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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 September 2013 (19.09.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/136128 A1

(51) International Patent Classification:
H04B 17/00 (2006.01) *H04W 64/00* (2009.01)
H04B 7/04 (2006.01) *G01S 5/00* (2006.01)

(21) International Application Number: PCT/IB2012/051231

(22) International Filing Date: 15 March 2012 (15.03.2012)

(25) Filing Language: English

(26) Publication Language: English

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(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, CL, 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, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: GENERATING RADIO CHANNEL MODELS PARAMETER VALUES

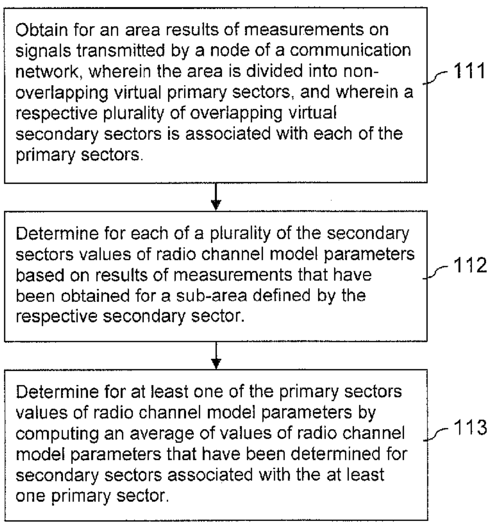

FIG. 2

(57) Abstract: An apparatus obtains, for an area, results of measurements on signals transmitted by a node of a communication network. The area is divided into non-overlapping virtual primary sectors, and a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors. The apparatus determines for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector. The apparatus determines for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.

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Generating radio channel models parameter values

FIELD OF THE DISCLOSURE

The invention relates to the field of radio channel models, and more specifically to the generation of radio channel model parameter values based on results of measurements on signals transmitted by a node of a communication network.

BACKGROUND

Modern global cellular and non-cellular positioning technologies are based on generating large global databases containing information on cellular and non-cellular signals. The information may originate entirely or partially from users of these positioning technologies.

The information provided by users is typically in the form of "fingerprints", which contain a location that is estimated based on, e.g., received satellite signals of a global navigation satellite system (GNSS) and measurements taken from one or more radio interfaces for signals of a cellular and/or non-cellular terrestrial system. In the case of measurements on cellular signals, the results of the measurements may contain a global and/or local identification of the cellular network cells observed, their signal strengths and/or pathlosses and/or timing measurements like timing advance (TA) or round-trip time. For measurements on wireless local area network (WLAN) signals, as an example of signals of a non-cellular system, the results of the measurements may contain a basic service set identification (BSSID), like the medium access control (MAC) address of observed access points, the service set identifier (SSID) of the access points, and the signal strength of received signals (received signal strength indication RSSI or physical Rx level in dBm with a reference value of 1 mW, etc.).

This data may then be transferred to a server or cloud, where the data may be collected and where further models may be generated based on the data for positioning purposes. Such further models can be coverage area estimates, base station positions and/or radio channel models, a base station being an exemplary node of a communication network. In the end, these refined models may be used for estimating the position of mobile terminals.

A radio channel model may consists for instance of a base station position and a pathloss model, or a plurality of pathloss models in the case of sectorized models.

SUMMARY OF SOME EMBODIMENTS OF THE INVENTION

A method is described, which comprises at an apparatus obtaining for an area results of measurements on signals transmitted by a node of a communication network, wherein the area is divided into non-overlapping virtual primary sectors, and wherein a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors. The method further comprises determining for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector. The method further comprises determining for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.

Moreover a first apparatus is described, which comprises means for realizing the actions of the presented method.

The means of this apparatus can be implemented in hardware and/or software. They may comprise for instance a processor for executing computer program code for realizing the required functions, a 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.

Moreover a second apparatus is described, which 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 the actions of the presented method.

Moreover a non-transitory computer readable storage medium is described, in which computer program code is stored. The computer program code causes an apparatus to realize the actions of the presented method when executed by a processor.

The computer readable storage medium could be for example a disk or a memory or the like. The computer program code could be stored in the computer readable storage medium in the form of instructions encoding the computer-readable storage medium. The computer readable storage medium may be intended for taking part in the operation of a device, like an internal or external hard disk of a computer, or be intended for distribution of the program code, like an optical disc.

It is to be understood that also the computer program code by itself has to be considered an embodiment of the invention.

Moreover a system is described, which comprises any of the described apparatuses and at least one of: a mobile device configured to provide results of measurements on signals transmitted by a node of a communication network; a memory configured to store results of measurements on signals transmitted by a node of a communication network; and a memory configured to store determined values of radio channel model parameters.

Any of the described apparatuses may comprise only the indicated components or one or more additional components.

Any of the described apparatuses may be a module or a component for a device, for example a chip. Alternatively, any of the described apparatuses may be a device, for instance a server or a mobile terminal.

In one embodiment, the described methods are information providing methods, and the described first apparatus is an information providing apparatus. In one embodiment, the means of the described first apparatus are processing means.

In certain embodiments of the described methods, the methods are methods for generating radio channel model parameter values. In certain embodiments of the described apparatuses, the apparatuses are apparatuses for generating radio channel model parameters.

Further, it is to be understood that the presentation 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 apparatus according to an exemplary embodiment of the invention;

Fig. 2 is a flow chart illustrating a method according to an exemplary embodiment of the invention;

Fig. 3 is a schematic block diagram of a system according to an exemplary embodiment of the invention;

Fig. 4 is a flow chart illustrating an exemplary operation in the system of Figure 3;

Fig. 5 is a diagram illustrating an exemplary division of a cell area into virtual sectors; and

Fig. 6 is a diagram illustrating an exemplary association of beams with sectors; and

Fig. 7 is a diagram illustrating an exemplary beam width.

DETAILED DESCRIPTION OF THE FIGURES

Figure 1 is a schematic block diagram of an apparatus 100. Apparatus 100 comprises a processor 101 and, linked to processor 101, a memory 102. Memory 102 stores computer program code for generating radio channel model parameters. Processor 101 is configured to execute computer program code stored in memory 102 in order to cause an apparatus to perform desired actions.

Apparatus 100 could be a server or any other device, for instance a mobile terminal. Apparatus 100 could equally be a module for a server or for any other device, like a chip, circuitry on a chip or a plug-in board. Apparatus 100 is an exemplary embodiment of any apparatus according to the invention. Optionally, apparatus 100 could have various other components, like a data interface, a user interface, a further memory, a further processor, etc.

An operation of apparatus 100 will now be described with reference to the flow chart of Figure 2. The operation is an exemplary embodiment of a method according to the invention. Processor 101 and the program code stored in memory 102 cause an apparatus to perform the operation when the program code is retrieved from memory 102 and executed by processor 101. The apparatus that is caused to perform the operation can be apparatus 100 or some other apparatus, in particular a device comprising apparatus 100.

The apparatus obtains for an area results of measurements on signals transmitted by a node of a communication network. The area is divided into non-overlapping virtual primary sectors, and a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors. (action 111)

The apparatus furthermore determines for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector. (action 112)

The apparatus furthermore determines for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector. (action 113)

When modeling a radio channel for a node, the landscape around the node plays a major role. Consider for example an omni-directional cell served by a base station at a land-water boundary. The radio frequency radiation from the base station towards the open water is close to the free space propagation. In contrast, on the land especially in urban conditions a pathloss exponent may be more than double of a pathloss exponent over the water. In general, the signal attenuation towards the different directions can deviate significantly. Modeling the radio environment in pieces, or sectors, allows adjusting radio channel model parameters for one direction independently of the some other direction.

