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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 November 2017 (02.11.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/188894 A1

(51) International Patent Classification:
G01S 5/02 (2010.01) *H04W 64/00* (2009.01)
G01S 5/00 (2006.01)

(21) International Application Number: PCT/SG2017/050218

(22) International Filing Date: 20 April 2017 (20.04.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10201603466W 29 April 2016 (29.04.2016) SG

(71) Applicant: CERTIS CISCO SECURITY PTE. LTD. [SG/SG]; 20 Jalan Afifi, Certis Cisco Centre, Singapore 409179 (SG).

(72) Inventors: **TAN, Poh Beng**; 718A Upper Changi Road East, #01-04, Singapore 486850 (SG). **YONG, Joon Keng**; 21 Elias Road, #08-03, Singapore 519929 (SG). **WONG, Keen Hon**; Blk 92 Pipit Road, #17-99, Singapore 370092 (SG). **ROBERT, Caitan Fernandes**; 20 Jalan Afifi, Singapore 409179 (SG).

(74) Agent: JOYCE A. TAN & PARTNERS LLC; 8 Temasek Boulevard, #15-04, Suntec Tower Three, Singapore 038988 (SG).

(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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

(54) Title: A GEOLOCATING SYSTEM FOR A MOBILE DEVICE

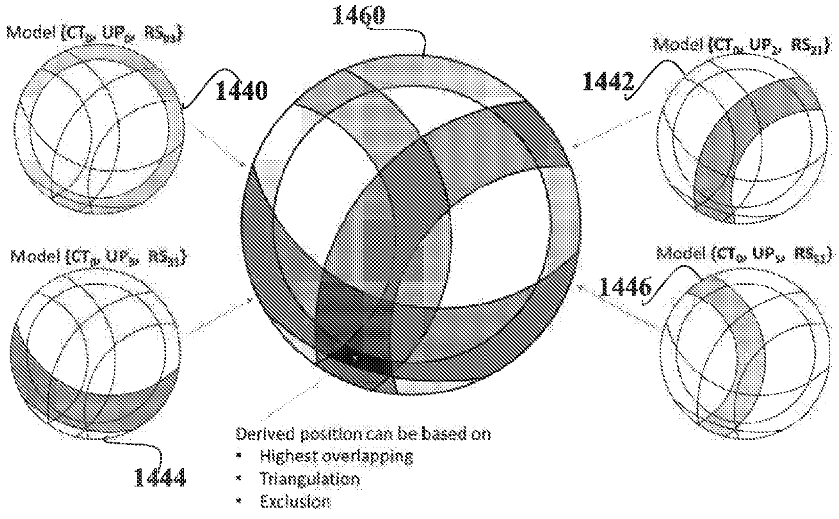

Figure 14

(57) Abstract: A method and system for determining a geolocation of a mobile device, which comprises capturing a plurality of first radio parameters of a first cellular tower, capturing a plurality of second radio parameters of a second cellular tower, wherein the plurality of second radio parameters are locally unique radio parameters, tagging the plurality of second radio parameters to the plurality of first radio parameters, generating a plurality of base cell models using the plurality of first and second radio parameters, extracting a plurality of resultant cell models based on a position query from the mobile device and plurality of base cell models, and determining the geolocation of the mobile device from the plurality of resultant cell models, whereby the geolocation of the mobile device is statistically determined using the plurality of resultant cell models.

WO 2017/188894 A1

[Continued on next page]

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

A GEOLOCATING SYSTEM FOR A MOBILE DEVICE

Field of the Invention

The present invention relates to a geolocating system for a mobile device. Specifically, the geolocating system information from cellular towers and cell models to determine the position of the mobile device.

Background of the Invention

The location of a mobile device may be determined using alternative methods other than the usual satellite-based signals like Global Positioning System (GPS), and these typically use information from cellular towers. With the advancement of mobile technology to 3G/4G, mobile devices no longer keeps track of complete Globally unique Identification (GUID) of the neighboring cells, only non-unique local radio parameter for other neighboring Cell Tower. By not keeping track of the GUID of neighboring cells, this improves the performance and reduces power consumption of the mobile device. Therefore, the traditional method to geo-locate a mobile device using GUID of registered cell and neighboring cells is no longer viable. The traditional method is unable to distinguish the ambiguity of which neighboring cells the mobile device is able to detect.

One of these methods is known as a disambiguation technique described in US2014/0243010. The disambiguation technique uses disambiguation information that is associated with the cellular tower that the mobile device is currently based on by using a radio scene received at the mobile device and mapping it to an estimate of the device's location. The radio scene is typically a list of all the radio transmitters or cellular towers that the mobile may detect. The mapping may then be carried out using techniques like trilateration or based on a predictive model learnt under supervision, in order to unambiguously identify as many of the neighboring visible transmitters as possible. However, the disambiguation technique requires a large amount of processing compared to traditional methods and is also prone to disambiguation errors. Conventional methods essentially work by disambiguating the non-unique parameters of the neighboring towers to their associated globally unique IDs.

The present invention was developed with a view to providing a solution that would alleviate these issues, by having a system and method that would allow mobile phones to determine their geolocation faster and more accurately than existing methods.

References to prior art documents in this specification are provided for illustrative purposes only and are not to be taken as an admission that such prior art is part of the common general knowledge in Singapore or elsewhere.

Summary of the Invention

The above and other problems are solved and an improvement in the art is made by a method and system in accordance with this invention. A first advantage in accordance with this invention is that a mobile device is able to determine its geolocation without using GPS and by using existing cellular tower information. This provides a mobile device with a fast and accurate geolocation service without requiring extra infrastructure or modifications to the cellular network and allows for geolocation indoors or places that do not have satellite coverage. A second advantage in accordance with this invention is the faster determination of the geolocation of a mobile device. This is because every tagged record acts as a unique cell model, thus requiring less processing and making the search and estimation shorted. A third advantage in accordance with this invention is the lack of ambiguity. This is improves the accuracy by using the unique cell models generated with the local non-unique parameters having the same global unique parameters.

In accordance with a first aspect of the present invention, there is provided a method for determining a geolocation of a mobile device comprising capturing a plurality of first radio parameters of a first cellular tower, then capturing a plurality of second radio parameters of a second cellular tower, wherein the plurality of second radio parameters are locally unique radio parameters. The method includes tagging the plurality of second radio parameters to the plurality of first radio parameters. The method further includes generating a plurality of base cell models using the plurality of first and second radio parameters, then extracting a plurality of resultant cell models based on a position query from the mobile device and the plurality of base cell models, and statistically determining the geolocation of the mobile device using the plurality of resultant cell models.

Additionally, the plurality of first radio parameters are globally unique. Also the first radio parameter is a globally unique tower ID of a cellular tower. Additionally, this globally unique tower ID of a cellular tower can be a mobile country code (MCC), a mobile network code (MNC), a location area code (LAC), or a Cell ID (CID). Further, the first radio parameter can be a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

According to a further embodiment of the invention, the second radio parameter is a combination of any of a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

In accordance with another embodiment of the invention, the second radio parameter is a location provided by a Global Positioning System (GPS) or a location provided by a user defined coordinate. Alternatively, another embodiment of the invention has the second radio parameter being a location provided by a plurality of technical parameters of a mobile network, wherein the plurality of technical parameters are converted into coordinates.

According to a further embodiment of the invention, the step of generating a plurality of base cell models is repeated with a plurality of third radio parameters, wherein the third radio parameters are locally unique and different from the second radio parameters. Also, the plurality of base cell models are combined using contouring, interpolation, triangulation, or fingerprinting.

According to another embodiment of the invention, the position query is based on any one or a combination of more than one method of identifying a location, such as a global unique identification (GUID), a local unique parameter, or a Received Signal Strength Indicator (RSSI).

In yet another embodiment of the invention, the step of extracting a plurality of resultant cell models further includes determining a method of presentation using overlap, triangulation or exclusion. Further, the resultant cell models are extracted from the position query pointing to the location with the greatest overlap, point of intersection or exclusion. Yet further in accordance with an embodiment of the invention, the geolocation of the mobile device is statistically determined based on a normal, a Gaussian, or a point confident technique.

According to an embodiment of the invention, the step of generating a plurality of base cell models is based on the plurality of first radio parameters and the plurality of second radio parameters stored in a database memory of a server.

In accordance with an embodiment of the invention, a system for determining a geolocation of a mobile device is disclosed, which has a server with means for communicating with a mobile device, a database in communication with the server to store a plurality of first radio parameters of a first cellular tower collected by a collecting device. In this embodiment, the database also stores a plurality of second radio parameters of a second cellular tower, and the plurality of second radio parameters are tagged to the plurality of first radio parameters to create a base cell model and the base cell model is stored on the database. Where upon a request from the mobile device, the server generates the geolocation based on extraction of the base cell model.

