perform method 500, as explained above.

Fig. 7 depicts a flow chart illustrating an example embodiment of a method 700 according to the invention. This method 700 may be used for implementing at least a part of method 400 depicted in Fig. 4, in particular action 420, or it may used with respect to method 700, as will be explained later.

According to the example of method 700 it is checked whether the information associated with a movement of the radio node (which is determined in action 410) can be considered to be uncertain or dubious (action 710). For instance, the information associated with a movement of the radio node may be considered to be uncertain or dubious if a fingerprint or some fingerprints used for obtaining the position related information associated with the radio node (e.g. obtained by action 210) is not reliable or if there are indications of uncertainty of this fingerprint(s). As an example, the information associated with a movement of the radio node may be considered to be uncertain or dubious when there is not enough evidence of e.g. radio node movement.

For instance, with respect to method 600 depicted in Fig. 6, reference sign 611 in Fig. 6 may jump to reference sign 701 in Fig. 7 in order to perform method 700. Thus, method 700 is initiated if the information associated with a movement of the radio node comprises information that the radio node is moving (i.e., checking in action 610 yields in a positive result), and then it may be

checked in action 710 whether this information that the radio node is moving is suspicious or uncertain.

As an example, this checking in action 710 may comprise checking whether the number of fingerprints (i.e. number of samples) indicating that the radio node moves is below a threshold or not. If the number of fingerprints indicating that the radio node moves is below the threshold it might be assumed that there is not enough evidence that the radio node moves and thus the information associated with the a movement of the radio node can be considered to be uncertain or dubious in action 710 such that the method 700 proceeds in action 720. For instance, this threshold may be 1, or 2, or 3, or 5, or 8, or 10, or any other well-suited number radio nodes. E.g., the number of fingerprints indicating that the radio node moves may correspond to the number of fingerprints that are used for determining information regarding a movement of the radio node based on the position related information from the first database in action 410 of method 400.

If the information associated with a movement may be considered to be uncertain or dubious of this information, i.e., if checking in action 710 yields a positive result, an identifier may be assigned to the radio node in the second database. Thus, this identifier may indicate that this radio node indicated by this identifier in the indoor radio map of the second database should be used carefully for positioning. For instance, this radio node could be excluded from the positioning in case there are enough verified nodes in the indoor radio map.

If the information associated with a movement may be not considered to be uncertain or dubious of this information, i.e., if checking in action 710 yields a negative result, method 700 may for instance jump from reference sign 712 to reference sign 505 of method 500 in Fig. 5 or to reference sign 612 of method 600 in Fig. 6.

For instance, checking in action 710 may comprise determining a number of samples associated with the information associated with a movement of the radio node, wherein the information is considered to be uncertain if said number of samples is below a threshold. Such a sample may represent a fingerprint of this radio node indicating that the radio node is moving, wherein the threshold may represent a number of fingerprints, as explained above. Thus, if the number of fingerprints of this radio node indicating that the radio node moves is below this threshold the information associated with a movement of the radio node may be considered to be uncertain or dubious and thus the radio node can be considered to be uncertain or dubious.

Furthermore, as an example embodiment, if a radio node has been considered to be uncertain or dubious, e.g. an identifier may have been assigned to this radio node in the second database during in action 720, and if at least one new fingerprint is obtained from this radio node, e.g. by apparatus or apparatus 300, the method 700 may proceed with action 710 in order to check whether the information associated with a movement of this radio node is considered to be uncertain or dubious further based on this at least one new fingerprint. For instance, if the number of fingerprints being indicative of the movement of the radio node without said at least one new fingerprint is an integer number n, and the number of the at least new fingerprint is m, with $m \geq 1$, the updated number of fingerprints being indicative of the movement of the radio node is n+m and it may be checked in action 710 whether this updated number of fingerprints is below the threshold or not, as explained above. If now the updated number of fingerprints is not longer below the threshold, the information associated with a movement of this radio node can now be considered not to be uncertain or dubious, and for instance, the identifier which has been assigned to said radio node in former action 720 in order to indicate that this radio node is suspicious or dubious may be removed or may be changed to identified indicating that this radio not is not suspicious or dubious, and, further the method 700 may proceed at reference sign 712 and may proceed in method 600 at reference sign 612.