With a high number of sectors, the models become increasingly accurate towards the corresponding azimuth angles, but at the same time the number of samples per sector decreases, making the modeling process unreliable. With a low number of samples from some virtual sector, it may be impossible to determine the model parameters.

Furthermore, when considering the sectors independently from each other, the radio channel parameters that are determined for adjacent sectors may differ considerably from each other. Sharp changes in the values of radio channel model parameters, which do not reflect corresponding conditions in the real-world, may lead to problems in a positioning phase making use of the radio channel model.

Certain embodiments of the invention may enable an apparatus to generate radio channel model parameters for a node of a communication network based on results of measurements on signals transmitted by the node. The area in which signals of the node may be detected can be divided into virtual sectors, which are referred to as primary sectors. For each primary sector, individual radio channel model parameters are determined to take account of different propagation conditions in different directions of transmission of the node. For determining these parameters, a plurality of secondary sectors is associated with each primary sector. The secondary sectors are overlapping. The same results of measurements may thus be valid for each of a plurality of overlapping secondary sectors, including secondary sectors that are associated with different primary sectors. Parameter values may then be determined for each secondary sector, and the parameter values for the primary sectors may be computed by averaging the parameter values of associated secondary sectors. The average can be computed in any desired way, for instance by determining an arithmetic mean, a geometric mean, or a median value, etc.

Dividing the cell into virtual sectors may have the effect in certain embodiments that the differences in the radio propagation in different directions can be taken into account. Using averaged parameter values from a plurality of overlapping secondary sectors for each sector may further have the effect in certain embodiments that more values of measurement results may be taken into account for a primary sector, and that the values of radio channel model parameters for neighboring primary sectors may be more consistent and change smoothly from one primary sector to the next primary sector.

Apparatus 100 illustrated in Figure 1 and the operation illustrated in Figure 2 may be implemented and refined in various ways.

The radio channel model parameters for the secondary sectors can be determined based on measurement results using any desired approach. They could be determined for instance using linear regression, for example but not exclusively Bayesian linear regression. Using Bayesian linear regression for the parameter fitting, for instance a Bayesian least-squares method, may have the effect that a-prior knowledge on the parameter values may be taken into account. This may result in better parameter estimates in the case of a small number of available measurement results.

The node could be a node of a cellular communication system, for instance a global system for mobile communications (GSM), a 3rd Generation Partnership Project (3GPP) based cellular system like a wide-band code division multiple access (WCDMA) system or a time division synchronous CDMA (TD-SCDMA) system, a 3GPP2 system like a CDMA2000 system, a long term evolution (LTE) or LTE-Advanced system, or any other type of cellular system, like a worldwide interoperability for microwave access (WiMAX) system. Alternatively, the node could be for example a node of a non-cellular communication system, like WLAN, Bluetooth and Zigbee, etc. The node of a cellular communication system could be for instance a transceiver or a base station of the cellular communication system. In general, a node of a cellular communication system could be an entity serving exactly one cell, or an entity serving a plurality of cells from a single position. The node of a WLAN could be a WLAN access point.

The measurement results may be obtained for instance from a database that is used for collecting measurement results provided by mobile devices, for example by communication terminals, like mobile phones, smart phones, laptops, tablet computers, etc. The measurement results could comprise for instance the results of measurements on terrestrial radio signals from the nodes of a communication system determined or collected at mobile devices at a respective location. In an exemplary embodiment, the results of measurements comprise signal strength measurement values and/or path loss estimates. Mobile devices providing measurement results could provide at the same time an indication of their current position, in order to enable an identification of a position for which the measurement results are valid.

In an exemplary embodiment, the sub-areas defined by the secondary sectors associated with a primary sector exceed a sub-area corresponding to the primary sector. This may have the effect that more measurement results can be considered than those measurement results that are associated with the sub-area covered by the primary sector. In addition, this may have the effect that a smooth transition of parameter values between the primary sectors may be obtained. It was found that using a plurality of secondary sectors per primary sector also results in a smoother change of parameters from one primary sector to the next primary sector than, for instance, using for each primary sector a single secondary sector that exceed a sub-area corresponding to the primary sector. Also the sub-area defined by an individual one of the plurality of secondary sector could be larger than the sub-area corresponding to the primary sector with which it is associated. This may have the effect that the probability is increased that there are sufficient samples for the secondary sectors for determining radio channel model parameters.

In some cases it may not be possible to compute radio channel model parameter values for a secondary sector based on results of measurements that have been obtained for a sub-area defined by this secondary sector. One reason might be that there are not enough measurement results available for the sub-area covered by the secondary sector. The number of required samples may be predetermined. Another reason might be that the computations result in some error condition, for instance a division by zero, etc. Yet another reason might be that the computed parameter values do not pass an optional validity check, for instance with respect to expected ranges. In an exemplary embodiment, values of radio channel model parameters for a particular secondary sector, for which values of radio channel model parameters cannot be determined based on results of measurements that have been obtained for a sub-area defined by the particular secondary sector, are obtained by interpolating the values of radio channel model parameters that have been determined for secondary sectors on both sides of the particular secondary sector. For each interpolation, for instance only the closest secondary sectors for which values of parameters could be determined may be taken into account, or a fixed or adjustable number of secondary sectors on each side of the particular secondary sector. The number of considered beams on different sides of the particular secondary sector could also be different. In certain embodiments, also secondary sectors associated with neighboring primary sectors may be taken into account in such an interpolation. In certain cases, parameters for the particular secondary sector might also be determined by extrapolating parameter values that have been determined for secondary sectors on a single side of the particular secondary sector. This approach might be used for instance in case there are no beams on the other side.

Alternatively, the secondary sectors for which no parameters may be determined could simply be ignored when determining the parameters for a respective sector.

In an exemplary embodiment, various types of information can be read from a configuration for supporting the determination of radio channel model parameters. The configuration could be for instance a configuration for a particular node, but it could also be a configuration for a plurality of nodes, for instance for all nodes of a particular type of a particular communication network. The information that is read from a configuration may comprise for instance an indication of a number of primary sectors and/or an indication of a number of secondary sectors and/or an indication of a number of secondary sectors per primary sector, and/or an indication of a width of the primary sectors, and/or an indication of a width of the secondary sectors. The number of primary or secondary sectors can be the number of sectors into which an area is to be divided. Using information from adjustable settings from a configuration may have the effect that the computations may easily be adapted to individual nodes and/or to varying situations. It is to be understood, however, that one or more of such numbers and widths could also be set to a respective fixed value.

The radio channel model could comprise for instance a pathloss model or a received signal strength model.

In an exemplary embodiment, the radio channel model parameters comprise an apparent transmit power and/or a path loss constant and/or a path loss exponent and/or parameter covariance matrix parameters, wherein the parameter covariance relates to the covariance of the other considered parameters of the radio channel model. A subset of these parameters allows determining the path loss or the signal strength of signals transmitted by a node that a mobile device can be expected to detect at a certain distance to the node. The information required for defining a radio channel model may be quite compact and requires a limited amount of storage space or transmission bandwidth.

A complete radio channel model for a node may comprise in addition the position of the node. This position may already be available, or it may be determined based on the obtained data as well. The position of the node is the same for all sectors, thus the position has to be determined, stored and/or transmitted only once for the radio channel models for all sectors of a node.