According to an embodiment of the invention, the plurality of first radio parameters are globally unique. Further, the first radio parameter is a globally unique tower ID of a cellular tower, a mobile country code (MCC), a mobile network code (MNC), a location area code (LAC), or a Cell ID (CID). In another embodiment of the invention, the first radio parameter is a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

In another embodiment of the invention, the second radio parameter is a combination of any of a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI). In a further embodiment of the invention, the second radio parameter is a location provided by a Global Positioning System (GPS) or a location provided by user defined coordinate. In yet another embodiment of the invention, the second radio parameter is a location provided by a plurality of technical parameters of a mobile network, where the plurality of technical parameters are converted into coordinates.

According to an embodiment of the invention, a further base cell model is generated with a plurality of third radio parameters, where the third radio parameters are locally unique and different from the second radio parameters. Further to this, a resultant cell model is extracted from a plurality of base cell models based on a normal, Gaussian, or point confident technique, and the geolocation of the mobile device is determined from the resultant cell model. According to a further embodiment, the step of extracting the resultant cell model is repeated to generate a plurality of resultant cell models and the geolocation of the mobile device is determined using a normal, Gaussian, or point confident technique.

In an embodiment of the invention, the plurality of base cell models are combined using contouring, interpolation, triangulation, or fingerprinting, and the database is updated.

In accordance with an embodiment of the invention, the mobile device is also the collecting device.

Brief Description of the Drawings

The accompanying drawings, which are incorporated herein and form part of the specification, illustrate various embodiments of the present disclosure and, together with the description, further serve to explain the principles of the disclosure and to enable a person skilled in the pertinent art to make and use the embodiments disclosed herein. In the drawings, like reference numbers indicate identical or functionally similar elements.

Figure 1 is a flow chart illustrating a mobile data collection process in accordance with an embodiment of the invention.

Figure 2 is a flow chart illustrating a model generation process in accordance with an embodiment of the invention.

Figure 3 is a flow chart illustrating a position query and model extraction process in accordance with an embodiment of the invention.

Figure 4 is a flow chart illustrating a position estimation and a presentation of results in accordance with an embodiment of the invention.

Figure 5 is an illustration of radio parameters captured by a mobile device in accordance with an embodiment of the invention.

Figure 6 is an illustration of radio parameters with GPS position data being sent to a server in accordance with an embodiment of the invention.

Figure 7 is an illustration of radio parameters with GPS position data being inserted into a database in accordance with an embodiment of the invention.

Figure 8 is an illustration of generating a data model for each cell in accordance with an embodiment of the invention.

Figure 9 is an illustration of generating another data model for each cell in accordance with an embodiment of the invention.

Figure 10 is an illustration of generating a further data model for each cell in accordance with an embodiment of the invention.

Figure 11 is an illustration of generating another further data model for each cell in accordance with an embodiment of the invention.

Figure 12 is an illustration of inserting and/or updating models in a model database in accordance with an embodiment of the invention.

Figure 13 is an illustration of a position query and an extraction of models in accordance with an embodiment of the invention.

Figure 14 is an illustration of a position estimation based on models in accordance with an embodiment of the invention.

Figure 15 is an illustration of a results presentation of the results in accordance with an embodiment of the invention.

Description of an Embodiment of the Invention

The present invention comprises a method of deriving the geolocation of a mobile device by taking advantage of the ambiguity and tagging the local non-unique parameter to have the same Global unique parameter to generate a unique Cell Model, and the extracting the cell models to derive the geolocation of the mobile device. This method may provide better accuracy compared to conventional methods as the error of the positioning technology is confined to one cell. The present invention may capture radio parameters in a different manner from conventional methods, by using the radio parameter ambiguity captured by the mobile device. Conventional methods try to unambiguously identify as many of the neighboring visible transmitters as possible in order to apply disambiguation of non-unique tower parameters for geo-location of the mobile device.

In some embodiments, the present invention may be described by showing a mobile device being camped on a base station cellular tower. This mobile device may be the same mobile device that generates the position query or a a separate mobile device, a collecting device, specifically for the purpose of collecting the parameters. The mobile device also being able to detect signals from other neighboring towers and the radio scene detected includes radio parameters like the globally unique tower ID of the base station cellular tower (or base station), the UTRA Absolute Radio Frequency Channel Number (UARFCN), the Primary Scrambling Code (PSC) and the Received Signal Strength Indicator (RSSI). The radio scene detected also includes radio parameters of neighboring towers that are non-unique tower parameters, for example 3G Serving Cell Radio Parameters:

CT_0, $UARFCN_0$, PSC_0, $EC/n0_0$, $RSCP_0$, $SQual_0$, $SRxLev_0$

CT_1, $UARFCN_1$, PSC_1, $EC/n0_1$, $RSCP_1$, $SQual_1$, $SRxLev_1$

ǔ ǔ

CT_n, $UARFCN_n$, PSC_n, $EC/n0_n$, $RSCP_n$, $SQual_n$, $SRxLev_n$

Some examples of captured Radio Parameters at given mobile site

525001015C13E7111, 10221, 143, -10.0, -66, 20, 39 -> 525001015C13E7111 is a Global Unique Radio Parameter

0, 10221, 212, -8.0, -76, 11, 36 -> Non-Unique Neighboring Cell Radio Parameters

0, 10221, 43, -14.0, -83, -3, 32 -> Non-Unique Neighboring Cell Radio Parameters

0, 10221, 214, -22.0, -90, -8, 25- > Non-Unique Neighboring Cell Radio Parameters

In an embodiment of the present invention, the method may be made of the following processes: mobile data collection (Figure 1), model generation (Figure 2), position query and model extraction (Figure 3), and position estimation and result presentation (Figure 4).

According to some embodiments the mobile data collection process 110 (shown in Figure 1) performed by the method and system is described as follows. The process 110 may begin with capturing radio parameters 120, followed by capturing the GPS position 130. The next step being to tag the local unique parameters and position with global unique parameters 140, followed by inserting the record with the position into a database 150.

In the embodiments, some examples of radio parameters are: the globally unique tower ID of a cellular tower, UARFCN, PSC and RSSI, or any other globally unique ID that is known in the art. Figure 5 shows cellular towers 510, 520, 530 with one of them 510 being the base station cellular tower and the mobile device 515 capturing the radio parameters. Examples of globally unique tower ID may be a mobile country code (MCC), mobile network code (MNC), location area code (LAC), Cell ID (CID), or any other fields that may provide the same function of identifying a cellular tower. Radio parameters may also be combined, for example, UARFCN and PSC may be combined together to form a local unique identifier, although one skilled in the art would appreciate that other combinations are also possible to arrive at a local unique identifier for a cellular tower. Looking at Figure 6, the radio parameters are tallied with GPS position data transmitted by satellites 640. This may also collected by a mobile device 615, and the information is sent back to a server 650. In other embodiments, other types of location based services and technology may also be used instead of GPS, for example real-time location system (RTLS) like Ultra-Wideband (UWB), Bluetooth Low Energy (BLE), Wi-Fi positioning system (WPS). Also some embodiments also allows the user to manually enter the coordinates and define them to preference, which may be in various forms. With sufficient data points to make a model of the cells, the model of the cells can be generated to track mobile devices without the need for further infrastructure or even modifications to the mobile device. For the purposes of location tracking indoors, some embodiments would have a shop name, description, or unit number in place of the coordinates. In some embodiments, the mobile device 615 (515) uses an application to obtain the technical parameters of a mobile network, and the application may have the ability to covert the technical parameters into estimated coordinates. The server 650 may be associated with a database (not shown in Figure 6).

In some embodiments as shown in Figure 7, the radio parameters with (GPS) position data 720, 730 may be inserted into a database 750, and in the process the local unique parameter is tagged to have the same global unique parameter 725. In some embodiments, this is done by tagging the local unique radio parameter of the neighboring cell to the global unique radio parameter of the connected cell to generate a unique cell model. Compared to existing methods, tagging the local unique parameter to have the same global unique parameter to generate a unique cell model makes the process faster since every tagged record acts a unique cell model. An example of tagging can be associating the local unique parameter with the global unique parameter.

According to some embodiments the model generation process 210 (shown in Figure 2) performed by the method and system is described as follows. The process 210 may begin with generating data models for each cell global unique cell-ID and tagged local unique parameter from the database 220, and examples of this are described later and shown in Figures 8-11. The databases 750, 850 and 950 may be the same database. Database 750 allows the records (720,730) from the mobile device to be inserted into the database 750, while database 850 demonstrates how the data collected is used to make a model, 820 and 830 depicts examples of records on a map. The generated model 920 corresponds to the record in database 950. The following step is to insert the cell models or update the cell models in the model database 230, and this is described and shown in Figure 12.