Furthermore, as an example, if at least one new fingerprint is obtained from this radio node, the method may proceed with method 400 and new information regarding a movement of this radio node may be determined in action 410 and checking of validity of this radio node may be performed in action 420. This action 420 may proceed with method 600 in order to check whether the information associated with a movement of the radio node comprises information that the radio node is moving in action 610. As an example, if said at least one new fingerprint does not indicate that the radio node moves this may result in a respective information regarding a movement of this radio determined in action 410 such that it may be determined in action 610 that the information associated with a movement of the radio node does not comprise information that the radio node is moving and, as an example, such that the radio node is not longer considered to be suspicious or dubios and, for instance, that an identifier which might have been assigned to this radio node during a former action 720 can be removed.

Or, if said at least one new fingerprint does indicate that the radio node moves this may result in a respective information regarding a movement of this radio determined in action 410 such that it

may be determined in action 610 that the information associated with a movement of the radio node does comprise information that the radio node is moving such that the method 600 may proceed at reference sign 611 and may proceed at reference sign 701 of method 700 wherein it is checked in action 710 whether the information associated with a movement of this radio node is considered to be uncertain or dubious further based on this at least one new fingerprint. For instance, as an example, if the number of fingerprints being indicative of the movement of the radio node without said at least one new fingerprint is an integer number n, and the number of the at least new fingerprint is m, with $m \geq 1$, the updated number of fingerprints being indicative of the movement of the radio node is n+m and it may be checked in action 710 whether this updated number of fingerprints is below the threshold or not, as explained above. If now the updated number of fingerprints is not longer below the threshold, the information associated with a movement of this radio node is now not considered to be uncertain or dubious, and for instance, the identifier which has been assigned to said radio node in former action 720 in order to indicate that this radio node is suspicious or dubious may be removed or may be changed to identified indicating that this radio not is not suspicious or dubious, and, further the method 700 may proceed at reference sign 712 and may proceed in method 600 at reference sign 612.

Fig. 8 depicts a flow chart illustrating an example embodiment of a method 800 according to the invention.

According to this example of method 800, a radio node is selected in the indoor radio map of the second database (action 810). For instance, the indoor radio map may comprise a plurality of radio nodes.

It is then checked whether this selected radio node exists in the global radio map of the first database (action 820). If not, the method 800 may proceed with action 830.

If the radio node exists in the global radio map the method 800 may proceed with method 200 by obtaining position related information associated with the selected radio node from the first database (action 210' – which may correspond to action 210 of method 200) and by checking validity of the radio node in the second database based on the position related information (action 220' – which may correspond to action 220 of method 200). For instance, this method 200 may further comprise one of the examples of methods 400, 500, 600 and 700.

Afterwards, it is checked whether there is a further radio node in the indoor radio map of the second database (action 830), and if this checking yields a positive results, method 800 may proceed with action 810 by selecting this further radio node. If there is no further radio node and checking in action 830 yields a negative result, method 800 may terminate.

Fig. 9 is a schematic illustration of examples of tangible storage media according to the present invention, that may for instance be used to implement memory 11 of Fig. 1, program memory 303 of Fig. 3 and/or program memory 304 of Fig. 3. To this end, Fig. 9 displays a flash memory 800', which may for instance be soldered or bonded to a printed circuit board, a solid-state drive 801 comprising a plurality of memory chips (e.g. Flash memory chips), a magnetic hard drive 802, a Secure Digital (SD) card 803, a Universal Serial Bus (USB) memory stick 804, an optical storage medium 805 (such as for instance a CD-ROM or DVD) and a magnetic storage medium 806.

Any presented connection in the described embodiments is to be understood in a way that the involved components are operationally coupled. Thus, the connections can be direct or indirect with any number or combination of intervening elements, and there may be merely a functional relationship between the components.

Further, as used in this text, the term 'circuitry' refers to any of the following:
(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry)
(b) combinations of circuits and software (and/or firmware), such as: (i) to a combination of processor(s) or (ii) to portions of processor(s)/ software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone, to perform various functions) and
(c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that re-quire software or firmware for operation, even if the software or firmware is not physically present.

This definition of 'circuitry' applies to all uses of this term in this text, including in any claims. As a further example, as used in this text, the term 'circuitry' also covers an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term 'circuitry' also covers, for example, a baseband integrated circuit or applications processor integrated circuit for a mobile phone.

Any of the processors mentioned in this text, in particular but not limited to processors 10, 20 and 30 of Figs. 1, 2 and 3, could be a processor of any suitable type. Any processor may comprise but is not limited to one or more microprocessors, one or more processor(s) with accompanying digital signal processor(s), one or more processor(s) without accompanying digital signal processor(s), one or more special-purpose computer chips, one or more field-programmable gate arrays (FPGAS), one or more controllers, one or more application-specific integrated circuits (ASICS), or one or more computer(s). The relevant structure/hardware has been programmed in such a way to carry out the described function.