The determined values of radio channel model parameters for a plurality of sectors can be determined for immediate use or for a later use. They can be determined upon request or on a regular basis. In an exemplary embodiment, the determined values of radio channel model parameters for a plurality of sectors are provided for storage in a database, for instance a radio channel model database, and/or for transmission to a mobile device and/or for transmission to a server, for instance a positioning server.

In an exemplary embodiment, the obtained results of measurements are associated with grid points of a virtual grid. Each grid point may correspond to a real location. The virtual grid may be defined to cover at least an area in which signals from the node can be detected, have been detected or are assumed to be detectable. The measurement results could be associated with grid points of a grid that represent locations close to the respective measuring position. This may have the effect that results of measurements can be stored efficiently, that is, for a limited number of locations and thus with a limited amount of data. New measured data that is mapped to a grid point can be used for replacing old data mapped to a grid point. It is to be understood, however, that a mapping to grid points of a grid is not essential. In certain embodiments, it would also be possible to store results of measurements along with the actual location of measurement, for example a location as provided by a mobile device providing the respective results of measurements.

When using data with a mapping to grid points of a grid, the position of the node may be determined, for instance, by analyzing the location of the high-energy grid points in a stored grid with associated signal strength values.

Figure 3 is a schematic block diagram of a system supporting a computation of radio channel models.

The system comprises a server 200. Server 200 is connected to a network 310, for example the Internet. Server 200 could also belong to network 310. Network 310 is suited to interconnect server 200 with other servers (not shown) and/or with mobile terminals 401, 402 via a cellular network 320 or via any of a plurality of WLANs 330.

Server 200 may provide or support a system for building up and updating a radio channel model database. Server 200 may be for instance a dedicated positioning server, a dedicated position data learning server, or some other kind of server. It comprises a processor 201 that is linked to a first memory 202, to a second memory 206 and to an interface (I/F) 204. Processor 201 is configured to execute computer program code, including computer program code stored in memory 202, in order to cause server 200 to perform desired actions.

Memory 202 stores computer program code for generating radio channel model parameters. The computer program code may comprise for example at least similar program code as memory 102. The memory 202 could comprise in addition program code for collecting and storing fingerprint data provided by mobile terminals and/or program code supporting a positioning of mobile terminals. In addition, memory 202 may store computer program code implemented to realize other functions, as well as any kind of other data. It is to be understood, though, that program code for any other actions than supporting a generation of radio channel model parameters could also be implemented on one or more other physical and/or virtual servers.

Processor 201 and memory 202 may optionally belong to a chip or an integrated circuit 205, which may comprise in addition various other components, for instance a further processor or memory.

Memory 206 stores at least one radio channel model database (DB) that is configured to comprise radio channel model parameters. Memory 206 may further store a fingerprint database with measurement data for nodes of cellular communication network 320 and/or for nodes of WLANs 330. Memory 206 may further store configuration settings for each of a plurality of nodes and/or for one or more groups of nodes. In addition, memory 206 could store other data, for instance other data supporting a positioning of mobile terminals. It is to be understood that any of the databases and/or the configuration settings could also be stored in a memory that is external to server 200; such a memory could be for instance on another physical or virtual server.

Interface 204 is a component which enables server 200 to communicate with other servers or devices, like mobile terminals 401 and 402, via network 310. Interface 204 could comprise for instance a TCP/IP socket.

Component 205 or server 200 could correspond to exemplary embodiments of an apparatus according to the invention.

Cellular communication network 320 comprises a plurality of base stations operating as nodes of the network. Each WLAN 320 comprises at least one access point as a node of a communication network. Each of the nodes transmits signals that can be observed in a certain associated area. In the case of a cellular communication network 320, the area may comprise the area of one or more cells.

Mobile terminal 401 may comprise a GNSS receiver. Mobile terminals 401 may further be configured to perform measurements on signals from nodes of cellular communication network 320 or WLANs 330. Further, mobile terminal 401 may be configured to report measurement results taken at different locations to server 200.

Mobile terminal 402 may equally be configured to perform measurements on signals from nodes of cellular communication network 320 or WLANs 330. In addition, it may be configured to generate location requests comprising results of such measurements to obtain an indication of its position. In addition or alternatively it may be configured to generate a request to be provided with radio channel model parameters and to determine its own position based on such parameters.

During an exemplary operation in the system of Figure 3, mobile terminal 401 may receive satellite signals and determine its current position based on the satellite signals. In addition, mobile terminal 401 may detect signals transmitted by one or more nodes of cellular network 320 for a respective cell. Mobile device 401 may assemble results of measurements on these signals, including Rx level values as an indication of received signal strengths. It may further associate an identification of a cell and thus of the node with the result or results for at least one cell, for instance a global cell identity and/or a local cell identity. In addition, mobile terminal 401 may detect signals transmitted by access points (AP) of one or more WLANs 330 and associate measurement results on these signals, including Rx level values as an indication of received signal strengths, with an identity of the WLAN APs. Mobile terminal 401 may then transmit the measurement results and the associated identifications along with an indication of the determined position as a fingerprint in a message to server 200. The transmission may take place via WLAN 330 and network 310 or via cellular network 320 and network 310. It has to be noted that in an alternative embodiment, the position of mobile device 401 could also be determined based on some other positioning technology than GNSS. For instance, mobile terminal 401 could determine its position based on WLAN signals instead of GNSS signals. Mobile terminal 401 may transmit similar messages from various locations to server 200 while moving around. In addition, other mobile terminals may transmit corresponding messages to server 200.

Server 200 may store received Rx level values, and possibly additional data, with a mapping to a grid point of a respective grid in a fingerprint database in memory 206 separately for each cell or node. The grid point of each grid may be determined based on the indicated position of mobile terminal 401. The data may be stored in various ways. Each grid could be represented for instance by a table that is stored in the fingerprint database in memory 206, and the measurement results and associated data could be inserted as an entry of the table. It is to be understood, however, that the storage of the data does not require storage of the entire grid or of a table corresponding to the entire grid. Since many grid points may not have any data associated with them so far, the data could be stored for instance efficiently using a run-length encoding in the fingerprint database. Further alternatively, the indices of the grid points, with which data are associated, followed by the respectively associated data could be stored in a sequence in the fingerprint database.

The Rx level data stored in memory 206 may be used for regularly updating further models, for example radio channel models, or for supporting a positioning of mobile terminals directly.

An exemplary operation at server 200 of the system of Figure 3 for generating or updating radio channel models will now be described with reference to the flow chart of Figure 4. Processor 201 and the program code stored in memory 202 cause server

200 to perform the presented operations when the program code is retrieved from memory 202 and executed by processor 201.

Server 200 reads Rx level values for a particular base station of cellular communication network 320, for which a radio channel model is to be generated, from the fingerprint database in memory 206. (action 211) Alternatively, the Rx level values of some other node, for instance of a WLAN AP, could be read. The Rx level values are mapped to a grid point of a grid, and the mapping information is obtained as well when reading the Rx level values. The grid covers an area in which signals from the base station can presumably be detected. Each grid point is associated with a particular location on Earth in the covered area.

Server 200 estimates the position of the base station based on the Rx level values and their mapping to a respective grid point. (action 212) The position may be estimated for instance using a weighted average of locations associated with those grid points to which Rx level values are mapped. The locations may be weighted for instance by the respectively associated Rx level value on a linear scale.

Furthermore, server 200 reads an indication of a number of sectors and an indication of a number of beams-per-sector from configuration settings for the base station in memory 206. (action 213) In this embodiment, the sectors correspond to the primary sectors and the beams to the secondary sectors. By way of example, there could be eight sectors and 10 beams-per-sector and thus a total of 80 beams. The numbers could be defined individually per node or per network, or they could be the same for all nodes.