According to some embodiments, a model 820, 830 is generated using the information from the database 850 and the outcome may be found in Figure 8. It may be seen that using the information, the model for $CT_0UP_0RS_0$ 820 and $CT_0UP_0RS_{11}$ 830 may be generated. By repeating this process for differing values from the database 950, a model for CT_0UP_0 920 may be generated as shown in Figure 9. In Figure 10, another model 1022 may be generated using further values of local unique identifiers from the database 1050 and is shown has an overlay on the CT_0UP_0 model 1020 of Figure 9. Repeating the process (in Figure 11) for yet further values of local unique identifiers from the database 1150, another model 1124 is generated, with CT_0UP_0 model 1120 shown in comparison. The step of inserting or in some cases updating the models in the model database in shown in Figure 12, whereby the various models generated 1220, 1222, 1224 are populated into the database 1250 accordingly, and this may be done by applying geometric and/or statistical methods such as contouring, interpolation, triangulation, fingerprinting.

According to some embodiments the position query and model extraction process 310 (shown in Figure 3) performed by the method and system is described as follows. The process 310 may begin with a position query request based on the one or a combination of the following fields reported by mobile device: global unique identification (GUID), local unique parameter, RSSI, etc 320. Based on the information provided, the data model database is searched 330, then the matching data or resultant cell model may be extracted 340 for the queried parameter or parameters along with the coordinates, location or geolocation or any other form outcome that may indicate the geolocation of the mobile device.

In other embodiments, the position estimation and result process 410 (shown in Figure 4) that may be performed by the method and system is described as follows. The process 410 begins by determining the method of presentation, either using overlap, triangulation or exclusion 420. Then proceeds to extract the appropriate data models based on the query parameters 430, and deriving the position based on the method applied, for example most overlap, point of intersect or exclusion 440. The position results may then be derived using statistical methods like normal, Gaussian, point confident 450 and the derived results may be presented, either using coordinates (x, y, radius) or any other form of geolocation reporting 460. By way of example, if point confident is used, the derived location will have coordinates like (x, y) and a confidence level that the point is of a certain accuracy.

An embodiment is shown in Figure 13, where a mobile device is requesting or sending a query for it geolocation or position, a query 1330 is sent to the database 1350, and various cell models are extracted in response 1340, 1342, 1344, 1346. The query is then resolved shown in Figure 14 by estimating the position of the mobile device using the extracted models 1440, 1442, 1444, 1446, and the position of the mobile device may be determined using the resultant cell model 1460, for example by highest overlapping, triangulation or exclusion method, or any other know method of determining intersection between the extracted models. This result 1560 is presented to the mobile device (and the user) in Figure 15 by deriving the position 1570 through statistical methods using estimation data, for example normal, Gaussian, point confident, or any other known method.

It is noted that determining the geolocation of the mobile device using the method as described is faster as all that is required is to extract cell models to derive the position based on the statistical method applied, with the added advantage of having no ambiguity.

The technical advantages of the invention;

i. Use the existing radio parameters such as globally unique Id and local non-unique captured by the mobile device without any disambiguation process.

ii. Radio parameters captured will be directly stored in database as records

iii. The records form a unique Cell model for the unique captured radio parameter

iv. The Cell Models are used for position query

v. The above said process adds to faster processing and extraction of the query.

vi. It is more accurate compared to the disambiguation technique as there is no ambiguity.

vii. May be adapted to indoor positioning with the appropriate process for data collection.

viii. May be adapted to outdoor positioning where GPS accuracy is affected by reflections, refractions and canopy effect; with the appropriate process for data collection.

New Cell Modelling approach for position extraction of Mobile devices for Geo-Location. For Geo-Location system to determine the physical location of mobile device correctly it need take reference positions from the nearby Cell Towers (Global Unique Identification ¯ GUID) and GPS co-ordinates. The above said limitation is overcome by New Cell Modelling Method, which makes use of the following Radio Parameters for position extraction,

i. Mobile Device Connected Cell Tower Global Unique Identification (GUID), UARFCN, PSC, RSSI.

iii. Local-unique radio parameters of neighboring cell- UARFCN, PSC, RSSI.

iv. GPS co-ordinates (x, y) of the Mobile Device at any given location

With the New Cell Modelling method the mobile device physical position may be extracted for Geo-Location Services.

In some embodiments, the method and system may include the following:

i. Cell Tower radio parameters captured by Mobile device at any given location of capture, Global unique Identification (GUID), UARFCN, PSC & RSSI, GPS (x, y)

ii. Local unique radio parameters of neighboring cell tower captured by Mobile device at any given location of interest,

iii. Tagging local unique radio parameter of the neighboring cell to Global unique radio parameter of the connected cell to generate a unique Cell Model.

iv. Unique Cell Model Generation from the captured radio parameters stored in the database

v. Cell Model Extraction for position query

vi. Cell Model Presentation.

In further embodiments, RSSI may be optional parameter under the Global Unique radio parameter, as the local unique radio parameter of either UARFCN or PSC would be sufficient. In other embodiments, the RSSI of local unique radio parameter is also an optional parameter.

In some embodiments, the radio parameter capturing process may be described using the following:

i. Radio parameters captured by the mobile device transferred over the air to the Database server

ii. Tagging local unique parameter to have the same Global unique parameter to generate a unique Cell Model performed on database Server and stored as records.

iii. Unique cell model is generated and stored for database record in the database server

iv. Position query is performed by extracting the unique cell models based on the statistical method applied

Cell Modelling approach for position extraction of Mobile devices for Geo-Location. For Geo-Location system to determine the physical location of mobile device correctly it need take reference positions from the nearby Cell Towers (Global Unique Identification ¯ GUID) and GPS co-ordinates.

The following steps describe the process:

Step 1: Radio Parameters Captured by Mobile Device. (Refer Figure. 5) Mobile Device Connected Cell Tower Global Unique Identification (GUID), UARFCN, PSC, RSSI.

- Non-unique Parameters UARFCN, PSC, RSSI.

Step 2: GPS position captured at a given location of interest. (Refer Figure. 6)

- GPS co-ordinates (x, y) of the Mobile Device at give location

Step 3: Captured Radio parameters and GPS Location is transferred to the database server. (Refer Figure. 6)

Step 4: Tagging local non- unique parameter to have the same Global unique parameter to generate a unique Cell Model. (Refer Figure. 7)

Process 1: Mobile Data Collection for Steps 1-3 (Refer to Figure 1).

Step 5: Unique Cell Model Generation from the radio parameters stored in the database (Refer Figures 8-12)

Process 2: Cell Model generation process for Step 5.

Step 6: Cell Model Extraction for position query (Figures 13 & 14)

Process 3: Process Query & Model Extraction for Step 6

Step 7: Position Estimation & Result Presentation (Figure. 15)

Process 4: Position Estimation & Results Presentation

The present invention has been fully described with reference to the drawing figures. Although the invention has been described based upon these preferred embodiments, to those of skill in the art, certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.

Claims:

1. A method for determining a geolocation of a mobile device comprising:

capturing a plurality of first radio parameters of a first cellular tower;

capturing a plurality of second radio parameters of a second cellular tower, wherein the plurality of second radio parameters are locally unique radio parameters;

tagging the plurality of second radio parameters to the plurality of first radio parameters;

generating a plurality of base cell models using the plurality of first and second radio parameters;

extracting a plurality of resultant cell models based on a position query from the mobile device and the plurality of base cell models; and

determining the geolocation of the mobile device from the plurality of resultant cell models;

wherein the geolocation of the mobile device is statistically determined using the plurality of resultant cell models.

2. The method of claim 1, wherein the plurality of first radio parameters are globally unique.

3. The method of claim 2, where the first radio parameter is a globally unique tower ID of a cellular tower.

4. The method of claim 3, where the globally unique tower ID of a cellular tower is a mobile country code (MCC), a mobile network code (MNC), a location area code (LAC), or a CellID (CID).

5. The method of claim 1, where the first radio parameter is a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

6. The method of claim 1, where the second radio parameter is a combination of any of a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

7. The method of claim 1, wherein the second radio parameter is a location provided by a Global Positioning System (GPS) or a location provided by a user defined coordinate.

8. The method of claim 1, wherein the second radio parameter is a location provided by a plurality of technical parameters of a mobile network, wherein the plurality of technical parameters are converted into coordinates.

9. The method of claim 1, wherein the step of generating a plurality of base cell models is repeated with a plurality of third radio parameters, wherein the third radio parameters are locally unique and different from the second radio parameters.

10. The method of claim 9, where the plurality of base cell models are combined using contouring, interpolation, triangulation, or fingerprinting.