Moreover, any of the actions described or illustrated herein may be implemented using executable instructions in a general-purpose or special-purpose processor and stored on a computer-readable storage medium (e.g., disk, memory, or the like) to be executed by such a processor. References to 'computer-readable storage medium' should be understood to encompass specialized circuits such as FPGAs, ASICs, signal processing devices, and other devices.

Furthermore, the wording "at least one of (i) …, (ii) … (n)" comprising n elements has to be understood that only one element of the n elements may be selected, or any combination of two or more of the n elements may be selected, or, that all n elements may be selected.

It will be understood that all presented embodiments are only exemplary, and that any feature presented for a particular exemplary embodiment may be used with any aspect of the invention on its own or in combination with any feature presented for the same or another particular exemplary embodiment and/or in combination with any other feature not mentioned. It will further be understood that any feature presented for an example embodiment in a particular category may also be used in a corresponding manner in an example embodiment of any other category.

Claims

1. A method, comprising:

Obtaining position related information associated with a radio node from a first database, the first database being associated with a global radio map, and

checking validity of said radio node in a second database based on the position related information, the second database being associated with an indoor radio map.

2. The method according to claim 1, wherein said validating comprises determining information associated with a movement of the radio node based on the position related information from the first database.

3. The method according to claim 2, wherein said information associated with a movement comprises a distance between a position of the radio node associated with first database and a position of the radio node associated with the second database.

4. The method according to claim 3, wherein the position of the radio node associated with the second database has been determined without usage of a Global Satellite navigation system satellite (GNSS) system.

5. The method according to one of claims 3 and 4, wherein the position of the radio node associated with the second database has been determined by a manual collection of a fingerprint triggered by a user interaction.

6. The method according to one of claims 3 to 5, comprising, if said distance is higher than a threshold, determining said radio node in the second database to be invalid.

7. The method according to one of claims 2 to 6, wherein the information associated with a movement of the radio node comprises information that the radio node is moving.

8. The method according to claim 7, wherein the information that the radio node is moving is determined based on the position related information associated with the radio node from the first database.

9. The method according to one of claims 7 and 8, comprising, if it is detected that radio node is moving, determining said radio node in the second database to be invalid.

10. The method according to one of the preceding claims 2 to 9, comprising determining whether the information associated with a movement of the radio node is considered to be uncertain.

11. The method according to claim 10, comprising determining a number of samples associated with the information associated with a movement of the radio node, wherein the information is considered to be uncertain if said number of samples is below a threshold.

12. The method according to one of claims 10 and 11, comprising assigning an identifier to said radio node in the second database if the informati1on is considered to be uncertain.

13. The method according to one of claims 6 and 9, comprising, if said radio node in the second database is determined to be invalid, one of:

- removing the radio node indicated to be invalid from the second database;
- assigning an invalid indicator to the radio node in the second database.

14. The method according to one of the preceding claims, comprising, if said radio node in the second database is determined to be valid, comprising providing an indicator to the radio node in the indoor radio map being indicative that this radio node has been successfully verified.

15. The method according to one of the preceding claims, wherein the position related information in the first database is obtained based on location information from a Global Satellite navigation system satellite (GNSS) system.

16. The method according to one of the preceding claims, wherein the indoor radio map of the second database has been generated based on indoor manual data collection.

17. The method according to one of the preceding claims, comprising generating or updating the indoor radio model of the second database based on said checking validity of said radio node in a second database.

18. The method according to claim 17, comprising, if the radio node is determined to not to be valid, not considering the radio node when generating the indoor radio map of the second database.

19. A computer program code, the computer program code when executed by a processor causing an apparatus to perform the actions of the method of any one of claims 1 to 18.

20. A computer readable storage medium in which computer program code according to claim 19 is stored.

21. An apparatus configured to realize or comprising respective means for realizing the method according to any one of claims 1 to 18.

22. An apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause an apparatus at least to perform the method according to any of claims 1 to 18.

23. The apparatus according to any one of claims 21 and 22, wherein the apparatus is one of

a server or a part thereof; and

a mobile device or a part thereof.

Intellectual Property Office

Application No:	GB1611075.1	**Examiner:**	Mr Max Emery
Claims searched:	1-20,22(23 only when dependent on 22)	**Date of search:**	22 December 2016

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	EP3028060 A1 (Here Global B.V.) - figure 4
A	-	WO2011/008613 A1 (Sky-Hook Wireless, Inc) - figure 3

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

G01C; G01S; H04W

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
G01S	0005/02	01/01/2010
G01C	0021/20	01/01/2006