Figure 5 is a diagram illustrating a division of an omni-directional cell into eight virtual sectors, Sector #1 to Sector #8. The sectors are arranged around a center, which corresponds to the estimated position of the base station. The sectors are of equal size, each covering an azimuth width of 45°, starting at an azimuth of 0°. It is to be understood, though, that the sectors could also be of different sizes. In this case, the width of the sectors could also be indicated in the configuration. Also the width of the beams could be either fixed or adaptive and indicated in the configuration. The beam width could vary from node to node and/or from sector to sector to which the beams are associated and/or among the beams associated to a single sector.

The sectors being referred to as virtual sectors means that they do not represent real cell sectors, but just an arbitrary division.

Figure 6 is a diagram illustrating the association of a plurality of beams with each sector. More specifically, the beam directions of various beams identified by a respective beam index are shown. Beams with beam indices #1-#10 are associated with Sector #1, and beams with beam indices #(10+1)-#(10+10) associated with Sector #2. Further beams (not shown) are associated in a corresponding manner with Sectors #3 to #8. The direction of each beam can be computed from the indicated number of beams-per-sector, when assuming a uniform distribution of beams radially extending from the estimated location of the base station.

In the example of Figure 6, the beams are distributed such that the beam direction of the first beam is located at an azimuth of 0°. As a result, the beam direction with the respective smallest angle selected for a sector coincides with the sector boundary with the smaller angle. It is to be understood that other associations of beams with sectors are possible as well. For instance, the beam direction with the respective largest angle associated with a sector could coincide with the sector boundary at the larger angle, meaning that ten beams with indices #2 to #10 and #(10+1) would be associated with Sector #1, etc. Further alternatively, the beams could be distributed in a manner that none of the beam directions coincides with a sector boundary, so that simply all beams with a beam direction within the sector boundaries would be associated with a sector.

Each beam covers a sub-area of the cell that is defined by beam direction and beam-width. The beam-width could be fixed to a predetermined value or be read from configuration settings in memory 206 as well. Figure 7 is a diagram illustrating an exemplary beam-width for a beam associated with Sector #2. The indicated beam direction corresponds to one of the beam directions illustrated in Figure 6, and is defined by angle θ, counting from the azimuth of 0° in the diagram of Figure 5. The beam-width can be expressed as an angle around the beam direction, defining an upper and lower beam limit on an azimuth scale. The beam-width is assumed to exceed the width of the sectors.

The following table shows an example of beam directions and associated beam widths, when using a total of N_{beams} = 80 beams. The beam width is assumed to be +/- 30°.

Beam #	Corresponding beam direction angle	Beam
1	0°	[330°, 30°]
2	4.5°	[334.5°, 34.5°]
...	...	...
K	(K-1)* 4.5°	[(K-1)* 4.5° - 30°, (K-1)* 4.5° + 30°] Note: negative beam border angles need to be wrapped back to range [0,360°)
...	...	...
80	355.5°	[325.5°, 25.5°]

Server 200 now computes radio channel model parameters for each beam, for which a sufficient number of read Rx level values is mapped to the sub-area defined by beam direction and beam width. (action 214) The required number of Rx level values may be predetermined.

Assuming a simple logarithmic-distance based radio channel model with a reference distance of 1 m, pathloss L (dB) from a base station (BS) to the i^{th} grid point can be written as

$$L_i = A + 10n\log_{10}\left(\left\|\underline{x_i} - \underline{x_{BS}}\right\|\right), \quad (1)$$

where A is the pathloss constant, n is the pathloss exponent, $\underline{x_i}$ is the position of i^{th} grid point, and $\underline{x_{BS}}$ is the position of the base station. In this case, the received signal power R_i in dBm at the i^{th} grid point may be written as

$$R_i = T - L_i + W_i = T - A - 10n\log_{10}\left(\left\|\underline{x_i} - \underline{x_{BS}}\right\|\right) + W_i, \quad (2)$$

where T is the transmitted signal power in dBm and where $W_i \sim N(0,\sigma^2)$ is a log-normally distributed random variable describing signal variations due to slow fading (shadowing). By combining T and A as an apparent transmission power, denoted as $T_a = T\text{-}A$, the received signal power can be rewritten as

$$R_i = T_a - 10n\log_{10}\left(\left\|\underline{x_i} - \underline{x_{BS}}\right\|\right) + W_i. \quad (3)$$

This is a linear function of the received signal power R_i as a function of logarithmic distance $\left\|\underline{x_i} - \underline{x_{BS}}\right\|$, with slow fading noise. The unknown parameters "apparent transmission power" T_a and "pathloss exponent" n are also referred to as radio propagation parameters or pathloss parameters. These parameters can now be estimated along with the associated 2x2 symmetric covariance matrix of the parameters T_a and n based on obtained Rx level values using Bayesian linear regression and taking into account a-priori information on the parameters.

For example, measurements may show that a typical value of n might be three with a 1-sigma uncertainty of one. Taking into account the standards, it may further be assumed that a typical transmit power might be 0 dBm. These assumptions may be used as a-priori information in the parameter fitting. Generally, an increasing number of grid points with associated measurement values may result in a decreasing weight of the a-priori information in the final set of parameters.

The beam direction and beam-width of a respective beam determine which ones of the read Rx level values are taken into account in the radio channel modeling process for the beam.

Server 200 then obtains parameter values for the remaining beams, for which too few Rx level values have been obtained from the fingerprint database for performing a radio channel modeling process, by interpolating parameter values that have been determined for neighboring beams. (action 215)

In order to enable such interpolation without constraints, the algorithm should fulfill the cyclic boundary condition, meaning that the beam parameters towards the beam angle 0° must equal those toward the beam angle 360°.

The interpolation must be carried out for all five parameters for which values are obtained for a respective beam in the parameter fitting process of action 214, namely the radio propagation parameters "apparent transmission power" T_a and "pathloss exponent" n, and the three different components of the associated 2x2 symmetric covariance matrix.

Server 200 now computes for each sector the average of the five parameters over all beams associated with the respective sector, in order to obtain the parameters for the sector. (action 216) An exemplary selection of 10 beams per sector can be seen again in Figure 6.

Let $a(i)$ denote the value of any of the five determined radio channel model parameters ("apparent transmission power", "pathloss exponent" or one of the three covariance matrix parameters) for the i^{th} beam (i=1, 2, ..., N_{beams}). Then the average of this parameter for the k^{th} sector $a_{sec,ave}(k)$ can be determined as

$$a_{\sec\_ave}(k) = \frac{1}{CONF\_BS\_N\_BEAMS\_PER\_SEC} \cdot \sum_{i=1+(k-1)CONF\_BS\_N\_BEAMS\_PER\_SEC}^{i=k \cdot CONF\_BS\_N\_BEAMS\_PER\_SEC} a(i), \quad (4)$$

wherein *CONF_BS_N_BEAMS_PER_SEC* is the number of beams-per-sector as defined in the configuration settings for a particular base station. This computation is carried out for each of the five parameters for each of the eight sectors.

Server 200 stores the determined five parameter values for each sector as values of radio channel model parameters for the base station in the radio channel model database in memory 206. In addition, the estimated base station position can be stored in the database as a value of a further radio channel model parameter for the base station. (action 217)

It is to be understood that if the measurement results that are read from the database in action 211 comprised pathloss values instead of Rx level values, the values of parameters of a pathloss model could be determined in actions 214 to 216 instead of the values of parameters of a received signal strength model. Such pathloss model could be based for example on above equation (1), with parameters "pathloss constant" A and "pathloss exponent" n, supplemented by a log-normally distributed random variable W_i as defined for above equation (2).