11. The method of claim 1, wherein the position query is based on any one or a combination of more than one method of identifying a location, such as a global unique identification (GUID), a local unique parameter, or a Received Signal Strength Indicator (RSSI).

12. The method of claim 1, where the step of extracting a plurality of resultant cell models further includes determining a method of presentation using overlap, triangulation or exclusion.

13. The method of claim 12, where the resultant cell models are extracted from the position query pointing to the location with the greatest overlap, point of intersection or exclusion.

14. The method of claim 13, where the geolocation of the mobile device is statistically determined based on a normal, a Gaussian, or a point confident technique.

15. The method as set forth in any one of the preceding claims, wherein the step of generating a plurality of base cell models is based on the plurality of first radio parameters and the plurality of second radio parameters stored in a database memory of a server.

16. A system for determining a geolocation of a mobile device comprising:

a server with means for communicating with a mobile device;

a database in communication with the server to store a plurality of first radio parameters of a first cellular tower collected by a collecting device, where the database also stores a plurality of second radio parameters of a second cellular tower,

wherein the plurality of second radio parameters are tagged to the plurality of first radio parameters to create a base cell model and the base cell model is stored on the database, and

wherein upon a request from the mobile device, the server generates the geolocation based on extraction of the base cell model.

17. The system of claim 16, where the plurality of first radio parameters are globally unique.

18. The system of claim 17, where the first radio parameter is a globally unique tower ID of a cellular tower, a mobile country code (MCC), a mobile network code (MNC), a location area code (LAC), or a Cell ID (CID).

19. The system of claim 16, where the first radio parameter is a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

20. The system of claim 16, where the second radio parameter is a combination of any of a UTRA Absolute Radio Frequency Channel Number (UARFCN), a Primary Scrambling Code (PSC) or a Received Signal Strength Indicator (RSSI).

21. The system of claim 16, where the second radio parameter is a location provided by a Global Positioning System (GPS) or a location provided by user defined coordinate.

22. The system of claim 16, where the second radio parameter is a location provided by a plurality of technical parameters of a mobile network, wherein the plurality of technical parameters are converted into coordinates.

23. The system of claim 16, where a further base cell model is generated with a plurality of third radio parameters, wherein the third radio parameters are locally unique and different from the second radio parameters.

24. The system of claim 23, where a resultant cell model is extracted from a plurality of base cell models based on a normal, Gaussian, or point confident technique, and the geolocation of the mobile device is determined from the resultant cell model.

25. The system of claim 24, where the step of extracting the resultant cell model is repeated to generate a plurality of resultant cell models and the geolocation of the mobile device is determined using a normal, Gaussian, or point confident technique.

26. The system of claim 23, where the plurality of base cell models are combined using contouring, interpolation, triangulation, or fingerprinting, and the database is updated.

27. The system of claim 16, where the mobile device is also the collecting device.

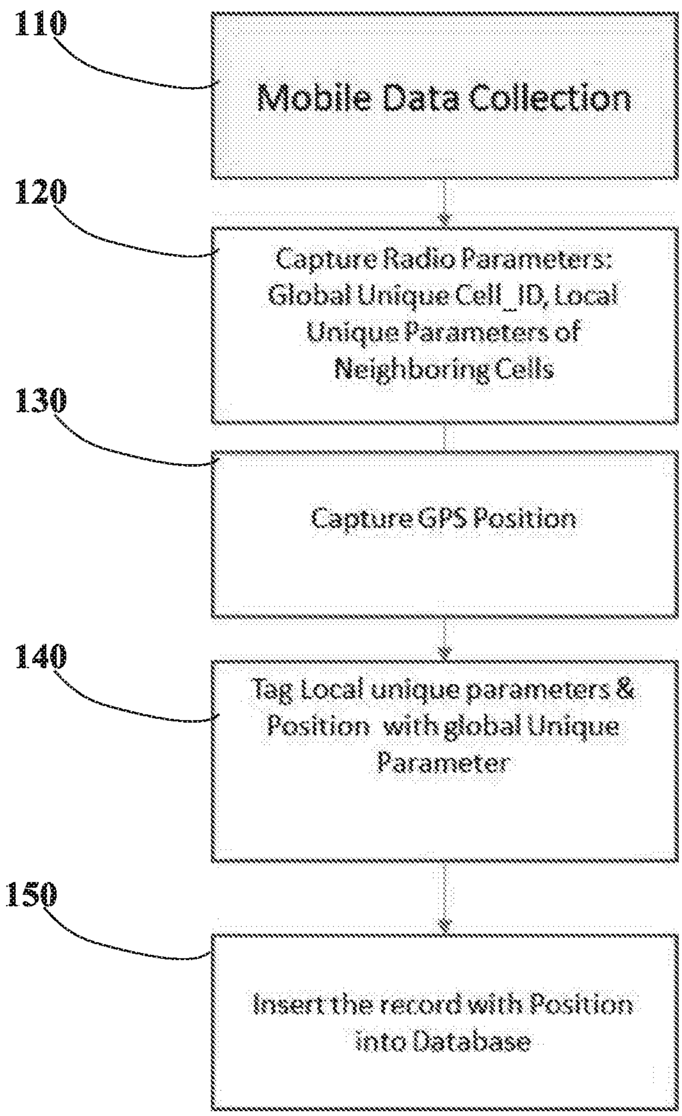
110
Mobile Data Collection
120
Capture Radio Parameters: Global Unique Cell_ID, Local Unique Parameters of Neighboring Cells
130
Capture GPS Position
140
Tag Local unique parameters & Position with global Unique Parameter
150
Insert the record with Position into Database