It is further to be understood that while it was assumed for actions 211 to 217 that a base station or some other node serves a single cell or area using omni-directional transmissions, a corresponding approach could be used for nodes serving a plurality of cells as well. In case a base station serves a plurality of cells, a separate set of Rx level values may be read for each of the cells in action 211. In this case, the sector cells might still simply be modeled as omni-directional cells. Actions 212 to 217 may then be performed in the same manner as described above separately for each of the cells.

Alternatively, the grid data could be analyzed at first, in order to determine whether a cell can be assumed to be a sector cell. The cell could then also be modeled as a sector cell, and this may be taken into account for interpolations. For example, there could be an assumed sector cell with a width of 120°. This sector cell might be divided into a plurality of "primary sectors", for instance three primary sectors having a width of 40°. 30 beams with directions of 0° to 116° and a spacing of 4° could be defined for instance as "secondary sectors", resulting in 10 beams per primary sector. The beam width could be for instance +/-30° again, but it could be of any other value as well. Based on the data from the 120° cell, it may be attempted to calculate the parameter values for the 30 beams. Parameter values may be interpolated again for any remaining beams of the 30 beams, for which no parameter values could be determined. However, in this case, the beam with direction 0° is not the same as a beam with direction 120°. Thus, a cyclic boundary condition is not given. Interpolation might thus only be performed for a remaining beam, if there are close neighboring beams, for which values of parameters have been determined, on both sides of the remaining beam. For obtaining parameter values for those remaining beams, for which no neighboring beams with parameter values are available on one side, the parameter values that have been determined for one or more beams on the other side could be extrapolated.

When a mobile terminal 402 now requests values of radio channel model parameters for all or selected nodes and/or cells, in order to be able to determine its own position, server 200 may read the parameter values for these nodes and/or cells from the radio channel model database in memory 206 and provide them to the requesting mobile terminal 402. (action 221) The parameter values could be requested directly from server 200 or via some other server.

To provide an example, a cell with a radius of 2 km could be covered by virtual grid having a 50 m grid spacing for storing Rx level values. If Rx level values are available for all of the grid points that are associated with the actual cell area, there are approximately 5000 grid points with data. Assuming that the data for each grid point can be stored using one byte, the storage consumption would be about 5 kilobyte.

When multiplied by, for example, 30 million cells that might be considered for the entire Earth, the fingerprint database consumes already 140 gigabyte, when only grids with Rx level data are considered.

The following table summarizes the contents of the radio channel model database for a particular base station:

Parameter	**Contents**	**Storage consumption**
BS position	Latitude and longitude	2 x 4 bytes
	Repeats for each sector	
Tx power	Apparent Tx power in dBm	1 byte
Tx power std	1-sigma uncertainty	1 byte
Pathloss exp	Pathloss exponent	1 byte
Pathloss exp std	1-sigma uncertainty	1 byte
Cross-corr	Cross-correlation between Tx power and pathloss exp	1 byte

Thus, an eight-sector model for a node consumes 2x4 + 8x5 = 48 bytes of data, which compares very favorably to the storage requirement for Rx level data. This justifies the generation of high quality radio channel models, which can be carried to a mobile device for positioning. Note that 30 million cells consume only about 150 megabyte of data, meaning that it would even be possible to store the radio channel model parameter values for every cell on Earth in the memory of a mobile device. It would not be feasible, in contrast, to carry Rx level data for a plurality of nodes to an end-user device, because of the high data amount.

Alternatively, mobile terminal 402 could send a location request including Rx level values and an indication of nodes and/or cells for which the Rx level values have been determined. Server 200 could then read the parameter values for selected nodes and/or cells identified in the request from the radio channel model database in memory 206 and use these parameters for estimating the location of mobile terminal 402. (action 231) The estimated location may then be transmitted to mobile terminal 402.

As mentioned above, such positioning computations could be performed as well by a separate positioning server. Such a server could receive the location request from mobile terminal 402, determine the relevant nodes and/or cells and provide a specific parameter value request for these nodes and/or cells to server 200.

It has to be noted that also mobile terminals with GNSS capability may benefit from using cellular / non-cellular positioning technologies, in order to accelerate the time-to-first-fix, using the obtained location as reference location, or in order to reduce the power consumption. Furthermore, not all applications require a GNSS based position. Furthermore, positioning technologies that are based on terrestrial radio signals may be better suited to work indoors than positioning technologies that are based on satellite signals.

Furthermore, it has to be understood that also a mobile device might be configured to compute radio channel model parameter values and benefit from an implementation using virtual secondary sectors, or beams, for computing these values. For instance, a mobile device could be configured to collect a large number of measurement results for one or more nodes, compute radio channel model parameter values for these nodes based on the collected measurement results, in a similar manner as described with reference to actions 211 to 216 of Figure 4 for server 200, and transmit only the radio channel model parameter values to a server for general usage, in order to limit the amount of data that has to be transmitted. Such an approach could be used for instance in case a mobile device is used specifically for a managed collection of fingerprint data.

Summarized, certain embodiments of the invention may thus enable a fitting of parameter values of a sectorized radio propagation model with the convolution over the azimuth angles. This may have the effect that gaps in collected data may be filled, and that the parameter behavior over different sectors may be smoother, since discontinuities at sector boundaries can be avoided. Thus, a robust method to model the radio channel for a given node using sparse data can be achieved.

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 require 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 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.

Any of the memories mentioned in this text could be implemented as a single memory or as a combination of a plurality of distinct memories, and may comprise for example a read-only memory, a random access memory, a flash memory or a hard disc drive memory etc.

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.

The functions illustrated by processor 101 or 201 in combination with memory 102 or 202, respectively, or the integrated circuit 205 can also be viewed as means for obtaining for an area results of measurements on signals transmitted by a node of a communication network, wherein the area is divided into non-overlapping virtual primary sectors, and wherein a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors; means for determining for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector; and means for determining for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.

The program codes in memory 102 and 202, respectively, can also be viewed as comprising such means in the form of functional modules.

Figures 2 and 4 may also be understood to represent exemplary functional blocks of a computer program code for supporting a generation of values for radio channel model parameters.

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 exemplary embodiment in a particular category may also be used in a corresponding manner in an exemplary embodiment of any other category.

What is claimed is:

1. A method comprising at an apparatus:

obtaining for an area results of measurements on signals transmitted by a node of a communication network, wherein the area is divided into non-overlapping virtual primary sectors, and wherein a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors;

determining for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector; and

determining for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.

2. The method according to claim 1, wherein determining values of radio channel model parameters for a secondary sector based on results of measurements that have been obtained for a sub-area defined by the secondary sector comprises using Bayesian linear regression.

3. The method according to claim 1 or 2, wherein the results of measurements comprise one of signal strength measurement values and path loss estimates.

4. The method according to one of claims 1 to 3, wherein the sub-areas defined by the secondary sectors associated with a primary sector exceed a sub-area corresponding to the primary sector.

5. The method according to one of claims 1 to 4, wherein values of radio channel model parameters for a particular secondary sector, for which values of radio

channel model parameters cannot be determined based on results of measurements that have been obtained for a sub-area defined by the particular secondary sector, are obtained by one of:

interpolating the values of radio channel model parameters determined for secondary sectors on both sides of the particular secondary sector; and

extrapolating the values of radio channel model parameters determined for secondary sectors on one side of the particular secondary sector.