Figure 1

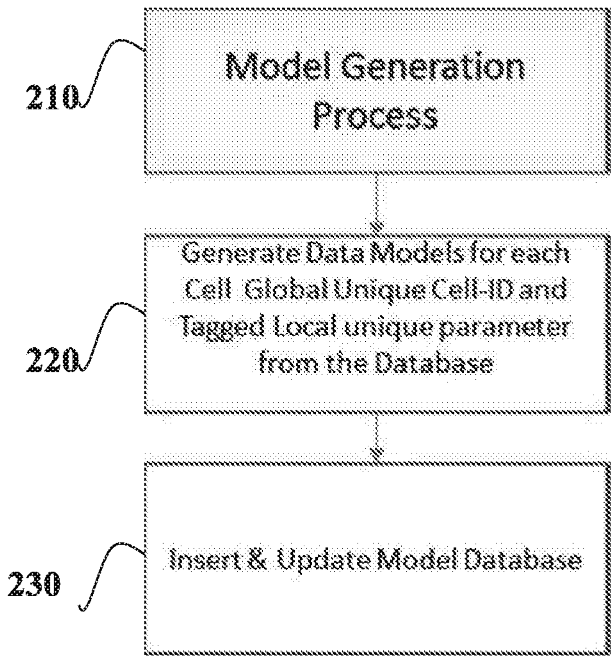

Figure 2

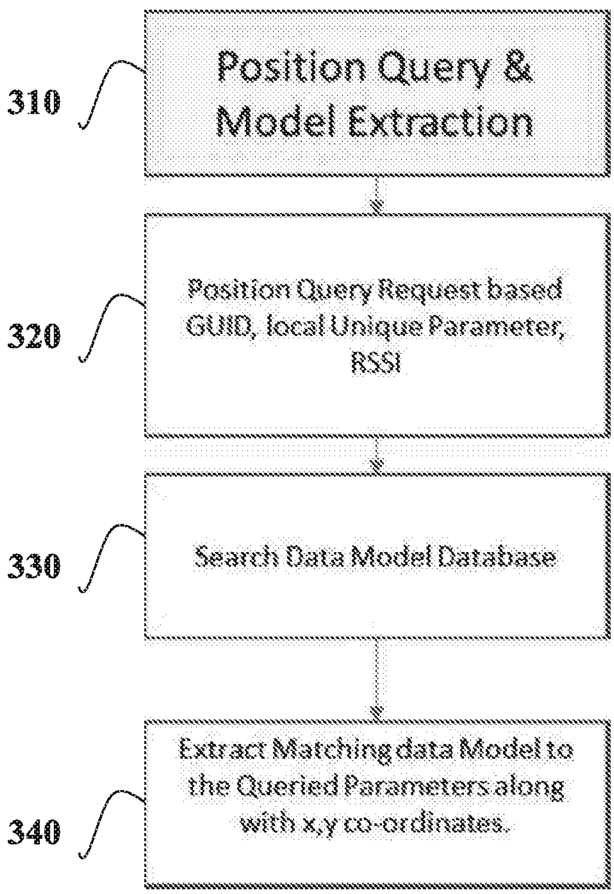

Figure 3

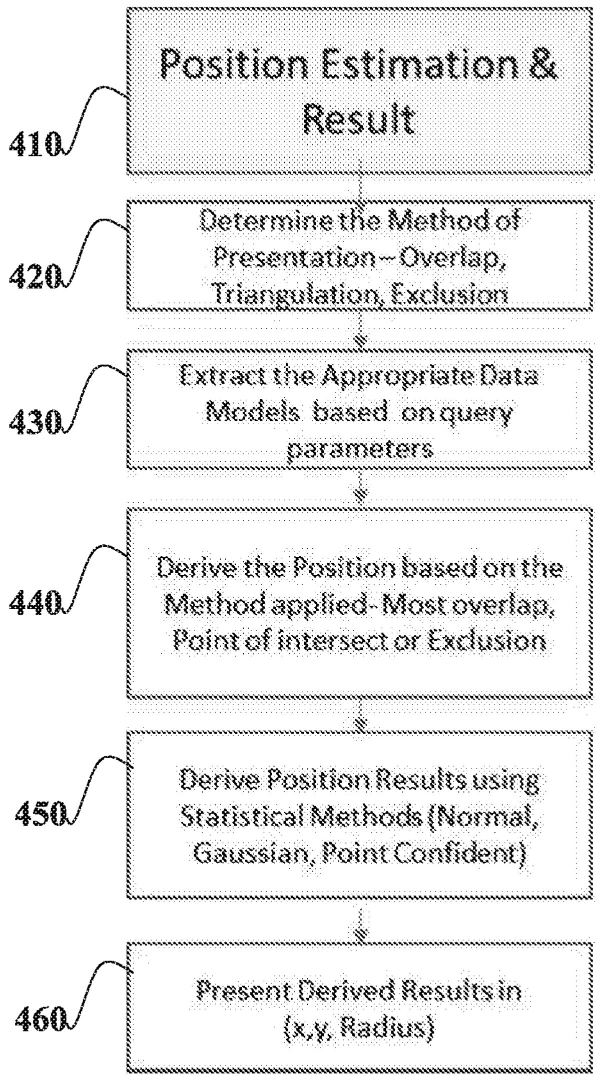
Position Estimation & Result
410
Determine the Method of Presentation – Overlap, Triangulation, Exclusion
420
Extract the Appropriate Data Models based on query parameters
430
Derive the Position based on the Method applied- Most overlap, Point of intersect or Exclusion
440
Derive Position Results using Statistical Methods (Normal, Gaussian, Point Confident)
450
Present Derived Results in (x,y, Radius)
460