6. The method according to one of claims 1 to 5, wherein at least one of the following is read from a configuration:

an indication of a number of primary sectors;

an indication of a number of secondary sectors;

an indication of a number of secondary sectors per primary sector;

an indication of a width of the primary sectors; and

an indication of a width of the secondary sectors.

7. The method according to one of claims 1 to 6, wherein the radio channel model parameters comprise at least one of:

an apparent transmit power;

a path loss constant;

a path loss exponent; and

parameter covariance matrix parameters.

8. The method according to one of claims 1 to 7, wherein the determined values of radio channel model parameters for a plurality of sectors are provided for at least one of:

storage in a database;

transmission to a mobile device; and

transmission to a server.

9. The method according to one of claims 1 to 8, wherein the obtained results of measurements are associated with grid points of a virtual grid, each grid point corresponding to a real location.

10. An apparatus comprising means for realizing the actions of any of claims 1 to 9.

11. The apparatus according to claim 10, wherein the apparatus is one of:

a server;
a component for a server;
a mobile terminal; and
a component for a mobile terminal.

12. 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:

obtain for an area results of measurements on signals transmitted by a node of a communication network, wherein the area is divided into non-overlapping virtual primary sectors, and wherein a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors;

determine for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector; and

determine for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.

13. The apparatus according to claim 12, wherein the computer program code is configured to, with the at least one processor, cause the apparatus to determine

values of radio channel model parameters for a secondary sector based on results of measurements that have been obtained for a sub-area defined by the secondary sector using Bayesian linear regression.

14. The apparatus according to claim 12 or 13, wherein the results of measurements comprise one of signal strength measurement values and path loss estimates.

15. The apparatus according to one of claims 12 or 14, wherein the sub-areas defined by the secondary sectors associated with a primary sector exceed a sub-area corresponding to the primary sector.

16. The apparatus according to one of claims 12 to 15, wherein the computer program code is configured to, with the at least one processor, cause the apparatus to obtain values of radio channel model parameters for a particular secondary sector, for which values of radio channel model parameters cannot be determined based on results of measurements that have been obtained for a sub-area defined by the particular secondary sector, by one of

interpolating the values of radio channel model parameters determined for secondary sectors on both sides of the particular secondary sector; and

extrapolating the values of radio channel model parameters determined for secondary sectors on one side of the particular secondary sector.

17. The apparatus according to one of claims 12 to 16, wherein the computer program code is configured to, with the at least one processor, cause the apparatus to read at least one of the following from a configuration:

an indication of a number of primary sectors;

an indication of a number of secondary sectors;

an indication of a number of secondary sectors per primary sector;

an indication of a width of the primary sectors; and

an indication of a width of the secondary sectors.

18. The apparatus according to one of claims 12 to 17, wherein the radio channel model parameters comprise at least one of:

    an apparent transmit power;
    a path loss constant;
    a path loss exponent; and
    parameter covariance matrix parameters.

19. The apparatus according to one of claims 12 to 18, wherein the computer program code is configured to, with the at least one processor, cause the apparatus to provide the determined values of radio channel model parameters for a plurality of sectors for at least one of:

    storage in a database;
    transmission to a mobile device; and
    transmission to a server.

20. The apparatus according to one of claims 12 to 19, wherein the obtained results of measurements are associated with grid points of a virtual grid, each grid point corresponding to a real location.

21. The apparatus according to one of claims 12 to 20, wherein the apparatus is one of:

    a server;
    a component for a server;
    a mobile terminal; and
    a component for a mobile terminal.

22. 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 of claims 1 to 9.

23. A computer readable storage medium in which computer program code is stored, the computer program code when executed by a processor causing an apparatus to perform the following:

obtaining for an area results of measurements on signals transmitted by a node of a communication network, wherein the area is divided into non-overlapping virtual primary sectors, and wherein a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors;

determining for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector; and

determining for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.

24. A system comprising an apparatus according to one of claims 10 to 21 and at least one of:

a mobile device configured to provide results of measurements on signals transmitted by a node of a communication network;

a memory configured to store results of measurements on signals transmitted by a node of a communication network; and

a memory configured to store determined values of radio channel model parameters for a plurality of primary sectors of a node.

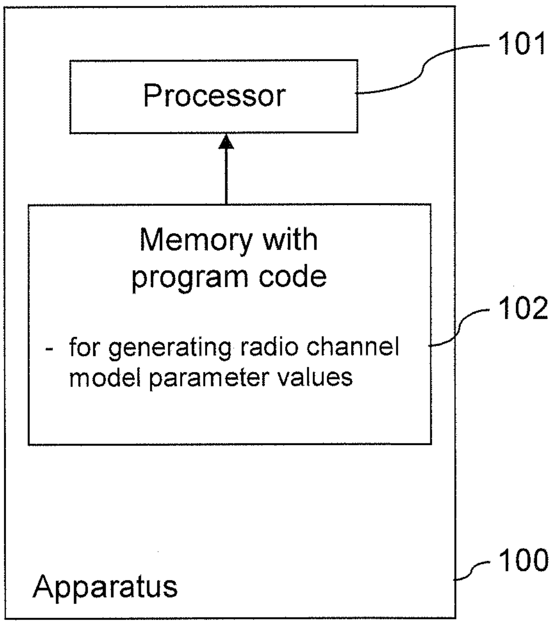
Processor
101
Memory with program code
- for generating radio channel model parameter values
102
Apparatus
100

FIG. 1

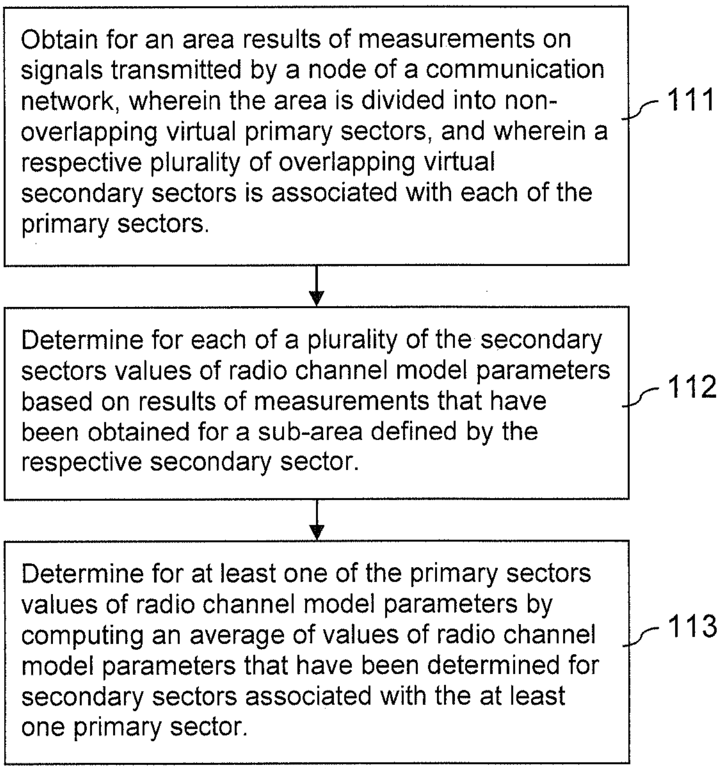
Obtain for an area results of measurements on signals transmitted by a node of a communication network, wherein the area is divided into non-overlapping virtual primary sectors, and wherein a respective plurality of overlapping virtual secondary sectors is associated with each of the primary sectors.
111
Determine for each of a plurality of the secondary sectors values of radio channel model parameters based on results of measurements that have been obtained for a sub-area defined by the respective secondary sector.
112
Determine for at least one of the primary sectors values of radio channel model parameters by computing an average of values of radio channel model parameters that have been determined for secondary sectors associated with the at least one primary sector.
113