Figure 4

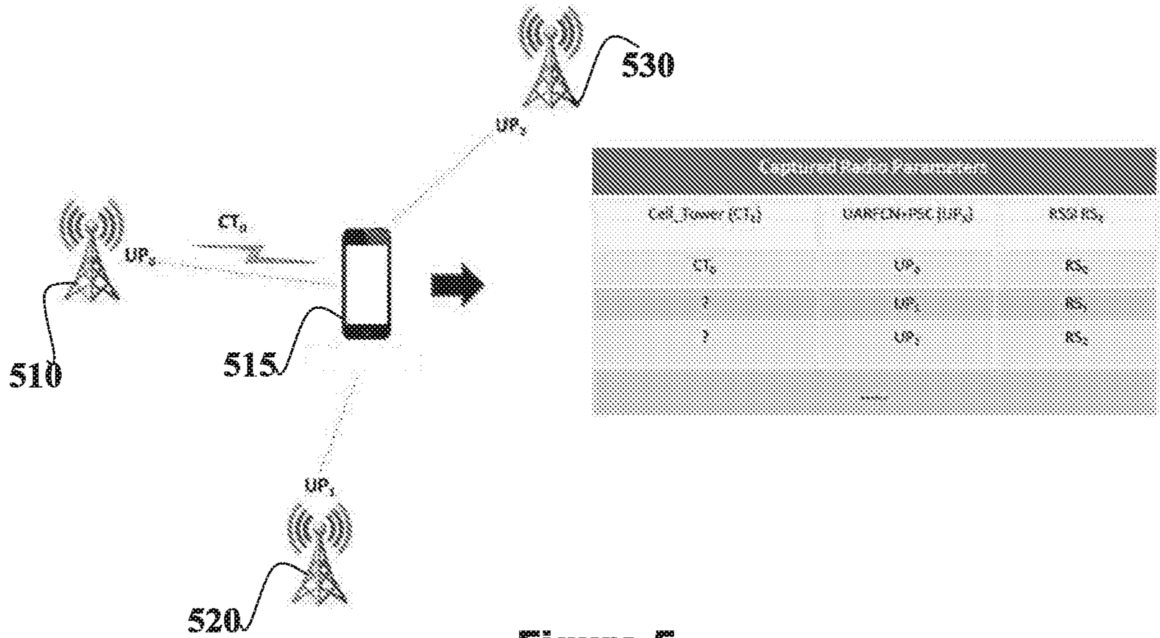

Figure 5

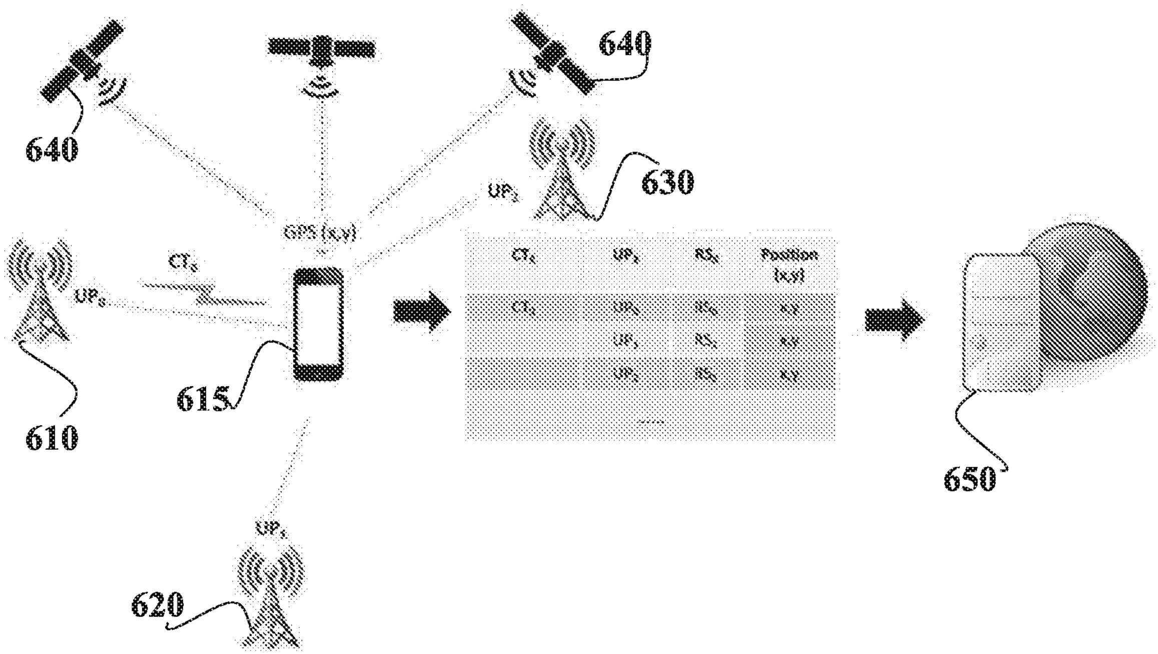

Figure 6

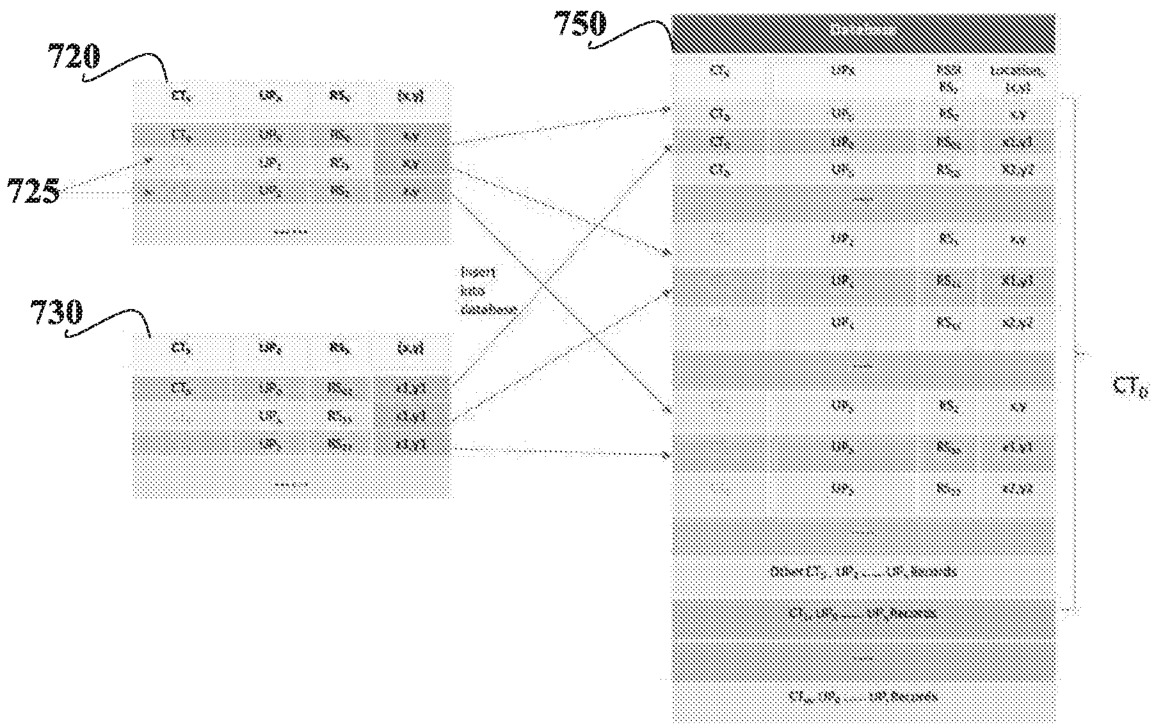

Figure 7

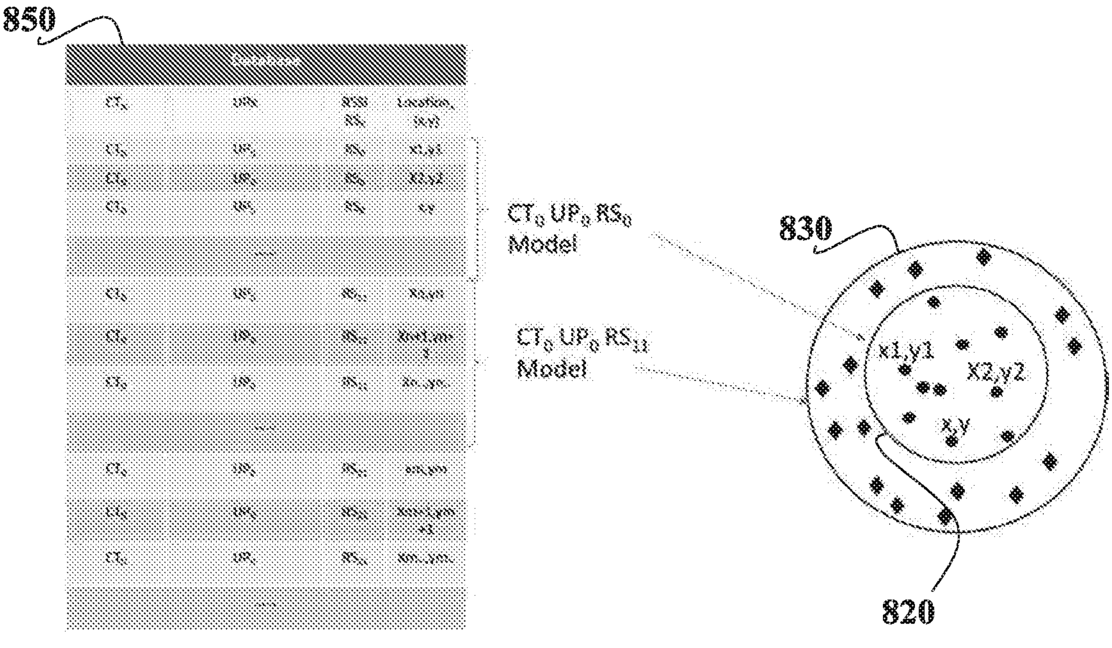

Figure 8

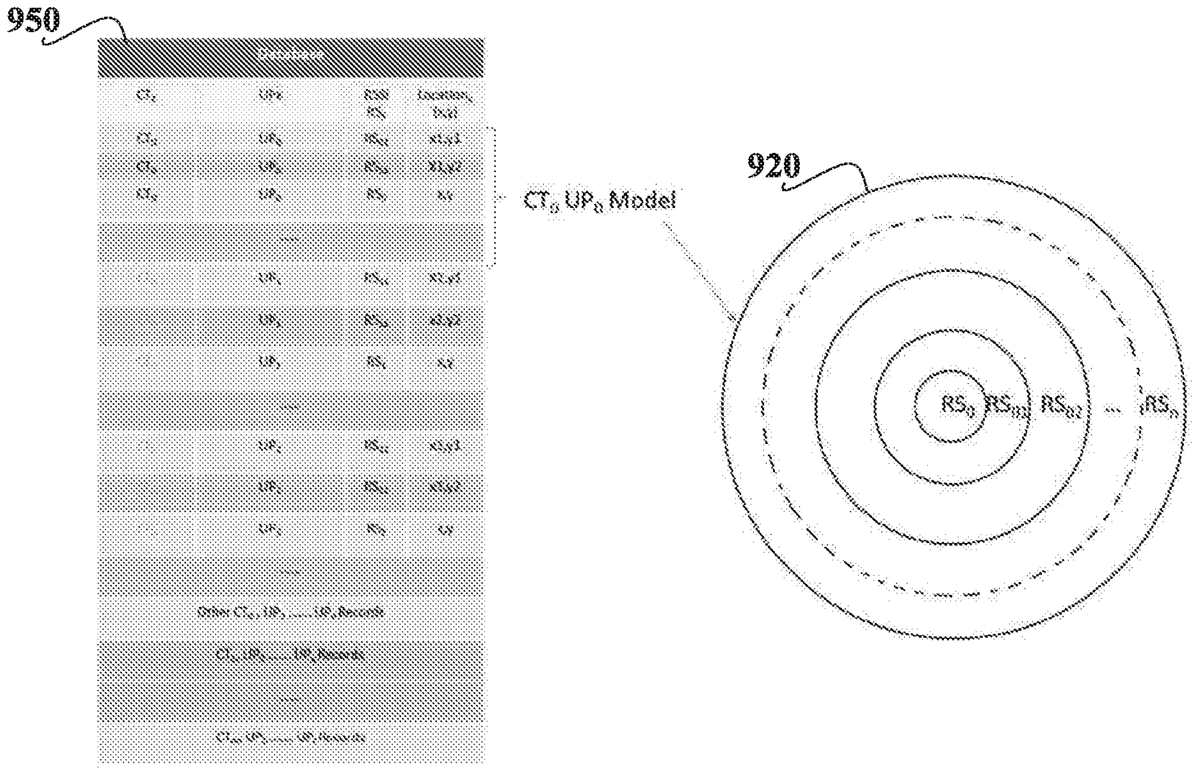

Figure 9

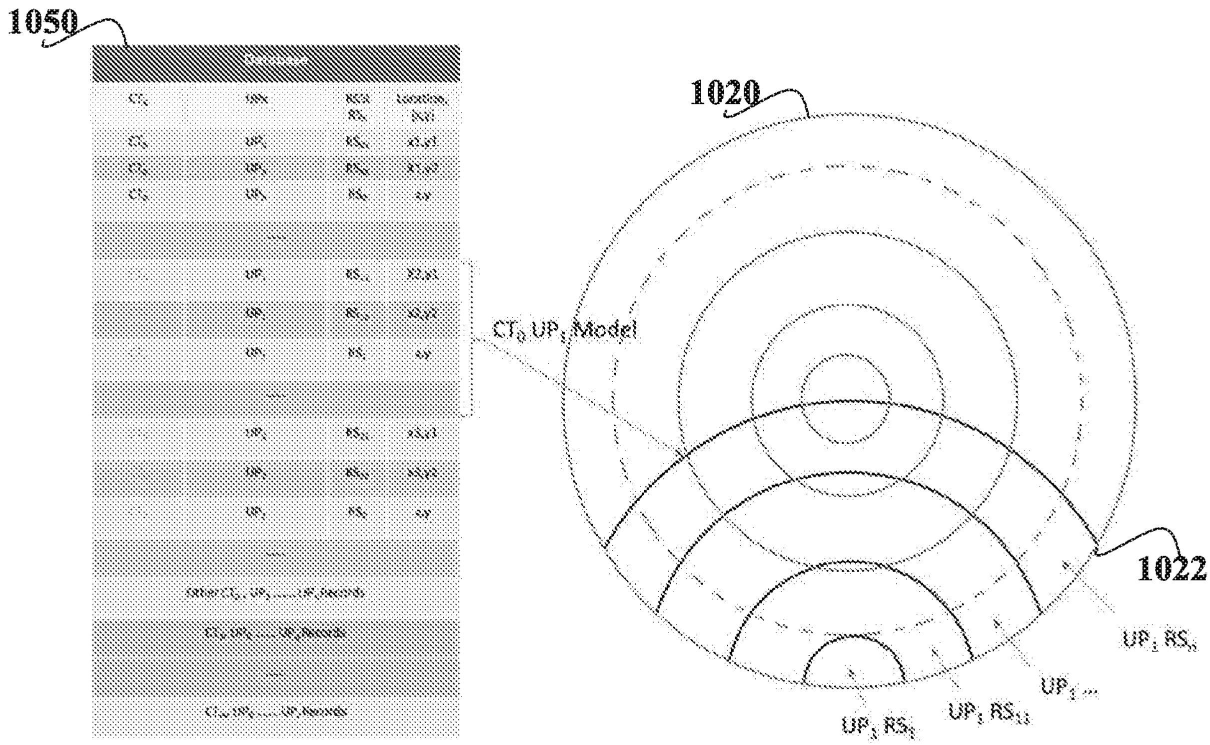

Figure 10

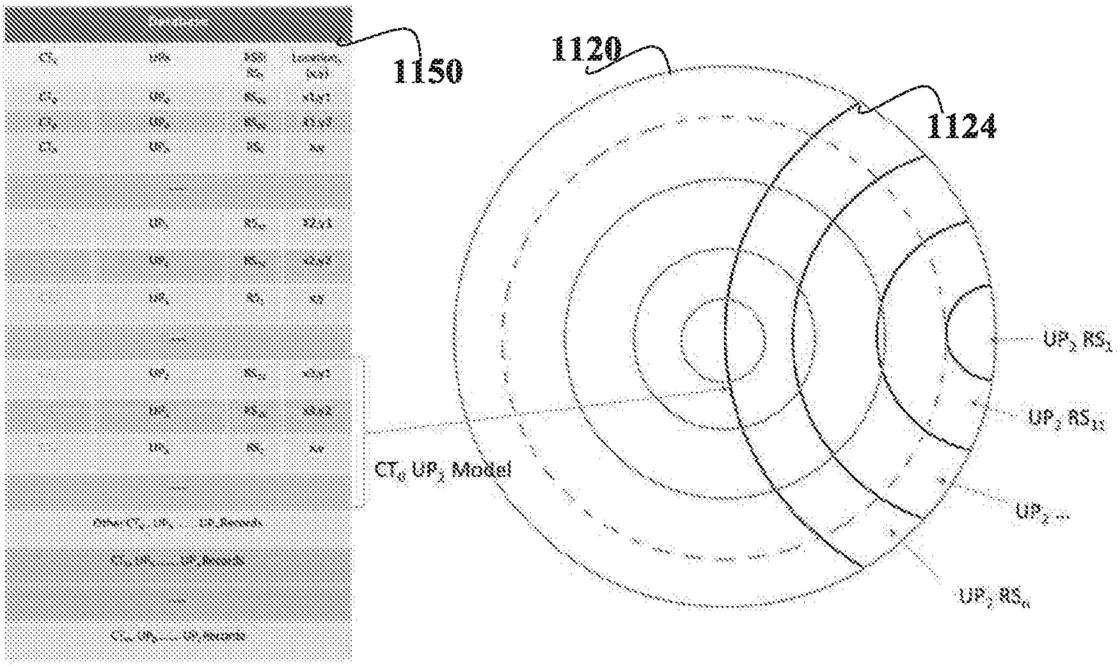

Figure 11

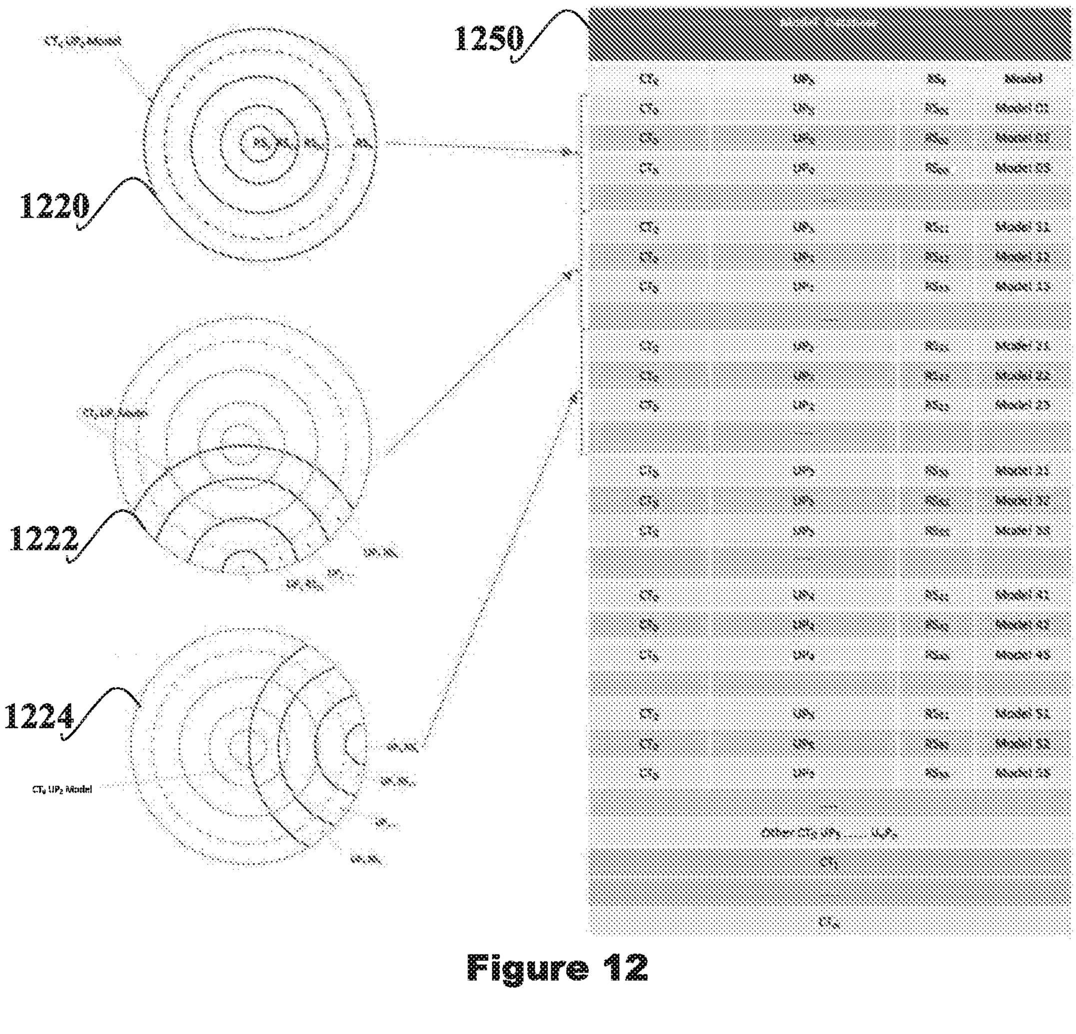

Figure 12

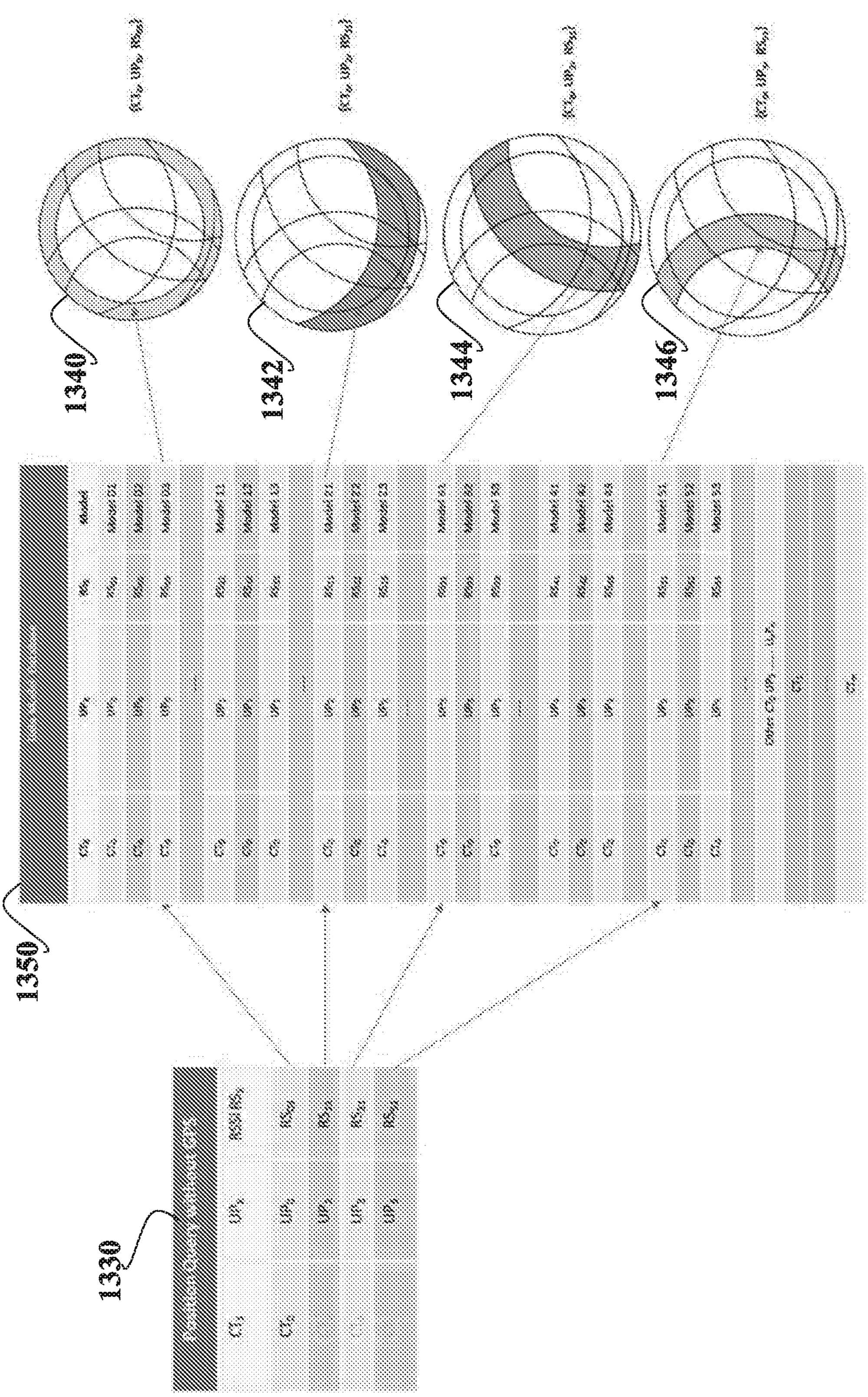

Figure 13

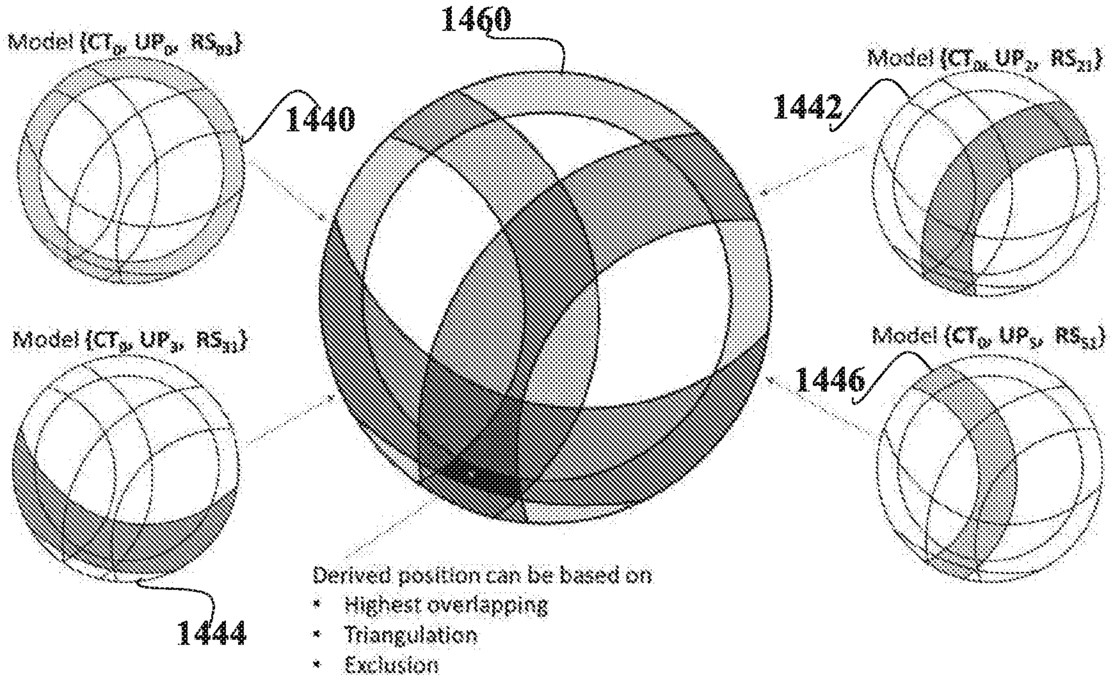

Figure 14

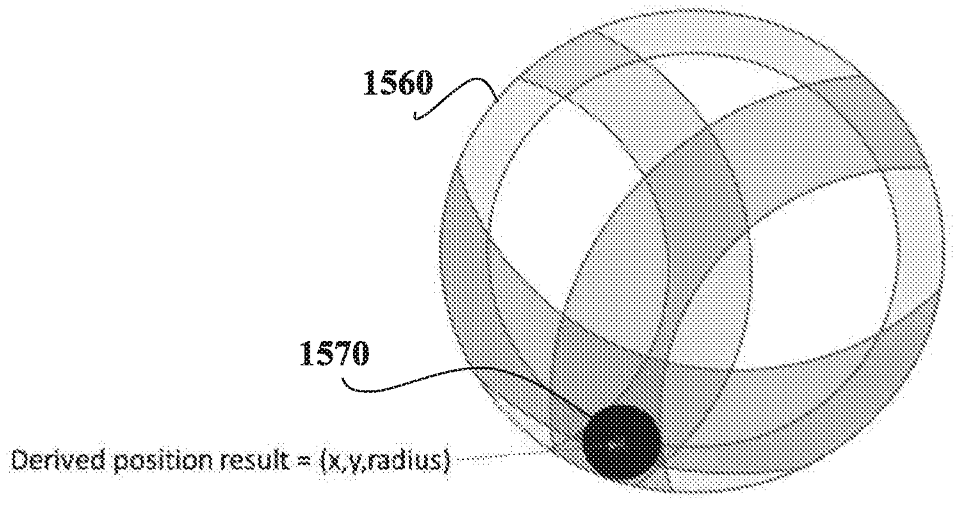

Figure 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2017/050218

A. CLASSIFICATION OF SUBJECT MATTER

G01S 5/02 (2010.01) G01S 5/00 (2006.01) H04W 64/00 (2009.01)

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)

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)

Databases: Google Patents, Google, Google Scholar, PATENW (EPODOC, WPIAP and TXTE);