FIG. 2

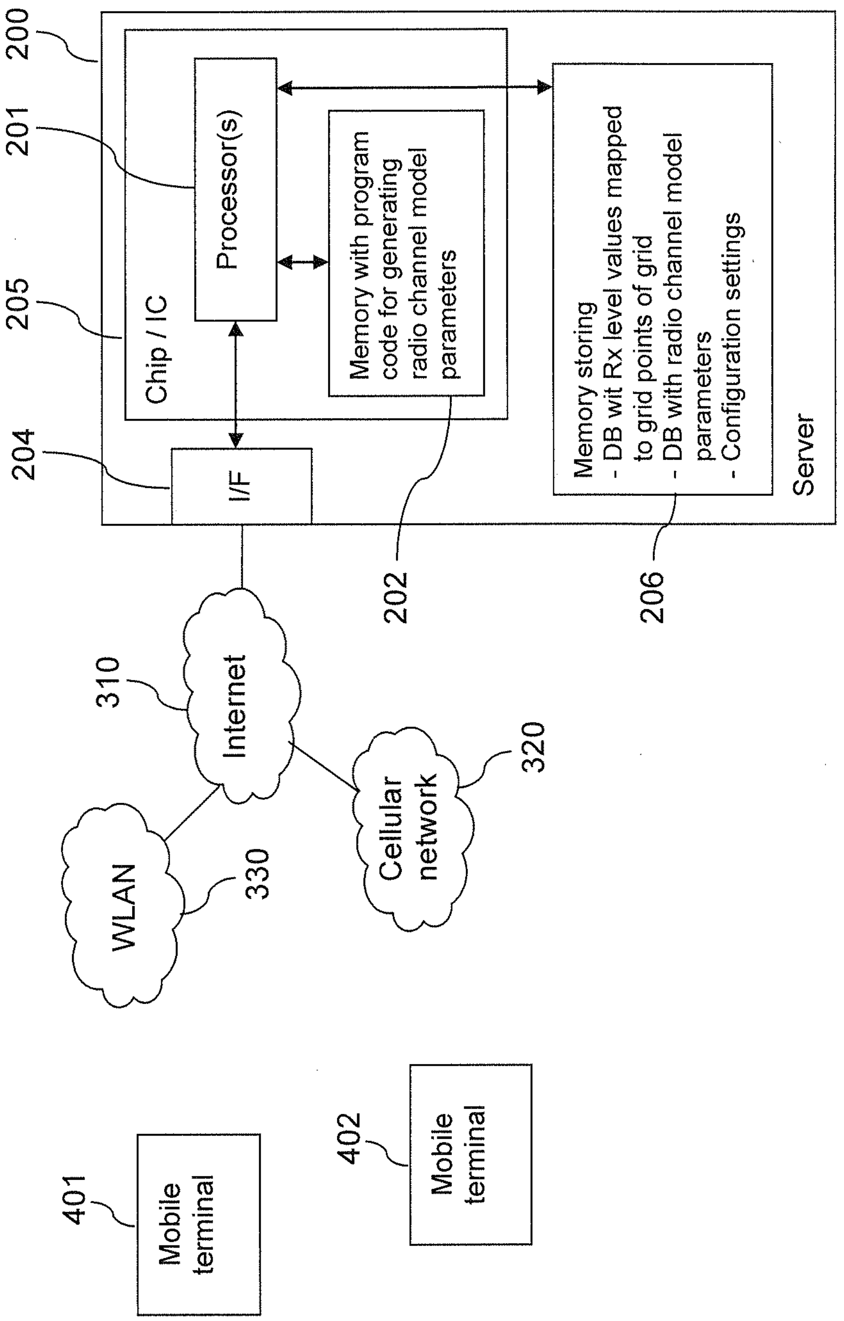
200
201
205
204
Processor(s)
Chip / IC
I/F
Memory with program code for generating radio channel model parameters
Memory storing
- DB wit Rx level values mapped to grid points of grid
- DB with radio channel model parameters
- Configuration settings
Server
202
206
310
Internet
320
Cellular network
330
WLAN
401
Mobile terminal
402
Mobile terminal

FIG. 3

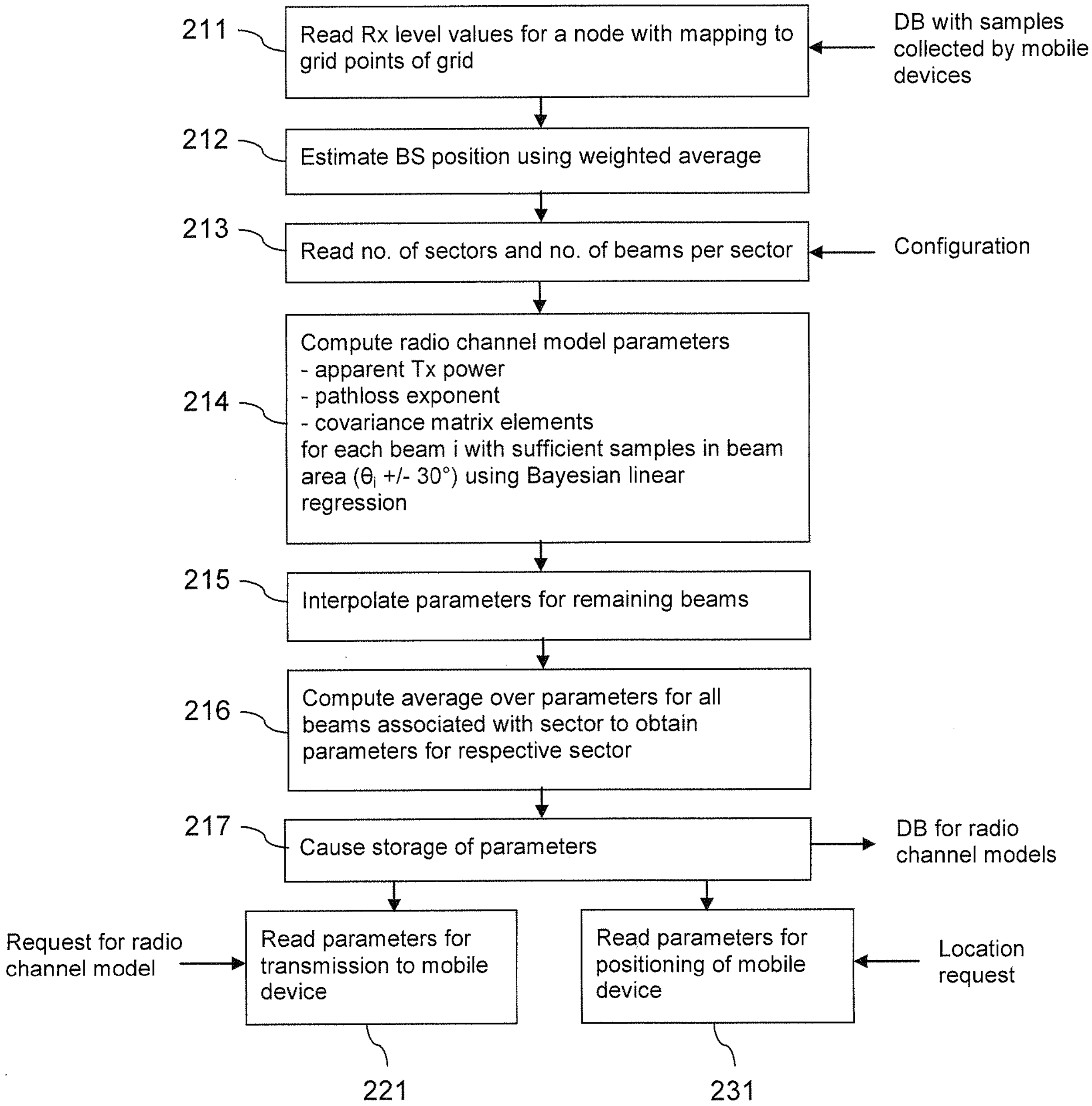
211
Read Rx level values for a node with mapping to grid points of grid
DB with samples collected by mobile devices
212
Estimate BS position using weighted average
213
Read no. of sectors and no. of beams per sector
Configuration
214
Compute radio channel model parameters
- apparent Tx power
- pathloss exponent
- covariance matrix elements
for each beam i with sufficient samples in beam area (θi +/- 30°) using Bayesian linear regression
215
Interpolate parameters for remaining beams
216
Compute average over parameters for all beams associated with sector to obtain parameters for respective sector
217
Cause storage of parameters
DB for radio channel models
Request for radio channel model
Read parameters for transmission to mobile device
Read parameters for positioning of mobile device
Location request
221
231