Keywords: (cellular, geolocation, positioning, location, fingerprint, cell model, contour, interpolation, extrapolation, triangulation, cell id, country code, network code, area code, ARFCN, scrambling code, RSS, GPS, AoA, ToA, TDoA, statistical, Bayesian, probability) and like terms; CPC symbols: G01S5/0252, G01S5/0278;
Applicant and inventors name search in Espacenet, AusPat and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] 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
7 September 2017	07 September 2017

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustralia.gov.au

Authorised officer

Pushpika Wijesinghe
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. +61262832589

INTERNATIONAL SEARCH REPORT

International application No. **PCT/SG2017/050218**

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KEMPPI, P., 'DATABASE CORRELATION METHOD FOR MULTI-SYSTEM LOCATION', A thesis submitted for the degree of Master of Science in Electrical and Communications Engineering, Department of Electrical and Communications Engineering, HELSINKI UNIVERSITY OF TECHNOLOGY, 01 August 2005, [retrieved from internet on 01 September 2017] <URL: http://www.tml.tkk.fi/Publications/Thesis/Kemppi-Location.pdf > Sections 3-5 including Tables 4.4 and 4.6, Figures 4.4, 4.15 and 4.20, and equation 3.2	1-27
X	US 2014/0171114 A1 (APPLE INC.) 19 June 2014 Abstract; Figs. 1-8, 12-13 and 17; paragraphs [0004]-[0005], [0031]-[0070], [0094]-[0110], [0137], [0149]	1-27
X	WO 2015/198090 A1 (HERE GLOBAL B.V.) 30 December 2015 Abstract; Fig. 3; pages 1-2 and 9-19	1-27

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/SG2017/050218**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 2014/0171114 A1	19 June 2014	US 2014171114 A1	19 Jun 2014
		US 8934921 B2	13 Jan 2015
		AU 2013360083 B2	02 Feb 2017
		CN 104813186 A	29 Jul 2015
		EP 2932293 A2	21 Oct 2015
		WO 2014092996 A2	19 Jun 2014
WO 2015/198090 A1	30 December 2015	WO 2015198090 A1	30 Dec 2015
		EP 3158354 A1	26 Apr 2017
		US 2017160373 A1	08 Jun 2017

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.