FIG. 4

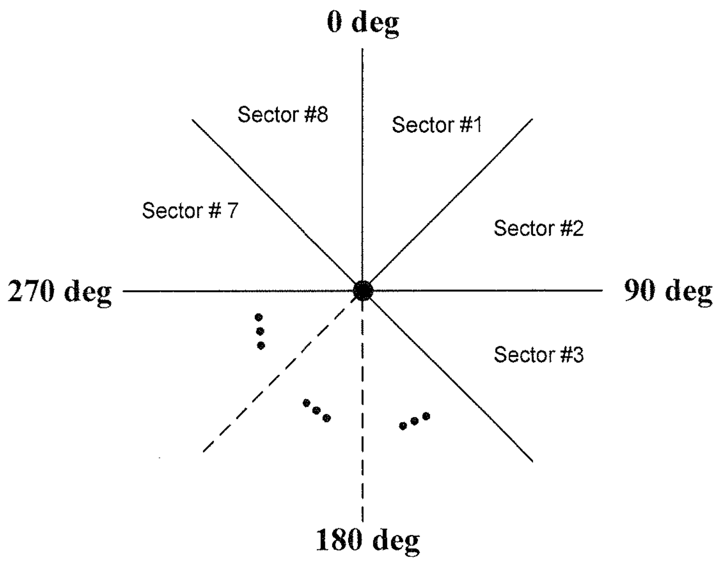
0 deg
Sector #8
Sector #1
Sector # 7
Sector #2
270 deg
90 deg
Sector #3
180 deg

FIG. 5

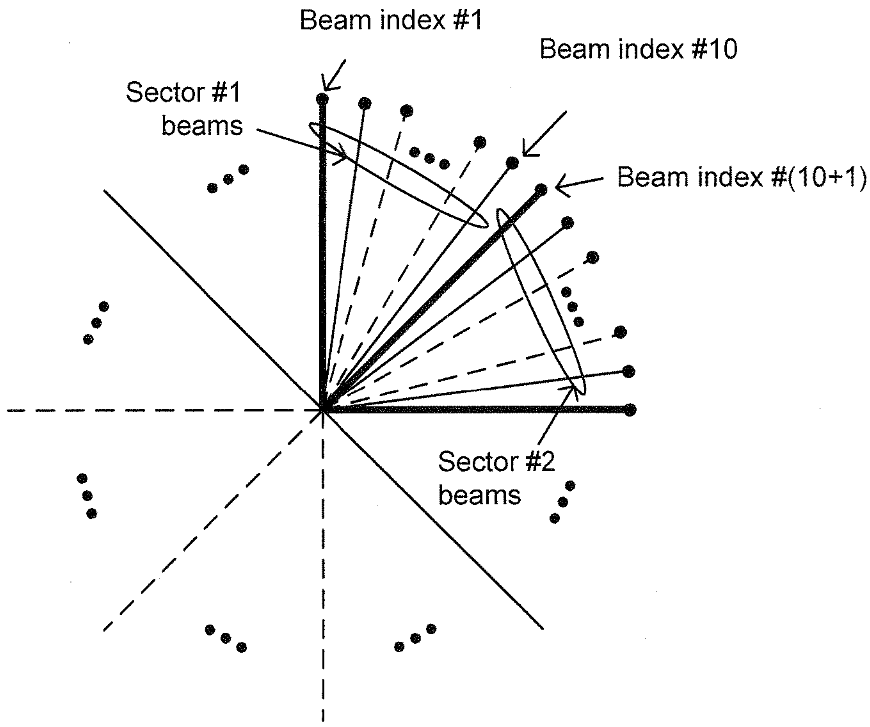
Beam index #1
Beam index #10
Sector #1 beams
Beam index #(10+1)
Sector #2 beams

FIG. 6

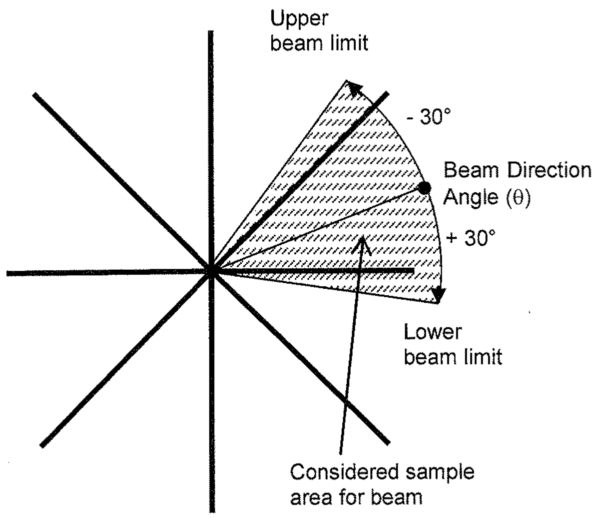
Upper
beam limit
- 30°
Beam Direction
Angle (θ)
+ 30°
Lower
beam limit
Considered sample
area for beam

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/051231

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B17/00 H04B7/04 H04W64/00 G01S5/00
ADD.

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)
H04B H04W G01S

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 960 341 A (LEBLANC FREDERICK WARREN [US] ET AL) 28 September 1999 (1999-09-28) abstract column 23, line 8 - column 31, line 63 figures 1, 5, 11, 12,14, 15, 25 -----	1-24
X	US 6 564 065 B1 (CHANG KIRK K [US] ET AL) 13 May 2003 (2003-05-13) abstract column 1, line 58 - column 2, line 43 column 3, line 13 - column 8, line 62 figures 1-5 -----	1-24
X	US 2011/117930 A1 (ZHANG YANG [CN]) 19 May 2011 (2011-05-19) paragraphs [0013], [014.], [0033] - [0040] claim 11 figures 2-5 -----	1-24

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2012	27/11/2012

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2012/051231

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5960341 A	28-09-1999	US 5602903 A US 5960341 A	11-02-1997 28-09-1999
US 6564065 B1	13-05-2003	NONE	
US 2011117930 A1	19-05-2011	EP 2301173 A1 US 2011117930 A1 WO 2010003450 A1	30-03-2011 19-05-2011 14-01-2010